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Minerals Yearbook

1983

Volume I

METALS AND MINERALS

Prepared by staff of the

BUREAU OF MINES

UNITED STATES DEPARTMENT OF THE INTERIOR • William P. Clark, Secretary

BUREAU OF MINES • Robert C. Horton, Director

As the Nation's principal conservation agency, the Department of the Interior has basic responsibilities to protect and conserve our land and water, energy and minerals, fish and wildlife, and park and recreation areas, and for the wise use of all those resources. The Department also has a major responsibility for American Indian reservation communities and for the people who live in Island Territories under U.S. administration.

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Foreword

This edition of the Minerals Yearbook discusses the performance of the worldwide minerals industry during 1983 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," included in this volume for the first time, 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 Foreign Data 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

Mining and Quarrying Trends in the Metal and Nonmetal Industries

By Robert J. Willard[1]

This chapter includes tables for 1982 that were not available in time for publication of the 1982 Minerals Yearbook, but does not include corresponding tables for 1983. The value of raw nonfuel minerals produced in the United States during 1983 was estimated at $21.1 billion, an increase of $1.5 billion over the value for 1982. This is a reversal of last year's downturn in value from that of 1981, which was the only decrease noted since 1971; hence, an overall trend of increasing values has been maintained for 12 years, except for 1982. Although the reversal is a basis for cautious economic optimism, it is tempered by continued problems in the domestic mining industry: inadequate funds for capital investment and competition with other countries that have lower production costs. Output of metal commodities in 1983 increased for 8 out of 21 metals, and metal values, in general, increased for 9 of the metals. Output of nonmetal commodities was mixed, with 24 nonmetals showing increases, 20 showing decreases, and 2 unchanged. Nonmetal values were also mixed in 1982: 25 showed increases, 20 declined, and 1 was unchanged.

Improvements in the international metals market have not been forthcoming because of the continued depressed prices for major metals. Governments in foreign producing countries have been concerned with maintaining employment and continuing foreign exchange flows through mineral exports. Consequently, the excess of supply in the face of shrinking demand brought downward pressure on metal prices in general, except for the precious metals. On the domestic front, this situation means U.S. mining companies must become even more cost efficient. The major trend in the mining industry in 1983 was to cut costs further, reduce or stabilize total production, reduce outlays for major capital equipment, modify existing systems and equipment, and streamline operations. Most of the accomplishments reported herein reflect this trend.

Legislation and Government Programs.—On March 10, 1983, the President signed a proclamation establishing the Exclusive Economic Zone (EEZ), an area contiguous to the territorial sea of the United States, the Commonwealth of Puerto Rico, the Commonwealth of the Northern Mariana Islands, and the U.S. overseas territories and possessions. The area covers about 3.9 billion acres and brings into the national domain an enormous new frontier in which the types of mineral and energy resources are fairly well known but which are still largely unassessed in terms of abundance and recoverability. To the extent permitted by international law, the proclamation confers sovereign rights to explore, exploit, conserve, and manage natural resources (living and nonliving) of the seabed and subsoil. Attention is focused on oil, gas, and minerals within 200 nautical miles of all U.S. land areas covered by the proclamation. The EEZ has great potential importance for the future, in terms of Outer Continental Shelf hard-minerals development. Development could counteract any future trend toward critical national or regional mineral shortages and provide an economically competitive alternate source of supply for critical minerals.

Two bills were considered that have a potential impact on the mining and minerals industry. The first bill was adopted late in the year by the House Committee on Science and Technology as Title 2 of S. 373, the Critical Materials Act of 1983. Title 2 would establish a National Critical Materials Council responsible for materials coordination and policy. The bill was jointly referred to the House Committee on Armed Services and Merchant Marine and Fisheries for consideration and possible House floor action some time in 1984. However, Administration opposition is building on this bill because it establishes a council that would duplicate the existing Cabinet Council on Material Resources and Environment and because there are programs in the U.S. Department of the Interior that work together to achieve the goals of this bill. The second bill, National Minerals and Materials Policy Coordination Act, would mandate that Interior strengthen public land mineral assessments and analyses, as well as establish a Minerals and Materials Council. The bill is pending in the House Interior Subcommittee on Mining, Forest Management and the Bonneville Power Administration.

During the first session of the 98th Congress, 47 individual wilderness bills were introduced. Of these, the Lee Metcalf Wilderness Management Act of 1983, establishing wilderness lands in the national forests of western Montana, was the only legislation passed and signed into law. Activity is expected to continue into 1984 on additional wilderness bills, and debate is certain to focus on a number of the bills that include areas of high mineral potential. Congressional work in 1983 has given a high priority to wilderness legislation.

Exploration.—Exploration remained at reduced levels through 1983, continuing the downturn reported in 1982. The two exceptions involved land deposits of precious metals and seabed deposits of polymetallic sulfides (PMS).

Exploration for gold is exemplified by the systematic sampling of tailings at the Saratoga Mines' century-old properties near Central City, CO. Since exploration also involves evaluations necessary to make decisions regarding the size, initial flowsheet, and annual output of potential mines, the old tailings piles have been considered as candidates for evaluation, particularly because they total an estimated 580,000 short tons with assays ranging from 0.40 to 0.10 ounce per ton, and because they are much less costly to exploit than in situ subsurface deposits. With respect to evaluation of old tailings in general, Geotechnical Engineering and Mining Services of Lakewood, CO, developed a low-cost, portable tailings drill. The drill can penetrate depths over 125 feet at rates up to 75 feet per hour in loose-to-medium-dense sand or tailings, and can be carried about and operated by two people. The drill is turned by a hand-held hydraulic power unit, and because of its counter rotating principle, there is no kickback during operation.

Increased exploration for PMS has been reported in the technical media, culminating in a national workshop at the U.S. Geological Survey's headquarters in Reston, VA, in November. The workshop, entitled "A National Program for the Assessment and Development of the Mineral Resources of the United States Exclusive Economic Zone," was cosponsored by three Interior agencies: the Bureau of Mines, the Minerals Management Service, and the Geological Survey. PMS deposits contain significant copper, zinc, and silver and continue to receive national attention because of the importance of these and other metals to the Federal policy on critical and strategic minerals. Although PMS deposits received the most attention, other hard-mineral deposits on the seafloor also received attention because of their importance to the Federal policy. They include cobalt-rich seamounts and seafloor crusts on the flanks of many U.S. island possessions and territories in the Pacific; titanium and rare-earth placers and phosphates and pavement-like deposits of manganese along the Atlantic margin; and placer deposits of titanium, platinum, and gold along the Alaska margin.

Improvements continue to be made in field assay equipment. UNC MAP of Richmond, VA, developed a portable, in situ assay system for silver, tin, uranium, and other elements.[2] The instrument is computerized so that all assay data including assay value, metal of interest, duration of assay identification number, in-hole footage, etc., are automatically stored in the system's memory. Assay data are obtained through use of interchangeable hand-held scanners or in-hole probes, and can be recalled or displayed, or the control box can be connected to a printer for making hard-copy printouts. The rugged construction and reliable assay capability under rough field conditions have made the system popular in a wide variety of mining and exploration settings.

Development.—With ever increasing emphasis on cost effectiveness in mining, the development phase has grown proportionately more important. For example, in surface mine development, deeper overburden and changing ore deposit characteristics encourage use of dragline systems with larger buckets and longer booms, such as are being used along the gulf coast and in the United Kingdom. Such systems are just as applicable to metal and nonmetal deposits as they are to coal deposits. For example, in the gulf coast lignite deposits, as stripping methods are applied to deeper deposits, draglines loom as the cheapest approach despite initially high capital costs. In the United Kingdom, the Ransomes and Rapier W2000 unit represents the new trend in dragline technology. It has a 313-foot boom that can bear loads up to 83.5 tons at an angle of 38°. The boom also has an operating radius of 266 feet when the tip is 186 feet above ground level. Dragline systems are also operating with increasing bucket capacity, some up to 65 cubic yards, to provide large tonnage volumes and high recovery rates in the pit. These kinds of capabilities are ideally suited for moving overburden greater distances at minimum cost, providing that the all-important ground stability is maintained around the dragline.

Optimization of ripping techniques has been worked out by Caterpillar Tractor Co., and is presented in its publication, "Handbook of Ripping."[3] The company regards ripping as a close competitor of drilling and blasting in breaking up massive rock formations, and in many cases, it has proven to be more cost effective. As a rule of thumb, the handbook recommends that when rippers can be used on a production basis they can loosen rock material for one-third to one-half the cost of drilling and blasting. In small mining operations, drilling and blasting averages 40 to 60 cents per bank cubic yard, and in large operations, 15 to 30 cents per bank cubic yard, so considerable savings can be realized by ripping, providing the ripping is carried out under carefully controlled conditions.

Shaft development set a new record in 1983 with completion of the deepest single-lift shaft in North America. The record-setting, 7,700-foot-deep shaft is located at the Hecla Mining Co.'s Lucky Friday Mine in Mullan, ID, and was scheduled to begin production by yearend. The entire project consists of a complete surface facility, the shaft, a complete ore pass and loading pocket system, and 2,000 feet of development and stope preparation. The project, completed in 4 years, will provide access to the silver-bearing ore below the 5,000-foot level.

A new mine design system was developed for open pit operations at Duval Inc.'s Esperanza-Sierrita Mine.[4] The system now in operation, is termed the "Pushback Extraction Design" (PED), and represents a practical adaptation of an earlier concept, the Sierrita Incremental Design system. Under the PED system, the ore body is divided into a sequential series of minable areas or pushbacks that are extracted in a manner that maximizes net present value over the life of the deposit. Each pushback is an optimized design that ties in sequentially to previously designed pushbacks. PED has been computerized so that mining variables can be changed readily and new designs produced by merely rerunning the program; for example, the optimum stripping ratio can be determined by running the program at various ratios.

Underground Mining.—Feeder-breakers are replacing jaw crushers at Dravo Lime Co.'s underground limestone mine near Maysville, KY. In operation for over 1 year, mine management has come to regard them as an improvement over other jaw crushers because they generate fewer fines, are more mobile, and have shown other advantages such as a consistent size reduction, a steady feed to downstream belt conveyors, and no need for operator attendance during operation. The Dravo lime breaker consists of a series of carbide-tipped picks on a solid steel shaft that can fracture mine-run feed up to 4 feet in diameter. The powerful force concentrated in the picks produces fewer fines than jaw crushers. This force is desired by management, since the fines cannot be made into lime of the size required for use in sulfur dioxide scrubbing systems. In terms of mobility, the feeder-breaker can be moved in a week at a fraction of the cost formerly needed to move a jaw crusher, which normally requires several months of excavation, fabrication, and erection work.

A flexible, rotary drill was developed by the Bendix Corp. under joint sponsorship with the Bureau of Mines and the U.S. Department of Energy.[5] The drill was originally developed for the production of holes to install longer-than-seam-height roof bolts, but its versatility enabled its adaptation to other types of drilling. It has the characteristic that only the portion of the drill string that is subjected to torque becomes straight and rigid; i.e., at the compact drive bead unit. The rest of the drill string that is not in the unit is not subjected to torque and remains flexible. Besides producing penetration rates similar to contemporary rotary drilling equipment, the drill has enough strength and reliability to be considered practical. The drill head can be operated from any position; for example, horizontal holes have been drilled in sandstone strata up to 33 feet deep. Other drilling applications are feasible, as under conditions where there is insufficient space for conventional drill feed masts or booms or in diamond bit drilling where a stable feed is required.

The Bureau of Mines-sponsored research with Flow Industries (FI) was completed on a high-pressure water-jet drill that can drill 1-inch-diameter holes.[6] The objective of the work was to develop a drill system that would cut the time to drill roof bolt holes by one-half. FI found that the water-jet drill was up to 65% faster than conventional drills in the same strata, and that the new drill could reduce roof bolting costs by 30%.

Fragmentation research conducted by the Bureau of Mines has focused on nonexplosive concepts that would enhance continuous automated operations and reduce time and costs of fragmentation in underground mines.[7] As an example, large-scale experimental drag cutters were tested successfully on hard rock up to 20,000 pounds per square inch with 3- and 6-inch bits. As a result, larger scale, proof-of-concept tests were to be conducted with a cutter capable of cutting a 6-foot opening in which mucking and holddown requirements can also be evaluated. Drag cutters thus far have shown the potential to double excavation rates while reducing operational costs up to 30%.

Since shuttle cars play a predominant role in underground haulage in room and pillar mines, any increase in their load-carrying capacity could increase productivity, providing that other parts of the total mine system are functioning properly. Accordingly, the Bureau of Mines and National Mine Service Co. designed, built, and tested a maximum capacity shuttle car that can be used in coal and noncoal mines. The NMS MC 36 shuttle car, now available on the market, is the result of this effort. The car can haul 8.5 tons of material when equipped with optional 6-inch sideboards, a configuration with more load capacity than other shuttle car designs in the same height-width range. For example, two MC 36 cars are hauling 11.5 tons of ore each trip in a New Mexico potash mine without exceeding peak capacity for their design. Added features that enhance their usefulness include solid-state controls, twin traction motors, and a floating operator.

Surface Mining.—A change in quarrying methods at Granite Rock Co.'s Logan Quarry near Aromas, CA, has enabled the company to realize a 30% savings in operating and maintenance costs. The main change involves use of an automated conveyor system to handle plant feed material from the face to the main plant area, in combination with two other procedural changes: elimination of drilling and blasting and a complete revamp of primary processing. Two D10 bulldozers rip the highly fractured granite and push it over the bank to the quarry floor. The 450-foot-long conveyor is walked along the long, narrow quarry (600 feet wide by 6,000 feet long) with a track-mounted feeder-breaker picking up the material; this technique eliminates six rear-dump haul trucks and drivers. The material is then transferred from the conveyor to a sectioned plan conveyor that empties into a 450-ton-capacity holding bin for later discharging into vibrating grizzly feeders. Despite increased maintenance costs on the feeder-breaker, owing to the highly abrasive granite, the total system has proven to be less expensive to operate than the previous system using haul trucks to move the material to the primary plant.

Another example of changing a mining method to cut costs involves use of conveyor belts at Tanner Co.'s Plant 66 in Tucson, AZ. A 3,000-foot overland conveyor was installed to transfer raw material (mostly minus 2-inch gravel) from the pits to the processing plant, thereby replacing 35-cubic-yard belly-dump haulage trucks. Considerable savings are anticipated from this change, since costs for fuel, tires, engine overhauls, and general truck maintenance will be practically eliminated. Because the gravel is almost at water level in a dried riverbed, it is removed in a wet condition by a wheel loader and loaded onto the conveyor, which helps it to dry before it reaches the surge pile on the pit rim.

In still another example, Springfield Quarry Products near Springfield, OR, is saving about 10% in extraction costs at its basalt quarry by replacing its drilling-blasting operation with a D10 ripper bulldozer. The bulldozer produces smaller ripped material than was possible by drilling-blasting, so crushing-screening costs are less. Although the basalt is a very dense and tough material, the ripper shank is able to get good penetration up to 4 feet, and the bulldozer provides good traction and power to pull the penetrated ripper. In actual operation, the bulldozer rips downhill for about 50 yards, then backs up and uses the blade to move the ripped stone into a pile from which it is loaded into haul trucks.

An innovative surface mining system has been developed for installation at Texas Utilities' Big Brown open pit lignite mine near Fairfield, TX. The system, applicable also to metal and nonmetal mining operations, employs a specially designed cross-pit spreader that allows overburden, previously removed by bucket wheel excavators, to be transported across the pit along the shortest possible route. Despite its novelty, the system is considered to be simple with an economical design that could revolutionize domestic surface mining. Plans call for it to be operational in late 1985.

A new kind of offroad hauler, the A464 Euc-Artic, was introduced by Euclid Inc., of Cleveland, OH.[8] The hauler has oscillating and articulating features for use in pit operations plagued by unstable ground conditions, narrow hoppers, inadequate haul roads, and hostile weather. It represents an alternative to scrapers with rigid frames that lack chassis agility. At 35 tons, the hauler is 15 to 20 tons lighter than most scrapers, thus improving its cost efficiency. Front and rear oscillating frames move independent of one another to reduce severe stresses encountered in offroad applications and to provide better performance in rough terrain, since all wheels are in constant contact with the haul road. It is particularly adept at "duckwalking" through deep ruts and loose dirt in the worst offroad conditions, aided by limited-slip differential gears, four-wheel drive, and wide-based, high-flotation tires.

The largest movable jaw crusher plant ever built for quarry operation will likely effect substantial cost savings compared to systems using large haul trucks. The plant, developed by Iowa Manufacturing Co., is contained on a single chassis that includes a Cedarapids 5460 overhead jaw crusher, a 62-inch by 24-foot vibrating grizzly feeder, a Cedarapids 60-inch by 38-foot conveyor, and a 35-cubic-yard hopper. Its total weight is 400,000 pounds, and the overall dimensions are 66 feet in length, 29-1/2 feet in height, and 20 feet in width, carried on 32 rear and 12 front wheels. The plant will be fed by 13-1/2-cubic-yard end loaders operating at distances up to 400 feet in a quartzite quarry. Using this arrangement, the quarry operator plans to relocate the plant every 3 to 6 months, depending on production.

In Situ Mining.—Precious metals continued to be profitable for mining, and industrial interest in solution mining for two of these metals, gold and silver, remained high during the year, largely because of a modest rebound in silver prices that brought several idle operations back into production. For example, Nerco Minerals Co. reopened its Candelaria Mine near Mineral, NV, where gold and silver were being heap leached from ore with a cyanide solution. There is general recognition that heavy equipment compacts the heap in heap-leach operations, and that leveling its top surface with a bulldozer reduces permeability. This condition was improved by confining trucks to a relatively small dumping area on the heap, and by ripping the top surface between leaching cycles. Other improvements in the effectiveness of heap leaching have been made by stressing uniform distribution of leach solution applications to avoid ponding or dry spots, and by using wobbler-type sprinklers rather than the rotating impulse type, because wobblers are less likely to become clogged and can operate at lower pressures. Heap leaching has grown in popularity since the early 1970's; since then, heaps of 5,000 to 2,000,000 tons and as low as 0.03 ounce of metal per ton have been successfully leached. Flexibility, low capital costs, and reasonable operating costs are inducements to undertake heap leaching, especially at today's high prices for precious metals.

Pegasus Gold Ltd. was successfully operating what may be the lowest grade but largest heap-leaching operation in the world. The operation is in the Little Rocky Mountains of north-central Montana at the Zortmann Mining Inc. and Landusky Mining Inc. minesites. A syenite host rock is stripped at a ratio of 0.9 to 1.0 to produce pits, the design of which are carefully planned to maximize use of waste rock for construction of leach pad foundations and dikes. The pits are then blasted to loosen the 0.03 troy ounce per ton of gold ore from the host. The fragmented material is stripped according to an ore-waste control plan, and using trucked-in bentonitic shale and polyvinyl chloride blanket, the heaps are constructed up to 100 feet high in 20- to 30-foot lifts. Estimates for 1983 production are 73,000 ounces of gold and 160,000 ounces of silver from a mining program geared to 4 million tons of ore, leading to a substantial profit. Such productivity, even with a cutoff grade of 0.01 ounce per ton will most likely buffer Pegasus against price declines, confirming that heap-leaching is cost effective at very low grades with proper mine planning and management.

A new process was developed at Saratoga Mines Nos. 1 and 2 operations near Central City, CO, to extract bullion from the century-old ore dumps.[9] Sampling of the dumps indicated a range of 0.04 to 0.10 ounce per ton, where a recovery of at least 0.02 ounce per ton is considered profitable. The process involves sifting of calcine kiln dust at $15 per ton over the tailings and wetting with water spray as they are being conveyed from the crusher to stockpile. The kiln dust binds clay in the tailings to the crushed rock, forming pellets that permit the leaching solution to readily percolate through the leach pile. Use of the dust is considered to be cost effective for several reasons: it is more economical than previously used commercial cement and lime, it is an effective acid neutralizer, it provides protective alkalinity and oxidation, and it helps reduce recovery costs by speeding up the agglomeration process, thereby permitting bullion recovery from lower grade deposits.

Three patents were issued during the year as the result of Bureau of Mines-sponsored research in branch well technology for in situ leach mining. The concepts contained in these patents apply to deep (greater than a 1,000 feet) in situ mining technology aimed at reducing total drill footage and increasing fluid coverage. The first patent covers multiple branch competition with common drilling and casing templates,[10] the second covers multiple branch wells containing one producer and one injector well,[11] and the third covers the method and apparatus to complete horizontal drain holes.[12]

A computerized cost model was developed by the Bureau of Mines for uranium in situ leach mining.[13] Data from a given minesite are factored into the model to estimate total capital and operational costs. The data include deposit characteristics such as depth, thickness, and ore grade and estimates of annual production, production life, rates of return, debt financing, cost base per year, and project start year. Other data are estimated based on a mix of experience, knowledge of the site, and information from other sites if available. The model takes a process engineering approach and determines through a discounted cash flow analysis the total costs for the life of the project. Project life is measured from the start of the pilot-scale operation through the site's restoration and reclamation. In addition, the model determines the production cost per pound of material mined, subject to the rate of return identified by the user. In addition, it will solve the rate of return realized for the specific sales price per pound. Although its current data base is limited to Texas and Wyoming, the only States with active in situ uranium mining, the model is usable for any in situ leach operation or any operation with the potential for in situ mining.

A case history report on in situ copper mining operations was released during the year by the Bureau of Mines.[14] The report brings together information about 10 commercial in situ operations and 14 experimental projects. These cases constitute most of the in situ copper mining activities that have taken place in the United States. Background information, geology, ore preparation, solution application, and recovery and processing are provided in each case. Production data and tables summarizing the engineering statistics for each case and an extensive in situ mining bibliography are included. In situ mining is predicted to become more attractive and play an increasingly important role in future copper production as conventional mining costs increase and ore grades decrease.

Beneficiation.—For a number of years, improvements in beneficiation technology have been the result of evolutionary extensions of present practice. This trend continues as increased use is made of larger grinding mills and flotation machines. Larger equipment reduces the number of units required, lowers maintenance costs, reduces floor space requirements, simplifies computerized process control systems, and can reduce energy costs providing mill throughput is adequate. However, the sizing of very large ball mills using scale-up functions is more complex than for smaller units. This complexity results from the fact that the residence time in a very large mill depends on several factors that can be neglected for smaller mills. Although the design criteria and scale-up factors for very large mills have been established, they have yet to be put on a quantitative basis. In 1979, for example, the largest available capacity for any flotation machine was 1,350 cubic feet. In 1983, both a 1,500- and a 2,500-cubic-foot-capacity cell were produced, and commercially available flotation circuits, in general, continue to be remodeled into larger machines. This trend means fewer machines will be required to meet production goals.

Another recent development is that of computerized process control for grinding and flotation circuits, including primary sensors, computer models of grinding mills and flotation cells, and feedback control protocol. The Comminution Generic Center at the University of Utah's Mineral Research Institute, for example, is conducting research in particulate characterization by automated image analysis for the measurement and prediction of mineral liberation. The research covers such areas as on-line measurement of particle size, modeling of a hydrocyclone, computer simulation of complex comminution circuits, and adaptive control strategies for rod and ball mills. Basic research is reflecting still another development in automation. Investigators are addressing problems on the synergistic effects of multiple minerals and on the effects of one unit operation on another. For example, the effects of metal ions dissolved into solution during grinding on both grinding media wear and subsequent flotation response are current topics of investigation. These investigations could be the forerunners of future commercial applications.

One of the most significant developments in froth flotation technology took place in 1983 with the introduction of nitrogen instead of air for bubble formation. Since nitrogen reduces the consumption of certain reagents, its main advantages under different flotation conditions are yet to be fully appreciated. Gibraltar Mines Ltd. in British Columbia, Canada, is one of the most recent mills to substitute nitrogen for air bubbles in the flotation of byproduct molybdenite.[15] At Gibraltar, a bulk copper-molybdenum concentrate is produced and followed by a differential flotation of the molybdenum from the copper. By substituting nitrogen externally for air, it was possible to reduce the sodium hydrosulfide requirement from 18 pounds per ton to about 4 pounds per ton.

Wemco's inert-gas flotation machine is a series of sealed flotation cells that do not need an external nitrogen supply. Ambient air is first trapped in the cells, and then the oxygen in this air is removed by oxygen-consuming reagents. What remains is almost entirely nitrogen, which continues to be used to aerate the pump, producing a nitrogen bubble froth. The nitrogen is recovered from the froth product by a degassing machine and recirculated through the pulp in a closed loop. The cells are kept under slight pressure, and the small nitrogen loss that generally occurs is replaced by the small amount of dissolved air that enters the cells with the pulp.

In another development that may influence future flotation trends, research is being conducted on direct measurement of surface chemical species. Techniques such as Fourier transform infrared spectroscopy, x-ray photoelectron spectroscopy, scanning Auger, and electron microscopies are making possible characterization of the mineral surface under a wide range of conditions encountered during grinding and flotation. Coupled with electrochemical research, the resulting data are yielding information on many of the synergistic effects of minerals during flotation induced by dissolved ions.

Recovery of mineral values from specific ores is often best accomplished by using a unique combination of different collectors. Realizing this, some flotation reagent manufacturers are now making customized collectors to be used with specific ore deposits. In addition, to reduce the quantity of lime required for pH adjustment, chemical manufacturers are attempting to develop sulfide collectors that work in neutral circuits, instead of in the high-pH range.

A Bureau of Mines study was released in 1983 on technological innovation in the copper industry.[16] The study forecasts that autogenous and semiautogenous grinding were likely to become more widely accepted because these grinding methods eliminate secondary and tertiary crushing, thus allowing more economical use of electric power.

Health and Safety.—Preliminary injury statistics compiled by the Mine Safety and Health Administration revealed the 1983 nonfatal injury rate to be 5.10 per 200,000 employee hours in metal and nonmetal mines, an increase over the 4.46 rate in 1982. The fatal injury rate was 0.05, up from 0.03 in 1982.

Bureau of Mines research has demonstrated the importance of medium frequency (MF) communication in mine rescue operations. MF utilizes existing mine conductors to provide a radio network between trapped miners and rescue teams. Small MF transceivers carried by miners emit signals up to hundreds of feet, and if the signal intersects mine wiring, the signal can be carried thousands of feet. Rescue teams, guided by sensitive receivers that pick up the signals, can proceed more rapidly and assuredly, thereby enhancing the chances for a successful rescue. As compared with other rescue systems, it has the advantage of being fully integrational with an operational MF communication system routinely used by underground mines, and therefore can always be in a state of readiness for emergencies.

In the area of mine ventilation, Engineers International Inc., under contract to the Bureau of Mines, found that when main mine fans are electrically reversed the airflow is reduced to 40% to 60% of the forward flow, and the pressure is reduced to 35% to 45% of the forward pressure. These findings are helpful because the reduced flow and pressure can aid in planning strategy to contain a mine fire, and can be adjusted to avoid ice buildup in shafts during cold weather.

An early warning system was developed by the Bureau of Mines to remotely monitor displacement of roof or ribs in underground mine entries.[17] The system detects critical ground movements that normally occur before sudden failure. It consists of a helium-neon laser mounted in a relatively stable area of the mine to focus on a string of small aperture targets installed along the mine roof or rib surface in the area to be monitored. A photodetector unit is mounted at the opposite end of the line of targets from the laser source. Any displacement of roof or rib rock results in misalignment of the target apertures and interruption of the light beam. When a loss of light occurs, the detector activates an alarm. Displacement can be determined from the distance and direction of target movement needed to realign the apertures with a reference beam. A microprocessor operates the system for periods up to one-half year without servicing, and the laser can be programed to operate continuously or intermittently. The system memory preserves records of significant changes in alignment of target apertures.

A new dual filament tungsten-halogen bulb was developed by GTE-Sylvania under a cooperative agreement with the Bureau of Mines.[18] The bulb emits 30% to 40% more light than lamps in present use, at the same life and power level, and is retrofittable into existing cap lamp headpieces. Design and evaluation work is being done on other parts of personal lighting systems for miners, as part of a Bureau effort to reduce injuries and accidents in the working environment through use of improved illumination systems. They include etching of the glass lamp wall to improve beam uniformity, testing the service life of a newly developed nickel-cadmium cap lamp battery, and redesigning the cap lamp for lamp relocation and fiber optics for light transmission.

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[1]Staff engineer, Twin Cities Research Center.

[2]Mining Journal (London). Portable Systems for Mining and Exploration. V. 302, No. 7750, Mar. 2, 1984, p. 143.

[3]Mining Engineering (New York). Tools, Techniques and Applications. V. 35, No. 1, Jan. 1983, pp. 13-16.

[4]Illes, C. D., and G. A. Perry. Sierrita Incremental Pit Design Systems. Min. Eng. (New York), v. 35, No. 2, Feb. 1983, pp. 152-155.

[5]Varnes, H. M. Flexible Rotary Drill Applications and Experience. Min. Eng. (New York), v. 35, No. 12, Dec. 1983, pp. 1641-1646.

[6]Johnson, B. U.S. Bureau of Mines Research Leads to a More Productive Minerals Industry. Min. Eng. (New York), v. 35, No. 11, Nov. 1983, p. 1518.

[7]Page 1516 of work cited in footnote 6.

[8]Tiller, R. Articulated Hauler Introduced at Mining Conference. Pit and Quarry, v. 76, No. 3, Sept. 1983, pp. 66-67.

[9]Todd, J. C. Saratoga Mines Uses New Process To Extract Bullion From Old Ore Dumps. Eng. and Min. J., v. 184, No. 10, Oct. 1983, pp. 19, 25.

[10]Wood, E. T., D. W. Dareing, R. Snyder, and W. C. Larson. Multiple Branch Completion With Common Drilling and Casing Template. U.S. Pat. 4,396,075, Aug. 2, 1983.

[11]Wood, E. T., D. W. Dareing, W. C. Larson, and R. Snyder. Multiple Branch Well Containing One Producer and One Injector Well. U.S. Pat. 4,396,230, Aug. 2, 1983.

[12]Wood, E. T., R. Snyder, W. C. Larson, and D. W. Dareing. Method and Apparatus To Complete Horizontal Drain Holes. U.S. Pat. 4,402,551, Sept. 6, 1983.

[13]Bureau of Mines. Cost Analysis Computer Model for Uranium In Situ Leach Mining. BuMines Technol. News, No. 159, Nov. 1982.

[14]Ahlness, J. K., and M. G. Pojar. In Situ Copper Leaching in the United States: Case Histories of Operations. BuMines IC 8961, 1983, 37 pp.

[15]Redfearn, M. A. The Role of Nitrogen in the Flotation of By-Product Molybdenite at Gibraltar Mines. Pres. at Soc. Min. Eng. Annual Meeting, Atlanta, GA, March 6-10, 1983. Soc. Min. Eng. AIME preprint 83-64, 8 pp.

[16]Mineral Systems Inc. Technological Innovation in the Copper Industry. Ongoing BuMines contract J0100063; for information, contact Division of Minerals Policy and Analysis, BuMines, Washington, DC.

[17]Bureau of Mines. A Summary of Significant Results in Mineral Technology and Economics. BuMines Research 1983, p. 55.

[18]Bureau of Mines, Pittsburgh Research Center. Fiscal year 1983 Annual Report. Pp. 15-40.

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:									
1978	554	995	1,550	74	21	95	628	1,020	1,640
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
Nonmetals:									
1978	2,320	571	2,890	87	1	88	2,410	572	2,980
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
Total metals and nonmetals:[1]									
1978	2,870	1,570	4,440	161	22	183	3,030	1,590	4,620
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

[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 was not available for 1981 because of biennial canvassing.
[4]Crushed and broken and dimension stone were not available for 1982 because of biennial canvassing.

Table 2.—Material handled at surface and underground mines[1] in the United States in 1982, 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	989	7,340	8,330	--	--	--	989	7,340	8,330
Copper	172,000	355,000	527,000	24,300	2,170	26,500	196,000	357,000	553,000
Gold:									
Lode	24,000	53,800	77,800	2,090	407	2,490	26,100	54,200	80,300
Placer	8,600	501	9,100	W	W	W	8,600	501	9,100
Iron ore	122,000	107,000	229,000	1,390	4,260	5,650	123,000	112,000	235,000
Lead	--	--	--	9,670	2,050	11,700	9,670	2,050	11,700
Silver	2,410	21,300	23,700	4,290	644	4,940	6,700	22,000	28,700
Titanium (ilmenite)	22,400	W	22,400	--	--	--	22,400	W	22,400
Tungsten	W	W	W	365	126	491	365	126	491
Uranium	7,550	79,600	87,100	3,430	935	4,360	11,000	80,500	91,500
Zinc	--	--	--	6,440	1,150	7,590	6,440	1,150	7,590
Other[3]	11,360	52,040	63,400	7,940	240	8,180	19,400	52,000	71,300
Total metals[2]	371,000	677,000	1,050,000	59,900	12,000	71,900	431,000	689,000	1,120,000
NONMETALS									
Abrasives[4]	73	44	117	W	W	W	73	44	117
Asbestos	W	W	W	--	--	--	W	W	W
Barite	2,580	3,250	5,830	--	--	--	2,580	3,250	5,830
Clays[e]	34,800	30,300	65,100	192	3	195	35,000	30,300	65,300
Diatomite	781	411	1,190	--	--	--	781	411	1,190
Feldspar	650	10	660	--	--	--	650	10	660
Fluorspar	W	W	W	193	37	230	193	37	230
Gypsum	8,390	4,750	13,100	2,220	--	2,220	10,600	4,750	15,400
Mica (scrap)	1,240	554	1,800	--	--	--	1,240	554	1,800
Perlite	623	546	1,170	--	--	--	623	546	1,170
Phosphate rock	161,000	324,000	485,000	W	--	W	161,000	324,000	485,000
Potassium salts	--	--	--	17,300	200	17,500	17,300	200	17,500
Pumice[5]	473	45	518	--	--	--	473	45	518

Salt	1,700	--	1,700	11,900	341	12,300	13,600	341	14,000
Sand and gravel[6]	621,000	--	621,000	--	--	--	621,000	--	621,000
Sodium carbonate (natural)	--	--	--	29,200	W	29,200	29,200	W	29,200
Stone:[7]									
Crushed and broken	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dimension	NA	NA	NA	NA	NA	NA	NA	NA	NA
Talc, soapstone, pyrophyllite	813	1,410	2,220	80	W	80	894	1,410	2,300
Other[8]	3,000	790	3,800	257	1,300	1,560	3,250	2,090	5,360
Total nonmetals[2]	837,000	366,000	1,200,000	61,400	1,880	63,300	899,000	368,000	1,270,000
Grand total[2]	1,210,000	1,040,000	2,250,000	121,000	13,900	135,000	1,330,000	1,060,000	2,390,000

[e]Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Excludes material from wells, ponds, or pumping operations.
[2]Data may not add to totals shown because of independent rounding.
[3]Includes antimony, beryllium, manganiferous ore, mercury, molybdenum, nickel, platinum, rare-earth metals, tin, vanadium, and metal items indicated by symbol W.
[4]Includes abrasive stone, emery, garnet, and tripoli.
[5]Excludes volcanic cinder and scoria.
[6]Includes construction and industrial sand and gravel in 1982.
[7]Crushed and broken and dimension stone were not available for 1982 because of biennial canvassing.
[8]Includes aplite, boron minerals, graphite, greensand marl, iron oxide pigments (crude), kyanite, lithium minerals, magnesite, millstones, vermiculite, wollastonite, and nonmetal items indicated by symbol W.

Table 3.—Material handled at surface and underground mines[1] in the United States in 1982, 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	9,790	1,250	11,000	--	--	--	9,790	1,250	11,000
Alaska	45,800	491	46,300	2	1	3	45,800	492	46,300
Arizona	130,000	188,000	318,000	20,800	2,200	23,000	151,000	190,000	341,000
Arkansas	9,490	5,440	14,900	--	--	--	9,490	5,440	14,900
California	96,900	10,700	108,000	293	123	416	97,200	10,800	108,000
Colorado	21,900	18,900	40,800	8,980	331	9,310	30,800	19,200	50,100
Connecticut	5,110	W	5,110	--	--	--	5,110	W	5,110
Delaware	1,300	--	1,300	--	--	--	1,300	--	1,300
Florida	181,000	274,000	455,000	--	--	--	181,000	274,000	455,000
Georgia	10,600	10,600	21,200	W	W	W	10,600	10,600	21,200
Hawaii	460	--	460	--	--	--	460	--	460
Idaho	10,100	40,800	50,900	811	214	1,030	10,900	41,000	51,900
Illinois	26,200	523	26,700	260	W	260	26,400	523	27,000
Indiana	13,700	435	14,200	W	--	W	13,700	435	14,200
Iowa	11,500	991	12,400	W	--	W	11,500	991	12,400
Kansas	10,700	577	11,300	1,010	--	1,010	11,700	577	12,300
Kentucky	7,210	607	7,810	W	W	W	7,210	607	7,810
Louisiana	18,900	283	19,200	3,640	W	3,640	22,500	283	22,800
Maine	6,740	W	6,740	--	--	--	6,740	W	6,740
Maryland	10,100	355	10,500	--	--	--	10,100	355	10,500
Massachusetts	12,400	183	12,500	--	--	--	12,400	183	12,500
Michigan	49,400	35,800	85,200	W	--	W	49,400	35,800	85,200
Minnesota	108,000	57,500	166,000	--	--	--	108,000	57,500	166,000
Mississippi	10,300	699	11,000	--	--	--	10,500	699	11,000
Missouri	9,420	1,790	11,200	10,900	6,310	17,200	20,400	8,100	28,500
Montana	23,800	4,100	27,900	3,330	115	3,440	27,100	4,210	31,300
Nebraska	9,860	116	9,980	--	--	--	9,860	116	9,980
Nevada	36,800	86,600	123,000	461	144	605	37,200	86,800	124,000
New Hampshire	4,340	10	4,350	--	--	--	4,340	10	4,350
New Jersey	11,600	54	11,700	W	--	W	11,600	54	11,700
New Mexico	19,400	55,300	74,700	19,400	863	20,300	38,800	56,100	94,900
New York	18,400	344	18,700	5,000	W	5,000	23,400	344	23,700
North Carolina	13,100	13,700	26,800	--	--	--	13,100	13,800	26,900
North Dakota	2,390	W	2,390	--	--	--	2,390	W	2,390
Ohio	28,900	1,400	30,300	W	W	W	28,900	1,400	30,300
Oklahoma	10,800	659	11,400	--	--	--	10,800	659	11,400
Oregon	11,000	845	11,900	W	W	W	11,000	845	11,900

Pennsylvania	15,000	809	15,800	535	W	535	15,500	809	16,300
Rhode Island	1,150	--	1,150	--	--	--	1,150	--	1,150
South Carolina	7,170	1,390	8,560	--	--	--	7,170	1,390	8,560
South Dakota	4,000	129	4,130	W	W	W	4,000	129	4,130
Tennessee	9,750	13,300	23,100	6,670	882	7,560	16,400	14,200	30,600
Texas	59,100	6,590	65,700	W	W	W	59,100	6,590	65,700
Utah	46,200	127,000	174,000	797	470	1,270	47,000	128,000	175,000
Vermont	3,240	--	3,240	--	--	--	3,240	--	3,240
Virginia	8,360	367	8,730	W	--	W	8,360	367	8,730
Washington	15,800	223	16,000	401	W	401	16,200	223	16,400
West Virginia	1,700	182	1,890	W	W	W	1,700	182	1,890
Wisconsin	16,100	W	16,100	--	--	--	16,100	W	16,100
Wyoming	13,100	78,000	91,100	29,500	1,360	30,800	42,500	79,400	122,000
Undistributed	162	1,850	2,000	8,570	841	9,410	8,730	2,690	11,430
Total[2] [3]	1,210,000	1,040,000	2,250,000	121,000	13,900	135,000	1,330,000	1,060,000	2,390,000

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 1982

(Value per ton)

Ore	Surface			Underground			All mines		
	Principal mineral product	By-product	Total	Principal mineral product	By-product	Total	Principal mineral product	By-product	Total
METALS									
Bauxite	$8.42	$20.63	$29.05	--	--	--	$8.42	$20.63	$29.05
Copper	8.46	1.38	9.84	$13.47	$3.26	$16.73	9.08	1.61	10.69
Gold:									
Lode	19.75	.26	20.01	45.07	11.58	56.65	22.74	1.60	24.34
Placer	1.68	--	1.68	--	--	--	1.68	--	1.68
Iron ore	11.54	W	11.54	W	W	W	11.54	W	11.54
Lead	--	--	--	28.02	10.14	38.16	28.02	10.14	38.16
Silver	14.15	6.02	20.17	40.17	11.19	51.36	31.53	9.47	41.00
Titanium (ilmenite)	2.06	2.23	4.29	--	--	--	2.06	2.23	4.29
Tungsten	W	W	W	54.15	W	54.15	54.15	W	54.15
Uranium	23.49	--	23.49	191.47	15.80	207.27	52.67	2.75	55.42
Zinc	--	--	--	29.25	W	29.25	29.25	W	29.25
Average[1]	10.81	.89	11.70	29.12	5.08	34.20	13.38	1.48	14.86
NONMETALS									
Barite	26.25	W	26.25	--	--	--	26.25	W	26.25
Clays	22.60	--	22.60	22.32	--	22.32	22.60	--	22.60
Diatomite	81.95	--	81.95	--	--	--	81.95	--	81.95
Feldspar	30.87	37.64	68.51	--	--	--	30.87	37.64	68.51
Fluorspar	W	--	W	57.79	W	57.79	57.79	W	57.79
Gypsum	8.63	--	8.63	7.82	--	7.82	8.46	--	8.46
Mica (scrap)	4.22	--	4.22	--	--	--	4.22	--	4.22
Perlite	15.13	--	15.13	--	--	--	15.13	--	15.13
Phosphate rock	5.87	W	5.87	W	--	W	5.87	W	5.87
Potassium salts	--	--	--	12.03	--	12.03	12.03	--	12.03
Pumice	4.38	--	4.38	--	--	--	4.38	--	4.38

Salt	4.12	11.94	16.06	14.23	2.01	16.24	12.97	3.25	16.22
Sand and gravel[2]	3.18	--	3.18	--	--	--	3.18	--	3.18
Sodium carbonate (natural)	--	--	--	18.37	--	18.37	18.37	--	18.37
Stone:[3]									
Crushed and broken	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dimension	NA	NA	NA	NA	NA	NA	NA	NA	NA
Talc, soapstone, pyrophyllite	22.17	--	22.17	16.44	--	16.44	21.43	--	21.43
Average[1]	5.29	.10	5.39	15.58	.41	15.99	6.00	.12	6.12
Average, metals and nonmetals[1]	6.95	.34	7.29	22.22	2.71	24.93	8.35	.55	8.90
Average, nonmetals (excluding sand and gravel)[1]	11.32	.43	11.75	15.58	.41	15.99	12.26	.30	12.56
Average, metals and nonmetals (excluding sand and gravel)[1]	11.00	.66	11.66	22.22	2.71	24.93	12.93	1.01	13.94

NA Not available. W Withheld to avoid disclosing company proprietary data.
[1]Includes unpublished data.
[2]Includes construction and industrial sand and gravel.
[3]Crushed and broken and dimension stone were not available for 1982 because of biennial canvassing.

Table 5.—Crude ore and total material handled at surface and underground mines in the United States in 1982, by commodity

(Percent)

Commodity	Crude ore		Total material	
	Surface	Under-ground	Surface	Under-ground
METALS				
Antimony	--	100.0	--	100.0
Bauxite	100.0	--	100.0	--
Beryllium	100.0	--	100.0	--
Copper	87.6	12.4	95.2	4.8
Gold:				
Lode	92.0	8.0	96.9	3.1
Placer	100.0	--	100.0	--
Iron ore	98.9	1.1	97.8	2.2
Lead	--	100.0	--	100.0
Manganiferous ore	100.0	--	100.0	--
Mercury	100.0	--	100.0	--
Molybdenum	[1]100.0	W	[1]100.0	W
Nickel	100.0	--	100.0	--
Rare-earth metals	100.0	--	100.0	--
Silver	36.0	64.0	82.8	17.2
Titanium (ilmenite)	100.0	--	100.0	--
Tungsten	W	[2]100.0	W	[2]100.0
Uranium	68.8	31.2	95.2	4.8
Vanadium	100.0	--	100.0	--
Zinc	--	100.0	--	100.0
Average	86.1	13.9	93.6	6.4
NONMETALS				
Abrasives	[1]100.0	W	[1]100.0	W
Aplite	100.0	--	100.0	--
Asbestos	100.0	--	100.0	--
Barite	100.0	--	100.0	--
Boron minerals	100.0	--	100.0	--
Clays	99.5	.5	99.7	.3
Diatomite	100.0	--	100.0	--
Feldspar	100.0	--	100.0	--
Fluorspar	W	[2]100.0	W	[2]100.0
Gypsum	79.0	21.0	85.5	14.5
Iron oxide pigments (crude)	100.0	--	100.0	--
Kyanite	100.0	--	100.0	--
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	[1]100.0	W	[1]100.0	W
Potassium salts	--	100.0	--	100.0
Pumice	100.0	--	100.0	--
Salt	12.4	87.6	12.1	87.9
Sand and gravel	100.0	--	100.0	--
Sodium carbonate (natural)	--	100.0	--	100.0
Talc, soapstone, pyrophyllite	91.0	9.0	96.5	3.5
Vermiculite	100.0	--	100.0	--
Average	93.2	6.8	95.0	5.0
Average, metals and nonmetals	90.9	9.1	94.4	5.6

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

Table 6.—Crude ore and total material handled at surface and underground mines in the United States in 1982, by State

(Percent)

State	Crude ore		Total material	
	Surface	Under-ground	Surface	Under-ground
Alabama	100.0	--	100.0	--
Alaska	100.0	--	100.0	--
Arizona	86.2	13.8	93.3	6.7
Arkansas	100.0	--	100.0	--
California	99.7	.3	99.6	.4
Colorado	70.9	29.1	81.4	18.6
Connecticut	100.0	--	100.0	--
Delaware	100.0	--	100.0	--
Florida	100.0	--	100.0	--
Georgia	[1]100.0	W	[1]100.0	W
Hawaii	100.0	--	100.0	--
Idaho	92.6	7.4	98.0	2.0
Illinois	99.0	1.0	98.9	1.1
Indiana	[1]100.0	W	[1]100.0	W
Iowa	[1]100.0	W	[1]100.0	W
Kansas	91.4	8.6	91.8	8.2
Kentucky	[1]100.0	W	[1]100.0	W
Louisiana	83.9	16.1	84.0	16.0
Maine	100.0	--	100.0	--
Maryland	100.0	--	100.0	--
Massachusetts	100.0	--	100.0	--
Michigan	[1]100.0	W	[1]100.0	W
Minnesota	100.0	--	100.0	--
Mississippi	100.0	--	100.0	--
Missouri	46.3	53.7	40.0	60.0
Montana	87.7	12.3	89.0	11.0
Nebraska	100.0	--	100.0	--
Nevada	98.8	1.2	99.5	.5
New Hampshire	100.0	--	100.0	--
New Jersey	[1]100.0	W	[1]100.0	W
New Mexico	50.0	50.0	78.7	21.3
New York	78.6	21.4	78.2	21.8
North Carolina	100.0	--	100.0	--
North Dakota	[1]100.0	W	100.0	--
Ohio	91.2	8.8	[1]100.0	W
Oklahoma	100.0	--	100.0	--
Oregon	[1]100.0	W	[1]100.0	W
Pennsylvania	96.6	3.4	96.6	3.4
Rhode Island	100.0	--	100.0	--
South Carolina	100.0	--	100.0	--
South Dakota	[1]100.0	W	[1]100.0	W
Tennessee	59.4	40.6	75.3	24.7
Texas	[1]100.0	W	[1]100.0	W
Utah	98.3	1.7	99.3	.7
Vermont	100.0	--	100.0	--
Virginia	[1]100.0	W	[1]100.0	W
Washington	97.5	2.5	97.5	2.5
West Virginia	[1]100.0	W	[1]100.0	W
Wisconsin	100.0	--	100.0	--
Wyoming	30.7	69.3	74.7	25.3
Average	90.9	9.1	94.4	5.6

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 1982, 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	--	1	5	2	--	--
Copper	32	3	1	5	1	15	7
Gold:							
Lode	101	41	28	11	14	6	1
Placer	47	10	13	16	5	3	--
Iron ore	26	--	2	4	6	8	6
Lead	17	7	1	--	2	7	--
Silver	63	32	14	6	10	1	--
Titanium (ilmenite)	5	--	--	--	1	4	--
Tungsten	23	18	2	2	1	--	--
Uranium	128	16	34	52	24	2	--
Zinc	14	--	1	2	9	2	--
Other[2]	21	5	7	2	2	5	--
Total	485	132	104	105	77	53	14
NONMETALS							
Abrasives[3]	14	2	8	4	--	--	--
Asbestos	3	--	--	3	--	--	--
Barite	32	1	5	17	9	--	--
Clays	972	46	267	569	90	--	--
Diatomite	12	--	3	7	2	--	--
Feldspar	15	--	1	14	--	--	--
Fluorspar	5	2	1	1	1	--	--
Gypsum	72	2	8	27	35	--	--
Mica (scrap)	11	2	3	1	5	--	--
Perlite	12	--	3	7	2	--	--
Phosphate rock	33	--	1	--	4	23	5
Potassium salts	7	--	--	--	2	5	--
Pumice	23	6	7	9	1	--	--
Salt	18	--	2	3	6	7	--
Sand and gravel[4]	5,139	118	825	2,608	1,547	40	1
Sodium carbonate	5	--	--	--	1	3	1
Stone:[5]							
Crushed and broken	NA	NA	NA	NA	NA	NA	NA
Dimension	NA	NA	NA	NA	NA	NA	NA
Talc, soapstone, pyrophyllite	28	3	8	14	3	--	--
Other[6]	29	7	5	10	6	1	--
Total	6,430	189	1,147	3,294	1,714	79	7
Grand total	6,915	321	1,251	3,399	1,791	132	21

NA Not available.
[1]Excludes wells, ponds, or pumping operations.
[2]Antimony, beryllium, manganiferous ore, mercury, molybdenum, nickel, rare-earth metals, tin, and vanadium.
[3]Abrasive stone, emery, garnet, and tripoli.
[4]Includes construction and industrial sand and gravel.
[5]Crushed and broken and dimension stone were not available for 1982 because of biennial canvassing.
[6]Includes aplite, boron minerals, graphite, greensand marl, iron oxide pigments (crude), kyanite, magnesite, millstones, olivine, vermiculite, and wollastonite.

Table 8.—Twenty-five leading metal and nonmetal[1] mines in the United States in 1982, in order of output of crude ore

Mine	State	Operator	Commodity	Mining method
		METALS		
Utah Copper	Utah	Kennecott	Copper	Open pit.
Hibbing Taconite	Minnesota	Pickands Mather & Co	Iron ore	Do.
Bagdad	Arizona	Cyprus Bagdad Copper Co	Copper	Do.
San Manuel	do	Magma Copper Co	do	Caving.
Sierrita	do	Duval Sierrita Corp	do	Open pit.
Morenci	do	Phelps Dodge Corp	do	Do.
Thunderbird	Minnesota	Oglebay Norton Co	Iron ore	Do.
Berkeley Pit	Montana	The Anaconda Company	Copper	Do.
Erie Commercial	Minnesota	Pickands Mather & Co	Iron ore	Do.
Twin Butte	Arizona	Anamax Mining Co	Copper	Do.
Minntac	Minnesota	United States Steel Corp	Iron ore	Do.
Tilden	Michigan	Tilden Mining Co	do	Do.
Empire	do	Empire Iron Mining	do	Do.
Round Mountains	Nevada	Copper Range Co	Lode gold	Do.
Pinto Valley	Arizona	Cities Service Co	Copper	Do.
Green Cove	Florida	Associated Minerals Corp	Titanium	Dredging.
Inspiration	Arizona	Inspiration Consolidated Copper Co.	Copper	Open pit.
Eisenhower	do	ASARCO Incorporated	do	Do.
Trail Ridge	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.
Tonopah	Nevada	The Anaconda Company	do	Open pit.
Highland	Florida	E. I. du Pont de Nemours & Co. Inc.	Titanium	Dredging.
Chino	New Mexico	Chino Mines Co	Copper	Open pit.
Minorca	Minnesota	Inland Steel Mining Co	Iron ore	Do.
Mission	Arizona	ASARCO Incorporated	Copper	Do.
		NONMETALS[2]		
Green River	Wyoming	FMC Corp., Industrial Chemicals Group.	Sodium carbonate.	Stopes.
Suwannee	Florida	Occidental Petroleum Corp	Phosphate rock.	Open pit.
Noralyn	do	International Minerals & Chemical Corp.	do	Do.
Ft. Meade	do	Mobil Oil Corp	do	Do.
Ft. Green	do	Williams Co	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.
Silver City	do	Estech General Chemical Corp.	do	Do.
Watson	do	do	do	Do.
Ft. Meade	do	Gardinier Inc	do	Do.
Swift Creek	do	Occidental Petroleum Corp	do	Do.
Nichols	do	Mobil Oil Corp	do	Do.
International	New Mexico	International Minerals & Chemical Corp.	Potassium salts.	Stopes.
Carlsbad	do	Amax Chemical Corp	do	Do.
Lee Creek	North Carolina	Texasgulf Inc	Phosphate rock.	Open pit.
St. Lucie	Florida	General Development Corp	Sand and gravel.	Dredging.
Payne Creek	do	Williams Co	Phosphate rock.	Open pit.
Hobbs	New Mexico	Kerr-McGee Chemical Corp	Potassium salts.	Do.
Retsof	New York	International Salt Co	Salt	Stopes.
Green River	Wyoming	Allied Chemical Co	Sodium carbonate.	Do.
Carlsbad	New Mexico	Potash Co. of America, a division of Ideal Basic Industries Inc.	Potassium salts.	Do.
Radum	California	Koppers Co., Kaiser Sand and Gravel.	Sand and gravel.	Open pit.

[1]Brines and materials from wells excepted.
[2]Crushed and broken and dimension stone were not available in 1982 because of biennial canvassing.

Table 9.—Twenty-five leading metal and nonmetal[1] mines in the United States in 1982, in order of output of total materials handled

Mine	State	Operator	Commodity	Mining method
		METALS		
Utah Copper	Utah	Kennecott	Copper	Open pit.
Bagdad	Arizona	Cyprus Bagdad Copper Co	do	Do.
Inspiration	do	Inspiration Consolidated Copper Co.	do	Do.
Twin Butte	do	Anamax Mining Co	do	Do.
Palmer	Michigan	Empire Iron Mining Co	Iron ore	Do.
Chino	New Mexico	Chino Mines Co	Copper	Do.
Hibbing Taconite	Minnesota	Pickands Mather & Co	Iron ore	Do.
Thunderbird	do	Oglebay Norton Co	do	Do.
Morenci	Arizona	Phelps Dodge Corp	Copper	Do.
Sierrita	do	Duval Sierrita Corp	do	Do.
Pinto Valley	do	Cities Service Co	do	Do.
Eisenhower	do	ASARCO Incorporated	do	Do.
Tonopah	Nevada	The Anaconda Company	Molybdenum	Do.
Pima	Arizona	Cyprus Pima Mining Co	Copper	Do.
Erie Commercial	Minnesota	Pickands Mather & Co	Iron ore	Do.
Shirley Basin	Wyoming	Pathfinder Mines Corp	Uranium	Do.
Tilden	Michigan	Tilden Mining Co	Iron ore	Do.
Tyrone	New Mexico	Phelps Dodge Corp	Copper	Do.
San Manuel	Arizona	Magma Copper Co	do	Do.
Climax	Colorado	Climax Molybdenum Co., a division of AMAX Inc.	Molybdenum	Caving and open pit.
Minntac	Minnesota	United States Steel Corp	Iron ore	Do.
Copper	Arizona	Kennecott	Copper	Do.
Battle Mountain	Nevada	Duval Corp	Lode gold	Do.
Round Mountains	do	Copper Range Co	do	Do.
Berkeley Pit	Montana	The Anaconda Company	Copper	Do.
		NONMETALS[2]		
Suwannee	Florida	Occidental Petroleum Corp	Phosphate rock.	Open pit.
Kingsford	do	International Minerals & Chemical Corp.	do	Do.
Ft. Green	do	Williams Co	do	Do.
Noralyn	do	International Minerals & Chemical Corp.	do	Do.
Lonesome	do	American Cyanamid Co	do	Do.
Ft. Meade	do	Mobil Oil Corp	do	Do.
Haynsworth	do	American Cyanamid Co	do	Do.
Clear Spring	do	International Minerals & Chemical Corp.	do	Do.
Green River	Wyoming	FMC Corp., Industrial Chemicals Group.	Sodium carbonate.	Stopes.
Silver City	Florida	Estech General Chemical Corp.	Phosphate rock.	Open pit.
Swift Creek	do	Occidental Petroleum Corp	do	Do.
Nichols	do	Mobil Oil Corp	do	Do.
Hookers	do	W. R. Grace & Co	do	Do.
Lee Creek	North Carolina	Texasgulf Inc	do	Do.
Watson	Florida	Estech General Chemical Corp.	do	Do.
Mabie Canyon	Idaho	Conda Partnership	do	Do.
Ft. Meade	Florida	Gardinier Inc	do	Do.
Conda	Idaho	J. R. Simplot Co	do	Do.
Wingate	Florida	Becker Industries Corp	do	Do.
Payne Creek	do	Williams Co	do	Do.
Bonny Lake	do	W. R. Grace & Co	do	Do.
Gay	Idaho	J. R. Simplot Co	do	Do.
Rockland	Florida	United States Steel Corp	do	Do.
Henry	Idaho	Monsanto Co	do	Do.
Vernal	Utah	Chevron Resources Co	do	Do.

[1]Brines and materials from wells excepted.
[2]Crushed and broken and dimension stone were not available in 1982 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 1982, by commodity

Commodity		Surface			Underground			Total[2]		
		Ore treated (thousand short tons)	Marketable product (units)	Ratio of units of ore to units of marketable product	Ore treated (thousand short tons)	Marketable product (units)	Ratio of units of ore to units of marketable product	Ore treated (thousand short tons)	Marketable product (units)	Ratio of units of ore to units of marketable product
METALS										
Bauxite	thousand long tons	1,470	720	2.0:1	--	--	--	1,470	720	2.0:1
Copper	thousand short tons	177,000	1,010	175.6:1	24,600	223	110.3:1	201,000	1,230	163.7:1
Gold:										
Lode	thousand troy ounces	16,200	849	19.0:1	2,170	260	8.3:1	18,300	1,110	16.5:1
Placer	do	8,620	39	224.0:1	--	--	--	8,620	39	224.0:1
Iron ore	thousand long tons	126,000	34,800	3.6:1	W	W	W	126,000	34,800	3.6:1
Lead	thousand short tons	--	--	--	9,540	523	18.2:1	9,540	523	18.2:1
Silver	thousand troy ounces	2,140	3,810	0.6:1	4,310	21,800	0.2:1	6,450	25,600	0.3:1
Titanium (ilmenite)	thousand short tons	9,270	233	39.8:1	--	--	--	9,270	233	39.8:1
Uranium	do	11,400	4	3,026.7:1	2,390	6	378.2:1	13,800	10	1,365.6:1
Zinc	do	--	--	--	6,490	247	26.3:1	6,490	247	26.3:1
NONMETALS										
Barite	do	2,650	1,810	1.5:1	--	--	--	2,650	1,810	1.5:1
Clays	do	35,000	34,900	1.0:1	192	192	1.0:1	35,200	35,100	1.0:1
Diatomite	do	1,310	613	2.1:1	--	--	--	1,310	613	2.1:1
Feldspar	do	654	610	1.1:1	--	--	--	654	610	1.1:1
Fluorspar	do	W	W	W	226	75	3.0:1	226	75	3.0:1
Gypsum	do	8,310	8,310	1.0:1	2,220	2,220	1.0:1	10,500	10,500	1.0:1
Mica (scrap)	do	1,230	73	16.9:1	--	--	--	1,230	73	16.9:1
Perlite	do	1,060	506	2.1:1	--	--	--	1,060	506	2.1:1
Phosphate rock	do	161,000	41,100	3.9:1	W	W	W	161,000	41,100	3.9:1
Potassium salts	do	--	--	--	17,000	1,650	10.3:1	17,000	1,650	10.3:1
Pumice	do	856	416	2.1:1	--	--	--	856	416	2.1:1
Salt	do	W	W	W	11,900	1,810	1.0:1	11,900	1,810	1.0:1
Sand and gravel[3]	do	621,000	616,000	1.0:1	--	--	--	621,000	616,000	1.0:1
Sodium carbonate (natural)	do	--	--	--	29,400	6,200	4.7:1	29,400	6,200	4.7:1
Stone:[4]										
Crushed and broken	do	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dimension	do	NA	NA	NA	NA	NA	NA	NA	NA	NA
Talc, soapstone, pyrophyllite	do	929	751	1.2:1	136	81	1.7:1	1,070	832	1.3:1

NA Not available. 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 construction and industrial sand and gravel.

[4]Crushed and broken and dimension stone were not available for 1982 because of biennial canvassing.

Table 11.—Material handled per unit of marketable product at surface and underground mines[1] in the United States in 1982, by commodity

Commodity	Surface			Underground			Total[2]		
	Total material handled[3] (thousand short tons)	Marketable product (units)	Ratio of units of material handled to units of marketable product[4]	Total material handled[3] (thousand short tons)	Marketable product (units)	Ratio of units of material handled to units of marketable product[4]	Total material handled[3] (thousand short tons)	Marketable product (units)	Ratio of units of material handled to units of marketable product[4]
METALS									
Bauxite ---- thousand long tons	7,950	720	6.7:1	--	--	--	7,950	720	6.7:1
Copper ---- thousand short tons	527,000	1,010	491.9:1	26,500	223	116.6:1	553,000	1,230	423.7:1
Gold:									
Lode ---- thousand troy ounces	77,900	849	74.0:1	2,490	260	8.6:1	80,300	1,110	58.7:1
Placer ---- do	9,110	39	236.0:1	--	--	--	9,110	39	236.0:1
Iron ore ---- thousand long tons	227,000	34,800	6.1:1	W	W	W	227,000	34,800	6.1:1
Lead ---- thousand short tons	--	--	--	11,700	523	18.8:1	11,700	523	18.8:1
Silver ---- thousand troy ounces	23,700	3,810	5.9:1	4,940	21,800	0.2:1	28,700	25,600	1.1:1
Titanium (ilmenite) ---- thousand short tons	34,400	233	147.4:1	--	--	--	34,400	233	147.4:1
Uranium ---- do	87,100	4	7,410.3:1	4,360	6	577.1:1	91,500	10	6,852.6:1
Zinc ---- do	--	--	--	7,590	247	27.3:1	7,590	247	27.3:1
NONMETALS									
Barite ---- do	5,830	1,810	2.7:1	--	--	--	5,830	1,810	2.7:1
Clays ---- do	65,400	34,900	1.9:1	195	192	1.0:1	65,600	35,100	1.9:1
Diatomite ---- do	1,190	613	1.9:1	--	--	--	1,190	613	1.9:1
Feldspar ---- do	660	610	1.1:1	--	--	--	660	610	1.1:1
Fluorspar ---- do	W	W	W	230	75	2.6:1	230	75	2.6:1
Gypsum ---- do	13,100	8,310	1.0:1	2,220	2,220	1.0:1	15,400	10,500	1.0:1
Mica (scrap) ---- do	1,800	73	24.7:1	--	--	--	1,800	73	24.7:1
Perlite ---- do	1,170	506	2.3:1	--	--	--	1,170	506	2.3:1
Phosphate rock ---- do	485,000	41,100	11.8:1	W	W	W	485,000	41,100	11.8:1
Potassium salts ---- do	--	--	--	17,500	1,650	10.6:1	17,500	1,650	10.6:1
Pumice ---- do	518	416	1.3:1	--	--	--	518	416	1.3:1

Salt	do	W	W	W	12,300	1,810	1.0:1	12,300	1,810	1.0:1
Sand and gravel[5]	do	621,000	616,000	1.0:1	--	--	--	621,000	616,000	1.0:1
Sodium carbonate (natural)	do	--	--	--	30,500	6,200	4.7:1	30,500	6,200	4.7:1
Stone:[6]										
Crushed and broken	do	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dimension	do	NA	NA	NA	NA	NA	NA	NA	NA	NA
Talc, soapstone, pyrophyllite	do	2,220	751	2.9:1	81	81	1.0:1	2,300	832	2.8:1

NA Not available. 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 construction and industrial sand and gravel.
[6]Crushed and broken and dimension stone were not available for 1982 because of biennial canvassing.

Table 12.—Mining methods used in open pit mining in the United States in 1982, by commodity

(Percent)

Commodity	Total material handled: Preceded by drilling and blasting	Total material handled: Not preceded by drilling and blasting[1]
METALS		
Bauxite	41	59
Copper	93	7
Gold:		
Lode	96	4
Placer	--	100
Iron ore	93	7
Manganiferous ore	--	100
Mercury	10	90
Molybdenum	91	9
Nickel	55	45
Rare-earth metals	100	--
Silver	99	1
Titanium (ilmenite)	1	99
Tungsten	4	96
Uranium	50	50
Vanadium	60	40
NONMETALS		
Abrasives	64	36
Aplite	100	--
Asbestos	100	--
Barite	77	23
Boron minerals	6	94
Clays	--	100
Diatomite	5	95
Feldspar	96	4
Fluorspar	100	--
Gypsum	94	6
Iron oxide pigments (crude)	--	100
Kyanite	100	--
Magnesite	100	--
Mica (scrap)	1	99
Millstones	100	--
Olivine	100	--
Perlite	66	34
Phosphate rock	93	7
Pumice	22	78
Salt	--	100
Sand and gravel	--	100
Stone:[2]		
Crushed and broken	NA	NA
Dimension	NA	NA
Talc, soapstone, pyrophyllite	100	--
Vermiculite	58	42
Average	58	42

NA Not available.

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

[2]Crushed and broken and dimension stone were not available for 1982 because of biennial canvassing.

Table 13.—Development and exploration activity in the United States in 1982, 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	6,890	1.0	--	--	6,890	0.8
Raising	63,400	8.9	571	0.3	63,900	7.2
Drifting, crosscutting, or tunneling	421,000	58.8	158,000	93.8	579,000	65.5
Solution mining	224,000	31.3	10,000	5.9	234,000	26.5
Total[1]	715,000	100.0	169,000	100.0	884,000	100.0
EXPLORATION						
Diamond drilling	750,000	13.8	136,000	32.4	885,000	15.2
Churn drilling	332,000	6.1	--	--	332,000	5.7
Rotary drilling	2,010,000	37.1	120,000	28.6	2,130,000	36.5
Percussion drilling	1,120,000	20.7	46,400	11.1	1,160,000	19.9
Other drilling	1,180,000	21.7	110,000	26.2	1,290,000	22.0
Trenching	33,300	.6	7,200	1.7	40,500	.7
Total[1]	5,420,000	100.0	419,000	100.0	5,840,000	100.0
Grand total[1]	6,140,000	XX	588,000	XX	6,720,000	XX

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 1982, by commodity

(Feet)

Commodity	Development					Exploration						
	Shaft and winze sinking	Raising	Drifting, cross-cutting, or tunneling	Solution mining	Total[1]	Diamond drilling	Churn drilling	Rotary drilling	Percussion drilling	Other drilling	Trenching	Total[1]
METALS												
Copper	W	W	45,500	--	45,500	27,900	--	12,900	--	W	150	41,000
Gold	1,840	6,590	41,000	--	49,400	196,000	W	102,000	87,000	12,400	32,100	430,000
Iron ore	--	--	2,670	--	2,670	24,700	--	5,150	--	--	--	29,900
Lead	748	40	32,500	--	33,300	180,000	65,200	1,550	--	265,000	150	512,000
Molybdenum	W	W	W	--	W	110,000	--	3,740	--	2,100	--	116,000
Silver	1,950	3,630	40,100	--	45,700	79,700	--	W	10,100	1,620	750	92,200
Tungsten	25	W	6,930	--	6,960	W	--	108	25	--	W	133
Uranium	W	11,300	164,000	224,000	399,000	77,200	215,000	1,610,000	650,000	361,000	--	2,910,000
Zinc	--	5,100	64,400	--	69,500	51,100	--	--	W	--	--	51,100
Other[2]	2,330	36,700	24,200	--	63,200	2,540	51,200	275,000	371,000	535,000	75	1,230,000
Total[1]	6,890	63,400	421,000	224,000	715,000	750,000	332,000	2,010,000	1,120,000	1,180,000	33,300	5,420,000
NONMETALS												
Abrasives	--	--	--	--	--	W	--	W	--	--	W	W
Barite	--	--	--	W	W	--	--	W	46,400	W	3,450	49,900
Fluorspar	--	W	W	--	W	W	--	W	--	--	--	W
Sodium carbonate	--	--	W	--	W	W	--	W	--	--	--	W
Other[3]	--	571	158,000	10,000	169,000	136,000	--	120,000	--	110,000	3,750	369,000
Total[1]	--	571	158,000	10,000	169,000	136,000	--	120,000	46,400	110,000	7,200	419,000
Grand total[1]	6,890	63,900	579,000	234,000	884,000	885,000	332,000	2,130,000	1,160,000	1,290,000	40,500	5,840,000

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, and titanium.
[3]Includes boron minerals, clays, diatomite, feldspar, perlite, potassium salts, salt, crushed and broken stone, and sulfur.

Table 15.—Development and exploration in the United States in 1982, by State

(Feet)

State	Development					Exploration						
	Shaft and winze sinking	Raising	Drifting, cross-cutting, or tunneling	Solution mining	Total[1]	Diamond drilling	Churn drilling	Rotary drilling	Percussion drilling	Other drilling	Trenching	Total[1]
Alaska	130	--	80	--	210	50,500	W	--	--	--	6,390	56,900
Arizona	3,140	30,700	47,300	--	81,100	15,700	--	W	14,300	--	160	30,200
California	345	1,570	6,560	--	8,480	5,380	W	5,880	4,470	50	1,000	16,800
Colorado	310	7,810	29,200	--	37,300	107,000	2,150	68,800	--	7,660	2,500	188,000
Idaho	1,600	3,870	10,700	--	16,200	19,800	--	W	W	--	W	19,800
Illinois	--	W	W	--	W	W	--	W	--	--	--	W
Missouri	W	--	34,200	--	34,200	151,000	65,200	1,550	--	70,200	W	288,000
Montana	358	115	2,380	--	2,850	11,900	--	--	W	--	W	11,900
Nevada	200	605	11,300	W	12,100	63,300	W	159,000	117,000	20,300	21,900	382,000
New Mexico	W	9,270	147,000	--	156,000	85,700	--	570,000	W	360,000	W	1,020,000
Oregon	--	--	W	--	W	--	--	W	--	--	W	W
South Dakota	--	W	W	--	W	W	--	154,000	--	--	--	154,000
Tennessee	--	W	31,500	--	31,500	47,300	--	--	W	--	--	47,300
Texas	--	--	W	W	W	W	--	305,000	W	--	--	305,000
Utah	W	779	29,500	--	30,300	19,600	36,800	277,000	W	W	--	333,000
Washington	--	--	W	--	W	W	--	40	--	--	80	120
Wyoming	--	86	164,000	6,680	171,000	6,410	176,000	308,000	W	--	100	491,000
Undistributed[2]	809	9,170	65,400	228,000	303,000	302,000	51,200	281,000	1,030,000	828,000	8,380	2,500,000
Total[1]	6,890	63,900	579,000	234,000	884,000	885,000	332,000	2,130,000	1,160,000	1,290,000	40,500	5,840,000

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, Arkansas, Georgia, Kentucky, Louisiana, Michigan, Minnesota, New York, North Carolina, and Pennsylvania.

Table 16.—Total material (ore and waste) produced by mine development in the United States in 1982, by commodity and State

(Thousand short tons)

	Shaft and winze sinking	Raising	Drifting, crosscutting, or tunneling	Stripping	Total[1]
COMMODITY					
METALS					
Copper	W	W	377	32,300	32,700
Gold	10	24	218	15,000	15,300
Iron ore	--	--	3,810	14,600	18,400
Lead	W	(2)	1,880	--	1,880
Silver	34	W	397	1,180	1,610
Uranium	W	W	724	21,700	22,400
Zinc	--	W	856	--	856
Other[3]	62	191	280	11,400	11,900
Total[1]	106	215	8,540	96,100	105,000
NONMETALS					
Abrasives	--	--	--	41	41
Barite	--	--	--	W	W
Fluorspar	--	W	W	--	W
Phosphate rock	NA	NA	NA	NA	NA
Sodium carbonate	--	--	W	--	W
Other[4]	--	6	1,340	5,540	6,890
Total[1]	--	6	1,340	5,540	6,890
Grand total[1]	106	221	9,880	102,000	112,000
STATE					
Alabama	--	--	--	W	W
Alaska	1	--	(2)	37	38
Arizona	W	W	394	28,000	28,400
Arkansas	--	--	--	3,500	3,500
California	1	5	59	2,220	2,270
Colorado	1	59	211	W	271
Georgia	--	--	--	W	W
Idaho	W	W	77	442	519
Illinois	--	W	W	--	W
Kentucky	--	W	--	--	W
Missouri	W	--	W	--	W
Montana	W	W	113	39	152
Nevada	(2)	W	116	13,200	13,300
New Mexico	W	W	534	W	534
New York	--	W	W	--	W
Oregon	--	--	W	W	W
Pennsylvania	--	--	W	--	W
South Dakota	--	W	W	--	W
Tennessee	--	W	740	--	740
Utah	W	W	265	W	265
Washington	--	--	W	W	W
Wyoming	--	(2)	1,400	18,200	19,600
Undistributed	102	158	5,960	36,100	42,560
Total[1]	106	221	9,880	102,000	112,000

NA Not available. W Withheld to avoid disclosing company proprietary data; included with "Undistributed."
[1]Data may not add to totals shown because of independent rounding.
[2]Less than 1/2 unit.
[3]Includes antimony, bauxite, beryllium, mercury, molybdenum, tungsten, and vanadium.
[4]Includes feldspar, gypsum, salt, talc, soapstone, and pyrophyllite.

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
1978	2,168,630	574,213	604,955	3,347,798	581,391	3,929,189
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

[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 1978-80 are not comparable to 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				
1978	38,530	208	618	39,356
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
OTHER HIGH EXPLOSIVES				
1978	27,741	25,400	59,974	113,115
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
WATER GELS AND SLURRIES				
1978	63,494	234,470	89,322	387,286
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
AMMONIUM NITRATE: FUEL-MIXED AND UNPROCESSED				
1978	2,038,865	314,135	455,041	2,808,041
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
TOTAL				
1978	2,168,630	574,213	604,955	3,347,798
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

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	1981 Quantity	1981 Value (thousands)	1982 Quantity	1982 Value (thousands)	1983 Quantity	1983 Value (thousands)
METALS						
Antimony ore and concentrate short tons, antimony content	646	W	503	W	838	W
Bauxite thousand metric tons, dried equivalent	1,510	$26,489	732	$12,334	679	$11,309
Copper (recoverable content of ores, etc.) metric tons	1,538,160	2,886,440	[r]1,146,975	[r]1,840,856	1,038,098	1,751,476
Gold (recoverable content of ores, etc.) troy ounces	1,379,161	633,918	[r]1,465,686	[r]550,968	1,957,379	829,929
Iron ore, usable (excluding byproduct iron sinter) thousand long tons, gross weight	72,158	2,914,689	35,751	1,491,705	44,295	1,938,496
Iron oxide pigments, crude short tons	67,214	2,285	67,294	2,702	40,023	2,368
Lead (recoverable content of ores, etc.) metric tons	445,535	358,821	[r]512,516	[r]288,579	449,038	214,623
Manganiferous ore (5% to 35% Mn) short tons, gross weight	174,760	2,889	31,509	293	33,523	216
Mercury 76-pound flasks	27,904	11,549	25,760	W	25,070	W
Molybdenum (content of concentrate) thousand pounds	118,916	945,540	[r]76,135	[r]504,089	49,163	167,164
Nickel (content of ore and concentrate) short tons	12,099	W	3,203	W	--	--
Silver (recoverable content of ores, etc.) thousand troy ounces	40,683	427,921	[r]40,248	[r]319,975	43,415	496,671
Titanium concentrate: Ilmenite short tons, gross weight	523,681	37,013	233,063	19,093	W	W
Tungsten ore and concentrate metric tons, contained W	3,545	62,281	1,575	22,062	1,016	10,528
Vanadium (recoverable in ore and concentrate) short tons	5,126	71,496	4,098	52,577	2,171	30,675
Zinc (recoverable content of ores, etc.) metric tons	312,418	306,879	[r]303,160	[r]257,116	275,294	251,204
Combined value of beryllium concentrates, magnesium chloride for magnesium metal, platinum-group metals (1981), rare-earth metal concentrate, tin, titanium concentrate (rutile), zircon concentrate, and values indicated by symbol W	XX	153,902	XX	154,917	XX	161,100
Total	XX	8,842,000	XX	[r]5,517,000	XX	5,866,000
NONMETALS (EXCEPT FUELS)						
Abrasive stones short tons	[2]2,501	[2]1,096	1,285	553	1,101	482
Asbestos metric tons	75,618	30,685	63,515	24,917	69,906	27,866
Asphalt and related bitumens, native: Bituminous limestone, sandstone, gilsonite thousand short tons	1,261	27,654	W	W	W	W
Barite do.	2,849	102,439	1,845	69,522	754	29,203
Boron minerals do.	1,481	435,387	1,234	384,597	1,303	439,181
Bromine thousand pounds	377,100	90,200	401,100	102,600	370,000	91,000
Calcium chloride short tons	704,691	61,692	[e]616,513	[e]61,483	W	W
Carbon dioxide, natural thousand cubic feet	1,577,053	2,607	2,067,500	3,399	--	--
Cement:						
Masonry thousand short tons	2,738	161,819	2,364	145,172	2,921	186,240
Portland do.	68,197	3,515,600	61,080	3,084,439	67,183	3,315,690
Clays do.	44,379	988,845	35,345	825,064	40,858	931,091
Diatomite do.	687	113,010	613	107,619	619	114,279
Feldspar short tons	665,000	21,000	615,000	20,300	710,000	22,500
Fluorspar do.	115,404	18,412	77,017	13,293	[e]61,000	[e]10,000
Garnet (abrasive) do.	25,451	2,059	27,303	2,321	29,767	2,533
Gem stones[e]	NA	7,625	NA	7,150	NA	7,425
Gypsum thousand short tons	11,497	98,101	10,538	89,131	12,884	101,361
Helium:						
Crude million cubic feet	175	2,100	W	W	W	W
Grade-A do.	1,223	31,798	[3]1,248	[3]42,432	[3]1,299	[3]45,465
Lime thousand short tons	18,856	884,197	14,075	696,207	14,867	757,611
Magnesium compounds short tons	W	W	W	W	556,113	145,084
Mica (scrap) thousand short tons	133	8,212	106	[r]6,398	140	6,479
Peat do.	757	18,783	[r]769	[r]16,871	725	18,667
Perlite short tons	591,000	17,458	506,000	16,044	474,000	15,664
Phosphate rock thousand metric tons	53,624	1,437,986	37,414	950,326	42,573	1,020,901
Potassium salts (K_2O equivalent) do.	1,908	328,900	1,784	265,600	1,513	220,800

See footnotes at end of table.

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

Mineral	1981 Quantity	1981 Value (thousands)	1982 Quantity	1982 Value (thousands)	1983 Quantity	1983 Value (thousands)
NONMETALS (EXCEPT FUELS) —Continued						
Pumice ---- thousand short tons--	499	$4,311	416	$3,750	449	$4,486
Pyrites ---- thousand metric tons--	797	49,160	676	41,943	W	W
Salt ------ thousand short tons--	38,907	637,568	r37,894	r671,424	34,573	597,081
Sand and gravel:						
Construction ---------do----	e690,000	e1,928,000	r594,000	r1,674,000	e655,100	e1,935,000
Industrial ---------do----	29,980	332,300	r27,400	r323,800	26,620	335,200
Sodium sulfate (natural) ----do----	608	43,186	W	W	423	39,425
Stone:[4]						
Crushed ------------do----	872,600	3,125,000	e790,030	e2,918,300	862,700	3,337,000
Dimension----------do----	1,331	150,461	e1,330	e145,113	1,186	149,483
Sulfur, Frasch process thousand metric tons--	5,910	715,683	3,598	434,660	4,111	445,131
Talc and pyrophyllite thousand short tons--	1,343	31,497	1,135	r20,671	1,066	20,280
Tripoli ------------short tons--	107,330	617	112,928	653	111,020	649
Vermiculite-- thousand short tons--	320	26,181	316	28,508	282	27,170
Combined value of aplite, emery, graphite (1982-83), iodine, kyanite, lithium minerals, magnesite, marl (greensand), olivine, sodium carbonate (natural), staurolite, wollastonite, and values indicated by symbol W -	XX	r994,115	XX	r959,269	XX	868,055
Total ------------------	XX	r16,446,000	XX	r14,158,000	XX	15,268,000
Grand total --------------	XX	r25,288,000	XX	r19,675,000	XX	21,134,000

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

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

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

[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 1983

Mineral	Principal producing States, in order of quantity	Other producing States
Antimony ore and concentrate	Idaho and Mont.	
Aplite	Va.	
Asbestos	Calif. and Vt.	
Asphalt (native)	Utah.	
Barite	Nev., Ga., Mo., Mont	Tenn., Ill., 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 Alaska, Conn., Del., Mass., Minn., N.H., N.J., N. Dak., R.I., Vt.
Clays	Ga., Tex., Wyo., N.C.	All other States except Alaska, Del., Hawaii, R.I., Vt., Wis.
Copper (mine)	Ariz., Utah, N. Mex., Mont	Alaska, Calif., Colo., Idaho, Mo., Nev., Oreg., 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., Iowa, Okla., Calif	Ariz., Ark., Colo., Idaho, Ind., Kans., La., Mich., 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., Wyo., Mo.	Calif., Colo., Mont., Nev., Tex., Utah.
Iron oxide pigments (crude)	Mich., Ga., Mo., Va.	
Kyanite	Va. and Ga.	
Lead (mine)	Mo., Idaho, Colo., N.Y	Alaska, Ariz., Calif., Ill., Mont., Nev., N. Mex., Oreg.
Lime	Ohio, Pa., Mo., Ky	All other States except Alaska, Del., Ga., Maine, Miss., N.H., N.J., 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	S.C. and Mont.	
Marl, greensand	N.J.	
Mercury	Nev.	
Mica (scrap)	N.C., S. Dak., N. Mex., S.C	Conn., Ga., Pa.
Molybdenum	Ariz., Colo., Mont., Utah	Nev. and N. Mex.
Olivine	N.C. and Wash.	
Peat	Mich., Fla., 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., Ariz., Calif., Nev	Colo., Idaho, Utah.
Phosphate rock	Fla., Idaho, N.C., Tenn	Ala., Mont., Utah.
Potassium salts	N. Mex., Utah, Calif.	
Pumice	Oreg., N. Mex., Calif., Idaho	Ariz., Hawaii, Kans., Okla.
Pyrites, ore and concentrate	Tenn. and Ariz.	
Rare-earth metal concentrate	Calif. and Fla.	
Salt	La., Tex., N.Y., Ohio	Ala., Ariz., Calif., Kans., Mich., Nev., N. Mex., N. Dak., Okla., Utah, W. Va.
Sand and gravel:		
Construction	Calif., Tex., Alaska, Ohio	All other States.
Industrial	Ill., Mich., N.J., Calif	All other States except Alaska, Del., Hawaii, Iowa, Maine, Md., N.H., N. Mex., N. Dak., R.I., S. Dak., Vt., Wyo.
Silver (mine)	Idaho, Mont., Nev., Utah	Alaska, Ariz., Calif., Colo., Ill., Mo., N. Mex., N.Y., Oreg., S. Dak., Tenn., 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., Vt., Va	All other States except Alaska, Del., Fla., Ky., La., Miss., Neb., Nev., N. Dak., W. Va.
Sulfur (Frasch)	Tex. and La.	
Talc and pyrophyllite	Tex., Vt., Mont., N.Y	Ark., Calif., Ga., N.C., Oreg., Va., Wash.
Tin	Alaska.	
Titanium concentrate	Fla. and N.Y.	
Tripoli	Ill., Okla., Ark.	
Tungsten ore and concentrate	Calif., Colo., Idaho.	
Vanadium	Colo., Utah, Idaho.	
Vermiculite	Mont., S.C., Va.	
Wollastonite	N.Y. and Calif.	
Zinc (mine)	Tenn., Mo., N.Y., Colo	Idaho, Ill., Ky., N.J., Pa.
Zircon concentrate	Fla.	

Table 3.—Value of nonfuel mineral production in the United States and principal nonfuel minerals produced in 1983

State	Value (thousands)	Rank	Percent of U.S. total	Principal minerals, in order of value
Alabama	$361,326	21	1.71	Cement, stone (crushed), lime, clays.
Alaska	122,452	36	.58	Sand and gravel (construction), gold, stone (crushed), tin.
Arizona	1,510,878	3	7.15	Copper, cement, molybdenum, sand and gravel (construction).
Arkansas	246,430	28	1.17	Bromine, cement, stone (crushed), sand and gravel (construction).
California	1,764,401	1	8.35	Boron minerals, cement, sand and gravel (construction), stone (crushed).
Colorado	337,652	22	1.60	Sand and gravel (construction), cement, molybdenum, gold.
Connecticut	71,213	43	.34	Stone (crushed), sand and gravel (construction), feldspar, sand and gravel (industrial).
Delaware	[1]3,200	50	.02	Magnesium compounds, sand and gravel (construction).
Florida	1,274,979	5	6.03	Phosphate rock, stone (crushed), cement, clays.
Georgia	850,224	7	4.02	Clays, stone (crushed), cement, stone (dimension).
Hawaii	52,411	44	.25	Stone (crushed), cement, sand and gravel (construction), lime.
Idaho	415,079	17	1.96	Silver, phosphate rock, gold, lead.
Illinois	406,907	19	1.93	Stone (crushed), cement, sand and gravel (construction), sand and gravel (industrial).
Indiana	250,542	26	1.19	Stone (crushed), cement, sand and gravel (construction), lime.
Iowa	247,360	27	1.17	Stone (crushed), cement, sand and gravel (construction), gypsum.
Kansas	267,004	25	1.26	Cement, salt, stone (crushed), helium (Grade-A).
Kentucky	224,517	31	1.06	Stone (crushed), lime, cement, sand and gravel (construction).
Louisiana	446,761	16	2.11	Sulfur (Frasch), salt, sand and gravel (construction), cement.
Maine	26,363	46	.12	Sand and gravel (construction), cement, stone (crushed), peat.
Maryland	199,409	33	.94	Stone (crushed), cement, sand and gravel (construction), clays.
Massachusetts	95,675	40	.45	Sand and gravel (construction), stone (crushed), lime, stone (dimension).
Michigan	1,160,691	6	5.49	Iron ore, cement, magnesium compounds, salt.
Minnesota	1,455,030	4	6.88	Iron ore, sand and gravel (construction), stone (crushed), sand and gravel (industrial).
Mississippi	89,705	42	.42	Sand and gravel (construction), cement, clays, stone (crushed).
Missouri	725,809	8	3.43	Lead, cement, stone (crushed), lime.
Montana	293,295	23	1.39	Gold, silver, copper, cement.
Nebraska	94,844	41	.45	Cement, stone (crushed), sand and gravel (construction), lime.
Nevada	615,785	12	2.91	Gold, silver, diatomite, cement.
New Hampshire	19,086	48	.09	Sand and gravel (construction), stone (dimension), stone (crushed), clays.
New Jersey	154,615	35	.73	Stone (crushed), sand and gravel (construction), sand and gravel (industrial), zinc.
New Mexico	517,194	13	2.45	Copper, potassium salts, gold, cement.
New York	506,644	14	2.40	Stone (crushed), cement, salt, sand and gravel (construction).
North Carolina	399,158	20	1.89	Stone (crushed), phosphate rock, lithium compounds, sand and gravel (construction).
North Dakota	25,370	47	.12	Sand and gravel (construction), lime, salt, clays.
Ohio	479,144	15	2.27	Stone (crushed), salt, lime, sand and gravel (construction).
Oklahoma	226,186	30	1.07	Cement, stone (crushed), sand and gravel (construction), sand and gravel (industrial).
Oregon	110,943	37	.52	Stone (crushed), sand and gravel (construction), cement, pumice.
Pennsylvania	635,141	10	3.01	Cement, stone (crushed), lime, sand and gravel (construction).
Rhode Island	7,930	49	.04	Stone (crushed), sand and gravel (construction), stone (dimension), gem stones.
South Carolina	230,594	29	1.09	Cement, stone (crushed), clays, sand and gravel (construction).
South Dakota	222,251	32	1.05	Gold, cement, stone (dimension), stone (crushed).
Tennessee	407,051	18	1.93	Stone (crushed), zinc, cement, pyrites.
Texas	1,568,557	2	7.42	Cement, stone (crushed), sulfur (Frasch), sand and gravel (construction).
Utah	656,579	9	3.11	Copper, gold, silver, cement.
Vermont	42,129	45	.20	Stone (dimension), asbestos, sand and gravel (construction), stone (crushed).
Virginia	289,344	24	1.37	Stone (crushed), cement, sand and gravel (construction), lime.
Washington	187,465	34	.89	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 1983 —Continued

State	Value (thousands)	Rank	Percent of U.S. total	Principal minerals, in order of value
West Virginia	$103,973	38	.49	Stone (crushed), cement, sand and gravel (industrial), salt.
Wisconsin	101,191	39	.48	Stone (crushed), sand and gravel (construction), lime, sand and gravel (industrial).
Wyoming	629,901	11	2.98	Sodium carbonate, clays, iron ore, cement (portland).
Total	21,134,000	XX	100.00	

XX Not applicable.
[1]Incomplete total.

Table 4.—Value of nonfuel mineral production per capita and per square mile in 1983, by State

State	Area (square miles)	1983 population (thousands)	Value of mineral production				
			Total (thousands)	Per square mile		Per capita	
				Dollars	Rank	Dollars	Rank
Alabama	51,705	3,959	$361,326	6,988	23	91	20
Alaska	591,004	479	122,452	207	50	256	10
Arizona	114,000	2,963	1,510,878	13,253	9	510	3
Arkansas	53,187	2,328	246,430	4,633	31	106	17
California	158,706	25,174	1,764,401	11,117	12	70	25
Colorado	104,091	3,139	337,652	3,244	37	108	16
Connecticut	5,018	3,138	71,213	14,192	7	23	43
Delaware	2,044	606	[1]3,200	1,566	45	5	50
Florida	58,664	10,680	1,274,979	21,734	1	119	14
Georgia	58,910	5,732	850,224	14,433	6	148	11
Hawaii	6,471	1,023	52,411	8,099	17	51	33
Idaho	83,564	989	415,079	4,967	30	420	4
Illinois	56,345	11,486	406,907	7,222	21	35	40
Indiana	36,185	5,479	250,542	6,924	24	46	34
Iowa	56,275	2,905	247,360	4,396	32	85	22
Kansas	82,277	2,425	267,004	3,245	36	110	15
Kentucky	40,409	3,714	224,517	5,556	29	60	28
Louisiana	47,752	4,438	446,761	9,356	16	101	18
Maine	33,265	1,146	26,363	793	48	23	44
Maryland	10,460	4,304	199,409	19,064	4	46	35
Massachusetts	8,284	5,767	95,675	11,594	10	17	48
Michigan	58,527	9,069	1,160,691	19,832	3	128	13
Minnesota	84,402	4,144	1,455,030	17,239	5	351	8
Mississippi	47,689	2,587	89,705	1,881	43	35	41
Missouri	69,697	4,970	725,809	10,414	13	146	12
Montana	147,046	817	293,295	1,995	42	359	7
Nebraska	77,355	1,597	94,844	1,226	46	59	29
Nevada	110,561	891	615,785	5,570	28	691	2
New Hampshire	9,279	959	19,086	2,057	41	20	47
New Jersey	7,787	7,468	154,615	19,856	2	21	45
New Mexico	121,593	1,399	517,194	4,254	35	370	6
New York	49,108	17,667	506,644	10,317	14	29	42
North Carolina	52,669	6,082	399,158	7,579	19	66	27
North Dakota	70,702	680	25,370	359	49	37	39
Ohio	41,330	10,746	479,144	11,593	11	45	36
Oklahoma	69,956	3,298	226,186	3,233	38	69	26
Oregon	97,073	2,662	110,943	1,143	47	42	38
Pennsylvania	45,308	11,895	635,141	14,018	8	53	30
Rhode Island	1,212	955	7,930	6,543	25	8	49
South Carolina	31,113	3,264	230,594	7,412	20	71	24
South Dakota	77,116	700	222,251	2,882	39	318	9
Tennessee	42,144	4,685	407,051	9,659	15	87	21
Texas	266,807	15,724	1,568,557	5,879	27	100	19
Utah	84,899	1,619	656,579	7,734	18	406	5
Vermont	9,614	525	42,129	4,382	33	80	23
Virginia	40,767	5,550	289,344	7,098	22	52	32
Washington	68,139	4,300	187,465	2,751	40	44	37
West Virginia	24,231	1,965	103,973	4,291	34	53	31
Wisconsin	56,153	4,751	101,191	1,802	44	21	46
Wyoming	97,809	514	629,901	6,440	26	1,225	1
Total[2] or average	3,618,702	233,357	21,134,000	5,840	XX	91	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	1981 Quantity	1981 Value (thousands)	1982 Quantity	1982 Value (thousands)	1983 Quantity	1983 Value (thousands)
ALABAMA						
Cement:						
Masonry ----- thousand short tons--	193	$10,721	150	$9,086	210	$13,417
Portland ---------------do----	2,270	89,216	2,558	104,461	3,279	150,255
Clays[2] ---------------do----	1,910	25,406	1,323	13,193	1,863	20,758
Gem stones-------------------	NA	1	NA	1	NA	1
Lime --------- thousand short tons--	1,219	59,454	907	42,380	981	41,149
Sand and gravel:						
Construction---------------do----	[e]9,503	[e]23,340	7,019	17,226	[e]8,600	[e]23,500
Industrial ---------------do----	182	864	960	8,096	418	3,256
Stone:						
Crushed---------------do----	20,706	88,377	[e]21,200	[e]89,600	20,558	95,374
Dimension ---------------do----	7	2,130	[e]8	[e]2,341	7	2,661
Combined value of asphalt (native, 1981), bauxite, clays (bentonite), phosphate rock, and salt -------------------	XX	14,288	XX	13,025	XX	10,955
Total-------------------	XX	313,797	XX	299,409	XX	361,326
ALASKA						
Gem stones-------------------	NA	$60	NA	$60	NA	$60
Gold (recoverable content of ores, etc.) troy ounces--	26,531	12,195	30,513	11,470	34,702	14,714
Sand and gravel (construction) thousand short tons--	[e]41,000	[e]75,600	40,832	74,895	[e]45,200	[e]97,200
Silver (recoverable content of ores, etc.) thousand troy ounces--	2	25	2	17	4	47
Stone (crushed) --- thousand short tons--	5,359	26,855	[e]5,100	[e]25,200	1,981	9,460
Tin --------------- metric tons--	136	1,200	W	W	W	W
Combined value of copper (1982-83), lead, platinum-group metals (1981), tungsten ore and concentrate (1981), and values indicated by symbol W ---------------	XX	265	XX	1,269	XX	971
Total-------------------	XX	116,200	XX	112,911	XX	122,452
ARIZONA						
Clays --------- thousand short tons--	148	$1,105	143	$998	151	$1,425
Copper (recoverable content of ores, etc.) metric tons--	1,040,813	1,953,142	[r]769,521	[r]1,235,055	678,216	1,144,285
Gem stones-------------------	NA	3,250	NA	2,800	NA	2,800
Gold (recoverable content of ores, etc.) troy ounces--	100,339	46,120	61,050	22,949	61,991	26,284
Gypsum-------- thousand short tons--	213	2,594	175	1,205	265	1,929
Lead (recoverable content of ores, etc.) metric tons--	993	800	359	202	144	69
Lime --------- thousand short tons--	538	29,913	326	17,080	340	16,700
Molybdenum (content of concentrate) thousand pounds--	35,808	254,345	[r]20,445	[r]89,928	23,934	79,459
Pumice -------- thousand short tons--	1	3	1	7	2	15
Sand and gravel:						
Construction---------------do----	[e]20,990	[e]63,340	19,124	58,375	[e]23,200	[e]75,000
Industrial ---------------do----	179	2,455	107	1,617	W	W
Silver (recoverable content of ores, etc.) thousand troy ounces--	8,055	84,728	[r]6,309	[r]50,159	4,492	51,383
Stone:						
Crushed------ thousand short tons--	6,315	26,263	[e]5,200	[e]22,200	4,755	24,079
Dimension ---------------do----	W	578	W	[e]580	([3])	1
Zinc --------------- metric tons--	138	135	--	--	--	--
Combined value of asbestos (1981), barite (1981), cement, perlite, pyrites, salt, tungsten ore and concentrate (1981), vanadium (1981), and value indicated by symbol W --	XX	93,009	XX	79,105	XX	87,449
Total-------------------	XX	2,561,780	XX	[r]1,582,260	XX	1,510,878

See footnotes at end of table.

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

Mineral	1981 Quantity	1981 Value (thousands)	1982 Quantity	1982 Value (thousands)	1983 Quantity	1983 Value (thousands)
ARKANSAS						
Abrasives short tons	W	W	1,085	$469	W	W
Bauxite thousand metric tons	1,242	$22,185	W	W	W	W
Clays thousand short tons	880	9,333	629	6,658	879	$9,956
Gem stones	NA	200	NA	200	NA	200
Lime thousand short tons	149	8,102	W	W	W	W
Sand and gravel:						
Construction do	[e]9,146	[e]22,400	[r]6,936	[r]18,700	[e]6,900	[e]19,600
Industrial do	642	8,236	[r]471	[r]5,625	386	4,796
Stone:						
Crushed do	13,834	47,260	[e]13,100	[e]48,500	13,448	51,267
Dimension do	7	411	[e]5	[e]290	9	573
Talc do	W	W	13	92	7	66
Combined value of barite (1981-82), bromine, cement, gypsum, tripoli, vanadium (1981-82), and values indicated by symbol W	XX	153,721	XX	169,754	XX	159,972
Total	XX	271,848	XX	[r]250,288	XX	246,430
CALIFORNIA						
Boron minerals thousand short tons	1,481	$435,387	1,234	$384,597	1,303	$439,181
Cement, portland do	7,896	518,966	6,464	401,883	7,567	420,949
Clays do	2,309	19,118	1,762	15,642	[2]1,816	[2]18,255
Diatomite do	W	W	340	68,139	W	W
Gem stones	NA	300	NA	250	NA	300
Gold (recoverable content of ores, etc.) troy ounces	6,271	2,882	10,547	3,965	38,443	16,300
Gypsum thousand short tons	1,456	13,948	1,088	10,614	1,213	10,668
Lime do	472	26,834	364	23,000	358	22,994
Mercury 76-pound flasks	85	35	--	--	--	--
Peat thousand short tons	W	W	W	W	13	612
Perlite do	36	1,044	W	W	W	W
Pumice do	98	1,501	59	1,285	65	1,582
Sand and gravel:						
Construction do	[e]107,200	[e]352,100	81,147	270,995	[e]91,000	[e]308,700
Industrial do	2,150	28,269	[r]2,167	[r]27,528	2,150	34,066
Silver (recoverable content of ores, etc.) thousand troy ounces	53	560	34	271	27	308
Stone:						
Crushed thousand short tons	34,560	118,698	[e]28,500	[e]105,400	35,582	146,289
Dimension do	29	1,909	[e]29	[e]1,895	20	2,839
Talc do	111	5,855	85	1,699	71	1,289
Combined value of asbestos, calcium chloride, carbon dioxide (1981-82), cement (masonry, 1982-83), clays (fire clay, 1983), copper, feldspar, iron ore, lead, magnesium compounds, molybdenum (1981-82), potassium salts, pyrophyllite (1981), rare-earth metal concentrate, salt, sodium carbonate, sodium sulfate, tungsten ore and concentrate, wollastonite, zinc (1981), and values indicated by symbol W	XX	446,310	XX	[r]293,851	XX	340,069
Total	XX	1,973,716	XX	[r]1,611,014	XX	1,764,401
COLORADO						
Clays thousand short tons	276	$1,734	201	$1,124	459	$2,650
Copper (recoverable content of ores, etc.) metric tons	W	W	575	[r]922	W	W
Gem stones	NA	80	NA	80	NA	80
Gold (recoverable content of ores, etc.) troy ounces	51,069	23,473	64,584	24,278	63,063	26,739
Gypsum thousand short tons	203	2,346	184	1,571	W	W
Lead (recoverable content of ores, etc.) metric tons	11,431	9,207	W	W	W	W
Molybdenum thousand pounds	73,615	636,037	41,691	360,626	14,244	51,850
Peat thousand short tons	33	299	47	275	W	W
Sand and gravel:						
Construction do	[e]23,500	[e]73,300	[r]18,590	[r]58,465	[e]21,200	[e]81,600
Industrial do	W	W	222	3,266	212	3,233
Silver (recoverable content of ores, etc.) thousand troy ounces	3,009	31,650	1,934	15,378	2,146	24,546

See footnotes at end of table.

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

Mineral	1981 Quantity	1981 Value (thousands)	1982 Quantity	1982 Value (thousands)	1983 Quantity	1983 Value (thousands)
COLORADO—Continued						
Stone:						
Crushed ------ thousand short tons--	6,969	$24,083	[e]6,900	[e]$27,800	6,790	$22,749
Dimension ---------------do----	1	64	[e]1	[e]64	1	86
Combined value of beryllium concentrate (1982), carbon dioxide (1981-82), cement, iron ore, lime, perlite, pyrites (1981-82), salt (1981-82), tin (1981-82), tungsten ore and concentrate, vanadium, zinc, and values indicated by symbol W -----------	XX	164,493	XX	142,049	XX	124,119
Total --------------------	XX	966,766	XX	[r]635,898	XX	337,652
CONNECTICUT						
Clays ---------- thousand short tons--	73	$391	56	$329	86	$515
Lime ------------------do----	16	1,190	8	568	5	400
Sand and gravel:						
Construction ---------------do----	[e]6,500	[e]15,400	[r]4,887	[r]16,237	[e]5,000	[e]17,900
Industrial ---------------do----	W	W	80	1,746	W	W
Stone:						
Crushed ----------------do----	6,837	36,745	[e]6,100	[e]32,700	7,692	45,890
Dimension ---------------do----	19	910	[e]20	[e]1,046	18	1,028
Combined value of feldspar, gem stones, mica (scrap), and values indicated by symbol W --	XX	3,985	XX	3,299	XX	5,480
Total --------------------	XX	58,621	XX	[r]55,925	XX	71,213
DELAWARE						
Sand and gravel (construction) thousand short tons--	[e]1,205	[e]$2,959	1,300	$3,197	[e]1,400	[e]$3,200
Total --------------------	XX	2,959	XX	3,197	XX	3,200
FLORIDA						
Cement:						
Masonry ------ thousand short tons--	288	$20,757	231	$16,267	313	$19,557
Portland ---------------do----	3,518	199,064	2,651	136,190	3,329	164,048
Clays ------------------do----	731	[2]35,319	672	[2]31,339	684	31,566
Gem stones --------------------	NA	6	NA	6	NA	6
Lime ---------- thousand short tons--	191	11,343	103	5,828	W	13,881
Peat -------------------do----	157	2,885	120	1,575	114	1,999
Sand and gravel:						
Construction ---------------do----	[e]14,910	[e]30,600	[r]13,616	[r]30,081	[e]14,900	[e]31,500
Industrial ---------------do----	349	4,419	341	4,257	329	3,447
Stone (crushed) ------------do----	65,067	226,192	[e]53,100	[e]182,300	57,282	235,700
Combined value of clays (kaolin, 1981-82), magnesium compounds, phosphate rock, rare-earth metal concentrate, staurolite, titanium concentrates (ilmenite and rutile), and zircon concentrates ------------	XX	1,197,304	XX	815,155	XX	773,275
Total --------------------	XX	1,727,889	XX	[r]1,222,998	XX	1,274,979
GEORGIA						
Cement:						
Masonry ------ thousand short tons--	89	$4,392	W	W	W	W
Portland ---------------do----	1,150	45,423	W	W	W	W
Clays ------------------do----	8,029	553,726	6,773	$475,768	7,859	$560,005
Gem stones --------------------	NA	20	NA	20	NA	20
Sand and gravel:						
Construction---- thousand short tons--	[e]3,364	[e]8,308	3,166	8,361	[e]3,800	[e]9,400
Industrial ---------------do----	W	W	541	6,793	539	7,298
Stone:						
Crushed ----------------do----	35,730	153,751	[e]34,800	[e]153,500	41,100	186,192
Dimension ---------------do----	268	17,894	[e]271	[e]18,510	198	21,672
Talc -------------------do----	26	182	20	141	14	101
Combined value of barite, bauxite, feldspar, iron oxide pigments (crude), kyanite, mica (scrap), peat, and values indicated by symbol W ----------------------	XX	17,067	XX	54,880	XX	65,536
Total --------------------	XX	800,763	XX	717,973	XX	850,224

See footnotes at end of table.

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

Mineral	1981 Quantity	1981 Value (thousands)	1982 Quantity	1982 Value (thousands)	1983 Quantity	1983 Value (thousands)
HAWAII						
Cement:						
Masonry ---- thousand short tons--	10	$807	6	$554	6	$641
Portland ----do----	302	23,024	227	18,122	216	20,673
Sand and gravel (construction) ----do----	e459	e1,198	449	1,221	e440	e1,000
Stone:						
Crushed----do----	6,036	31,403	e4,500	e26,600	5,532	29,703
Dimension ----do----	(3)	4	e(3)	e4	(3)	3
Combined value of gem stones, lime, and pumice----	XX	589	XX	388	XX	391
Total----	XX	57,025	XX	46,889	XX	52,411
IDAHO						
Antimony ore and concentrate, antimony content----short tons--	432	W	294	W	585	W
Clays ---- thousand short tons--	26	$288	8	$101	6	$91
Copper (recoverable content of ores, etc.) metric tons--	4,245	7,966	3,074	r4,933	3,556	6,000
Gem stones----	NA	75	NA	75	NA	100
Lead (recoverable content of ores, etc.) metric tons--	38,397	30,923	W	W	25,726	12,296
Lime ---- thousand short tons--	W	W	W	W	85	7,686
Phosphate rock -- thousand metric tons--	5,361	108,964	W	W	W	W
Sand and gravel (construction) thousand short tons--	e3,063	e7,329	2,340	6,258	e3,000	e9,800
Silver (recoverable content of ores, etc.) thousand troy ounces--	16,546	174,033	14,830	117,901	17,684	202,308
Stone (crushed) --- thousand short tons--	1,437	6,206	e1,200	e6,000	1,935	7,480
Combined value of cement, garnet (abrasives), gold, gypsum, perlite, pumice, sand and gravel (industrial), stone (dimension), tungsten ore and concentrate, vanadium, zinc, and values indicated by symbol W --	XX	89,093	XX	164,810	XX	169,318
Total----	XX	424,877	XX	r300,078	XX	415,079
ILLINOIS						
Cement, portland -- thousand short tons--	1,574	$61,536	1,757	$78,444	1,857	$74,975
Clays[2]----do----	322	1,540	455	2,305	717	3,360
Gem stones----	NA	15	NA	15	NA	15
Peat ---- thousand short tons--	46	1,502	W	W	W	W
Sand and gravel:						
Construction----do----	e25,150	e68,970	21,557	59,149	e21,100	e58,400
Industrial ----do----	4,646	49,186	3,989	45,665	4,060	42,871
Stone:						
Crushed----do----	44,159	165,218	e42,900	e148,300	42,761	166,860
Dimension ----do----	2	85	e2	e98	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	79,434	XX	55,618	XX	60,355
Total----	XX	427,486	XX	389,594	XX	406,907
INDIANA						
Cement:						
Masonry ---- thousand short tons--	252	$10,972	W	W	W	W
Portland ----do----	1,538	59,344	1,523	$58,055	W	W
Clays ----do----	691	1,602	501	1,221	2558	2$1,421
Gem stones----	NA	1	NA	1	NA	1
Peat ---- thousand short tons--	105	3,140	89	r2,243	81	1,973
Sand and gravel:						
Construction----do----	e15,870	e41,330	13,097	34,579	e14,400	e37,900
Industrial ----do----	257	1,179	W	W	W	W
Stone:						
Crushed----do----	25,349	79,910	e20,300	e65,500	24,051	82,782
Dimension ----do----	145	13,672	e135	e13,337	144	11,015

See footnotes at end of table.

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

Mineral	1981 Quantity	1981 Value (thousands)	1982 Quantity	1982 Value (thousands)	1983 Quantity	1983 Value (thousands)
INDIANA—Continued						
Combined value of abrasives (natural), clays (fire clay, 1983), gypsum, lime, and values indicated by symbol W	XX	$40,212	XX	$40,199	XX	$115,450
Total	XX	251,362	XX	[r]215,135	XX	250,542
IOWA						
Cement:						
Masonry ..... thousand short tons	41	$3,227	W	W	37	$3,425
Portland ..... do	1,779	92,099	1,622	$82,225	1,644	87,836
Clays ..... do	476	2,375	437	2,392	576	3,258
Gem stones	NA	1	NA	1	NA	1
Gypsum ..... thousand short tons	1,383	12,706	1,177	11,345	1,612	13,518
Peat ..... do	10	453	W	W	W	W
Sand and gravel (construction) ..... do	[e]10,330	[e]29,080	10,064	25,618	[e]11,800	[e]32,800
Stone (crushed) ..... do	22,424	82,891	[e]22,600	[e]88,800	24,844	101,097
Combined value of lime, sand and gravel (industrial, 1981-82), stone (dimension), and values indicated by symbol W	XX	6,559	XX	8,256	XX	5,425
Total	XX	229,391	XX	218,637	XX	247,360
KANSAS						
Cement:						
Masonry ..... thousand short tons	51	$2,835	46	$2,628	W	W
Portland ..... do	1,641	81,792	1,549	79,558	W	W
Clays ..... do	915	4,756	664	3,656	718	$3,921
Gem stones	NA	1	NA	1	NA	1
Helium:						
Crude ..... million cubic feet	W	W	--	--	188	3,572
Grade-A ..... do	W	W	790	26,860	775	27,125
Salt[4] ..... thousand short tons	1,410	60,148	[r]1,601	[r]72,146	1,719	67,195
Sand and gravel:						
Construction ..... do	[e]10,500	[e]21,000	9,720	20,612	[e]12,400	[e]26,600
Industrial ..... do	W	W	331	3,635	199	2,184
Stone:						
Crushed ..... do	14,143	45,738	[e]14,400	[e]41,100	12,192	44,540
Dimension ..... do	14	605	[e]11	[e]395	W	W
Combined value of gypsum, lime, pumice, salt (brine), and values indicated by symbol W	XX	32,185	XX	5,745	XX	91,866
Total	XX	249,060	XX	[r]256,336	XX	267,004
KENTUCKY						
Clays[2] ..... thousand short tons	490	$2,395	579	$2,039	669	$2,142
Gem stones	NA	1	NA	1	NA	1
Sand and gravel:						
Construction ..... thousand short tons	[e]6,939	[e]16,070	6,499	15,936	[e]5,500	[e]13,000
Industrial ..... do	W	247	7	116	10	124
Stone (crushed) ..... do	32,433	108,257	[e]29,500	[e]104,300	33,399	117,842
Combined value of cement, clays (ball clay, fire clay, 1983), lime, and zinc	XX	81,559	XX	84,555	XX	91,408
Total	XX	208,529	XX	206,947	XX	224,517
LOUISIANA						
Clays ..... thousand short tons	[2]380	[2]$6,338	326	[2]$6,216	[2]505	$10,793
Gem stones	NA	1	NA	1	NA	1
Salt ..... thousand short tons	12,565	114,476	[r]12,171	117,569	11,544	100,936
Sand and gravel:						
Construction ..... do	[e]17,240	[e]53,550	16,558	50,966	[e]14,200	[e]46,600
Industrial ..... do	293	4,026	378	4,590	291	4,252
Stone (crushed) ..... do	W	W	W	W	5,758	25,702
Sulfur (Frasch) ..... thousand metric tons	2,235	W	1,239	W	1,643	W
Combined value of cement, clays (bentonite, 1981-82), gypsum, lime, and values indicated by symbol W	XX	388,005	XX	238,325	XX	258,477
Total	XX	566,396	XX	417,667	XX	446,761

See footnotes at end of table.

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

Mineral	1981 Quantity	1981 Value (thousands)	1982 Quantity	1982 Value (thousands)	1983 Quantity	1983 Value (thousands)
MAINE						
Clays thousand short tons	57	$166	37	$76	43	$93
Peat do	W	W	r8	r508	W	W
Sand and gravel (construction) do	e7,500	e19,400	6,701	15,118	e4,800	e12,100
Stone (crushed) do	1,375	5,532	e1,200	e4,000	848	2,851
Combined value of other nonmetals and values indicated by symbol W	XX	18,271	XX	r15,723	XX	11,319
Total	XX	43,369	XX	r35,425	XX	26,363
MARYLAND						
Clays[2] thousand short tons	597	$1,984	405	$1,346	484	$1,747
Gem stones	NA	2	NA	2	NA	2
Lime thousand short tons	9	441	7	396	7	383
Peat do	W	W	r4	W	4	W
Sand and gravel (construction) do	e9,500	e31,800	9,720	32,386	e10,600	e37,800
Stone:						
Crushed do	16,485	74,289	e15,100	e73,500	19,284	80,429
Dimension do	34	1,002	e32	e1,001	12	682
Combined value of cement, clays (ball clay), and values indicated by symbol W	XX	65,937	XX	r62,891	XX	78,366
Total	XX	175,455	XX	r171,522	XX	199,409
MASSACHUSETTS						
Clays thousand short tons	259	$1,322	210	$1,115	237	$1,298
Lime do	170	10,793	135	9,414	156	10,671
Sand and gravel:						
Construction do	e12,500	e31,300	12,003	34,438	e10,400	e36,200
Industrial do	87	W	140	1,615	W	W
Stone:						
Crushed do	7,997	41,037	e6,900	e33,500	7,740	36,002
Dimension do	50	8,616	e51	e9,158	51	10,488
Combined value of gem stones, peat, and values indicated by symbol W	XX	1,669	XX	62	XX	1,016
Total	XX	94,737	XX	89,302	XX	95,675
MICHIGAN						
Cement:						
Masonry thousand short tons	173	$10,584	136	$8,752	W	W
Portland do	3,871	180,641	3,254	149,533	W	W
Clays do	1,610	5,862	1,022	4,370	1,199	$5,693
Gem stones	NA	15	NA	15	NA	15
Gypsum thousand short tons	1,066	6,762	682	5,150	1,097	8,104
Iron ore (usable) thousand long tons, gross weight	14,193	W	W	W	10,713	W
Lime thousand short tons	807	36,800	571	26,823	503	23,142
Peat do	237	4,540	241	4,917	215	4,286
Salt do	2,321	103,293	2,002	106,303	1,355	93,306
Sand and gravel:						
Construction do	e28,100	e68,050	20,567	47,726	e23,000	e52,300
Industrial do	4,393	29,787	2,920	21,934	3,545	27,577
Stone:						
Crushed do	30,013	94,324	e20,700	e67,100	24,763	82,152
Dimension do	6	129	e4	e110	4	112
Combined value of bromine, calcium chloride, copper (1981-82), iodine, iron oxide pigments (crude), magnesium compounds, silver (1981-82), and values indicated by symbol W	XX	899,618	XX	r592,451	XX	864,004
Total	XX	1,440,405	XX	r1,035,184	XX	1,160,691
MINNESOTA						
Clays thousand short tons	84	$1,077	W	W	W	W
Gem stones	NA	5	NA	$5	NA	$5
Iron ore (usable) thousand long tons, gross weight	50,176	2,062,118	23,715	1,021,056	30,699	1,342,455
Lime thousand short tons	155	3,818	133	4,694	W	W

See footnotes at end of table.

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

Mineral	1981		1982		1983	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
MINNESOTA—Continued						
Manganiferous ore short tons	139,571	W	16,307	W	11,314	W
Peat thousand short tons	25	$940	W	W	W	W
Sand and gravel:						
Construction do	[e]23,950	[e]49,770	20,276	$44,222	[e]24,600	[e]$53,000
Industrial do	W	W	694	5,903	685	12,932
Stone:						
Crushed do	6,995	18,438	[e]7,100	[e]20,900	8,580	25,320
Dimension do	41	14,298	[e]40	[e]11,940	28	11,365
Combined values of items indicated by symbol W	XX	4,297	XX	1,406	XX	9,953
Total	XX	2,154,761	XX	1,110,126	XX	1,455,030
MISSISSIPPI						
Clays thousand short tons	1,218	$23,309	805	$21,181	1,446	$23,846
Sand and gravel (construction) do	[e]10,480	[e]29,260	9,455	27,115	[e]11,000	[e]34,600
Stone (crushed) do	W	W	W	W	1,651	4,377
Combined value of cement, sand and gravel (industrial), and values indicated by symbol W	XX	39,682	XX	24,389	XX	26,882
Total	XX	92,251	XX	72,685	XX	89,705
MISSOURI						
Barite thousand short tons	185	$9,725	107	$5,703	W	W
Cement:						
Masonry do	103	5,495	88	4,855	146	$7,339
Portland do	3,732	168,567	3,205	120,339	3,499	157,249
Clays do	1,747	18,414	[2]1,383	[2]13,409	[2]1,418	[2]11,848
Copper (recoverable content of ores, etc.) metric tons	8,411	15,783	7,941	[r]12,745	7,725	13,033
Gem stones	NA	10	NA	10	NA	10
Iron ore thousand long tons	W	W	717	W	877	27,054
Lead (recoverable content of ores, etc.) metric tons	389,721	313,870	474,460	267,150	409,280	195,620
Sand and gravel:						
Construction thousand short tons	[e]7,500	[e]16,900	6,359	14,477	[e]7,700	[e]17,700
Industrial do	778	8,602	750	8,997	600	7,541
Silver (recoverable content of ores, etc.) thousand troy ounces	1,837	19,322	2,241	17,817	2,021	23,124
Stone (crushed) thousand short tons	40,910	116,297	[e]38,600	[e]113,300	39,454	120,700
Zinc (recoverable content of ores, etc.) metric tons	52,904	51,966	63,680	54,009	57,044	52,052
Combined value of clays (fuller's earth, 1982), iron oxide pigments (crude), lime, stone (dimension), and values indicated by symbol W	XX	130,317	XX	100,698	XX	92,539
Total	XX	875,268	XX	[r]733,509	XX	725,809
MONTANA						
Antimony short tons	214	W	209	W	253	W
Barite thousand short tons	W	W	W	W	10	$750
Clays do	601	$23,111	[2]218	[2]$8,064	194	6,205
Copper (recoverable content of ores, etc.) metric tons	62,485	117,257	[r]64,951	[r]104,245	33,337	56,245
Gem stones	NA	100	NA	225	NA	300
Gold (recoverable content of ores, etc.) troy ounces	54,267	24,943	75,171	28,258	161,436	68,449
Lead (recoverable content of ores, etc.) metric tons	194	157	661	372	1,163	556
Lime thousand short tons	194	7,621	45	2,331	86	W
Sand and gravel (construction) do	[e]5,640	[e]12,910	5,338	12,794	[e]5,000	[e]10,200
Silver (recoverable content of ores, etc.) thousand troy ounces	2,989	31,437	6,169	49,041	5,708	65,299

See footnotes at end of table.

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

Mineral	1981 Quantity	1981 Value (thousands)	1982 Quantity	1982 Value (thousands)	1983 Quantity	1983 Value (thousands)
MONTANA—Continued						
Stone (crushed) ___ thousand short tons__	1,582	$5,137	[e]1,400	[e]$4,700	872	$2,344
Zinc (recoverable content of ores, etc.) metric tons__	25	24	W	W	--	--
Combined value of cement, clays (fire clay, 1982), graphite (1982-83), gypsum, iron ore, molybdenum (1983), peat, phosphate rock, sand and gravel (industrial), stone (dimension), talc, tungsten ore and concentrate (1981-82), vermiculite, and values indicated by symbol W	XX	80,384	XX	[r]60,723	XX	82,947
Total	XX	303,081	XX	[r]270,753	XX	293,295
NEBRASKA						
Clays ______ thousand short tons__	136	$409	134	$392	164	$501
Gem stones	NA	W	NA	W	NA	W
Sand and gravel:						
Construction ___ thousand short tons__	[e]11,770	[e]28,310	[r]9,731	[r]23,851	[e]10,100	[e]25,000
Industrial ______ do____	19	144	14	105	4	W
Stone (crushed) ______ do____	3,139	14,024	[e]3,100	[e]14,300	5,641	30,047
Combined value of cement, lime, and values indicated by symbol W	XX	36,718	XX	36,632	XX	39,296
Total	XX	79,605	XX	[r]75,280	XX	94,844
NEVADA						
Barite ______ thousand short tons__	2,482	$79,716	1,575	$52,727	663	$21,736
Clays ______ do____	73	2,948	103	2,640	58	2,348
Gem stones	NA	1,000	NA	1,200	NA	1,200
Gold (recoverable content of ores, etc.) troy ounces__	524,802	241,220	[r]757,099	[r]284,601	920,331	390,220
Gypsum ______ thousand short tons__	778	6,914	656	4,523	998	7,896
Iron ore ______ thousand long tons__	99	1,490	77	1,119	W	W
Lead (recoverable content of ores, etc.) metric tons__	W	W	W	W	14	7
Mercury ______ 76-pound flasks__	27,819	11,514	25,760	W	25,070	W
Sand and gravel (construction) thousand short tons__	[e]7,065	[e]15,770	6,027	11,724	[e]7,500	[e]16,200
Silver (recoverable content of ores, etc.) thousand troy ounces__	3,039	31,970	3,142	24,981	5,164	59,073
Stone (crushed) ___ thousand short tons__	1,343	5,664	[e]1,300	[e]4,500	1,269	5,358
Zinc (recoverable content of ores, etc.) metric tons__	W	W	--	--	--	--
Combined value of cement (portland), copper, diatomite, fluorspar, lime, lithium, magnesite, molybdenum (1982-83), perlite, salt, sand and gravel (industrial), tungsten ore and concentrate (1981-82), and values indicated by symbol W	XX	108,453	XX	[r]144,448	XX	111,747
Total	XX	506,659	XX	[r]532,463	XX	615,785
NEW HAMPSHIRE						
Sand and gravel (construction) thousand short tons__	[e]4,528	[e]$12,990	4,332	$12,593	[e]4,000	[e]$12,100
Stone:						
Crushed ______ do____	665	2,599	[e]600	[e]3,100	946	2,853
Dimension ______ do____	89	6,889	[e]107	[e]7,500	58	4,032
Combined value of other nonmetals	XX	122	XX	101	XX	101
Total	XX	22,600	XX	23,294	XX	19,086
NEW JERSEY						
Clays ______ thousand short tons__	62	$563	63	$566	62	$596
Gem stones	NA	1	NA	1	NA	1
Peat ______ thousand short tons__	26	1,476	W	W	W	W

See footnotes at end of table.

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

Mineral	1981 Quantity	1981 Value (thousands)	1982 Quantity	1982 Value (thousands)	1983 Quantity	1983 Value (thousands)
NEW JERSEY—Continued						
Sand and gravel:						
Construction ___ thousand short tons__	[e]9,756	[e]$26,050	7,940	$25,722	[e]10,800	[e]$34,300
Industrial ______do____	2,305	26,438	2,140	28,151	2,386	31,819
Stone (crushed) ______do____	10,434	57,819	[e]10,700	[e]57,800	12,301	70,421
Zinc (recoverable content of ores, etc.) metric tons__	16,198	15,911	16,800	14,248	16,475	15,033
Combined value of iron ore (1981), magnesium compounds, marl (greensand), stone (dimension), titanium concentrate (ilmenite, 1981-82), and values indicated by symbol W ______	XX	20,404	XX	5,922	XX	2,445
Total ______	XX	148,662	XX	132,410	XX	154,615
NEW MEXICO						
Clays ______ thousand short tons__	[2]64	[2]$119	[2]60	[2]$112	50	$115
Copper (recoverable content of ores, etc.) metric tons__	154,114	289,204	W	W	W	W
Gem stones______	NA	200	NA	200	NA	200
Gold (recoverable content of ores, etc.) troy ounces__	65,749	30,221	W	W	W	W
Gypsum______ thousand short tons__	166	2,256	198	887	169	1,016
Lead (recoverable content of ores, etc.) metric tons__	W	W	W	W	258	123
Lime ______ thousand short tons__	W	W	W	W	17	W
Manganiferous ore (5% to 35% Mn) short tons__	12,741	W	--	--	--	--
Perlite ______ thousand short tons__	489	14,983	408	13,355	394	13,297
Potassium salts __ thousand metric tons__	1,601	261,200	1,497	204,600	1,278	174,700
Pumice ______ thousand short tons__	93	919	97	809	110	1,070
Sand and gravel______do____	[e]6,496	[e]19,780	5,616	17,670	[e]7,000	[e]20,000
Silver (recoverable content of ores, etc.) thousand troy ounces__	1,632	17,170	805	6,397	W	W
Stone:						
Crushed______ thousand short tons__	4,162	12,485	[e]2,800	[e]13,700	4,730	15,121
Dimension ______do____	26	173	[e]18	[e]138	18	141
Combined value of carbon dioxide (1981-82), cement, clays (fire clay 1981-82), helium (Grade-A), mica (scrap), molybdenum, salt, sand and gravel (industrial, 1982), vanadium (1981), zinc (1981), and values indicated by symbol W ______	XX	47,697	XX	[r]171,432	XX	291,411
Total ______	XX	696,407	XX	[r]429,300	XX	517,194
NEW YORK						
Clays[2]______ thousand short tons__	597	$2,310	352	$897	371	$869
Gem stones______	NA	30	NA	30	NA	30
Lead (recoverable content of ores, etc.) metric tons__	968	780	[r]1,065	[r]600	1,299	621
Peat______ thousand short tons__	39	811	W	W	18	W
Salt ______do____	5,597	103,668	6,205	117,718	4,859	100,119
Sand and gravel:						
Construction______do____	[e]18,280	[e]45,560	[r]17,338	[r]46,871	[e]18,700	[e]54,200
Industrial ______do____	55	W	45	512	W	W
Silver (recoverable content of ores, etc.) thousand troy ounces__	29	303	27	[r]216	33	379
Stone:						
Crushed______ thousand short tons__	30,681	117,689	[e]28,700	[e]132,800	32,331	137,982
Dimension ______do____	21	2,291	[e]22	[e]2,293	24	4,310
Zinc (recoverable content of ores, etc.) metric tons__	36,889	36,235	[r]52,237	[r]44,303	56,748	51,783
Combined value of cement, clays (ball clay), emery, garnet (abrasive), gypsum, iron ore (1981-82), lime, talc, titanium concentrate (ilmenite), wollastonite, and values indicated by symbol W ______	XX	171,554	XX	[r]155,959	XX	156,351
Total ______	XX	481,231	XX	[r]502,199	XX	506,644

See footnotes at end of table.

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

Mineral	1981 Quantity	1981 Value (thousands)	1982 Quantity	1982 Value (thousands)	1983 Quantity	1983 Value (thousands)
NORTH CAROLINA						
Clays[2] thousand short tons	2,110	$6,838	1,573	$5,243	2,068	$6,681
Feldspar short tons	462,864	13,517	428,755	12,255	508,641	13,610
Gem stones	NA	50	NA	50	NA	50
Mica (scrap) thousand short tons	92	6,398	67	4,793	69	4,266
Sand and gravel:						
Construction do	[e]6,294	[e]18,330	5,198	15,395	[e]5,600	[e]16,900
Industrial do	1,236	10,440	716	4,878	1,066	11,689
Stone:						
Crushed do	28,833	117,092	[e]27,500	[e]117,600	33,694	145,602
Dimension do	30	2,773	[e]30	[e]2,814	87	8,267
Talc and pyrophyllite do	[5]104	[5]825	83	1,266	89	1,452
Combined value of cement, clays (kaolin), lithium compounds, olivine, peat (1982-83), phosphate rock, and talc (1981)	XX	[r]256,997	XX	[r]135,142	XX	190,641
Total	XX	[r]433,260	XX	[r]299,436	XX	399,158
NORTH DAKOTA						
Gem stones	NA	$2	NA	$2	NA	$2
Lime thousand short tons	W	W	W	W	57	6,798
Peat do	W	36	W	W	W	W
Sand and gravel (construction) do	[e]3,000	[e]6,500	2,347	4,873	[e]3,800	[e]15,000
Combined value of clays, salt, and values indicated by symbol W	XX	8,310	XX	8,102	XX	3,570
Total	XX	14,848	XX	12,977	XX	25,370
OHIO						
Cement:						
Masonry thousand short tons	105	$7,129	86	$6,170	97	$7,454
Portland do	1,461	69,517	1,326	59,598	1,575	71,599
Clays do	2,217	10,411	1,451	6,100	1,716	8,061
Gypsum do	148	1,566	109	1,335	W	W
Lime do	2,767	127,751	1,666	76,370	1,906	84,928
Peat do	10	191	5	144	W	W
Salt do	3,608	90,254	3,514	90,572	2,565	85,988
Sand and gravel:						
Construction do	[e]32,240	[e]95,570	[r]26,160	[r]83,015	[e]27,200	[e]84,600
Industrial do	1,487	20,893	1,223	17,816	1,226	17,848
Stone:						
Crushed do	36,950	125,588	[e]30,300	[e]105,200	32,937	114,059
Dimension do	W	W	W	W	49	2,923
Combined value of abrasives, gem stones, and values indicated by symbol W	XX	3,290	XX	3,240	XX	1,684
Total	XX	552,160	XX	[r]449,560	XX	479,144
OKLAHOMA						
Cement:						
Masonry thousand short tons	W	W	W	W	45	$3,074
Portland do	W	W	W	W	1,719	83,685
Clays do	838	$2,064	752	$1,907	862	2,288
Gem stones	NA	2	NA	2	NA	2
Gypsum thousand short tons	1,177	9,870	1,254	10,089	1,351	11,571
Helium:						
Grade-A million cubic feet	49	1,274	--	--	--	--
Crude do	22	264	--	--	--	--
Pumice thousand short tons	1	W	1	W	1	W
Sand and gravel:						
Construction do	[e]9,000	[e]21,700	7,490	17,733	[e]7,500	[e]17,300
Industrial do	1,500	14,317	1,222	13,114	1,184	13,221
Stone:						
Crushed do	29,930	83,407	[e]30,100	[e]84,200	23,865	76,941
Dimension do	18	738	[e]18	[e]968	10	737
Combined value of feldspar, iodine, lime, salt, tripoli, and values indicated by symbol W	XX	100,876	XX	97,031	XX	17,367
Total	XX	234,512	XX	225,044	XX	226,186

See footnotes at end of table.

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

Mineral	1981 Quantity	1981 Value (thousands)	1982 Quantity	1982 Value (thousands)	1983 Quantity	1983 Value (thousands)
OREGON						
Clays thousand short tons	176	$300	149	$212	188	$275
Gem stones	NA	600	NA	500	NA	600
Gold (recoverable content of ores, etc.) troy ounces	2,830	1,301	W	W	322	137
Nickel (content of ores and concentrates) short tons	12,099	W	3,203	W	--	--
Sand and gravel (construction) do	[e]12,000	[e]35,100	9,513	30,629	[e]11,000	[e]37,000
Silver (recoverable content of ores, etc.) thousand troy ounces	7	79	--	--	1	10
Stone:						
Crushed thousand short tons	16,482	46,055	[e]14,200	[e]41,900	13,089	39,876
Dimension do	([3])	5	[e]([3])	[e]5	W	W
Talc and soapstone do	W	W	([3])	82	([3])	123
Combined value of cement, copper (1981 and 1983), diatomite, lead (1981 and 1983), lime, pumice, sand and gravel (industrial 1983), and values indicated by symbol W	XX	56,107	XX	[r]34,516	XX	32,922
Total	XX	139,547	XX	[r]107,844	XX	110,943
PENNSYLVANIA						
Cement:						
Masonry thousand short tons	293	$14,799	256	$14,048	262	$17,095
Portland do	5,150	215,883	4,800	212,945	5,154	218,539
Clays[2] do	1,246	7,497	931	5,616	916	4,311
Gem stones	NA	5	NA	5	NA	5
Lime thousand short tons	1,690	85,418	1,297	70,902	1,507	81,682
Mica (scrap) do	3	134	W	W	W	W
Peat do	25	647	27	669	22	628
Sand and gravel:						
Construction do	[e]14,000	[e]61,100	13,081	55,527	[e]11,800	[e]52,000
Industrial do	W	W	969	13,589	W	W
Stone:						
Crushed do	53,258	207,821	[e]50,400	[e]200,900	51,523	226,948
Dimension do	51	7,193	[e]48	[e]6,354	53	5,799
Tripoli short tons	1,263	W	W	W	--	--
Zinc (recoverable content of ores, etc.) metric tons	24,732	24,293	24,762	21,001	16,792	15,322
Combined value of clays (kaolin) and values indicated by symbol W	XX	13,966	XX	[r]1,094	XX	12,812
Total	XX	638,756	XX	[r]602,650	XX	635,141
RHODE ISLAND						
Sand and gravel:						
Construction thousand short tons	[e]1,332	[e]$3,985	1,146	$3,671	[e]1,000	[e]$2,400
Industrial do	W	W	5	52	--	--
Stone (crushed) do	141	1,116	[e]130	[e]1,100	971	5,507
Combined value of other nonmetals and value indicated by symbol W	XX	63	XX	18	XX	23
Total	XX	5,164	XX	4,841	XX	7,930
SOUTH CAROLINA						
Cement, portland thousand short tons	1,765	$79,407	1,624	$66,385	W	W
Clays[2] do	1,632	28,600	1,535	28,166	1,813	$34,830
Gem stones	NA	10	NA	10	NA	10
Manganiferous ore thousand short tons	[r]22	W	15	W	22	W
Peat do	--	--	5	W	W	W
Sand and gravel:						
Construction do	[e]5,131	[e]13,240	4,727	13,170	[e]5,200	[e]15,000
Industrial do	803	10,531	720	10,902	842	13,169
Stone:						
Crushed do	14,825	49,830	[e]14,000	[e]53,000	15,786	61,054
Dimension do	18	1,109	[e]14	[e]904	17	1,165
Combined value of cement (masonry), clays (fuller's earth), copper (1981), gold (1981), mica (scrap), silver (1981), vermiculite, and values indicated by symbol W	XX	22,989	XX	[r]22,181	XX	105,366
Total	XX	205,716	XX	[r]194,718	XX	230,594

See footnotes at end of table.

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

Mineral	1981 Quantity	1981 Value (thousands)	1982 Quantity	1982 Value (thousands)	1983 Quantity	1983 Value (thousands)
SOUTH DAKOTA						
Cement:						
Masonry ----- thousand short tons--	6	$454	4	$383	4	$359
Portland ---------------do----	450	23,290	520	27,978	603	37,435
Clays[2] ------------------do----	116	209	128	346	123	353
Feldspar -------------short tons--	W	W	W	W	7,109	107
Gem stones-------------------	NA	70	NA	70	NA	70
Gold (recoverable content of ores, etc.) troy ounces--	278,162	127,854	185,038	69,558	309,784	131,348
Sand and gravel (construction) thousand short tons--	[e]4,285	[e]9,224	3,816	8,604	[e]5,100	[e]11,500
Silver (recoverable content of ores, etc.) thousand troy ounces--	56	587	26	209	62	713
Stone:						
Crushed------ thousand short tons--	2,985	9,085	[e]2,600	[e]7,400	3,906	12,982
Dimension --------------do----	50	17,543	[e]48	[e]16,270	43	15,952
Combined value of beryllium, clays (bentonite), gypsum, lime, mica (scrap), and values indicated by symbol W ------------	XX	6,382	XX	4,855	XX	11,432
Total-------------------	XX	194,698	XX	135,673	XX	222,251
TENNESSEE						
Cement:						
Masonry ----- thousand short tons--	66	$3,209	W	W	W	W
Portland ---------------do----	974	39,378	763	$36,689	W	W
Clays ------------------do----	1,047	23,134	766	20,107	1,066	$26,516
Gem stones-------------------	NA	5	NA	5	NA	5
Phosphate rock -- thousand metric tons--	1,828	16,201	897	11,596	1,193	28,879
Sand and gravel:						
Construction--- thousand short tons--	[e]8,830	[e]24,130	5,051	15,917	[e]6,100	[e]18,700
Industrial --------------do----	1,142	5,610	468	4,826	483	5,455
Stone:						
Crushed----------------do----	W	W	W	W	30,578	111,506
Dimension --------------do----	11	1,063	[e]10	[e]1,012	7	1,161
Zinc (recoverable content of ores, etc.) metric tons--	117,684	115,597	121,306	102,882	109,958	100,336
Combined value of barite, copper, gold (1981), lime, pyrites, silver, and values indicated by symbol W -----------------	XX	192,822	XX	[r]185,453	XX	114,493
Total-------------------	XX	421,149	XX	[r]378,487	XX	407,051
TEXAS						
Cement:						
Masonry ----- thousand short tons--	229	$15,699	236	$16,440	276	$19,704
Portland ---------------do----	10,262	567,391	9,732	545,679	9,760	534,298
Clays ------------------do----	4,172	29,135	4,193	26,497	3,955	22,575
Gem stones-------------------	NA	200	NA	200	NA	225
Gypsum-------- thousand short tons--	1,783	14,900	1,954	16,681	2,049	16,357
Helium (Grade-A)---- million cubic feet--	238	6,188	458	15,572	524	18,340
Lime --------- thousand short tons--	1,393	67,158	1,125	62,277	1,067	60,193
Salt --------------------do----	8,397	84,240	7,421	82,805	8,028	65,670
Sand and gravel:						
Construction-------------do----	[e]46,000	[e]150,000	45,527	154,515	[e]58,500	[e]208,000
Industrial --------------do----	2,242	36,992	[r]2,201	[r]35,974	1,788	29,637
Stone:						
Crushed----------------do----	72,454	219,086	[e]68,000	[e]205,000	76,453	239,642
Dimension --------------do----	42	5,543	[e]50	[e]5,822	50	11,071
Sulfur (Frasch) -- thousand metric tons--	3,674	W	2,360	W	2,468	W
Talc and pyrophyllite thousand short tons--	282	4,127	205	3,024	250	3,933
Combined value of asphalt (native, 1981), fluorspar, helium (crude), iron ore, magnesium chloride, magnesium compounds, sodium sulfate, and values indicated by symbol W----------------------	XX	551,751	XX	[r]374,912	XX	338,912
Total-------------------	XX	1,752,410	XX	[r]1,545,398	XX	1,568,557

See footnotes at end of table.

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

Mineral	1981 Quantity	1981 Value (thousands)	1982 Quantity	1982 Value (thousands)	1983 Quantity	1983 Value (thousands)
UTAH						
Clays ---------- thousand short tons--	290	$2,296	[2]183	[2]$994	[2]227	[2]$1,569
Copper (recoverable content of ores, etc.) metric tons--	211,276	396,471	189,090	[r]303,483	169,751	286,403
Gem stones--------------------	NA	80	NA	80	NA	80
Gold (recoverable content of ores, etc.) troy ounces--	227,706	104,663	174,940	65,762	238,459	101,107
Gypsum-------- thousand short tons--	300	2,705	231	2,363	305	2,736
Iron ore (usable)------ thousand long tons, gross weight--	691	W	W	W	W	W
Lead (recoverable content of ores, etc.) metric tons--	1,662	1,338	W	W	--	--
Lime ---------- thousand short tons--	333	16,679	286	15,121	315	16,771
Perlite -------------------do----	([3])	4	--	--	W	W
Salt ----------------------do----	1,072	21,775	1,227	23,210	936	23,184
Sand and gravel:						
Construction--------------do----	[e]8,212	[e]54,550	7,579	14,920	[e]9,800	[e]19,800
Industrial ---------------do----	22	286	W	W	24	W
Silver (recoverable content of ores, etc.) thousand troy ounces--	2,883	30,321	4,342	34,522	4,567	52,242
Stone:						
Crushed------ thousand short tons--	2,840	12,157	[e]2,500	[e]9,800	4,407	14,636
Dimension ---------------do----	8	280	[e]8	[e]280	W	W
Zinc (recoverable content of ores, etc.) metric tons--	1,576	1,548	--	--	--	--
Combined value of asphalt (native), beryllium concentrate, carbon dioxide (natural, 1981), cement, clays (fuller's earth, 1982-83), magnesium compounds, molybdenum, phosphate rock, potassium salts, sodium sulfate, tungsten ore and concentrate (1981), vanadium, and values indicated by symbol W--	XX	174,729	XX	145,669	XX	138,051
Total--------------------	XX	819,882	XX	[r]616,204	XX	656,579
VERMONT						
Sand and gravel (construction) thousand short tons--	[e]3,196	[e]$7,254	3,218	$6,854	[e]3,000	[e]$6,200
Stone:						
Crushed-----------------do----	1,319	5,144	[e]1,200	[e]5,300	1,339	5,579
Dimension ---------------do----	207	30,756	[e]202	[e]29,446	118	19,995
Combined value of other nonmetals ------	XX	10,919	XX	8,550	XX	10,355
Total--------------------	XX	54,073	XX	50,150	XX	42,129
VIRGINIA						
Clays ---------- thousand short tons--	502	$2,016	422	$2,237	784	$5,467
Gem stones--------------------	NA	20	NA	20	NA	20
Iron oxide pigments --------short tons--	W	W	1,269	372	W	W
Lead (recoverable content of ores, etc.) metric tons--	1,607	1,294	--	--	--	--
Lime ---------- thousand short tons--	804	35,984	641	29,118	557	24,637
Sand and gravel (construction)-----do----	[e]7,109	[e]24,470	6,978	28,522	[e]7,200	[e]30,800
Stone:						
Crushed-----------------do----	37,071	152,630	[e]35,200	[e]142,300	37,959	158,724
Dimension ---------------do----	4	1,130	[e]4	[e]1,130	93	3,067
Zinc (recoverable content of ores, etc.) metric tons--	9,731	9,558	--	--	--	--
Combined value of aplite, cement, gypsum, kyanite, sand and gravel (industrial), talc, vermiculite, and values indicated by symbol W----------------------	XX	52,178	XX	59,484	XX	66,629
Total--------------------	XX	279,280	XX	263,183	XX	289,344

See footnotes at end of table.

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

Mineral	1981 Quantity	1981 Value (thousands)	1982 Quantity	1982 Value (thousands)	1983 Quantity	1983 Value (thousands)
WASHINGTON						
Cement:						
Masonry ______ thousand short tons__	15	$1,284	W	W	W	W
Portland ______________ do____	1,560	100,845	1,154	$75,988	W	W
Clays ________________ do____	[2]263	[2]1,524	251	1,829	[2]282	[2]$1,715
Gem stones__________________	NA	200	NA	200	NA	200
Sand and gravel:						
Construction____ thousand short tons__	[e]16,870	[e]42,130	15,190	40,295	[e]15,800	[e]50,300
Industrial ______________ do____	304	3,358	242	2,809	337	4,581
Silver ________ thousand troy ounces__	67	709	W	W	W	W
Stone:						
Crushed______ thousand short tons__	9,516	25,619	[e]8,600	[e]23,800	10,451	29,607
Dimension ______________ do____	15	2,378	[e]14	[e]2,375	1	37
Talc __________________ do____	--	--	8	20	W	W
Combined value of barite (1982-83), clays (fire clay, 1983), copper (1981-82), diatomite, gold, gypsum, lead (1982), lime, olivine, peat, tungsten ore and concentrate (1981), and values indicated by symbol W______	XX	30,461	XX	[r]24,766	XX	101,025
Total__________________	XX	208,508	XX	[r]172,082	XX	187,465
WEST VIRGINIA						
Clays[2]_________ thousand short tons__	220	$502	210	$583	249	$532
Salt __________________ do____	W	W	942	W	1,026	W
Sand and gravel (construction) _____ do____	[e]651	[e]2,601	751	3,392	[e]700	[e]3,400
Stone (crushed) ____________ do____	7,885	28,399	[e]5,900	[e]22,700	9,439	37,962
Combined value of cement, clays (fire clay), lime, sand and gravel (industrial), and values indicated by symbol W ________	XX	56,046	XX	[r]48,945	XX	62,079
Total__________________	XX	87,548	XX	[r]75,620	XX	103,973
WISCONSIN						
Iron ore (usable)_____ thousand long tons, gross weight___	W	W	263	W	--	--
Lime _________ thousand short tons__	326	$17,548	312	$17,685	319	$17,624
Peat __________________ do____	10	535	9	W	9	W
Sand and gravel:						
Construction______________ do____	[e]18,210	[e]34,522	14,515	29,218	[e]14,200	[e]28,800
Industrial ______________ do____	1,100	13,180	788	9,662	621	7,208
Stone:						
Crushed________________ do____	15,189	39,962	[e]11,400	[e]36,100	14,252	39,896
Dimension ______________ do____	40	4,259	[e]37	[e]2,644	24	2,884
Combined value of abrasive stone, cement, peat (1982), and values indicated by symbol W ______________________	XX	41,749	XX	[r]16,400	XX	4,779
Total__________________	XX	151,755	XX	[r]111,709	XX	101,191
WYOMING						
Clays _________ thousand short tons__	3,855	$100,926	2,561	$73,696	2,140	$49,059
Gem stones__________________	NA	250	NA	250	NA	250
Gypsum________ thousand short tons__	299	2,625	283	2,805	382	2,963
Sand and gravel (construction) _____ do____	[e]3,680	[e]10,120	3,382	10,279	[e]2,400	[e]8,000
Stone (crushed) ____________ do____	3,224	9,858	[e]2,300	[e]7,300	2,019	7,769
Combined value of beryllium concentrate (1982-83), cement (masonry, 1981, portland), iron ore, lead (1981), lime, sodium carbonate, and zinc (1981)______________	XX	644,279	XX	573,865	XX	561,860
Total__________________	XX	768,058	XX	668,195	XX	629,901

[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]Excludes salt in brines; value included in "Combined value" figure.

[5]Excludes talc; 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	1981		1982		1983	
	Quantity	Value	Quantity	Value	Quantity	Value
American Samoa: Stone	6	127	NA	NA	NA	NA
Guam: Stone	332	W	NA	NA	329	2,192
Virgin Islands: Stone	W	W	NA	NA	237	2,305

NA Not available. W Withheld to avoid disclosing company proprietary data.
[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	1981		1982		1983	
	Quantity	Value	Quantity	Value	Quantity	Value
Cement (portland)	1,226	105,420	986	81,822	931	82,509
Clays	200	474	162	298	125	251
Lime	34	3,884	37	1,906	35	3,885
Sand and gravel	NA	NA	NA	NA	NA	NA
Stone:						
Crushed	20,473	96,223	NA	NA	5,536	26,611
Dimension	105	2,040	NA	NA	W	W
Total[2]	XX	208,041	XX	84,026	XX	113,256

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	1982		1983	
	Quantity	Value (thousands)	Quantity	Value (thousands)
METALS				
Aluminum:				
Ingots, slabs, crude short tons	401,174	$476,186	397,608	$534,048
Scrap do	214,299	157,666	262,159	249,156
Plates, sheets, bars, etc. do	193,837	440,373	178,898	388,679
Castings and forgings do	7,180	41,156	10,492	55,346
Aluminum sulfate metric tons	6,121	1,280	14,094	1,593
Other aluminum compounds do	36,329	26,663	49,706	36,447
Antimony, metals and alloys, crude short tons	830	1,711	304	1,038
Bauxite including bauxite concentrate thousand metric tons	49	8,545	74	10,561
Beryllium pounds	134,013	3,696	37,477	2,693
Bismuth, metals and alloys do	52,758	371	306,128	703
Cadmium metal metric tons	11	126	170	351
Chromium:				
Ore and concentrate:				
Exports thousand short tons	8	1,574	11	1,874
Reexports do	57	9,172	5	1,350
Ferrochromium do	5	5,081	4	4,822
Cobalt (content) thousand pounds	596	7,690	824	5,715
Copper:				
Ore, concentrate, composition metal, unrefined (copper content) metric tons	200,157	225,261	57,126	67,759
Scrap do	54,419	63,484	47,986	66,929
Refined copper and semimanufactures do	115,147	438,219	157,664	532,595
Other copper manufactures do	17,591	32,787	9,439	18,360
Ferroalloys not elsewhere listed:				
Ferrophosphorus short tons	4,031	1,402	26,933	3,716
Ferroalloys, n.e.c do	4,980	8,481	5,775	7,965
Gold:				
Ore and base bullion troy ounces	1,333,210	498,139	1,257,800	501,016
Bullion, refined do	1,637,184	590,947	1,881,233	825,418
Iron ore thousand long tons	3,178	150,522	3,781	182,744
Iron and steel:				
Pig iron short tons	54,333	3,784	6,364	528
Iron and steel products (major):				
Steel mill products do	1,842,313	1,601,431	1,198,623	1,054,794
Other steel products do	342,406	913,111	246,642	553,894
Iron and steel scrap: Ferrous scrap including rerolling materials, ships, boats, other vessels for scrapping thousand short tons	6,925	622,711	7,752	650,540

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

Mineral	1982		1983	
	Quantity	Value (thousands)	Quantity	Value (thousands)
METALS—Continued				
Lead:				
Ore and concentrate ---- metric tons	29,104	$10,135	20,119	$7,502
Pigs, bars, anodes, sheets, etc ---- do	55,629	48,818	20,449	19,090
Scrap ---- do	51,752	17,254	50,918	13,139
Magnesium, metal and alloys, scrap, semimanufactured forms, n.e.c ---- short tons	39,613	104,845	46,690	124,714
Manganese:				
Ore and concentrate ---- do	28,560	2,510	19,314	1,972
Ferromanganese ---- do	10,311	7,517	8,433	5,765
Silicomanganese ---- do	2,952	1,532	6,426	1,746
Metal ---- do	2,948	8,861	6,391	8,531
Molybdenum:				
Ore and concentrate (molybdenum content) thousand pounds	49,783	232,214	47,068	185,122
Metal and alloys, crude and scrap ---- do	697	2,317	577	1,860
Wire ---- do	632	9,072	610	7,085
Semimanufactured forms, n.e.c ---- do	190	4,762	216	4,589
Powder ---- do	426	2,356	396	2,737
Ferromolybdenum ---- do	255	1,085	171	687
Compounds ---- do	12,441	41,806	8,597	22,158
Nickel:				
Alloys and scrap including unwrought metal, ingots, bars, sheets, anodes, etc ---- short tons	49,729	257,182	38,844	154,536
Catalysts ---- do	2,874	19,654	3,165	13,940
Wire ---- do	481	6,011	1,089	8,831
Semifabricated forms, n.e.c ---- do	3,945	32,248	1,365	14,420
Platinum-group metals:				
Ore and scrap ---- troy ounces	r397,307	r83,722	782,967	193,463
Palladium, rhodium, iridium, osmiridium, ruthenium, osmium (metal and alloys including scrap) ---- do	262,764	41,057	261,188	45,799
Platinum (metal and alloys) ---- do	175,805	57,682	184,599	70,652
Rare-earth metals: Ferrocerium and alloys ---- short tons	27	264	73	393
Selenium ---- thousand pounds	259	749	206	771
Silicon:				
Ferrosilicon ---- short tons	14,932	11,996	11,338	10,712
Silicon carbide, crude and in grains (including reexports) do	6,979	8,374	5,590	7,164
Silver:				
Ore, concentrate, waste, sweepings thousand troy ounces	12,594	102,768	18,294	208,066
Bullion, refined ---- do	12,876	105,977	13,658	169,383
Tantalum:				
Ore, metal, other forms ---- thousand pounds	r617	20,113	332	14,030
Powder ---- do	115	16,231	123	14,397
Tin:				
Ingots, pigs, bars, etc.:				
Exports ---- metric tons	5,769	84,454	1,340	17,305
Reexports ---- do	rNA	rNA	NA	NA
Tinplate and terneplate ---- do	r217,840	118,870	171,121	83,827
Titanium:				
Ore and concentrate ---- short tons	21,682	1,280	4,391	1,006
Unwrought and scrap metal ---- do	4,496	8,192	5,676	9,173
Intermediate mill shapes and mill products, n.e.c ---- do	3,600	100,608	2,154	52,197
Pigments and oxides ---- do	74,122	82,068	93,521	92,132
Tungsten (tungsten content):				
Ore and concentrate ---- thousand pounds	672	3,387	2	11
Carbide powder ---- do	1,214	14,059	729	9,277
Alloy powder ---- do	1,327	17,239	785	7,692
Vanadium:				
Ore and concentrate (vanadium content) ---- do	114	626	117	273
Pentoxide, etc ---- do	3,163	6,808	5,297	7,871
Ferrovanadium ---- do	653	3,436	1,550	6,144
Zinc:				
Slabs, pigs, or blocks ---- metric tons	341	547	427	801
Sheets, plates, strips, other forms, n.e.c ---- do	995	2,351	957	2,142
Waste, scrap, dust (zinc content) ---- do	19,059	13,818	22,856	11,169
Semifabricated forms, n.e.c ---- do	1,891	3,549	1,708	3,257
Ore and concentrate ---- do	77,289	32,534	60,168	22,868
Zirconium:				
Ore and concentrate ---- thousand pounds	22,023	3,268	26,443	3,316
Oxide ---- do	2,033	5,420	1,396	1,898
Metals, alloys, other forms ---- do	1,756	43,952	1,494	39,514
NONMETALS				
Abrasives (includes reexports):				
Industrial diamond, natural or synthetic:				
Powder or dust ---- thousand carats	30,625	66,934	42,312	82,499
Other ---- do	1,930	22,525	3,185	34,065
Diamond grinding wheels ---- do	473	5,714	467	4,910
Other natural and artificial metallic abrasives and products	NA	r101,603	NA	95,431

See footnotes at end of table.

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

Mineral	1982 Quantity	1982 Value (thousands)	1983 Quantity	1983 Value (thousands)
NONMETALS—Continued				
Asbestos:				
Exports:				
Unmanufactured metric tons	58,525	$19,543	54,236	$19,398
Products do	NA	126,704	NA	128,584
Reexports:				
Unmanufactured do	246	170	398	285
Products do	NA	1,163	NA	998
Barite: Natural barium sulfate short tons	48,533	6,510	22,816	3,514
Boron:				
Boric acid do	35,030	19,082	38,498	20,688
Sodium borates, refined do	r227,404	r59,000	224,672	51,000
Bromine compounds thousand pounds	55,600	21,100	61,300	21,600
Calcium:				
Other calcium compounds including precipitated calcium carbonate short tons	31,282	15,613	20,000	13,700
Chloride do	55,057	11,065	40,597	9,550
Dicalcium phosphate do	61,308	36,454	48,000	32,600
Cement: Hydraulic and clinker do	r203,366	27,456	118,393	17,360
Clays:				
Kaolin or china clay thousand short tons	1,296	146,989	1,338	157,882
Bentonite do	668	54,713	554	42,580
Other do	655	65,998	592	53,775
Diatomite do	141	29,863	146	31,569
Feldspar, leucite, nepheline syenite thousand pounds	21,600	989	18,720	856
Fluorspar short tons	10,573	1,084	9,236	962
Gem stones (including reexports):				
Diamond thousand carats	2,683	638,655	2,489	622,411
Pearls	NA	4,247	NA	4,985
Other	NA	106,105	NA	104,020
Graphite, natural short tons	10,335	4,099	9,435	3,455
Gypsum:				
Crude, crushed or calcined thousand short tons	123	13,319	117	13,621
Manufactured, wallboard and plaster articles	NA	16,231	NA	18,467
Helium million cubic feet	378	19,735	368	19,626
Lime short tons	22,541	3,199	28,154	4,815
Lithium compounds:				
Lithium carbonate[1] thousand pounds	10,910	13,506	17,779	23,953
Lithium hydroxide do	5,250	8,931	5,719	10,159
Other lithium compounds do	8,738	12,791	4,278	8,183
Magnesium compounds:				
Magnesite, dead-burned short tons	12,869	2,721	10,855	1,955
Magnesite, crude, caustic-calcined, lump or ground do	23,125	10,925	16,621	8,426
Mica:				
Waste, scrap, ground thousand pounds	22,000	2,886	20,416	2,657
Block, film, splittings do	294	296	70	109
Manufactured, cut or stamped, built-up do	NA	5,499	NA	4,001
Mineral-earth pigments, iron oxide, natural and synthetic short tons	9,065	17,795	12,661	20,692
Nitrogen compounds (major) thousand short tons	7,806	1,178,740	7,484	1,050,061
Phosphate rock thousand metric tons	9,735	383,554	12,197	423,361
Phosphatic fertilizers:				
Phosphoric acid do	1,423	407,081	1,219	322,146
Superphosphates do	1,148	158,140	1,263	164,672
Diammonium phosphates do	3,707	678,685	4,758	729,233
Elemental phosphorus metric tons	15,084	25,125	21,752	34,116
Pigments and compounds: Zinc oxide (metal content) thousand metric tons	r323	r528	330	492
Potash:				
Potassium chloride metric tons	691,040	56,710	385,980	30,700
Potassium sulfate do	140,000	27,648	86,320	16,390
Quartz, crystal:				
Cultured thousand pounds	115	3,500	80	3,258
Natural do	69	380	28	156
Salt:				
Crude and refined thousand short tons	1,001	16,647	517	12,368
Shipments to noncontiguous territories do	65	8,451	30	4,101
Sand and gravel:				
Construction:				
Sand do	631	5,397	934	4,620
Gravel do	497	2,680	369	1,810
Industrial sand do	818	26,320	1,047	26,057
Sodium compounds:				
Sodium sulfate do	111	12,162	91	11,380
Sodium carbonate do	1,109	140,616	1,636	154,584
Stone:				
Crushed do	2,065	19,026	2,413	23,021
Dimension do	NA	18,678	NA	21,185
Sulfur, crude thousand metric tons	961	122,143	992	109,298
Talc, crude and ground thousand short tons	232	12,957	218	12,916
Total	XX	r13,158,477	XX	12,317,027

rRevised. NA Not available. XX Not applicable.

[1]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	1982 Quantity	1982 Value (thousands)	1983 Quantity	1983 Value (thousands)
METALS				
Aluminum:				
Metal short tons	679,375	$858,017	818,676	$1,021,273
Scrap do	74,338	54,240	97,524	87,468
Plates, sheets, bars, etc do	214,343	416,033	286,614	537,319
Aluminum oxide (alumina) thousand metric tons	r3,182	770,444	4,030	811,021
Antimony:				
Ore and concentrate (antimony content) short tons	2,769	4,289	2,770	2,335
Sulfide including needle or liquated do	88	188	47	58
Metal do	1,900	3,893	1,282	1,987
Oxide do	10,433	18,045	10,604	13,318
Arsenic:				
White (As_2O_3 content) do	16,092	15,241	11,229	8,406
Metallic do	150	1,044	268	1,401
Bauxite, crude thousand metric tons	10,122	NA	7,601	NA
Beryllium ore short tons	2,652	3,215	2,194	2,755
Bismuth, metals and alloys (gross weight) pounds	2,026,245	3,206	1,971,956	3,121
Cadmium metal metric tons	2,305	4,684	2,196	3,842
Calcium metal pounds	333,054	967	332,834	866
Cesium compounds do	16,647	799	19,227	617
Chromium:				
Ore and concentrate (Cr_2O_3 content) thousand short tons	209	29,670	86	10,390
Ferrochromium (gross weight) do	141	77,495	280	109,012
Ferrochromium-silicon do	7	3,322	1	670
Metal do	2	10,078	3	13,687
Cobalt:				
Metal thousand pounds	11,610	137,652	15,853	110,076
Oxide (gross weight) do	362	2,560	403	1,813
Salts and compounds (gross weight) do	1,340	2,650	1,671	2,244
Columbium ore do	910	2,765	1,482	3,316
Copper (copper content):				
Ore and concentrate metric tons	118,055	141,478	90,597	81,695
Matte do	4,042	3,609	3,252	4,286
Blister do	97,374	142,249	46,371	66,027
Refined in ingots, etc do	258,439	394,654	459,568	700,564
Scrap do	28,076	35,281	43,723	62,947
Ferroalloys not elsewhere listed, including spiegeleisen short tons	7,115	21,896	3,098	15,801
Gallium kilograms	5,199	1,958	7,294	3,195
Germanium do	12,459	9,287	20,916	10,527
Gold:				
Ore and base bullion troy ounces	682,661	242,885	993,793	401,548
Bullion, refined do	4,237,669	1,650,719	3,599,188	1,575,570
Hafnium pounds	---	---	478	50,058
Indium thousand troy ounces	686	2,186	1,073	2,795
Iron ore thousand long tons	14,501	470,847	13,246	445,731
Iron and steel:				
Pig iron short tons	321,702	48,940	242,114	31,917
Iron and steel products (major):				
Steel mill products do	16,536,292	8,947,132	17,034,388	6,333,636
Other products do	744,790	1,342,878	804,095	795,481
Scrap including tinplate thousand short tons	r474	r38,020	641	48,219
Lead:				
Ore, flue dust, matte (lead content) metric tons	18,945	8,784	19,753	5,712
Base bullion (lead content) do	19	28	53	23
Pigs and bars (lead content) do	94,855	58,633	134,357	64,225
Reclaimed scrap, etc. (lead content) do	4,834	1,755	4,212	1,340
Sheets, pipes, shot do	467	694	496	1,632
Magnesium:				
Metal and scrap short tons	3,652	5,732	3,969	7,174
Alloys (magnesium content) do	955	3,889	2,143	6,151
Sheets, tubing, ribbons, wire, other forms (magnesium content) do	177	5,982	238	2,939
Manganese:				
Ore (35% or more contained manganese) do	237,759	16,160	368,297	19,867
Ferromanganese do	492,708	154,490	341,608	93,083
Ferrosilicon-manganese (manganese content) do	41,121	21,471	91,992	40,117
Metal do	5,226	5,213	5,950	5,323
Mercury:				
Compounds pounds	37,974	269	135,758	717
Metal 76-pound flasks	8,916	3,003	12,786	3,813

See footnotes at end of table.

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

Mineral	1982		1983	
	Quantity	Value (thousands)	Quantity	Value (thousands)
METALS—Continued				
Molybdenum:				
Ore and concentrate (molybdenum content) thousand pounds	3,115	$13,429	1,673	$3,528
Waste and scrap (gross weight) do	NA	1,474	NA	2,141
Metal:				
Unwrought (molybdenum content) do	67	1,370	97	1,398
Wrought (gross weight) do	79	1,959	94	2,331
Ferromolybdenum (gross weight) do	1,665	6,308	1,157	3,189
Material in chief value molybdenum (molybdenum content) do	2,749	12,143	3,445	12,985
Compounds (gross weight) do	4,772	13,030	5,791	9,425
Nickel:				
Pigs, ingots, shot, cathodes short tons	82,297	446,850	90,839	418,943
Plates, bars, etc do	5,120	50,348	4,105	84,553
Slurry do	58,568	105,633	62,454	83,613
Scrap do	4,300	13,349	6,071	17,691
Powder and flakes do	12,132	72,845	12,725	65,747
Ferronickel do	21,352	28,215	45,134	65,264
Oxide do	3,144	13,461	4,209	19,083
Platinum-group metals:				
Unwrought:				
Grains and nuggets (platinum) troy ounces	3,298	1,120	8,513	2,145
Sponge (platinum) do	689,647	305,356	1,005,208	435,333
Sweepings, waste, scrap do	339,095	42,236	417,431	44,308
Iridium do	19,402	9,242	23,266	7,150
Palladium do	1,039,210	98,285	1,223,951	151,149
Rhodium do	68,968	36,284	119,958	48,171
Ruthenium do	133,798	5,395	163,623	5,379
Other platinum-group metals do	23,429	7,501	22,875	7,248
Semimanufactured:				
Platinum do	114,028	42,515	109,376	36,663
Palladium do	60,760	5,159	108,247	12,643
Rhodium do	1,005	459	11,245	1,539
Other platinum-group metals do	1,066	384	213	69
Rare-earth metals:				
Ferrocerium and other cerium alloys short tons	95	1,092	115	1,185
Monazite do	7,940	3,070	4,440	1,517
Metals including scandium and yttrium pounds	7,094	139	1,766	182
Rhenium:				
Metal including scrap do	176	88	623	180
Ammonium perrhenate do	5,193	803	5,947	1,131
Selenium and selenium compounds (selenium content) do	765,731	7,711	654,839	5,922
Silicon:				
Metal (over 96% silicon content) short tons	26,338	52,195	28,173	52,026
Ferrosilicon do	76,732	40,343	159,443	67,445
Silver:				
Ore and base bullion thousand troy ounces	12,530	91,638	13,911	145,419
Bullion, refined do	96,917	786,154	161,199	1,926,102
Sweepings, waste, doré do	8,010	49,287	4,781	52,048
Tantalum ore thousand pounds	1,297	16,286	536	4,017
Tellurium (tellurium content) pounds	36,600	906	26,080	622
Thallium do	2,827	103	3,110	448
Tin:				
Concentrate (tin content) metric tons	1,961	21,544	969	9,549
Dross, skimmings, scrap, residue, tin alloys, n.s.p.f. do	3,068	4,364	1,193	1,219
Tinfoil, powder, flitters, etc	NA	12,288	NA	10,728
Tin scrap and other tin-bearing material excluding tinplate scrap	NA	NA	NA	NA
Tin compounds metric tons	321	2,667	642	4,120
Titanium:				
Ilmenite[1] short tons	596,211	41,630	398,036	29,423
Rutile do	163,325	39,610	111,578	23,532
Metal do	3,713	40,680	3,787	27,899
Ferrotitanium and ferrosilicon titanium do	152	263	893	1,288
Pigments do	138,922	146,569	174,857	165,495
Tungsten ore and concentrate (tungsten content) thousand pounds	7,778	46,748	6,307	25,717
Vanadium (vanadium content):				
Ferrovanadium do	1,339	8,065	1,362	6,259
Pentoxide do	238	1,063	754	2,363
Vanadium-bearing materials do	2,225	5,194	115	86

See footnotes at end of table.

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

Mineral	1982 Quantity	1982 Value (thousands)	1983 Quantity	1983 Value (thousands)
METALS —Continued				
Zinc:				
Ore (zinc content) metric tons	66,809	$27,132	63,156	$16,548
Blocks, pigs, slabs do	456,233	370,773	617,679	503,888
Sheets, etc do	700	694	319	426
Fume (zinc content) do	11	6	631	420
Waste and scrap do	2,653	1,232	3,900	1,676
Dross and skimmings do	7,104	3,134	6,508	3,314
Dust, powder, flakes do	5,864	6,925	6,533	7,126
Manufactured	NA	540	NA	543
Zirconium:				
Ore including zirconium sand short tons	68,465	6,144	44,487	4,420
Metal, scrap, compounds do	1,243	15,431	1,687	15,901
NONMETALS				
Abrasives:				
Diamond (industrial) thousand carats	19,127	85,837	24,877	88,617
Other	NA	159,211	NA	201,248
Asbestos metric tons	241,737	64,925	196,387	57,956
Barite:				
Crude and ground thousand short tons	2,344	120,518	1,397	67,404
Witherite short tons	333	126	50	16
Chemicals do	23,857	13,163	27,832	16,093
Boron:				
Boric acid do	4,362	1,903	7,881	3,456
Calcium borate, crude[2] do	39,000	6,386	40,000	8,309
Calcium chloride do	60,623	3,010	13,784	1,293
Cement: Hydraulic and clinker thousand short tons	2,929	110,886	4,268	161,439
Clays short tons	24,245	4,514	20,864	3,488
Cryolite do	6,218	4,266	7,199	4,784
Feldspar:				
Crude do	48	24	18	6
Ground and crushed do	--	--	46	25
Fluorspar do	543,723	67,665	453,314	47,032
Gem stones:				
Diamond thousand carats	4,636	1,917,612	6,265	2,275,373
Emeralds do	2,167	120,809	2,117	134,130
Other	NA	346,031	NA	446,951
Graphite, natural short tons	[r]53,150	[r]15,676	43,586	11,921
Gypsum:				
Crude, ground, calcined thousand short tons	6,720	36,285	8,035	63,983
Manufactured	NA	17,361	NA	30,614
Iodine, crude thousand pounds	4,728	27,709	6,218	34,039
Lime:				
Hydrated short tons	60,108	3,305	58,811	3,431
Other do	288,266	13,503	223,752	11,345
Lithium:				
Ore do	15	5	8	4
Compounds do	133	568	189	1,978
Magnesium compounds:				
Crude magnesite do	[r]3,305	306	54	25
Lump or ground caustic-calcined magnesia do	13,959	2,055	25,457	5,476
Refractory magnesia, dead-burned, fused magnesite, dead-burned dolomite do	59,519	14,588	80,429	14,340
Compounds do	44,797	7,965	50,029	9,780
Mica:				
Waste, scrap, ground thousand pounds	15,854	2,151	14,091	2,189
Block, film, splittings do	3,173	1,449	1,899	986
Manufactured, cut or stamped, built-up do	724	2,936	735	2,583
Mineral-earth pigments, iron oxide:				
Ocher, crude and refined short tons	31	20	(3)	3
Siennas, crude and refined do	112	46	141	56
Umber, crude and refined do	3,768	649	6,640	996
Vandyke brown do	423	153	769	309
Other natural and refined do	880	576	841	342
Synthetic do	20,641	11,886	22,356	14,978
Nepheline syenite:				
Crude do	316	16	212	13
Ground, crushed, etc do	455,280	13,735	407,139	13,984
Nitrogen compounds (major) including urea thousand short tons	4,841	681,368	6,281	793,574
Peat:				
Fertilizer-grade short tons	309,467	38,605	371,486	46,001
Poultry- and stable-grade do	60,533	7,752	47,220	6,066
Phosphates, crude and apatite thousand metric tons	(3)	1,302	9	376
Phosphatic fertilizers:				
Fertilizer and fertilizer materials do	8	1,672	36	3,622
Elemental phosphorus do	(3)	1,017	2	3,410
Other do	41	[r]6,812	20	5,841

See footnotes at end of table.

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

Mineral	1982		1983	
	Quantity	Value (thousands)	Quantity	Value (thousands)
NONMETALS —Continued				
Pigments and salts:				
Lead pigments and compounds ____ metric tons__	12,904	$10,613	15,667	$11,444
Zinc pigments and compounds__ do__	35,721	30,932	40,876	34,709
Potash __ do__	6,337,900	575,400	7,322,100	600,600
Pumice:				
Crude or unmanufactured ____ short tons__	2,887	102	2,699	113
Wholly or partly manufactured__ do__	r118,233	r695	181,606	1,166
Manufactured, n.s.p.f ____	NA	r103	NA	106
Quartz crystal (Brazilian lascas) __ thousand pounds__	417	245	153	121
Salt__ thousand short tons__	5,451	56,184	5,997	60,194
Sand and gravel:				
Industrial sand__ do__	r90	2,523	58	1,619
Other sand and gravel ____ do__	185	1,479	123	1,047
Sodium compounds:				
Sodium bicarbonate__ do__	7	1,360	(4)	(4)
Sodium carbonate __ do__	18	r2,419	20	2,704
Sodium sulfate __ do__	394	28,758	343	27,921
Stone:				
Crushed __ do__	1,664	10,570	2,277	10,709
Dimension ____	NA	r169,874	NA	195,378
Calcium carbonate fines ___ thousand short tons__	192	5,811	392	4,104
Strontium:				
Minerals__ short tons__	33,075	2,057	49,796	3,706
Compounds __ do__	1,943	1,850	1,138	1,125
Sulfur and compounds, sulfur ore and other forms, n.e.s ____ thousand metric tons__	1,905	164,885	1,695	129,110
Talc, unmanufactured ____ thousand short tons__	27	r6,264	44	7,691
Total__	XX	r24,397,961	XX	23,984,432

rRevised. NA Not available. XX Not applicable.

[1]Includes titanium slag averaging about 70% TiO_2. For details, see Titanium chapter.

[2]Owing to a change of reporting, 1982 calcium borate, crude, imports are not comparable with those of previous years.

[3]Less than 1/2 unit.

[4]No longer reported.

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

(Thousand short tons unless otherwise specified)

Mineral	1982 World production[1]	1982 U.S. production	1982 U.S. percent of world production	1983[p] World production[1]	1983[p] U.S. production	1983[p] U.S. percent of world production
METALS, MINE BASIS						
Antimony (content of ore and concentrate) short tons	59,277	503	1	53,301	838	2
Arsenic trioxide[2] metric tons	26,264	W	NA	25,276	W	NA
Bauxite[3] thousand metric tons	77,793	732	1	76,016	679	1
Beryl[2] short tons	3,414	W	NA	3,189	W	NA
Bismuth thousand pounds	8,799	W	NA	8,935	W	NA
Chromite	8,770	--	--	8,921	--	--
Cobalt (content of ore and concentrate) short tons	26,846	--	--	26,596	--	--
Columbium-tantalum concentrate (gross weight) thousand pounds	56,261	NA	NA	45,846	--	--
Copper (content of ore and concentrate) thousand metric tons	8,071	1,147	14	8,027	1,038	13
Gold (content of ore and concentrate) thousand troy ounces	43,057	1,466	3	44,533	1,957	4
Iron ore (gross weight) thousand long tons	769,149	35,433	5	730,080	38,000	5
Lead (content of ore and concentrate) thousand metric tons	3,408	513	15	3,324	449	14
Manganese ore (35% or more Mn, gross weight)	26,607	--	--	24,739	--	--
Mercury thousand 76-pound flasks	198	26	13	188	25	13
Molybdenum (content of ore and concentrate) thousand pounds	207,344	84,381	41	137,861	33,951	25
Nickel (content of ore and concentrate)	705	3	(4)	759	---	--
Platinum-group metals[2] thousand troy ounces	6,431	8	(4)	6,482	6	(4)
Silver (content of ore and concentrate) do	383,766	40,248	10	390,618	43,415	11
Tin (content of ore and concentrate) metric tons	237,176	W	NA	211,620	W	NA
Titanium concentrates (gross weight):						
Ilmenite	3,346	263	8	2,876	W	NA
Rutile	374	W	NA	359	W	NA
Tungsten ore and concentrate (contained tungsten) metric tons	45,305	1,521	3	38,882	980	3
Vanadium (content of ore and concentrate) short tons	35,898	4,098	11	30,087	2,171	7
Zinc (content of ore and concentrate) thousand metric tons	6,238	303	5	6,246	275	4
METALS, SMELTER BASIS						
Aluminum (primary only)	14,802	3,609	24	15,284	3,696	24
Cadmium metric tons	16,452	1,007	6	17,244	1,052	6
Cobalt short tons	21,649	508	2	20,316	103	1
Copper smelter (primary and secondary)[5] thousand metric tons	8,281	1,021	12	8,304	987	12
Iron, pig	502,400	43,342	9	505,000	48,770	10
Lead, smelter (primary and secondary)[6] thousand metric tons	5,255	1,088	21	5,234	1,018	19
Magnesium (primary)	273	102	37	291	115	40
Nickel[7]	660	45	7	685	33	5
Selenium[8] kilograms	1,119,821	242,996	22	1,326,533	353,860	27
Steel, raw	707,081	[9]74,577	11	724,480	[9]84,615	12
Tellurium[8] kilograms	101,746	W	NA	110,900	W	NA
Tin metric tons	239,213	[10]3,500	1	222,035	[10]2,500	1
Zinc (primary and secondary) thousand metric tons	5,865	302	5	6,175	305	5
NONMETALS						
Asbestos do	4,080	64	2	4,157	70	2
Barite	8,257	[11]1,845	22	6,348	[11]754	12
Boron minerals	2,503	1,234	49	2,450	1,303	53
Bromine thousand pounds	826,963	[11]401,100	48	795,770	[11]370,000	46
Cement, hydraulic	969,338	[12]64,341	7	1,020,346	[12]71,347	7
Clays:						
Bentonite[8]	5,628	[11]3,245	58	4,284	[11]1,938	45
Fuller's earth[8]	2,216	[11]1,683	76	2,452	[11]1,912	78
Kaolin[2]	21,098	[11]6,362	30	22,217	[11]7,203	32

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	1982			1983[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__	20,918	--	--	19,384	--	--
Diamond ____thousand carats__	44,367	--	--	56,119	--	--
Diatomite	1,666	[11]613	37	1,677	[11]619	37
Feldspar	3,745	615	16	3,842	710	18
Fluorspar	4,713	77	2	4,741	61	1
Graphite ____short tons__	646,674	W	NA	645,333	W	NA
Gypsum	78,970	10,538	13	85,824	12,884	15
Iodine, crude ____ thousand pounds__	27,016	W	NA	27,491	W	NA
Lime	118,082	[11 12]14,112	12	119,147	[11 12]14,902	12
Magnesite	12,119	W	NA	12,103	W	NA
Mica (including scrap and ground) thousand pounds__	474,867	212,000	45	534,831	280,000	52
Nitrogen, N content of ammonia	83,563	12,968	16	85,442	11,246	13
Peat	414,039	798	([4])	413,511	704	([4])
Perlite	1,556	[11]506	33	1,532	[11]474	31
Phosphate rock (gross weight) thousand metric tons__	122,202	37,414	31	135,000	42,573	32
Potash (K_2O equivalent) ____do____	24,664	1,784	7	26,678	1,429	5
Pumice[8]	12,707	416	3	11,766	449	4
Salt	181,951	[11 12]37,910	21	182,752	[11 12]34,605	19
Sodium compounds, natural and manufactured:						
Sodium carbonate	30,367	7,819	26	31,262	8,467	27
Sodium sulfate	5,370	864	16	5,229	855	16
Strontium[8] ____short tons__	122,779	--	--	121,210	--	--
Sulfur, all forms thousand metric tons__	50,776	9,787	19	50,472	9,290	18
Talc and pyrophyllite	7,539	1,135	15	7,553	1,066	14
Vermiculite[8]	562	316	56	495	282	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

Consumption of abrasive materials in the United States increased 22% in value over that of 1982 to $320 million; of which, 59% was manufactured abrasive, 35% was industrial diamond (natural and synthetic), and 6% was natural abrasive.

Production value of natural abrasives, excluding industrial diamond, remained virtually unchanged. Production of crude tripoli, a porous siliceous rock, decreased slightly; however, shipments of processed tripoli increased 13% in quantity and 32% in value. Production of garnet, an abundant iron-aluminum silicate, continued to increase primarily because of further increases in production from one plant that had completed an expansion program in late 1981. Production of special silica stone, both crude and finished, decreased in 1983 because of reduced demand for oilstones

Table 1.—Salient U.S. abrasives statistics

	1979	1980	1981	1982	1983
Natural abrasives production by producers:					
Tripoli (crude) ... short tons	127,878	121,233	107,330	112,928	111,020
Value ... thousands	$831	$676	$617	$653	$649
Special silica stone[1] ... short tons	594	631	[2]2,501	[2]1,285	[2]1,101
Value ... thousands	$1,764	$1,933	[2]$1,096	[2]$553	[2]$482
Garnet[3] ... short tons	21,240	26,909	25,451	27,303	29,767
Value ... thousands	$1,535	$1,908	$2,059	$2,321	$2,533
Emery ... short tons	10,005	W	W	W	W
Value ... thousands	$204	W	W	W	W
Manufactured abrasives[4] ... short tons	712,733	614,963	[5]586,915	418,224	[5]418,153
Value ... thousands	$230,024	$216,946	[5]$225,503	$167,471	[5]$167,430
Foreign trade (natural and artificial abrasives):					
Exports (value) ... do	$185,587	$193,679	$189,719	$174,126	$192,794
Reexports (value) ... do	$42,922	$47,521	$27,758	[r]$22,650	$24,111
Imports for consumption (value) ... do	$270,599	$268,842	$301,695	$245,048	$289,865

[r]Revised. 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 1979-80, quantity and value were for finished products; 1981-83 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.

and whetstones; over 70% of the oilstone-whetstone cutting operations reported decreases in production. Production of emery, an impure aluminum oxide, continued its downward trend with a decrease of 22% in quantity and 20% in value.

The nonmetallic manufactured abrasives industry underwent a very troubled year. This old-line industry was surprised when Standard Oil of Ohio (Sohio) announced that it was closing or selling Carborundum Co.'s worldwide bonded and coated abrasives operations. This action did not affect the production of crude silicon carbide or fused aluminum oxide; however, Carborundum's large silicon carbide plant in Vancouver, WA, was idle during the year. Ferro Corp. permanently discontinued production of its only crude silicon carbide plant, located in Canada, and another domestic silicon carbide producer sought protection under chapter 11 of the Bankruptcy Act. ESK Corp. and The Exolon Co.'s proposed merger plan was approved and was expected to be finalized in early 1984.

Production of manufactured abrasive materials remained at the 1982 level in both quantity and value and was again reported at its lowest level since 1963 and reflected continuing reduced economic activity in the related industrial segments. Nonmetallic abrasives consisted of fused aluminum oxide and crude silicon carbide produced in the United States and Canada and accounted for 61% of the value of manufactured abrasives. Metallic abrasives shipments included chilled and annealed iron shot and grit, steel shot and grit, cut wire, aluminum, and stainless steel shot.

The potentially large Australian diamond mining operation started production from its alluvial deposits and recovered 6.2 million carats; of which, 65% was industrial, more than tripling the original estimate for 1983. The mining of its kimberlite pipe was scheduled to begin in 1986 with an initial annual production rate of 25 million carats. Approximately 75% of production from the kimberlite pipe was expected to be of industrial quality.

Total imports of abrasive materials increased 18% in value in 1983. Imports of industrial diamond increased 3% in value and 30% in quantity. This small increase in value and large increase in quantity was attributed to an increase in imports of synthetic powder dust with a unit value decrease of 20% to $1.47 per carat and an increase in imported stones with a corresponding value decrease of 21% to $9.98 per carat. Total exports and reexports of abrasive materials increased 10% in value.

Domestic Data Coverage.—Domestic production data for abrasive materials were developed by the Bureau of Mines from six separate, voluntary surveys. Of the 56 operations canvassed, all responded, representing 100% of the total production data shown in tables 1, 5, 6, 8, 15, 16, and 17.

FOREIGN TRADE

Exports plus reexports of industrial diamonds, loose, increased 40% in volume to 45.5 million carats, and 30% in value to $116.6 million. This was a record in quantity and value. The increases were attributed to the record level exports of domestically produced synthetic diamond powder and dust. The diamond content in diamond wheels, exported and reexported, was 467,000 carats, a slight decrease; the declared value was $4.9 million, a decrease of 14%. The value of imported diamond wheels decreased 11% to $5.4 million.

Imports of abrasive materials increased 18% in value, and exports plus reexports increased 10% in value. Net imports were valued at $73.0 million.

Industrial diamond imports totaled 24.9 million carats of loose material valued at $88.6 million, an increase of 30% in quantity and 3% in value. The small increase in value with the corresponding large increase in quantity were attributed to two occurrences: (1) an increase in imports of 3.8 million carats of synthetic powder dust at only $1.47 per carat compared with $1.84 per carat in 1982 and (2) an increase in imports of stones of 1.4 million carats while the value decreased $2.66 per carat to $9.98. Ireland, the largest U.S. source of imported industrial diamonds in terms of quantity, shipped to the United States a total of 11.7 million carats, mostly synthetic, valued at $20.9 million. Although the quantity increased 36%, the value decreased 7%, primarily because of a 25% decline in the unit price of synthetic powder and dust. Of the 11.7 million carats from Ireland, 10.2 million carats was synthetic powder and dust with an average value of $1.62 per carat. The share of imports from Ireland was 47% of total quantity and 24% 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 5.3 million carats valued at $42.4 million, an increase of 26% in quantity and 32% in value. The share of imports from the Republic of South Africa was 21% of the total quantity and 48% of the total value. Of the 5.3 million carats, 3.7 million carats was industrial stones with an average value of $10.47 per carat, 9% less than that of 1982.

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

(Thousands)

Kind	1982 Quantity	1982 Value	1983 Quantity	1983 Value
NATURAL ABRASIVES				
Industrial diamond, natural or synthetic, powder or dust ---- carats	29,588	$63,666	41,071	$79,419
Industrial diamond, natural or synthetic, other ---- do	415	3,826	1,252	14,223
Emery, natural corundum, pumice in blocks ---- pounds	10,403	781	9,389	866
MANUFACTURED ABRASIVES				
Artificial corundum (fused aluminum oxide) ---- do	58,709	17,083	23,486	14,393
Silicon carbide, crude or in grains ---- do	13,957	8,365	10,611	6,768
Carbide abrasives, n.e.c ---- do	616	1,138	675	1,022
Other refined abrasives ---- do	25,191	11,575	30,333	13,125
Grinding and polishing wheels and stones:				
Diamond ---- carats	470	5,590	459	4,793
Polishing stones, whetstones, oilstones, hones, similar stone ---- number	714	2,320	917	2,642
Wheels and stones, n.e.c ---- pounds	4,928	23,837	3,514	19,459
Abrasive paper and cloth, coated with natural or artificial abrasive materials ---- do	11,259	28,521	10,990	31,513
Grit and shot including wire pellets ---- do	23,053	7,424	14,217	4,571
Total	XX	174,126	XX	192,794

XX Not applicable.

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

(Thousands)

Kind	1982 Quantity	1982 Value	1983 Quantity	1983 Value
NATURAL ABRASIVES				
Industrial diamond, natural or synthetic, powder or dust ---- carats	1,037	$3,268	1,241	$3,080
Industrial diamond, natural or synthetic, other ---- do	1,515	18,699	1,933	19,842
Emery, natural corundum, pumice in blocks ---- pounds	13	42	420	276
MANUFACTURED ABRASIVES				
Artificial corundum (fused aluminum oxide) ---- do	18	6	--	--
Silicon carbide, crude or in grains ---- do	(1)	9	568	396
Grinding and polishing wheels and stones:				
Diamond ---- carats	3	124	8	117
Polishing stones, whetstones, oilstones, hones, similar stone ---- number	(1)	2	1	10
Wheels and stones, n.e.c ---- pounds	64	294	28	219
Abrasive paper and cloth, coated with natural or artificial abrasive materials ---- do	71	206	68	171
Grit and shot, including wire pellets ---- do	--	--	--	--
Total	XX	r22,650	XX	24,111

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

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

(Thousands)

Kind	1982 Quantity	1982 Value	1983 Quantity	1983 Value
Emery, flint, rottenstone, tripoli, crude or crushed ... short tons	4	$273	4	$367
Silicon carbide, crude ... do	63	27,453	79	39,573
Aluminum oxide, crude ... do	116	42,849	131	53,670
Other crude artificial abrasives ... do	1	140	(1)	136
Abrasives, ground grains, pulverized or refined:				
Rottenstone and tripoli ... do	(1)	1	--	--
Silicon carbide ... do	4	7,325	5	7,890
Aluminum oxide ... do	9	7,295	12	9,848
Emery, corundum, flint, garnet, other, including artificial abrasives ... do	1	2,309	3	3,712
Papers, cloths, other materials wholly or partly coated with natural or artificial abrasives	(2)	39,935	(2)	52,248
Hones, whetstones, oilstones, polishing stones ... number	776	927	1,045	1,009
Abrasive wheels and millstones:				
Burrstones manufactured or bound up into millstones short tons	(1)	4	(1)	21
Solid natural stone wheels ... number	116	101	40	77
Diamond ... do	97	6,121	148	5,416
Abrasive wheels bonded with resins ... pounds	4,135	7,213	5,654	10,445
Other	(2)	8,592	(2)	8,635
Articles not specifically provided for:				
Emery or garnet	(2)	102	(2)	97
Natural corundum or artificial abrasive materials	(2)	3,681	(2)	3,321
Other, n.s.p.f	(2)	2,460	(2)	2,239
Grit and shot including wire pellets ... pounds	9,813	1,958	8,946	2,149
Diamond, natural and synthetic:				
Diamond dies ... number	7	472	8	395
Crushing bort ... carats	146	234	46	145
Natural industrial diamond stones ... do	3,683	51,564	5,303	55,393
Miners' diamond ... do	[3]984	7,418	[3]761	5,134
Powder and dust, synthetic ... do	10,990	20,179	14,792	21,714
Powder and dust, natural ... do	3,324	6,442	3,975	6,231
Total	XX	245,048	XX	289,865

XX Not applicable.
[1]Less than 1/2 unit.
[2]Quantity not reported.
[3]Includes 48,000 carats of synthetic miners' diamond in 1982, and 2,000 carats in 1983.

TRIPOLI

Fine-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) decreased in quantity and value because several producers reduced mine output and withdrew stocks from crude inventories. However, processed tripoli, sold or used, increased 13% in quantity and 32% in value; most of this increase was in filler material.

Because tripoli grains lack distinct edges and corners, it was used as a mild abrasive in toothpaste and industrial soaps, and as a buffing and polishing compound 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 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, 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.

Malvern Minerals, Hot Springs, AR, reported that the previously announced expansion was to be completed by early 1984 and would more than double plant capacity.

Prices quoted in Engineering and Mining Journal, December 1983, 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., in dollars per ton:	
Elco, IL:	
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		1979	1980	1981	1982	1983
Abrasives	short tons	53,600	39,352	34,494	35,798	38,073
Value	thousands	$2,468	$2,253	$2,206	$2,477	$3,203
Filler	short tons	62,409	59,909	56,932	55.314	65,138
Value	thousands	$3,811	$4,025	$4,393	$4,557	$6,077
Total[3]	short tons	116,009	99,261	91,426	91,111	103,211
Total value[3]	thousands	$6,279	$6,277	$6,600	$7,034	$9,280

[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 grades were as follows:

Trade name	Use
Washita Stone	Rapid sharpening.
Soft Arkansas	General purpose.
Hard Arkansas	Polishing blades to a very fine edge.
Black Hard Arkansas	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 65% of the total value and 46% of the total quantity of special silica stone products sold or used by U.S. producers.

The survey of oilstone and whetstone producers was expanded in 1982 to include many additional producers of finished stone that purchased crude material from producers with quarrying operations. Grinding pebbles and tube-mill liners were eliminated from the survey because of lack of accurate data.

Marvin Wright Whetstone Co., a new company, announced plans to develop a deposit of novaculite located in Garland County, AR, and to market the crude stone. The company also planned to start cutting and finishing whetstones and oilstones at the site by March 1984. The mine and plant were to be located near the town of Glenwood, Hot Springs County, AR.

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

Year	Quantity (short tons)	Value (thousands)
1979	594	$1,764
1980	631	1,933
1981	523	[2]3,928
1982	713	[2]5,360
1983	602	[2]3,814

[1]Includes grindstones, oilstones, and whetstones. Excludes grinding pebbles and tube-mill liners.
[2]Large increase in value because nonquarrying finished stone producers were included.

Table 7.—Producers of special silica stone products in 1983

Company and location	Type of operation	Product
American Trails Whetstone Co.:		
Glenwood, AR	Stone cutting and finishing	Whetstone 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.
Frontier Whetstone Cutting Co.:		
Hot Springs, AR	Stone cutting and finishing	Whetstones and oilstones.
Halls Arkansas Oilstones Inc.:		
Pearcy, AR	do	Do.
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.
Natural Hones Inc.:		
Malvern, AR	Stone cutting and finishing	Whetstones and oilstones.
Norton Co. Oilstones, Norton Pike Div.:		
Littleton, NH	do	Do.
Hot Springs, AR	Quarry	Crude novaculite.
Pioneer Whetstone Co.:		
Hot Springs, AR	Stone cutting and finishing	Whetstones and oilstones.
Poor Boy Whetstones:		
Hot Springs, AR	do	Do.
Wallis Whetstone:		
Malvern, AR	do	Do.
Wallis Whetstone Inc.:		
Malvern, AR	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 about 75% of the world's garnet production; the remainder was produced primarily in Australia, India, and the U.S.S.R. Four 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.

Several producers reported that the levels of shipments in 1983 were approximately the same as those of 1982. However, the producer in Maine reported substantial increases in production and shipments, attributed to its recently completed plant expansion.

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

Year	Quantity (short tons)	Value (thousands)
1979	23,303	$4,647
1980	26,550	4,934
1981	25,519	5,204
1982	26,660	5,549
1983	28,902	5,816

CORUNDUM AND EMERY

Corundum.—There were no imports of abrasive-grade corundum during 1980-83. Demand was met by withdrawal from stocks. In recent years, the domestic supply had consisted almost entirely of material imported from Zimbabwe through the Republic of South Africa by one firm in Massachusetts. Another Massachusetts firm accounted for one-half of the total consumption. Corundum was used in grinding and polishing optical components.

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

(Short tons)

Country	1979	1980	1981	1982[p]	1983[e]
India	1,002	1,603	1,424	1,494	110
South Africa, Republic of	82	155	100	68	[2]54
U.S.S.R.[e]	9,400	9,500	9,500	9,500	9,600
Uruguay[e]	250	206	240	250	220
Zimbabwe	18,329	20,592	13,450	9,606	9,400
Total	29,063	32,056	24,714	20,918	19,384

[e]Estimated. [p]Preliminary.
[1]Table includes data available through May 30, 1984.
[2]Reported figure.

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 crude material, a gray rock and an impure corundum containing magnesium-aluminum silicates, was processed by two companies—Washington Mills Abrasive 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 1982, production of emery in Greece was estimated to be 10,000 short tons and production in Turkey was reported to be 31,909 tons.

Prices quoted for emery by domestic suppliers in December 1983 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 level of 69 million carats, a 30% increase and the prime contributing factor to the record 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 1.8 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 Government industrial diamond stockpile inventory, as of December 31, was reduced to 22.0 million carats of crushing bort and 15.5 million carats of stone, but still exceeded the goal for stone of 7.7 million carats. Available for disposal, from prior enabling legislation, was 1.5 million carats of stone. The inventory of small diamond dies was 25,473 pieces; the goal was 60,000 pieces.

The United States remained the largest consumer of natural industrial diamond stones but was totally dependent on foreign sources, importing approximately 6.1 million carats. Owing to political instability, supplies from Zaire and other areas remained in potential danger of disruption. Output was largely dependent on the output of gem diamond, which was limited by economic and other factors not directly related to the demand for industrial stones. Discovery of a large deposit of diamond predominantly of industrial quality in Australia was expected to substantially improve the supply by 1986. Increased use of synthetic polycrystalline diamond compacts and other synthetic products was also expected to alleviate any supply shortfall.

Exports plus reexports of industrial diamond dust and powder, including synthetics, was at a record level of 42.3 million carats valued at $82.5 million. Exports plus reexports of stone totaled 3.2 million carats valued at $34.1 million.

Several of the more than 100 known kimberlite occurrences in the Colorado-Wyoming State Line District and the Iron Mountain District of Wyoming had been evaluated and 14 had yielded diamond. According to the Deputy Director of the Geological Survey of Wyoming, one of the exploration companies temporarily stopped its project because the evaluation of several of the diamondiferous kimberlites had yielded only 0.005 to 0.01 carat per ton. It was reported that the gem-to-industrial-diamond ratio of these samples was similar to that of the Republic of South Africa and that one of the stones weighed approximately 1 carat.[4] This firm again instigated an evaluation program. Another firm that was investigating the Sloan kimberlite had given no evaluation reports and curtailed the program because one of the joint venture partners withdrew.

Rapid detection and analysis fieldwork, partially funded by the National Aeronautics and Space Administration, was completed by the Geological Survey of Wyoming and the University of Wyoming, Department of Geology. Initial findings were encouraging, and results indicate that some kimberlite occurrences can be detected with remote techniques. The Survey was continuing its stream sediment program. This program proved to be the most effective and valid method of locating the kimberlites; however, the technique is very time consuming and labor intensive.

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

(Thousand carats and thousand dollars)

Year	Quantity	Value
1981	20,404	110,510
1982	19,127	85,837
1983	24,877	88,617

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

(Thousand carats and thousand dollars)

Country	Natural industrial diamond stones (including glaziers' and engravers', unset) 1982 Quantity	1982 Value	1983 Quantity	1983 Value	Miners' diamond 1982 Quantity	1982 Value	1983 Quantity	1983 Value	Mixed and dust, synthetic 1982 Quantity	1982 Ve	1982 Value	1983 Quantity	1983 Value	Powder 1982 Quantity	1982 Value
Australia	[illegible]	106	[illegible]	79	[illegible]	47	[illegible]	--	[illegible]	[illegible]	--	--	--	[illegible]	[illegible]
Belgium-Luxembourg	[illegible]	3,343	[illegible]	1,248	[illegible]	32	3[illegible]	54	[illegible]	[illegible]	70	28	46	[illegible]	[illegible]
Canada	[illegible]	73	[illegible]	25	[illegible]	--	5[illegible]	148	[illegible]	[illegible]	31	30	44	[illegible]	[illegible]
China	[illegible]	126	[illegible]	102	[illegible]	--	--	--	[illegible]	[illegible]	23	32	59	[illegible]	[illegible]
Congo	[illegible]	7,205	[illegible]	4,620	[illegible]	--	--	--	[illegible]	[illegible]	--	--	--	[illegible]	[illegible]
Finland	[illegible]	--	[illegible]	--	[illegible]	--	--	--	[illegible]	[illegible]	[illegible].053	231	214	[illegible]	[illegible]
France	[illegible]	--	[illegible]	12	[illegible]	5	1	68	[illegible]	[illegible]	--	(3)	3	[illegible]	[illegible]
Germany, Federal Republic of	[illegible]	61	[illegible]	25	[illegible]	1	5[illegible]	287	[illegible]	[illegible]	289	634	909	[illegible]	[illegible]
Ghana	[illegible]	78	[illegible]	69	[illegible]	3	(3)	2	[illegible]	[illegible]	--	--	--	[illegible]	[illegible]
Greece	[illegible]	--	[illegible]	--	[illegible]	--	--	--	[illegible]	[illegible]	410	347	322	[illegible]	[illegible]
Hong Kong	[illegible]	634	[illegible]	120	[illegible]	--	--	--	[illegible]	[illegible]	48	7	27	[illegible]	[illegible]
Ireland	[illegible]	98	[illegible]	361	[illegible]	5,113	360	931	7,[illegible]	5,[illegible]	653	10,216	16,593	[illegible]	1,[illegible]
Israel	[illegible]	876	[illegible]	136	[illegible]	--	--	--	[illegible]	[illegible]	--	77	186	[illegible]	[illegible]
Japan	[illegible]	2,084	[illegible]	313	[illegible]	--	3	3	1,[illegible]	[illegible]	689	1,465	1,032	[illegible]	[illegible]
Mexico	[illegible]	--	[illegible]	4	[illegible]	40	7	50	[illegible]	[illegible]	--	29	56	[illegible]	[illegible]
Netherlands	[illegible]	1,272	[illegible]	887	[illegible]	9	(3)	24	[illegible]	[illegible]	20	(3)	(3)	[illegible]	[illegible]
South Africa, Republic of	2,[illegible]	28,234	3,[illegible]	38,459	[illegible]	149	15	527	[illegible]	[illegible]	152	500	994	[illegible]	2,[illegible]
Switzerland	[illegible]	303	[illegible]	1,294	[illegible]	--	1	143	[illegible]	[illegible]	440	177	167	[illegible]	[illegible]
U.S.S.R.	[illegible]	--	[illegible]	--	[illegible]	--	--	--	[illegible]	[illegible]	96	83	25	[illegible]	[illegible]
United Kingdom	[illegible]	3,969	[illegible]	1,800	[illegible]	5	(3)	19	[illegible]	[illegible]	99	810	587	[illegible]	[illegible]
Venezuela	[illegible]	56	[illegible]	352	[illegible]	82	--	--	[illegible]	[illegible]	--	--	--	[illegible]	[illegible]
Zaire	[illegible]	652	[illegible]	1,202	[illegible]	1,915	223	579	[illegible]	1,[illegible]	--	33	49	[illegible]	[illegible]
Other Africa, n.e.c.	[illegible]	2,272	[illegible]	4,178	[illegible]	--	(3)	119	[illegible]	[illegible]	--	--	--	[illegible]	[illegible]
Other	[illegible]	r125	[illegible]	107	[illegible]	16	8	179	[illegible]	[illegible]	105	94	400	[illegible]	[illegible]
Total[4]	3,6[illegible]	51,564	5,[illegible]	55,393	[illegible]	7,418	761	[illegible]134	10,[illegible]	7,[illegible]	[illegible]179	14,792	21,[illegible]14	[illegible]	6,[illegible]

r Revised.

[1] Excludes 145,000 carats from Ghana, Japan, ... the Rep... South Africa, and the Central African Republic in 1982 ... 45,600 carats from Japan ... Netherlands, ... South Africa, and the United Kingdom in 1983 ...

[2] Includes 48,000 carats of synthetic miners' diamond in 1982 and 2,000 carats in 1983. ... 1983.

[3] Less than 1/2 unit.

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

WORLD REVIEW

Angola.—Companhia de Diamantes de Angola (DIAMANG) diamond mining company was 77% controlled by the Government through the state mining enterprise Empresa Nacional de Diamantes de Angola. The Belgian companies, Société Generale des Mines and Sibeka, together shared a 17.4% interest.

Hindering efforts to improve productivity has been the increase in the amount of smuggling and theft, estimated to deprive the Government of up to 50% of diamond income.

DIAMANG's total work force numbered about 17,000 deployed at several operations within a vast concession in Lunda Norte Province. There were three regional mining divisions—Andrada, Lucapa, and Cuango—with some operations as far as 400 kilometers from the mine headquarters at Dundo. The formidable infrastructural problems and support services required that the engineering division alone employ some 7,500 workers.

The great majority of diamonds were recovered from alluvial terrace and riverbed gravels, the latter frequently requiring extensive river diversions during the dry season and the use of explosives to gain access to the rich gravels in deep potholes and crevices on the riverbed. Whereas the average grade of alluvial gravels in the Lucapa and Andrada divisions runs from 0.2 to 0.3 carat per cubic meter, the river gravels of the Cuango River average 2.5 carats per cubic meter, with some rich pockets yielding up to 100 carats per cubic meter. About 90 kilometers of the Cuango River remained to be mined. There were also ample alluvial reserves remaining in other regions, so that there was no great haste to mine the extensive kimberlites that had been discovered. Limited open pit mining of the weathered tops of two pipes, Catoca and Camajico, was carried out, but the Camofuca Camazombo pipe—one of the largest in the world—was still being evaluated.[5]

Australia.—The diamond processing plant capacity of Argyle Diamond Mines Pty. Ltd. alluvial deposits was expanded from 2,000 to 4,000 tons per day in early 1983 and was targeted to reach 5 million carats.[6] However, by yearend, the output exceeded 6.2 million carats partially attributed to a higher-than-anticipated diamond yield per ton of raw material processed. In the first commercial sale of diamonds from the alluvial mining operation, 200,000 carats was sold for an estimated $1.9 million to De Beers Consolidated Mines Ltd.'s Central Selling Organization (CSO).[7] The CSO was expected to market 95% of the gem-quality diamond and 71% of the near-gem and industrial stone during the mining of the alluvial deposits and during the first 5 years of full production from the AK-1 kimberlite pipe.

Development of the AK-1 kimberlite pipe to full production was given the go-ahead by the Western Australia government. Partners to the joint venture had been negotiating for some time with the State government over infrastructure development for the mine. The joint venture wanted to fly its workers in and out of the remote Kimberley region minesite while the government wanted a new township built. The two parties signed an agreement, modifying the original State agreement, to delete the requirement that a new town be built. In return, the State government would receive $43.5 million in additional advance royalties. There was to be an equivalent offset against royalties otherwise payable between 1986 and 1993. The State used part of the advance payment to purchase the Bond Corp.'s wholly owned Northern Mining Corp. NL for $36.5 million. This is the same amount paid by Bond when it acquired the holding, then owned 39% by Endeavor Resources Ltd., in late June.[8]

The second phase of the $413 million AK-1 kimberlite pipe project was to involve preparation of the pipe for commercial mining, which includes prestripping of 20 million tons of overburden; construction of a 3-million-ton-per-year-capacity treatment plant; construction of metal-style accommodation and recreational facilities; construction of an all-weather jet aircraft landing strip; and construction of offices, workshops, and warehouses. The Argyle kimberlite mine was expected to be in production in 1986. Annual output was expected to eventually reach 25 million carats of diamond per year, with a projected minimum mine life of 20 years. The alluvial mine was to continue operating during construction of the stage two project.[9] When completed, the Argyle Mine was expected to be by far the world's largest diamond mine and Australia the world's largest diamond-producing country.

Another alluvial diamond deposit was discovered off Bow River near Lake Argyle in northwest Western Australia. Gem Exploration and Minerals Ltd. reported that diamondiferous gravel totaling 58 million tons, which could eventually be upgraded to more than 220 million tons, was found following tests carried out in conjunction with Freeport of Australia Pty. Inc. A total of 2,371 diamonds was recovered from 2,590 tons of material during bulk testing. The average diamond size was 0.16 carat, including an average of 0.21 carat in one area. The 398 carats obtained from the bulk sample represent a grade of almost 17 carats per 110 tons. The largest stone weighed 5 carats and was of industrial quality, but the batch included a 3.2-carat gem diamond. The diamonds were valued at an average of $15.65 per carat.[10]

Afro-West Mining Ltd. reported recovery of diamonds from claims tested along Smoke Creek in Western Australia. The company was increasing its treatment capacity at the Smoke Creek claims, downstream from the Argyle project, and was working in joint venture with Aracca Minerals Ltd., a wholly owned subsidiary of Aracca Petroleum Corp. A total of 4,000 tons of material was stockpiled adjacent to the treatment area so that testing could be continued into the wet season. Afro-West regarded the initial results as encouraging.[11]

Botswana.—Continued increases in production from the new mine at Jwaneng in conjunction with output from the Oprapa and Lethakane Mines made Botswana second in world production of natural diamond and first in production of gem diamond. During the past few years, Falconbridge Ltd., Exploration Div., had centered its main diamond prospecting efforts in Botswana, and over 60 kimberlite pipes had been located in northeastern Kgalagadi District and in the southern part of Kgalagadi around Tshabong. The most promising discovery covers 27 acres, and Falconbridge, with The Superior Oil Co. of Houston, a major partner, started operation of a bulk sampling treatment facility at the site. De Beers had the right to acquire a 50% interest.[12]

Guinea.—Aredor Holdings Ltd. of Australia planned to bring on-stream in early 1984 the world's latest diamond mine. With a rated production of 250,000 carats per year, the operation, by world standards, was not particularly large but 90% of the output was expected to be gem-quality diamonds. Initial prospecting showed the average size of stone to be 0.8 to 1 carat with an estimated value of $185 to $200. Aredor had sufficient reserves to last about 14 years, although the company hoped to establish further reserves in the lease area that would enable 1 million tons per year of gravel to be processed. The cost of the venture had reached $79.1 million. Aredor, which had an equal share in the project with the Government of Guinea, was owned by Bridge Oil Ltd. (79.2%), the International Bank for Reconstruction and Development (World Bank) (11.3%), Industrial Diamond Co. (5%), Bankers Trust of Australia (3.5%), and Simonius Visher and Co. (1%).[13] Based on the results of a detailed feasibility study, the U.S. Government agency, Overseas Private Investment Corp. agreed to provide political risk insurance on Bridge Oil's investment in the project.[14] The gem stones were to be marketed by both Aredor Sales of Aredor Guinea SA and the Guinean Government on a 70-30 basis, while the industrial stones were to be sold on a 50-50 basis.[15]

Namibia.—Production of diamonds had fallen 35% since 1980. De Beers cut back production, closing one of the four main conglomerate treatment plants, because of the weak diamond market and huge stockpile, particularly the large gem stones over 1 carat in size that Consolidated Diamond Mines (Pty.) Ltd. (CDM) produced in abundance. During the first half of 1983, sales of rough diamonds by CSO were 40% higher in dollar terms than for the second half of 1982, confirming an ongoing recovery of demand.

The fall in sales by CDM had particularly serious consequences on Namibia's finances. Normally, the 10% diamond export duty, diamond profits, and income tax had covered 40% of the administration's expenditures, but, in 1983, the revenues only covered 4% of expenditures.[16]

Romania.—After developing its own technology, Romania had set up the Dacia Synthetic Diamond Plant in 1974. Four types of synthetic diamond were produced, ranging in size from 0.25 to 800 micrometers. Romania planned to start large-scale production and use of synthetic diamond bits and blades. The use of this type of equipment has increased sevenfold from 1976 to 1981. Synthetic diamond bits were expected to play an important role in oil well drilling. Romania was also interested in developing technology for the production of synthetic polycrystalline compacts and cubic boron nitride compacts.[17]

South Africa, Republic of.—A new offshore diamond field, extending from Namaqualand, near the border with Namibia, to within 120 kilometers of Cape Town, was opened by the South African Department of Mineral and Energy Affairs. The field was divided into eight shallow and middepth sections and two deepwater sections. More than 500 tenders were made. The area was unusually rich in gem stone-quality diamonds.[18]

De Beers continued to investigate and evaluate the cluster of diamondiferous pipes on the Venetian farm in northern Transvaal and other prospectors flocked to the area. Trans Hex Co. purchased Dawn Diamond Co. and planned to explore and develop the areas in which Dawn had been operating.[19]

Mafikeng Diamonds Ltd. conducted a test mining operation on an alluvial diamond deposit located about 10 kilometers from Mafikeng Bophuthatswana, in the Republic of South Africa. The mine, managed by Rio Tinto South Africa, a subsidiary of Rio Tinto Zinc Corp. Ltd., commenced operations in June at a planned output of 1,300 tons per day of gravel. It was thought that a full year of operation would be needed before the distribution and value of the diamonds in the deposit could be determined. The deposit had first been actively mined in the 1920's by individual diggers. Rio Tinto first began investigations into the area in 1981 and, after confirming the presence of diamonds, took out a mining lease; a modern diamond recovery plant was installed. Although the deposit is known to be of low grade, the company was hoping that modern recovery methods applied on a larger scale than previously practiced would justify a long-term mining operation.[20]

U.S.S.R.—Production of new types of synthetic diamond began at the Kabardino-Balkar diamond instrument plant at Terels in the Caucasian region in honor of the Lenin Komsomal.[21] The first batch of synthetic diamonds from the Tashkent Abrasive Plant was of superior quality. New synthesizing equipment was installed that was claimed to increase production tenfold.

Venezuela.—A new law that revoked a system of unlimited approval of mining rights resulted in some 20,000 small miners in the Guaniamo diamond district losing their sole means of livelihood. The new law was introduced because of poor diamond recoveries caused by inefficient mining techniques. In addition, an estimated 65% of the diamonds was being smuggled out of the country. Under the new arrangement, miners and companies were required to demonstrate their technical and economic ability before being granted mining rights. As a result, small mines were forming cooperatives that would be regulated by the National Superintendency of Cooperatives and the Ministry of Energy and Mines.[22]

Zaire.—The Société Minière de Bakwanga (MIBA) had been experiencing problems resulting from a substantial decline in its ore grade and, in an effort to ensure its future, had resorted to more intensive kimberlite mining and exploration of the Mbujimoyi riverbed and its adjacent flats using new dredging techniques. The company had invested more than $10 million in 1982 on this project, and the new dredge was scheduled to start operating by yearend.

The average selling price had decreased substantially in 1981 to $9.39 per carat and continued the decline in 1982 to $7.59 per carat. However, the new agreement for marketing of MIBA's production, signed in March 1983 between Société Zairoise de Commercialisation de Minerais and British Diamond Distributors Ltd., which belonged to CSO, opened the way for a return to a higher level of price.[23]

Financing was arranged for further development of the MIBA Mine. The goal was to increase production from the present level of 6 million to 12 million carats per year, which had been the level of output in the early 1970's.[24]

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

(Thousand carats)

Country	1979 Gem	1979 Industrial	1979 Total	1980 Gem	1980 Industrial	1980 Total	1981 Gem	1981 Industrial	1981 Total	1982[p] Gem	1982[p] Industrial	1982[p] Total	1983[e] Gem[2]	1983[e] Industrial	1983[e] Total
Angola	630	211	841	1,110	370	1,480	1,050	350	1,400	915	310	1,225	900	300	1,200
Australia	--	--	--	--	48	48	21	184	205	70	487	557	2,170	4,030	[3]6,200
Botswana	659	3,735	4,394	765	4,336	5,101	744	4,217	4,961	1,165	6,604	7,769	4,300	6,431	[3]10,731
Brazil[e 4]	236	384	620	253	414	667	163	926	1,089	80	450	530	80	450	530
Central African Republic	205	110	315	227	115	342	209	103	312	186	91	277	[3]230	[3]65	[3]295
China[e]	NA	NA	NA	360	1,440	1,800	380	1,520	1,900	400	1,600	2,000	400	1,600	2,000
Ghana	125	1,128	1,253	126	1,132	1,258	85	751	836	68	616	684	30	270	300
Guinea[e]	27	58	85	12	26	38	12	26	38	13	27	40	15	30	45
Guyana	6	10	16	4	6	10	4	6	10	[e]5	[e]6	[e]11	4	5	9
India	14	2	16	12	2	14	14	2	16	11	2	13	13	2	15
Indonesia[e]	3	12	15	3	12	15	3	12	15	3	12	15	5	22	27
Ivory Coast	24	24	48	--	--	--	--	--	--	--	--	--	--	--	--
Lesotho	48	4	52	50	4	54	49	4	53	39	3	42	--	--	--
Liberia	170	132	302	123	175	298	132	204	336	170	263	433	132	198	[3]330
Namibia	1,570	83	1,653	1,482	78	1,560	1,186	62	1,248	963	51	1,014	915	48	[3]963
Sierra Leone	434	451	885	317	275	592	208	97	305	203	87	290	192	83	275
South Africa, Republic of:															
Finsch Mine	465	2,120	2,585	465	2,442	2,907	1,002	3,463	4,465	847	3,003	3,850	1,765	3,278	[3]5,043
Premier Mine	468	1,613	2,081	407	1,632	2,039	510	1,530	2,040	615	1,845	2,460	800	1,844	[3]2,644
Other De Beers properties[5]	1,850	1,370	3,220	1,550	1,489	3,039	1,603	1,069	2,672	1,359	906	2,265	1,400	569	[3]1,969
Other	403	95	498	390	145	535	314	35	349	521	58	579	589	66	[3]655
Total	3,186	5,198	8,384	2,812	5,708	8,520	3,429	6,097	9,526	3,342	5,812	9,154	4,554	5,757	[3]10,311
Tanzania	157	157	314	137	137	274	110	107	217	[e]100	[e]120	[e]220	125	125	250
U.S.S.R.[e]	2,200	8,500	10,700	2,250	8,600	10,850	2,100	8,500	10,600	2,100	8,500	10,600	3,700	7,000	10,700
Venezuela	247	556	803	238	483	721	102	388	490	99	394	493	100	400	500
Zaire	294	8,440	8,734	345	9,890	10,235	450	8,550	9,000	[e]450	[e]8,550	[e]9,000	3,172	8,266	[3]11,438
World total	10,235	29,195	39,430	10,626	33,251	43,877	10,451	32,106	42,557	10,382	33,985	44,367	21,037	35,082	56,119

[e]Estimated. [p]Preliminary. NA Not available.

[1]Table includes data available through May 16, 1984. 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 (1980-83), the Central African Republic (1979-81), Liberia (1979-81), Sierra Leone (1979-81), the Republic of South Africa (1979), and Venezuela (1979-81), 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]Figures represent officially reported output plus official Brazilian estimates of output by nonreporting mines; officially reported output was as follows, in thousand carats: 1979—83; 1980—158; 1981—136; 1982—212; and 1983—not available.

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

TECHNOLOGY

An industrial diamond plant was established in Ireland by the Specialty Materials group of General Electric. The plant, which was to initially employ 250 workers, was to produce superabrasive diamonds for use in drilling and metal cutting.[25]

A study by the Japanese was conducted on the effects of graphite additives on the sinterability of diamond compacts. Diamond and diamond-graphite powder mixtures were sintered on tungsten carbide-cobalt substrates at 1,400° C to 1,500° C and 5.8 gigapascals. Microstructure and cutting performance were studied in detail for the sintered diamonds obtained as functions of the particle size of the diamond, graphite and cobalt content, and type of graphite used. Well-sintered bodies with a fine-grained homogeneous microstructure and extensive direct bonding between diamond particles were produced when graphite obtained from diamond or partially graphitized diamond was used. Cutting performance was evaluated by measuring the surface roughness of an aluminum-silicon alloy finished with tools made from the sintered bodies and by determining the flank wear resistance of the tools. An optimum graphite content was found at about 50% to 70% by volume in the partially graphitized starting material.[26]

Needle-shaped crystals found in samples of synthetic diamond grits were examined by X-ray diffraction, optical methods, and scanning electron microscopy. It was shown that these crystals are cyclic twins with a morphology hitherto unreported. The crystal habit of these cyclic twin crystals results from pronounced (100) faceting, characteristic of synthetic diamond, in addition to the (111) growth faces, thereby producing the needle-shaped crystals observed. This was different from the five-branched star cyclic twin crystal habit previously found in both natural and synthetic diamond grits and in which only (111) facets were present.[27]

Study of inclusions in the diamonds and xenoliths of diamond-bearing rock supplied important information about the composition of the upper mantle of the Earth at a depth of 150 to 250 kilometers. Further study of kimberlite mineralogy will be required to solve fundamental problems of composition and physicochemical conditions in the Earth's mantle before these techniques will be an aid in the search for new primary sources of diamond.[28]

The Bureau of Mines tested new designs of drag bit cutters with sintered diamond inserts instead of standard tungsten carbide tips. The bits were tested for orthogonal cutting forces, primary dust generation, and incendivity, with a standard plumb-bob-type conical cutter (60° included tip angle) as the reference. Preliminary wear and impact-failure testing was also done. The results were mixed. Two new designs had forces similar to those of the reference bit, but one new design had about twice the normal force. This same design had almost twice the specific energy during shallow cutting but generated an equal or slightly lower amount of primary dust than did the reference bit. Incendivity was eliminated for two radial designs. One conical design had ignition only after more than 15 impacts, but the other conical design was incendive. Impact failure occurred, but not as quickly as anticipated. Over 7,500 impacts on a sandstone face, with a total cutting distance of more than 1,980 meters, only scuffed the leading edge of the sintered diamond cutting face but caused hairline cracks in the substrate mounting pad. Additional design and testing were recommended to develop an optimum cutter, but the material appeared to be promising.[29]

A newly developed laser-welded saw blade effectively launched diamond technology into an area traditionally held by the conventional abrasive blade. Conventional dry-cutting blades had been used with portable saws to cut bricks, concrete, tiles, and other building materials. Although they were relatively inexpensive, blade life was short, downtime owing to blade changing was high, and cutting rates were often very low. Moreover, there was a continuing safety hazard from possible blade bursting. The need for water coolant prevented the application of the diamond saw as the preferred blade for portable machines in the traditional building areas. However, the new laser-welding technique used to bond the diamond segments to the steel blade center provided a joint that was actually stronger than either the steel or the diamond-impregnated segment. Consequently, the temperatures generated in dry cutting, which would dislodge conventionally brazed segments, were no longer significant.[30]

A recently developed synthetic polycrystalline diamond product manufactured by a domestic producer was obtaining excellent results in core drilling when used in applications usually reserved for natural, single-crystal industrial diamond. This synthetic diamond product was being supplied in triangular, rectangular, and cylindrical shapes for setting in drill bits and for uses as diamond dressers and tools. Economic bit life of the triangular diamond set in core bits proved to be 60% longer than mined diamond bits, and drilling cost per foot was 33% lower when used in drilling shale and sandstone formations. Penetration rates were twice as fast as that of the natural diamond bit without any increase in the weight on the bit.[31] When the synthetic diamond shapes were used for dressing aluminum oxide grinding wheels, the synthetic diamond product outlasted the mined diamond tool through three relaps, resulting in two to three times longer tool life. The synthetic diamond product was also being used successfully for dressing silicon carbide grinding wheels.[32]

Abstracts relative to diamond materials and machines, including patents, were published monthly from January to June in the Industrial Diamond Review. Each 1983 monthly report contained 17 to 23 pages of abstracts and patent information.

MANUFACTURED ABRASIVES

Manufactured abrasives operations continued to be depressed. These materials had supported heavy industries such as steel, foundry, and automotive and were reliable indicators of economic condition of the industrial segment of the economy both nationally and worldwide. Production was approximately the same as that of 1982 and was again reported at its lowest level for silicon carbide since 1963, for fused aluminum oxide since 1958, and for metallic abrasives since 1964.

Five firms produced crude fused alumina in the United States and Canada at eight plants. Production was at only 42% of furnace capacity. Reported production of white high-purity material increased 7% to 15,940 tons, but was only 50% of the normal previous level. Production of regular material increased 4% in quantity and 14% in value to 121,167 tons and $42.6 million, respectively. Almost all of the combined output of white and regular material was for abrasive application. One company reported shipping a small quantity of regular material for refractory manufacture. Reported yearend stocks totaled 12,427 tons.

During the latter part of the year Suriname Aluminum Co., a subsidiary of Aluminum Co. of America in Suriname, announced that it would no longer supply calcined bauxite for abrasive applications. Suriname had been the largest supplier of abrasive-grade calcined bauxite to North America.[33] Most of the companies made up supply shortages by purchasing calcined bauxite from Australia and China; however, some of the companies were uneasy with the primary supply being so remote and preferred long-term commitments from a more proximate supplier.

Sohio made an unexpected announcement in mid-March of plans to close or sell Carborundum's worldwide bonded and coated abrasives operations. The only exceptions were to be the integrated operations in Brazil and the Republic of South Africa. Although Carborundum withdrew from the bonded and coated abrasive market, it continued to produce silicon carbide and fused aluminum oxide through its Electrominerals Div., which was consolidated with the Processed Minerals Sector of Sohio Chemical and Industrial Products Co., along with Qit-Fer et Titane Inc.[34]

The Domestic Coated Div. of Carborundum was sold to a Chicago investor group and was to operate as Carborundum Abrasive Inc. The domestic bonded abrasive operations in Logan, OH, were purchased by two former Carborundum executives and were to operate as the Carborundum Grinding Co. The Niagara Falls, NY, bonded abrasive operation was not expected to reopen. The Canadian coated abrasives operations were sold to former Carborundum executives and a Canadian investor group. The other foreign operations were sold to division and plant management employees together with local investors.

Exolon, Tonawanda, NY, and ESK, Hennepin, IL, signed a memorandum of intent to combine all of their silicon carbide and fused aluminum oxide operations to form a new company, The Exolon-ESK Co. The merger was expected to be formalized by early 1984. ESK was owned by the West German company Wacker Chemie AG, which also owned Elektroschmelzwerk Kempten AG in the Federal Republic of Germany. No changes were anticipated in the existing operations, and the sales and executive offices were to be located in Tonawanda. The principal reasons given for the proposed merger were that Exolon was not self-sufficient in silicon carbide capacity while ESK had no facilities for processing crude silicon carbide and could adequately supply Exolon's processing operations.[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.

Seven firms in the United States and Canada produced silicon carbide in seven plants. The companies produced crude material for abrasives, refractories, and other nonabrasive uses. Total production was only 52% of furnace capacity. Output during the year decreased 3% to 109,000 tons and value decreased 5%. Abrasive use decreased 1% and accounted for 36% of output. Metallurgical applications decreased 17% and accounted for 39% of the output. Refractory applications increased 31% and accounted for 25% of the total output. Yearend stocks totaled 12,136 tons as of December 31.

Ferro permanently closed its Canadian silicon carbide operation, Produits Refractaires et Abrasives Electro du Canada Ltée., in Quebec Province in June. The plant was dismantled and the building shell and property were to be sold. It had been in operation for over 35 years. The closing was another setback for the North American abrasives industry with an additional loss of industry furnace capacity. Ferro planned to continue to produce abrasive and refractory silicon carbide grain and to purchase crude silicon carbide from domestic and Canadian suppliers.

Superior Graphite Co. announced that it had become actively involved in the marketing of silicon carbide following the successful completion of the test of its commercial-scale proprietary silicon carbide continuous furnace. The material was developed for a wide range of uses including metallurgical additions, refractories, fine abrasive grit, and for high-performance ceramics. The silicon carbide products were derived from the direct run-of-furnace (ROF) silicon carbided carbon grain. This material was made by forming silicon carbide on the external and internal surfaces of relatively porous carbon particles. The silicon carbide is in the beta (cubic) crystalline phase form. The ROF grain is free flowing and can be used directly in metallurgical and refractory applications. It can also be further processed to remove free carbon and other impurities to meet specifications for fine abrasive grit and high-purity silicon carbide powders for reaction bonding and pressureless sintering.[36]

Silicon Products Ltd. began recovery of silicon carbide from granite sludge at its new plant in Elberton, GA. The proprietary beneficiation process developed by Silicon Products produced a 92%-silicon-carbide concentrate that was filtered, dried, and air classified into two commercial sizes, a coarse minus 100-mesh plus 325-mesh product and a fine minus 325-mesh plus 10-micrometer product. A company official estimated that approximately 50,000 tons of recoverable silicon carbide was located in the Elberton area and that an additional 5,000 tons was being added annually from the waste of the granite-cutting companies. The city of Elberton recently passed an ordinance governing the dumping of emery (actually silicon carbide) residue into its storm drains.[37]

In the yearend Stockpile Report to the Congress by the General Services Administration, the inventory of crude fused aluminum oxide abrasive grain was about 51,000 tons. Stocks of silicon carbide crude were 80,550 tons, and the goal was 29,000 tons.

Metallic abrasives were produced by 11 firms in 12 plants in the United States. One firm that had usually operated two plants operated only one plant during 1983. Steel shot and grit comprised 89% of the total quantity of metallic abrasives sold or used; the balance included chilled iron shot and grit and annealed iron shot and grit. Four States supplied 100% of the total sold or used—Pennsylvania, 38%; Ohio and Michigan, 24% each; and Virginia, 14%. The total quantity, sold or used, increased 5% in volume and 4% in value.

Shipments of chilled and annealed iron shot and grit, produced by two companies, one in Indiana and one in Ohio, decreased 6% in quantity and 4% in value. Cut wire shot production, primarily stainless steel was reported by two firms, one in Michigan and one in New York.

TECHNOLOGY

The hard river-quartz aggregates found in many parts of the country were known to produce especially hard and durable portland cement concrete (PCC) highways. The major concern when applying a thin-coated PCC overlay was that, prior to application the highway surface had to be clean and a good profile needed to be developed that ensured bonding. Because the quartz aggregate was so hard, the profile was not readily developed and PCC resurfacing had been uneconomical. A shot blaster was developed that can economically clean PCC surfaces. The shot blaster uses a veined wheel to hurl steel shot at the surface, wearing away between 1/16 to 1/8 inch of concrete. After hitting the surface, the shot rebounds and is caught and recycled. Filters collect the dust. In Iowa, last summer, the machine cleaned nearly 1 mile of 18-foot-wide, hard-aggregate PCC highway per day. Because of the superior quality of the cleaning and the profile of the cleaned surface, special mixes of concrete were not needed for the overlay. The shot blaster makes PCC overlays competitive with asphalt.[38]

The physical and chemical properties of boron nitride (BN) are very similar to carbon. Graphite-like (g-BN), wurtzite (w-BN), and zinc blende (z-BN) are known as polymorphs of BN, corresponding to graphite, hexagonal, and cubic diamond, respectively. A study was undertaken to clarify the structural change in shock-compressed BN and to obtain superhard sintered compacts. Results showed that the transformation from w-BN to z-BN increased with treatment temperature. The content of z-BN was about 50%, after 15 minutes at 1,500° C, and 80% at 1,600° C. The apparent density increased with temperature. The densities reached theoretical at about 1,600° C, but decreased at higher temperatures. The hardness also changed with temperature. A new process using dynamic and static very high pressure was developed for producing very hard compacts. A sintered compact, obtained at very high pressure and temperature, 6.7 gigapascals and 1,600° C, for 15 minutes and consisting of 20% by weight w-BN and 80% by weight z-BN, had theoretical density and extremely high hardness.[39]

Cubic boron nitride (CBN) has been given another big boost in effectiveness in honing. CBN has been used as an industrial abrasive for over 15 years, but recent discoveries in honing technology has sharply upgraded the usefulness of this material. CBN had made honing an attractive alternative to grinding, reaming, and boring. Not only does honing provide superior control of bore geometry and size and finish, but it now offers some important additional benefits because operator inputs are reduced when stone life goes up on the order of 20 to 30 times, and breakdown becomes far more consistent and much more predictable. Bore size and finish are more closely controlled with far less adjusting and compensating by the operator. The time saved in changing stones alone becomes a sizable bonus. Part preparation is less critical with greater stock removal capacity and improved wear characteristics. The superabrasives can tolerate a much wider variation in rough bores coming in and still produce good pieces at good rates. Previous operations can be speeded up without paying a prohibitive cost premium at the finish end. Industry reports cycle time reductions ranging from 30% to 80% and output improvements ranging from 15 parts per aluminum oxide stone to 1,900 parts per CBN stone.[40]

To identify construction materials for emerging technology in chemical metallurgical processes, the Bureau of Mines investigated the acid resistance of ceramic materials. Eight commercial ceramic materials were evaluated. Carbon brick samples had the best acid-resistant properties based on leached ion weight loss, followed by silicon carbide bricks.[41]

Significant research continued in silicon carbide materials technology. Several new high-technology products were developed in Japan in a range of organosilicon oligomers. One of these materials, polycarbosilane, converted to fine silicon carbide crystals when heated to 800° C to 1,300° C and had potential as a bonding material for forming very dense silicon carbide refractories for advanced ceramic materials.[42]

A unique method to mass produce an extremely heat-resistant and high-tensile-strength silicon carbide whisker was developed in Japan. The fibers, which were expected to make an excellent reinforcer, were produced by heating a silicon-carbon compound to temperatures of 1,500° C to 1,600° C. The fiber maintained its properties when exposed to temperatures up to 1,600° C and showed only minimum strength loss from 1,600° C to 2,400° C. Tensile strength ranged from 7 to 33 times that of ordinary steel and from 0.9 to 4.0 times that of carbon fibers.[43]

In February, the successful demonstration of a nonlubricated, uncooled ceramic diesel engine was announced at the national meeting of the Society of Automotive Engineers. The engine, based on the design of Dr. Seamus Timoney at University College, Dublin, Ireland, used Carborundum designed and built silicon carbide cylinders, pistons, and liners. Initial results showed a 20% to 50% reduction in friction and significant reduction in noise levels. Using a number of advanced ceramic materials, the engine was to be further tested under a recently awarded U.S. Department of Defense contract.[44]

[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]Lincoln, J. B. Schaffer-Aultman Kimberlite Complexities, Albany County, WY. Paper in Proceedings of the Denver Region Exploration Geologist Society Symposium (Denver, CO, Nov. 4-5, 1982). Denver Region Explor. Geol. Soc., Denver, CO, 1983, pp. 71-77.
[5]Mining Journal (London). Angola. V. 302, No. 7750, Mar. 2, 1984, pp. 137-138.
[6]Lyons, L. A. Discovery and Development of Australian Diamonds. World Min., v. 36, No. 9, Sept. 1983, pp. 50-56.
[7]Wall Street Journal. First Diamond Sale From Australian Mine Valued at $1.9 Million. V. 201, No. 83, Apr. 28, 1983, p. 35.
[8]Mining Journal (London). Mining Week. V. 301, No. 7730, Oct. 14, 1983, pp. 270-277.
[9]CRA Limited (Melbourne, Australia). Press release, Nov. 6, 1983, 3 pp.
[10]Engineering and Mining Journal. V. 185, No. 1, Jan. 1984, p. 82.
[11]Mining Journal (London). Industry in Action. V. 301, No. 7732, Nov. 4, 1983, p. 329.
[12]———. Mining Annual Review. Botswana, 1983. June 1983, p. 395.
[13]Industrial Minerals (London). Guinea. No. 197, Feb. 1984, p. 10.
[14]Mining Journal (London). Guinea. V. 301, No. 7740. Dec. 23, 1983, pp. 451-452.
[15]Synge, R. Guinea, 1983. Art. in Mining Annual Review. Min. J. (London), June 1983, p. 424.
[16]Mining Journal (London). Diamond Sector Cut Back. V. 301, No. 7732, Nov. 4, 1983, p. 323.
[17]Gafton, P. Synthetic Diamond Production—Romania. Radio Free Europe Res., RFE/RL, Oct. 26, 1982, p. SR 18.
[18]U.S. Embassy, Pretoria, Republic of South Africa. State Dep. Airgram A-34, Nov. 25, 1983, pp. 1-2.
[19]U.S. Consulate, Johannesburg, Republic of South Africa. State Dep. Airgram A-17, Jan. 6, 1983, pp. 46-47.
[20]Industrial Minerals (London). South Africa. No. 193, Oct. 1983, p. 11.
[21]Izvestiya (Moscow). Apr. 29, 1982, p. 1.
[22]Mining Journal (London). Mining Annual Review. Venezuela, 1983. June 1983, p. 325.
[23]———. Sibeka—Extracts From the Report of the Board of Directors. V. 301, No. 7718, July 22, 1983, p. 70.
[24]———. De Beers Loan for MIBA Mine. V. 301, No. 7714, June 24, 1983, p. 432.
[25]Industrial Minerals (London). No. 189, June 1983, p. 91.
[26]Akaishi, M., Y. Sato, N. Setaka, M. Tsutsumi, T. Ohsawa, and O. Fukunga. Effect of Additive Graphite on Sintering of Diamond. Am. Ceram. Soc. Bull., v. 62, No. 6, June 1983, pp. 689-694.
[27]Pipkin, N. J. Crystal Morphology of Cyclic Twins in Synthetic Diamond Grits. De Beers Diamond Res. Lab., Johannesburg, Republic of South Africa, Monthly Pub. No. 010831, Item No. 011047, NTIS June 1970-Mar. 1983, p. 17; PB 83 862219.
[28]Sabolev, V. S. Main Results of Research and Future Task in the Prediction of Diamond Occurrences. Geologiya i Geofizika, v. 12, 1980, pp. 3-11; Abstracted Ind. Diamond Rev., v. 43, No. 498, May 1983, p. 286.
[29]Roepke, W. W., B. D. Hanson, and C. E. Longfellow. Drag Bit Cutting Characteristics Using Sintered Diamond Insert. BuMines IC 8802, 1983, 30 pp.
[30]Herbert, S. New Dry-Cutting Blade for On-Site Work. Ind. Diamond Rev., v. 43, No. 496, Mar. 1983, pp. 142-143.
[31]General Electric Co., Specialty Materials Department (Worthington, OH). Core Bits Made With Geoset Drill Diamond. Case history No. 504, July 1983, p. 1.
[32]———. Formset Dresser Diamond. Sales brochure No. SMD 23-427, July 1983, 3 pp.
[33]Harben, P., and T. Dickson. Non-Metallurgical Grades—Bauxite's Creme de la Creme. Ind. Miner. (London), No. 192, Sept. 1983, pp. 25-43.
[34]Industrial Minerals (London). No. 187, Apr. 1983, p. 21.
[35]———. No. 195, December 1983, p. 15.
[36]Superior Graphite Co. (Chicago, IL) Private communication, Feb. 23, 1984; available upon request from J. F. Smoak, Bureau of Mines, Washington, DC.
[37]Banner-Herald (Elberton, GA). Elberton City Council Tells Granite Companies, Clean Up. Nov. 17, 1983.
[38]Engineering News Record. Clearing a Way for Overlays. V. 212, No. 5, Feb. 2, 1984, p. 16.
[39]Sawaoka, A. Structural Changes by Shock Compression and Preparation of Superhard Compacts by Very High Pressure Sintering. Am. Ceram. Soc. Bull., v. 62, No. 12, Dec. 1983, pp. 1379-1383.
[40]Chadwell, T. Heftier Role for Honing. Machine and Tool Blue Book, v. 78, No. 9, Sept. 1983, pp. 52-56.
[41]Bennet, J. P. Corrosion Resistance of Ceramic Materials to Hydrochloric Acid. BuMines RI 8807, 1983, 14 pp.
[42]Industrial Minerals (London). Japan. New Materials. No. 193, Oct. 1983, p. 11.
[43]Japan Economic Journal. Tokai Carbon Co., New Way Is Found To Turn Out Silicon Fiber Whiskers. Sept. 21, 1982.
[44]Janeway, P. A. Carborundum Expands Technology Base in SiC Components. Ceram. Ind., v. 14, No. 4, Oct. 1983, pp. 39, 55.

Table 13.—Crude artificial abrasives manufacturers in 1983

Company	Location	Product
Carborundum Electro Minerals Co., a division of Standard Oil of Ohio.	Niagara Falls, NY	Fused aluminum oxide (high purity).
	Vancouver, WA (inactive)	Silicon carbide.
	Niagara Falls, Ontario, Canada	Fused aluminum oxide (regular).
	Shawinigan, Quebec, Canada	Silicon carbide.
ESK Corp	Hennedin, IL	Do.
The Exolon Co	Thorold, Ontario, Canada	Fused aluminum oxide (regular) and silicon carbide.
Ferro Corp., Abrasive Div	Cap-de-la-Madeleine, Quebec, Canada (permanently discontinued operations in June 1983).	Silicon carbide.
General Abrasives, a division of Dresser Industries Inc.	Niagara Falls, NY	Fused aluminum oxide (high purity).
	Niagara Falls, Ontario, Canada	Fused aluminum oxide (regular) and silicon carbide.
Norton Co	Huntsville, AL	Fused aluminum oxide (high purity).
	Worcester, MA	General abrasive processing.
	Cap-de-la-Madeleine, Quebec, Canada	Silicon carbide.
	Chippewa, Ontario, Canada	Fused aluminum oxide (regular and high purity) and aluminum-zirconium oxide.
Satellite Alloy Corp	Springfield, PA	Silicon carbide.
Washington Mills Abrasives Co	Niagara Falls, Ontario, Canada	Fused aluminum oxide (regular).

Table 14.—Producers[1] of metallic abrasives in 1983

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	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	1979	1980	1981	1982	1983
Silicon carbide[1]	[e]196	170	156	112	109
Value	[e]$62,702	$64,346	$68,839	$54,507	$52,016
Aluminum oxide (abrasive grade)[1]	[e]225	193	203	132	137
Value	[e]$67,511	$63,881	$73,712	$45,975	$50,565
Aluminum-zirconium oxide	28	19	W	8	W
Value	$14,893	$8,438	W	$4,600	W
Metallic abrasives[2]	264	233	228	166	172
Value	$84,918	$80,281	$82,952	$62,389	$64,849
Total	[e]713	615	[3]587	418	[3]418
Total value	[e]$230,024	$216,946	[3]$225,503	$167,471	[3]$167,430

[e]Estimated. W Withheld to avoid disclosing company proprietary data.
[1]Figures include 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	1982			1983		
	Quantity (short tons)	Value (thousands)	Yearend stocks (short tons)	Quantity (short tons)	Value (thousands)	Yearend stocks (short tons)
SILICON CARBIDE						
Abrasives	40,367	$22,917	4,955	39,896	$20,680	3,953
Metallurgical	51,251	20,596	8,551	42,300	17,875	5,571
Refractories and other	20,596	10,994	1,647	26,903	13,461	2,612
Total	112,214	54,507	15,153	109,099	52,016	12,136
ALUMINUM OXIDE						
Regular: Abrasives plus refractories[1]	116,727	37,506	19,726	121,167	42,587	10,490
High purity	14,846	8,470	1,382	15,940	7,978	1,937
Total	131,573	[2]45,975	21,108	137,107	50,565	12,427

[1]Abrasives combined with refractories to avoid disclosing company proprietary data.
[2]Data do not add to total shown because of independent rounding.

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)	
1982:					
Chilled iron shot and grit	W	W	W	W	W
Annealed iron shot and grit	W	W	W	W	W
Steel shot and grit	149,741	$54,571	146,910	$55,448	273,000
Other[3]	20,394	7,181	19,530	6,941	36,000
Total	170,135	61,752	166,440	62,389	XX
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

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 chilled iron shot and grit, annealed iron shot and grit, cut wire, aluminum, and stainless steel shot.

Aluminum

By Frank X. McCawley[1] and Pamela A. Stephenson[2]

World production of primary aluminum increased as national economies slowly recovered from the 1982 recession. North America led the rest of the world in increasing primary production. Planning for and construction of new smelters, previously deferred, were resumed during the year as the world aluminum demand began to recover. Several of the world's major aluminum producers announced reorganizations and changes in operations.

Domestic Data Coverage.—Domestic 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 144 monthly survey requests sent to 12 companies, 92% responded, representing 95% of the total primary aluminum production data shown in tables 1, 7, and 15. Production data for the nonrespondents were estimated based on total primary aluminum monthly and annual production data from various sources.

Table 1.—Salient aluminum statistics

(Thousand short tons and thousand dollars unless otherwise specified)

	1979	1980	1981	1982	1983
United States:					
Primary production	5,023	5,130	4,948	3,609	3,696
Value	$6,130,302	$7,346,410	$7,520,841	$5,485,121	$5,754,298
Price: Producer list, ingot, average cents per pound	61.0	71.6	76.0	76.0	77.8
Secondary recovery	1,401	1,389	1,537	1,616	[e]1,724
Exports (crude and semicrude)	773	1,483	867	824	855
Imports for consumption (crude and semicrude)	840	713	935	968	1,203
Aluminum industry shipments[1]	6,922	6,003	6,054	5,610	[p]6,654
Consumption, apparent	5,888	5,065	5,087	4,818	5,543
World: Production	[r]16,044	[r]16,944	16,596	[p]14,802	[e]15,284

[e]Estimated. [p]Preliminary. [r]Revised.
[1]To domestic industry.

Legislation and Government Programs.—The Direct Service Industries (DSI), which include six domestic producers in the Pacific Northwest, appealed to the Supreme Court a ruling of the three-judge panel of the Federal Court of Appeals in San Francisco, CA, that gave public utilities the first rights to nonfirm power provided by the Bonneville Power Administration (BPA). The Supreme Court agreed to hear the dispute during the October 1983 term and scheduled early January 1984 for the presentation of arguments. A ruling was expected in June 1984. On December 23, DSI filed two lawsuits against BPA contesting the customer charge for unused contracted power resulting from aluminum production cutbacks. One suit filed in the Federal Court of Appeals, San Francisco, claimed that the customer charge violated the BPA-DSI contracts since the charge was not provided for in the contracts. The second suit, filed in the Washington Court of Claims, asked for total damages of $20 million per month for BPA industrial customers.

In a separate action, Portland General Electric Co., a utility that receives its power from BPA, filed a suit in the Federal Court of Appeals, San Francisco, criticizing BPA's authority to set a reduced rate for surplus power. Specifically, the suit challenged the rights of Martin Marietta Aluminum Inc. and Intalco Aluminum Corp. to cutrate power.

DOMESTIC PRODUCTION

Primary.—Domestic production of primary aluminum was 3,696,315 short tons in 1983. The increase in annual production capacity resulted from improved efficiency and upgrading of annual production facilities at the Aluminum Co. of America (Alcoa) smelters at Evansville, IN, and Wenatchee, WA; the Alumax Inc. smelter at Mount Holly, SC; and the National-Southwire Aluminum Co. smelter at Hawesville, KY.

At the beginning of the year, the operating rate of the primary smelters was 58%, with 2,282,300 tons of annual capacity shut down because of poor economic conditions and a weak aluminum market. Additional potline closings in January and February reduced the operating rate to 56.6%. At the beginning of March, the status of the U.S. primary aluminum industry was as follows: 2 smelters permanently closed, 6 temporarily shut down, 20 operating at reduced capacity, and 5 operating at full capacity. In April, producers began to restart idle potlines because of an increased demand for aluminum by the building and transportation industries. In addition, Pacific Northwest producers responded to BPA's offer to supply surplus power at a reduced rate. Idle potlines continued to be restarted throughout the remainder of the year because of increased demand, and by the end of the year, the U.S. primary aluminum operating rate was 78%. At yearend, the status of the industry was as follows: 2 smelters permanently closed, 5 temporarily shut down, 7 operating at reduced capacity, and 19 operating at full capacity. Plans were also announced for additional restarts of idle potlines in early 1984.

Facilities shut down during January and February of 1983 were as follows: Kaiser Aluminum and Chemical Corp., a 55,000-ton-per-year potline at Chalmette, LA; Arco Metals Co., a 36,000-ton-per-year potline at Columbia Falls, MT; and Intalco, a 14,000-ton-per-year potline at Ferndale, WA. Between April and yearend, production was restarted at Alcoa's smelters in Evansville, IN, Badin, NC, Alcoa, TN, Rockdale, TX, and Vancouver and Wenatchee, WA; at Kaiser's smelters in Spokane, WA, and Ravenswood, WV; at Reynolds Metals Co.'s smelters in Jones Mills, AR, Troutdale, OR, and Longview, WA; and at Arco's smelters in Sebree, KY, and Colombia Falls, MT. Potlines were also restarted at Consolidated Aluminum Corp.'s (CONALCO) smelter at New Johnsonville, TN; Intalco's smelter at Ferndale, WA; Martin Marietta's smelters at The Dalles, OR, and Goldendale, WA; National-Southwire Aluminum's smelter at Hawesville, KY; and Noranda Aluminum Inc.'s smelter at New Madrid, MO.

In August, Alumax purchased the assets of Howmet Aluminum Corp., Greenwich, CT, the U.S. subsidiary of Péchiney (formerly the Péchiney Ugine Kuhlmann Group), for a reported $235 million. The acquisition gave Alumax full ownership of Eastalco Aluminum Co. in Frederick, MD, and Intalco in Ferndale, WA, both of which were formerly jointly owned by Alumax and Howmet. Also included in the purchase were mill facilities in Hawesville, KY, and Lancaster, PA; home products facilities in Tifton, GA, Lakeland, FL, and Hutchinson, KS; fabrication and extrusion facilities; and sales and distribution operations. Alumax also acquired an option to a 25% share of the planned Bécancour smelter in Quebec, Canada.

Arco announced that it was searching for a partner to take a 40% share in its Colombia Falls, MT, smelter as a result of a reduced requirement for primary metal by the company.

In the third quarter, Kaiser wrote off 144,000 tons of annual production capacity at its 260,000-ton-per-year Chalmette, LA, smelter. Restart of the plant reportedly was unlikely. The smelter was shut down in February when the last two 27,500-ton-per-year potlines were idled.

Kaiser closed its Halethorpe, MD, hard extrusion plant at yearend reportedly because of uncompetitive labor costs compared with costs at similar facilities. In May, Kaiser sold its Woodbury, NY, extrusion plant, which supplied construction and transportation markets, to Davidson Aluminum and Metal Corp. At yearend, Kaiser announced that its Dolton, IL, extrusion plant would be closed by April 1984 because of an impasse with the local union over wage and benefit concessions. Kaiser's remaining extrusion operations are located in Los Angeles, CA, Sherman, TX, and Newark, OH. During 1983, Kaiser also sold its can body plants in Houston, TX, and Jacksonville, FL, and a lid making plant in Wanatah, IN, to the National Can Corp., Chicago, IL. Negotiations continued for Continental Can Co. Inc. to purchase can manufacturing plants in Edison, NJ, and Union City, CA, from Kaiser.

Reynolds permanently closed its Phoenix, AZ, extrusion and fabricating facility in October reportedly because of high production costs and a decline in the demand for extrusion products. Other closures during the year were the Macauley can manufacturing plant at Woodbridge, NJ, and the wire, rod, and bar facility at Listerhill, AL. A $125 million modernization of Reynolds' sheet and plate production complex in McCook, IL, included the addition of a single-stand, four-high cold-rolling mill, a horizontal roller hearth heat-treating line for plate, a computerized plate saw, and other fabrication equipment.

In November, Alcoa announced a $250 million investment in technology and equipment to modernize its Alcoa, TN, rolling facilities. The modernization, expected to be completed in 5 to 8 years, included increasing coil size capabilities, new casting technology, and the addition of a continuous multistand cold-rolling mill.

Reynolds purchased a carbon anode facility at Lake Charles, LA, formerly owned by CONALCO and renamed it Lake Charles Carbon Co. The new company was organized to produce calcined coke and carbon anodes used for the production of aluminum. Modernization of the plant began immediately with full production expected in 2 years. Reynolds reportedly had no plans to operate the 36,000-ton-per-year primary aluminum smelter at this facility that was shut down in August 1981.

In December 1983, Reynolds announced the permanent closing of its wire, rod, and bar operations at Listerhill, AL, by March 31, 1984, after local union members rejected a cut in wages. The operation was considered noncompetitive with similar plants, and the closing removed Reynolds from the wire, rod, and bar business. The alloys, recycling, and reduction plants at Listerhill were not affected by the closing.

In January, Kaiser and the United Steelworkers of America (USWA) agreed on several union contract changes for personnel at Kaiser's Ravenswood, WV, smelter. The plant was idle since January 1982. Under the agreement, workers reportedly exchanged work rules, seniority, and job combination rights for Kaiser's pledge to restart a Ravenswood potline prior to restarting other Kaiser facilities. A 40,000-ton-annual-capacity potline was started at Ravenswood in May.

Arco and workers at the Sebree, KY, smelter, represented by the Aluminum, Brick & Glass Workers International Union (ABGWIU), settled a 3-month strike in August. Under the new agreement, wages were frozen, but cost-of-living-allowance (COLA) increases after a 1-year freeze would follow every 0.5% change in the Consumer Price Index. The smelter was operating at 66% of annual capacity, and salaried personnel operated the smelter throughout the strike. In December, a 60,000-ton-per-year potline at Sebree was closed as a result of a power switch failure associated with freezing weather. The smelter was operating at 100% capacity prior to the emergency shutdown. Full operation of the potline was expected to be restored in March 1984.

The major aluminum producers and the USWA and ABGWIU in 1983 signed a new 3-year master labor contract expiring in May 1986. The contract included a freeze on wages, modified COLA provisions, and some cuts in benefits and bonuses. Similar contracts were signed by other producers and the unions; however, several smelters experienced work disruptions until agreements were finalized with local unions. By yearend, disagreements between management and the union were settled with the exception of the Metal Trade Council and the Ferndale, WA, smelter where negotiations were in progress.

In April, BPA offered producers in the Pacific Northwest surplus power at 11.2 mills per kilowatt hour (kW•h), a considerable reduction from the list rate of 24.6 mills/kW•h. The offer extended through October 31, when it was withdrawn. On November 1, BPA raised its power rate 9% from 24.6 to 26.8 mills/kW•h. The rate also included a provision for a customer demand charge of 7.34 mills/kW•h for power not used below 90% of full demand.

The Tennessee Valley Authority (TVA) increased its power rate from 35.9 to 37.8 mills/kW•h for nondisruptable power. In November, TVA offered producers surplus interruptible power at a rate of 25 mills/kW•h for plants operating between 20% and 50% of total capacity. Several smelters were negotiating with TVA for this lower cost power.

On December 8, the New York Commodity Exchange (COMEX) began trading aluminum futures for the first time. Contracts are sold for lots of 40,000 pounds of 99.5% or 99.7% metal in ingot, sow, or T-bars. Ninety-three producers from forty countries received approval for their product from COMEX.

The Toth Aluminum Corp., New Orleans, LA, announced plans to begin commercial production of aluminum and other metal chlorides in January 1984. The $8.5 million plant located in Yacherie, LA, reportedly has an annual capacity of 8,000 tons.

Secondary.—The secondary aluminum industry increased production and shipments of aluminum throughout 1983 because of increasing demand for metal by the transportation and construction markets. Primary producers continued to increase their utilization of aluminum scrap as a means of lowering energy costs for production of ingot. Because of low scrap inventories, increased purchases of scrap by the Japanese, and competition for scrap material between primary and secondary producers, scrap prices rose rapidly during the year.

Used beverage can scrap (UBC) continued to be the largest source of old aluminum scrap. Recycled UBC consumed was 574,000 tons, a 2% increase compared with the 564,000 tons consumed in 1982. Recycled UBC was equivalent to 46.7% of the 1.23 million tons of aluminum beverage cans used in 1983.[3] Furthermore, for past 2 years, the percentage of cans recycled declined, decreasing from 49.2% in 1981. The decline occurred although there was an increasing use of aluminum cans each year.

In 1983, nine States had "bottle-bill" legislation that placed a mandatory deposit on beverage containers. Mandatory deposit legislation originally was intended to reduce litter by encouraging the use of returnable glass bottles. However, aluminum has often replaced steel, glass, and plastic as a packaging material reportedly because of its redemption value and ease of handling compared to the heavier container materials. The State of New York, where over 7% of the Nation's beer and soft drinks are sold annually in about 8 billion containers, about one-half of which are aluminum, implemented its mandatory deposit law in July. In most States that have enacted bottle-bill legislation, aluminum container returns have exceeded 90%.[4]

Zenith Metals Inc., a subsidiary of Industrial Mineral Products Co., closed its Los Angeles, CA, 1,200-ton-per-year secondary smelter in February as a result of poor economic conditions. The smelter, which was offered for sale, produced notch bars for deoxidizing ferrous materials. The Aluminum Smelting and Refining Co. Inc. began production of 15,000 tons per year of steel-mill deoxidizing notch bars at its previously closed 45,000-ton-per-year secondary smelter in Painsville, OH, in March.

Dow Chemical Co. acquired an interest in Metal Mark Inc. Metal Mark had four subsidiaries that processed up to 30,000 tons annually of aluminum-bearing drosses generated by primary, secondary, and other type aluminum plants, primarily located in the Midwest.

In October, Alumax formed the Alumax Recycling Group, which will operate the secondary aluminum smelters of its subsidiary Apex International Alloys Inc. The group will operate secondary aluminum operations in Cleveland, OH, and Bicknell, IN, and will have its headquarters in Des Plains, IL.

Alcan Aluminum Corp., Cleveland, OH, formed the Alcan Recycle Div. for processing UBC. The company installed $4.3 million of decoating and auxiliary equipment at its Greensboro, GA, recycling plant and planned to install $9 million of casting equipment for the production of 25,000- and 30,000-pound sheet ingots.

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

Company	1973	1983	1983
	Yearend capacity (thousand short tons)		Ownership (percent)
Alumax Inc.:			
Mount Holly, SC	--	200	AMAX Inc., 50%; Mitsui & Co., 45%; Nippon Steel Corp., 5%.
Aluminum Co. of America:			
Alcoa, TN	270	220	Aluminum Co. of America, 100%.
Badin, NC	120	127	Do.
Evansville (Warrick), IN	280	298	Do.
Massena, NY	135	226	Do.
Palestine, TX	--	16	Do.
Point Comfort, TX	185	--	Do.
Rockdale, TX	285	342	Do.
Vancouver, WA	115	121	Do.
Wenatchee, WA	180	226	Do.
Total	1,570	1,576	
Arco Metals Co.:[1]			
Colombia Falls, MT	180	180	Atlantic Richfield Co., 100%.
Sebree, KY	120	180	Do.
Total	300	360	
Consolidated Aluminum Corp.:			
Lake Charles, LA[2]	36	--	Swiss Aluminium Ltd., 100%.
New Johnsonville, TN	141	146	Do.
Total	177	146	
Eastalco Aluminum Co.:[3]			
Frederick, MD	88	176	Alumax Inc., 100%.
Intalco Aluminum Corp.:[3]			
Ferndale, WA	260	280	Do.
Kaiser Aluminum and Chemical Corp.:			
Chalmette, LA	260	260	Kaiser Aluminum and Chemical Corp., 100%.
Mead (Spokane), WA	206	220	Do.
Ravenswood, WV	163	164	Do.
Tacoma, WA	81	80	Do.
Total	710	724	
Martin Marietta Aluminum Inc.:			
The Dalles, OR	90	90	Martin Marietta Corp., 87.2%; private interests, 12.8%.
Goldendale, WA	111	185	Do.
Total	201	275	
National-Southwire Aluminum Co.:			
Hawesville, KY	180	190	National Steel Corp., 50%; Southwire Co., 50%.
Noranda Aluminum Inc.:			
New Madrid, MO	70	225	Noranda Mines Ltd., 100%.
Ormet Corp.:			
Hannibal, OH	250	270	Revere Copper and Brass Inc., 34%; Consolidated Aluminum Corp., 66%.
Revere Copper and Brass Inc.:			
Scottsboro, AL	112	116	Revere Copper and Brass Inc., 100%.
Reynolds Metals Co.:			
Arkadelphia, AR	68	68	Reynolds Metals Co., 100%.
Corpus Christi, TX	114	114	Do.
Jones Mills, AR	125	125	Do.
Listerhill, AL	202	202	Do.
Longview, WA	210	210	Do.
Massena, NY	126	126	Do.
Troutdale, OR	130	130	Do.
Total	975	975	
Grand total	4,893	5,513	

[1]Purchased from Anaconda Aluminum Co. in 1982.
[2]Sold to Reynolds Metals Co. in 1983.
[3]Equity share sold by Howmet Inc. in 1983.

CONSUMPTION

The packaging industry continued to be the major consumer of aluminum. Approximately 1.23 million tons of aluminum was used to make 56.6 billion cans,[5] assuming 23 cans to the pound. An aluminum beverage bottle, a new type of recyclable container, was introduced in Oshkosh and Eau Claire, WI, by Pepsico Inc. and in Pensacola, FL, and Mobile, AL, by Dr. Pepper Inc. during a test-marketing period. The unique features of the container are its resealability and adaptability to be filled by conventional bottling machinery.[6] Continental Can manufactured the bottle on a pilot line in Baltimore, MD. Alcoa and Continental Can entered a joint venture to produce a two-piece aluminum food can scheduled for possible production in mid-1984.[7] The cans, using 5042 aluminum alloy, were to be manufactured by a drawing process from as-rolled metal sheet and were to have a higher height-to-diameter ratio than present cans made from precoated aluminum sheet. Acting on a petition based on research by Reynolds, the Food and Drug Administration amended its regulation on processing food in retortable pouches to allow foods to be processed at temperatures up to 135° C.[8] The number of food products and the quality of food available in aluminum-laminated pouches were expected to increase as a result of the amendment.

Domestic passenger car sales increased during 1983, increasing the demand for aluminum metal. However, the weight of aluminum utilized in new models did not increase. Lower interest rates and a higher employment rate were the leading causes for increased use of aluminum in the construction of homes and buildings and the production of consumer durables.

Table 3.—Consumption of and recovery from purchased new and old aluminum scrap[1] in the United States, by class

(Short tons)

Class	Consumption	Calculated recovery	
		Aluminum	Metallic
1982			
Secondary smelters	888,828	712,847	769,555
Primary producers	741,713	621,509	666,280
Fabricators	218,128	186,024	199,175
Foundries	90,315	76,080	81,871
Chemical producers	39,904	17,683	18,300
Total	1,978,888	1,614,143	1,735,181
Estimated full industry coverage	2,095,000	1,707,000	1,836,000
1983			
Secondary smelters	905,379	725,033	783,445
Primary producers	853,133	716,809	768,322
Fabricators	212,216	181,900	194,654
Foundries	95,489	79,652	85,678
Chemical producers	41,413	18,840	19,466
Total	2,107,630	1,722,234	1,851,565
Estimated full industry coverage	2,226,000	1,817,000	1,954,000

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

Table 4.—Aluminum recovered from purchased scrap processed in the United States, by kind of scrap and form of recovery

(Short tons)

	1982	1983
KIND OF SCRAP		
New scrap:		
Aluminum-base	[1]855,429	[2]924,453
Copper-base	103	[e]90
Zinc-base	176	273
Magnesium-base	167	193
Total	[r]855,875	[e]925,009
Old scrap:		
Aluminum-base[3]	758,714	797,720
Copper-base	49	[e]45
Zinc-base	670	711
Magnesium-base	322	322
Total	[r]759,755	[e]798,798
Grand total	[r]1,615,630	[e]1,723,807
FORM OF RECOVERY		
Unalloyed	387	433
Aluminum alloys	1,572,174	1,678,688
In brass and bronze	152	[e]135
In zinc-base alloys	846	984
In magnesium alloys	489	515
Dissipative forms	41,582	43,052
Total	[r]1,615,630	[e]1,723,807

[e]Estimated. [r]Revised.

[1]The amount of aluminum alloys recovered from aluminum-base scrap in 1982, including all constituents, was 913,189 tons from new scrap and 821,992 tons from old scrap and sweated pig, a total of 1,735,181 tons.

[2]The amount of aluminum alloys recovered from aluminum-base scrap in 1983, including all constituents, was 986,952 tons from new scrap and 864,613 tons from old scrap and sweated pig, a total of 1,851,565 tons.

[3]Includes recovery in deoxidizing ingot assuming 85% aluminum content in such ingot.

Table 5.—Stocks, receipts, and consumption of purchased new and old aluminum scrap[1] and sweated pig in the United States in 1983

(Short tons)

Class of consumer and type of scrap	Stocks, Jan. 1	Net receipts[2]	Consumption	Stocks, Dec. 31
Secondary smelters:				
New scrap:				
Solids and clippings	17,513	259,850	260,307	17,056
Borings and turnings	12,791	156,038	156,535	12,294
Foil	W	W	W	W
Dross and skimmings	7,872	88,198	86,243	9,827
Other[3]	250	17,333	17,273	310
Total	38,426	521,419	520,358	39,487
Old scrap:				
Castings, sheet, clippings	12,552	174,051	175,787	10,816
Aluminum-copper radiators	1,452	24,303	23,053	2,702
Aluminum cans	2,226	[4]102,295	[4]102,357	2,164
Other	202	7,698	7,761	139
Total	16,432	308,347	308,958	15,821
Sweated pig	10,405	73,789	76,063	8,131
Total secondary smelters	65,263	903,555	905,379	63,439
Primary producers, foundries, fabricators, chemical plants:				
New scrap:				
Solids and clippings	24,414	501,952	498,719	27,647
Borings and turnings	374	28,346	28,140	580
Foil	W	W	W	W
Dross and skimmings	830	35,371	35,406	795
Other[3]	3,565	39,952	38,258	5,259
Total	29,183	605,621	600,523	34,281
Old scrap:				
Castings, sheet, clippings	987	90,012	90,020	979
Aluminum-copper radiators	55	1,368	1,345	78
Aluminum cans	17,590	[4]469,658	[4]471,825	15,423
Other	2,027	24,978	24,586	2,419
Total	20,659	586,016	587,776	18,899
Sweated pig	1,046	13,565	13,952	659
Total primary producers, etc	50,888	1,205,202	1,202,251	53,839
All scrap consumed:				
New scrap:				
Solids and clippings	41,927	761,802	759,026	44,703
Borings and turnings	13,165	184,384	184,675	12,874
Foil	2,208	8,219	8,031	2,396
Dross and skimmings	8,702	123,569	121,649	10,622
Other	1,607	49,066	47,500	3,173
Total new scrap	67,609	1,127,040	1,120,881	73,76[illegible]
Old scrap:				
Castings, sheet, clippings	13,539	264,063	265,807	11,79[illegible]
Aluminum-copper radiators	1,507	25,671	24,398	2,78[illegible]
Aluminum cans	19,816	571,953	574,182	17,58[illegible]
Other	2,229	32,676	32,347	2,55[illegible]
Total old scrap	37,091	894,363	896,734	34,72[illegible]
Sweated pig	11,451	87,354	90,015	8,79[illegible]
Total of all scrap consumed	116,151	2,108,757	2,107,630	117,27[illegible]

W Withheld to avoid disclosing company proprietary data.

[1]Includes imported scrap. According to reporting companies, 6.0% of total receipts of aluminum-base scrap, or 125,82[illegible] short 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 6.—Production and shipments of secondary aluminum alloys by independent smelters in the United States

(Short tons)

	1982		1983	
	Production	Net shipments[1]	Production	Net shipments[1]
Die-cast alloys:				
13% Si, 360, etc. (0.6% Cu, maximum)	94,899	94,277	103,786	103,743
380 and variations	381,456	382,153	391,837	396,685
Sand and permanent mold:				
95/5 Al-Si, 356, etc. (0.6% Cu, maximum)	34,618	34,954	36,705	36,662
No. 12 and variations	W	W	W	W
No. 319 and variations	47,580	47,192	48,828	49,330
F-132 alloy and variations	10,717	11,176	10,463	10,728
Al-Mg alloys	661	819	610	681
Al-Zn alloys	5,058	5,188	5,363	5,234
Al-Si alloys (0.6% to 2.0% Cu)	4,759	4,842	6,009	6,051
Al-Cu alloys (1.5% Si, maximum)	3,352	3,464	3,236	3,443
Al-Si-Cu-Ni alloys	13,781	13,689	5,201	5,330
Other	2,448	2,590	2,437	2,491
Wrought alloys: Extrusion billets	106,426	106,507	118,994	122,088
Destructive and other uses: Steel deoxidation:				
Grades 1, 2, 3, and 4	28,116	27,926	28,467	27,874
Miscellaneous:				
Pure (97.0% Al)	399	638	446	482
Aluminum-base hardeners	972	1,173	1,748	1,635
Other[2]	19,363	19,247	15,971	16,137
Total	754,605	755,835	780,101	788,594
Less consumption of materials other than scrap:				
Primary aluminum	40,262	--	44,675	--
Primary silicon	39,593	--	41,913	--
Other	2,405	--	3,406	--
Net metallic recovery from aluminum scrap and sweated pig consumed in production of secondary aluminum ingot[3]	672,345	--	690,107	--

W Withheld to avoid disclosing company proprietary data; included with "Other" under "Sand and permanent mold."
[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 7.—Apparent aluminum supply and consumption in the United States

(Thousand short tons)

	1979	1980	1981	1982	1983
Primary production	5,023	5,130	4,948	3,609	3,696
Change in stocks:[1] Aluminum industry	+184	+25	-765	+203	+595
Imports	840	713	935	968	1,203
Secondary recovery:[2]					
New scrap	1,163	1,058	1,137	974	1,050
Old scrap	614	680	836	862	904
Total supply	7,824	7,606	7,091	6,616	7,448
Less total exports	773	1,483	867	824	855
Apparent aluminum supply available for domestic manufacturing	7,051	6,123	6,224	5,792	6,593
Apparent consumption[3]	5,888	5,065	5,087	4,818	5,543

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

Industry	1981 Quantity (thousand short tons)	1981 Percent of total	1982 Quantity (thousand short tons)	1982 Percent of total	1983p Quantity (thousand short tons)	1983p Percent of total
Building and construction	1,265	18.8	1,159	18.5	1,441	19.8
Transportation	1,072	15.9	925	14.8	1,192	16.4
Containers and packaging	1,756	26.1	1,784	28.5	1,959	26.9
Electrical	666	9.9	579	9.2	662	9.1
Consumer durables	488	7.2	411	6.6	528	7.3
Machinery and equipment	421	6.2	353	5.6	399	5.5
Other markets	318	4.7	268	4.3	297	4.1
Statistical adjustment	+68	1.0	+131	2.1	+176	2.4
Total to domestic users	6,054	89.8	5,610	89.6	6,654	91.5
Exports	685	10.2	648	10.4	620	8.5
Grand total	6,739	100.0	6,258	100.0	7,274	100.0

pPreliminary.

Source: The Aluminum Association Inc.

Table 9.—Net shipments of aluminum wrought[1] and cast products in the United States, by producers

(Short tons)

	1981	1982	1983p
Wrought products:			
Sheet, plate, foil	3,414,272	3,030,142	3,579,079
Rolled and continuous-cast rod and bar; wire	r520,339	431,223	475,298
Extruded rod, bar, pipe, tube, shapes; drawn and welded tubing	r1,110,932	1,004,640	1,149,089
Powder, flake, paste	53,873	39,986	39,333
Forgings (including impacts)	69,501	52,105	58,106
Total	r5,168,917	4,558,096	5,300,905
Castings:[2]			
Sand	r119,079	89,208	111,709
Permanent mold	r145,783	119,586	140,086
Die	r578,432	529,135	480,528
Other	r66,596	64,731	17,423
Total	r909,890	802,660	749,746
Grand total	r6,078,807	5,360,756	6,050,651

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.

[2] U.S. Department of Commerce revised this series of data going back to 1962.

Source: U.S. Department of Commerce.

Table 10.—Distribution of wrought products in the United States

(Percent)

	1981	1982	1983^{p}
Sheet, plate, foil:			
Nonheat-treatable	54.3	55.4	56.7
Heat-treatable	3.6	3.1	3.1
Foil	8.2	8.0	7.8
Rolled and continuous-cast rod and bar; wire:			
Rod, bar, wire	3.3	2.7	2.5
Cable and insulated wire	6.8	6.8	6.5
Extruded products:			
Rod and bar	1.0	1.0	1.2
Pipe and tubing	^{r}1.2	1.1	1.3
Shapes	^{r}17.4	18.7	18.0
Tubing:			
Drawn	.7	.7	.6
Welded	1.1	.5	.5
Powder, flake, paste	1.0	.9	.7
Forgings (including impacts)	1.4	1.1	1.1
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, decreased from 3,099,740 tons at the end of 1982 to 2,504,616 tons at the end of 1983.

PRICES

The producer list price for 99.5%-pure aluminum ingot was 76 cents per pound from the beginning of the year until late August, when the major producers increased the list price to 81 cents. Within a few weeks, most other producers raised their list price to 81 cents, where it remained through yearend. During midyear and early September, a few producers abolished their producer list price and instituted a transaction or selling price more comparable with the market or spot prices. For 99.7%-pure aluminum ingot, the producer list price was normally 0.5 cent above that for 99.5% ingot. The average annual spot, or market, price for aluminum ingot, usually 99.7%-pure, as published by Metals Week (McGraw-Hill) was 68.3 cents per pound. The average monthly spot price was 50.6 cents per pound at the beginning of the year, decreased to 42 cents in February, then increased to an average of 79 cents by the first week of September. For the remainder of the year, the average spot price fluctuated between 73 and 76 cents per pound, ending the year at a December average of 75.2 cents. On December 8, the initial opening price on the COMEX was 77.4 cents per pound for aluminum deliveries in March 1984. The COMEX price remained steady, closing out 1983 at 77.1 cents per pound. Prices on the London Metal Exchange (LME) began the year at an average of 45 cents per pound. By September, the average price for LME aluminum was 73.2 cents, but prices slowly fell to 68.7 cents in November before closing out the year at an average price of 70.2 cents per pound. The average annual LME price was about 65.3 cents per pound.

The price of secondary alloyed ingot as quoted in the American Metal Market, increased throughout the year from a range of 46 to 49 cents per pound at the beginning of 1983 to a high range of 77 to 89 cents in September and October. After a slight dip in price in November, the secondary ingot price at yearend ranged from 77 to 88 cents per pound. Depending on the location of the material, the price of aluminum borings and cast scrap ranged from 8 to 17 cents at the beginning of the year to 24 to 36 cents by yearend. Segregated aluminum-copper clippings price ranged from 21 to 25 cents in January and 40 to 54 cents at yearend. The price for both types of scrap was a few cents lower in November.

FOREIGN TRADE

U.S. tariff rates in effect during 1983 for aluminum products were as follows:[9]

Item	TSUS No.	Import duty
Unwrought metal (in coils)	618.01	2.9% ad valorem.
Unwrought (other than Si-Al alloys)	618.02	0.5 cent per pound.
Wrought (bars, plates, sheets, strip)	618.25	3% ad valorem.
Waste and scrap	618.10	2% ad valorem.

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

Class	1982 Quantity (short tons)	1982 Value (thousands)	1983 Quantity (short tons)	1983 Value (thousands)
Crude and semicrude:				
Ingots, slabs, crude	401,174	$476,186	397,608	$534,048
Scrap	214,299	157,666	262,159	249,156
Plates, sheets, bars, etc.	193,837	440,373	178,898	388,679
Castings and forgings	7,180	41,156	10,492	55,346
Semifabricated forms, n.e.c	7,979	42,874	5,924	32,578
Total	824,469	1,158,255	855,081	1,259,807
Manufactures:				
Foil and leaf	18,632	34,163	19,316	31,742
Powders and flakes	3,041	9,590	2,135	7,058
Wire and cable	27,625	66,259	20,686	45,999
Total	49,298	110,012	42,137	84,799
Grand total	873,767	1,268,267	897,218	1,344,606

Table 12.—U.S. exports of aluminum, by country

Country	1982						1983					
	Metals and alloys, crude		Plates, sheets, bars, etc.[1]		Scrap		Metals and alloys, crude		Plates, sheets, bars, etc.[1]		Scrap	
	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)
Australia	164	$373	1,648	$5,690	233	$331	1,412	$1,717	1,313	$5,225	1	$7
Belgium-Luxembourg	18	43	2,072	3,676	3,827	3,094	138	163	1,592	4,572	779	850
Brazil	578	1,319	689	3,145	4,013	2,770	93	595	491	1,912	62	66
Canada	18,360	26,191	92,570	206,366	24,402	18,508	15,023	25,612	109,000	244,491	28,322	25,457
Chile	413	595	219	1,022	192	281	335	412	70	358	325	425
China	--	--	34	209	--	--	61,674	86,560	20	135	--	--
Colombia	158	268	446	1,277	115	129	574	810	585	1,948	3	8
France	2,995	4,488	1,373	8,047	438	483	153	493	919	6,346	381	316
Germany, Federal Republic of	170	410	2,859	11,307	4,880	3,915	129	804	3,114	10,755	2,639	2,054
Hong Kong	303	849	1,813	6,353	90	145	72	117	844	2,422	80	112
India	--	--	1,468	2,607	99	81	43	175	61	308	271	254
Ireland	1	12	1,040	4,273	--	--	1	17	2,168	4,182	--	--
Israel	30	184	2,399	7,393	24	25	72	255	3,061	9,390	11	1
Italy	109	1,346	3,188	15,158	3,060	1,046	31	377	4,813	15,348	664	630
Japan	344,608	392,173	3,528	20,080	146,357	106,078	279,184	355,117	4,098	15,871	206,009	200,112
Korea, Republic of	2,224	2,898	1,023	3,797	2,304	1,812	5,279	8,125	1,943	6,160	1,291	938
Malaysia	39	45	176	312	--	--	1,160	1,774	25	126	--	--
Mexico	13,186	19,521	36,687	77,861	15,168	12,816	6,505	11,816	8,827	18,204	13,860	11,806
Netherlands	1,116	1,086	2,745	10,832	2,002	1,509	40	142	3,015	11,557	164	153
Pakistan	1,762	1,975	4,119	4,961	19	21	--	--	13	47	60	38
Saudi Arabia	48	156	3,213	12,567	4	13	39	216	1,864	5,175	--	--
Singapore	1,113	1,444	476	1,819	119	98	338	552	567	2,392	5	3
South Africa, Republic of	2	8	619	1,705	696	771	--	--	373	1,071	3,072	2,975
Spain	26	68	932	3,777	3,493	2,115	1	9	769	2,690	616	271
Sweden	208	443	3,848	9,203	--	--	27	129	7,856	21,676	20	2
Taiwan	2,471	3,014	1,701	10,938	1,724	975	18,097	25,189	1,487	9,688	2,646	1,558
Thailand	5,170	6,540	301	880	63	76	2,771	4,079	745	2,219	1	8
United Kingdom	623	1,369	21,283	41,915	596	301	281	649	23,609	39,441	101	179
Venezuela	593	1,205	7,012	17,053	11	15	7	36	5,572	11,303	--	--
Other	r4,686	r8,163	r9,515	r30,180	r370	r258	4,129	8,108	6,500	21,591	776	933
Total	401,174	476,186	208,996	524,403	214,299	157,666	397,608	534,048	195,314	476,603	262,159	249,156

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

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

Class	1982		1983	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Crude and semicrude:				
Metals and alloys, crude	679,375	$858,017	818,676	$1,021,273
Circles and disks	8,202	16,245	9,565	18,154
Plates, sheets, etc., n.e.c	199,844	384,657	260,204	487,003
Rods and bars	5,658	11,670	15,260	26,467
Pipes, tubes, etc	639	3,461	1,585	5,695
Scrap	74,338	54,240	97,524	87,468
Total	968,056	1,328,290	1,202,814	1,646,060
Manufactures:				
Foil	9,664	41,180	14,619	47,078
Leaf	(1)	102	(1)	99
Flakes and powders	2,758	4,436	4,147	6,406
Wire	971	2,236	1,679	3,549
Total	13,393	47,954	20,445	57,132
Grand total	981,449	1,376,244	1,223,259	1,703,192

[1]1982—aluminum leaf not over 30.25 square inches in area, 537,541 leaves, and aluminum leaf over 30.25 square inches in area, 85,990,034 square inches; 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.

Table 14.—U.S. imports for consumption of aluminum, by country

Country	1982						1983					
	Metals and alloys, crude		Plates, sheets, bars, etc.[1]		Scrap		Metals and alloys, crude		Plates, sheets, bars, etc.[1]		Scrap	
	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)
Argentina	3,807	$4,602	4,210	$5,540	--	--	2,110	$2,640	5,267	$7,272	--	--
Australia	2	4	15,372	29,367	--	--	--	--	15,727	28,481	--	--
Austria	--	--	1,440	3,081	--	--	22	24	1,845	3,762	--	--
Belgium-Luxembourg	738	1,033	18,344	30,099	665	$328	837	972	20,335	31,692	1,568	$1,766
Brazil	58	55	275	432	--	--	12,991	17,519	819	1,271	--	--
Canada	462,300	529,358	26,032	52,361	58,794	46,562	610,697	748,465	45,093	88,175	73,924	66,886
Egypt	--	--	--	--	--	--	2,965	3,745	--	--	--	--
France	2,115	2,649	10,994	24,562	44	27	3,707	4,642	14,813	30,554	205	200
Germany, Federal Republic of	5,101	9,409	13,783	27,267	1,882	1,526	9,739	15,038	11,635	24,592	596	717
Ghana	188,407	289,210	--	--	--	--	43,815	66,564	--	--	--	--
Hong Kong	--	--	1,696	2,919	332	176	--	--	1,819	2,967	160	87
Hungary	--	--	1,138	1,598	--	--	--	--	3,410	4,405	--	--
Israel	--	--	894	3,473	702	349	417	469	2,138	6,494	431	220
Italy	572	482	5,202	9,000	(2)	3	12,493	15,544	5,705	9,228	262	280
Japan	59	381	88,324	173,895	4	3	183	404	116,539	218,207	53	31
Mexico	134	67	266	290	6,994	2,143	550	319	308	453	4,601	3,843
Netherlands	218	353	3,159	10,622	57	48	816	794	5,046	19,116	703	432
Norway	1,299	1,662	7,127	11,057	--	--	107	204	12,204	17,303	468	542
Romania	--	--	837	1,309	--	--	5,518	8,259	33	53	--	--
South Africa, Republic of	1,649	2,489	1	4	--	--	11,682	14,860	--	--	--	--
Spain	551	740	1,318	2,155	83	89	1,859	2,575	332	611	103	73
Sweden	663	805	709	2,443	--	--	1	2	1,362	4,228	--	--
Switzerland	1,211	1,800	863	1,824	--	--	956	1,147	1,851	3,510	--	--
United Arab Emirates	--	--	--	--	--	--	10,363	13,342	60	71	--	--
United Kingdom	2,463	2,918	4,777	9,610	3,569	2,292	26,953	28,328	2,226	6,678	9,083	8,152
Venezuela	6,155	8,228	563	786	--	--	54,118	67,683	7,399	11,136	2,864	2,783
Yugoslavia	--	--	6,700	11,682	--	--	4,437	5,973	9,151	14,255	11	26
Other	[r]1,873	[r]1,772	[r]319	[r]657	1,212	694	1,340	1,761	1,497	2,805	2,492	1,430
Total	679,375	858,017	214,343	416,033	74,338	54,240	818,676	1,021,273	286,614	537,319	97,524	87,468

[r]Revised.
[1]Includes circles, disks, rods, bars, pipes, tubes, etc.
[2]Less than 1/2 unit.

WORLD REVIEW

Because of the turnaround in world demand for aluminum, many of the canceled or deferred plans for, and construction of, capacity expansions or new smelters were activated. World annual capacity for primary aluminum increased about 360,000 tons as a result of new smelter potlines or other expansions in Australia, Brazil, Egypt, Indonesia, the Republic of South Africa, and Yugoslavia. France, however, closed down several old, low-capacity smelters.

World production of primary aluminum increased slightly; however, primary aluminum production in Europe and some Far Eastern countries showed little improvement compared with that of 1982, and in many countries, primary production decreased. Ghana decreased production owing to the lack of power caused by a severe drought. Japan continued to cutback production of aluminum because of the high cost of energy.

Primary aluminum inventories held by members of the International Primary Aluminum Institute (IPAI), which represent the bulk of stocks held outside the centrally controlled economies, decreased 31% to 2.23 million tons. IPAI reported that total inventory, including secondary aluminum, was 4.04 million tons at yearend.

Australia.—In September, Tomago Aluminium Co. Pty. Ltd. began production at the first 240-pot, 121,000-ton-per-year potline at its Tomago, New South Wales, primary smelter. Full production was expected in early 1984. A second 121,000-ton-per-year potline was scheduled to come on-stream in the third quarter of 1984. The smelter, using the most advanced technology and equipment for maximum power efficiency, was a joint venture of Péchiney Australia Pty. Ltd. (35%), Gove Alumina Ltd. (35%), Australian Mutual Provident Society (15%), VAW Australia Pty. Ltd. (12%), and Hunter Douglas Ltd. (3%).

Alcan Australia Ltd. announced it would resume construction of the partially completed third potline at its Kurri Kurri, New South Wales, primary smelter. The potline would increase capacity by 61,000 tons per year to 160,000 tons per year. Construction began in 1981 but was postponed in mid-1982 because of weak market conditions.

Alcoa of Australia and the Victoria State government reportedly were to each take a 25% interest in a planned 145,000-ton-per-year smelter at Portland. Together they were seeking partners to take the remaining 50% interest.

Brazil.—Cia. Brasileira de Alumínio announced plans to increase its capacity from 138,000 tons per year to 171,000 tons per year by 1985 at its Sorocaba, São Paulo, primary smelter.

The Alumar alumina-aluminum complex jointly owned by Alcoa Alumínio do Brasil S.A. (60%) and Shell Brasil S.A. (40%), a subsidiary of Billiton Metais S.A., was scheduled to start production in 1984 with a 551,000-ton-per-year alumina production plant and a 110,000-ton-per-year aluminum smelter at São Luis, Maranhão. Reportedly, further expansion of 110,000 tons per year of primary capacity was being considered for 1986, with Construcoes e Comercio Camargo Correa contributing 20% of the $235 million cost.

The Brazilian Government in 1983 granted Vereinigte Aluminium-Werke AG (VAW), Federal Republic of Germany, a second extension, until June 1986, to decide on building a $750 million, 242,000-ton-per-year smelter at Recife, Pernambuco.

Canada.—Taking advantage of low power rates, Canada maintained a high production rate of primary aluminum during 1983. Announced restarts for early 1984 were expected to increase the operating rates in Canada to 98%.

Péchiney of France and the Société Generale de Financement (SGF), the investment body of the Province of Quebec, signed an agreement providing guidelines for financing the 253,500-ton-per-year aluminum smelter at Bécancour, Quebec. The agreement provided for Péchiney to finance at least 51%, but no more than 67%, of the Can$1.5 billion cost of the project, and SGF was to finance no more than 33%. Construction of the smelter started in June with the laying of the foundation. The smelter, with two potlines of 240 pots each, will use Péchiney's latest aluminum technology. The first potline was scheduled to begin production of metal in early 1987.

Canadian Reynolds Metals Co. Ltd. is proceeding on schedule with its $500 million, 125,000-ton-per-year expansion of the Baie Comeau primary smelter in Quebec. Completion in late 1984 will increase Baie Comeau's production capacity to 300,000 tons per year.

VAW suspended negotiations with Hydro-Quebec, the Quebec government energy enterprise, for constructing a primary aluminum smelter in Quebec. VAW reportedly believed conditions were too uncertain.

Negotiations took place between the Province of Newfoundland government and Arco, on the possible construction of a $1 billion, 200,000-ton-per-year primary smelter, to be located either near Corner Brook on the Island of Newfoundland or near Goose Bay on the mainland in Labrador. Arco completed a preliminary economic feasibility study of the project in April.

Alcan started the second and third 63,000-ton-per-year potlines at its Grande Baie, Quebec, primary aluminum smelter as demand for metal increased. The potlines completed in 1981 and 1982 were not placed in operation because of poor market conditions. The second line began operation in September and the third in December 1983. Alcan reactivated a 23,700-ton-per-year potline at its Arvida, Quebec, aluminum smelter in June and one-half of a 44,000-ton-per-year potline at its Kitimat, British Columbia, smelter in July, raising the operating rates of these smelters to 95% and 100% of their annual production capacities, respectively. Alcan planned to begin construction of a new 275,000-ton-per-year aluminum smelter at Laterriere, Quebec, as part of a "rebuild" program in 1984. The Laterriere smelter was to replace a portion of the 476,000-ton-per-year Arvida smelter and was to use existing hydropower facilities.

The Province of Quebec announced that it would remove restrictions on the sale and use of aluminum beverage cans. Alcan, Canadian Reynolds, and several container manufacturing companies were installing and/or increasing capacity to produce aluminum can sheet and cans. The government of Quebec was reportedly considering a bottle-bill approach as a long-term policy for recycling aluminum cans.

China.—Construction of the largest aluminum plant in China began at Yemenkou in Shanxi Province. The plant was expected to have an initial annual capacity of 220,000 tons of aluminum, with the first stage of the plant scheduled for completion by 1986.

Representatives of the Chinese aluminum industry met with Japanese primary aluminum producers to negotiate the purchase by China of at least 110,000 tons per year of primary capacity. Reportedly, negotiations on acquiring part of the idled 180,000-ton-per-year Naoetsu smelter in Japan were conducted with Mitsubishi Light Metal Industries Co. Ltd. If successful, the plant would be dismantled and reassembled in China.

Egypt.—The Aluminium Co. of Egypt (Egyptal) completed construction of two new potlines totaling 36,000 tons per year at its Nag Hamadi smelter, increasing capacity to 183,000 tons per year. In addition, Egyptal installed a new casthouse for forming billets and slabs.

France.—Péchiney announced plans to restructure its primary aluminum activities in France. The St. Jean de Maurienne smelter would be increased from 44,000 to 132,000 tons per year capacity by 1985, at an estimated cost of $130 million. In addition, the 4,400-ton-per-year La Saussaz and the 13,200-ton-per-year La Praz smelters were closed in 1983; the 26,500-ton-per-year Sabart smelter was to be closed by yearend 1984; and the 43,000-ton-per-year Argentière smelter by 1985.

Germany, Federal Republic of.—The Federal and state governments agreed to a $3.2 million, 1-year subsidy to reduce power costs at Alcan Aluminium-Werke GmbH's primary smelter at Ludwigshafen.

Ghana.—In February, Volta Aluminium Co. (VALCO) closed the third 44,000-ton-per-year potline at the Tema aluminum smelter at the request of the Volta River Authority. Two 44,000-ton-per-year potlines were previously shut down in 1982. In June, the remaining two potlines were idled because of inadequate energy supply caused by extremely low water levels at Volta Lake because of drought for the last 8 years.

VALCO and the Government of Ghana began negotiations to revise the power rates paid by VALCO. The last revision to the 1962 agreement was made in 1977 setting the power rates at 6 mills/kW•h. After several rounds of discussion, the negotiations remained deadlocked.

Iceland.—After many months of negotiations, the Government of Iceland and Swiss Aluminium Ltd. (Alusuisse) reached an interim agreement for an Alusuisse subsidiary, Icelandic Aluminium Co. Ltd., to pay a surcharge for power. Reportedly, the power rate increased from 6.45 to 10 mills/kW•h. Further negotiations on tax provisions, smelter expansion, and participation by the Government were planned.

India.—A new 275-megawatt captive power generator came on-stream in April at Hindustan Aluminium Co. Ltd.'s 132,000-ton-per-year primary smelter in Renukoot, Uttar Pradish. Reportedly, the company requested permission to build two additional 67.5-megawatt generators in order to raise primary capacity to 221,000 tons per year.

Bharat Aluminium Co. was granted a license to build a 270-megawatt captive powerplant at its 110,000-ton-per-year smelter at Korba, Madhya Pradish. The plant was scheduled to become operational in 1986 or 1987. Persistent power shortages had prevented the startup of two of the smelter's 27,500-ton-per-year potlines since their completion in 1979.

Indonesia.—Indonesia Asahan Aluminium Co. completed the second 83,000-ton-per-year potline at its primary smelter at Kuala Tanjung, North Sumatra. A third 83,000-ton-per-year potline was scheduled to come on-stream in 1984.

Iran.—An expansion program at Arak Aluminium Co.'s primary smelter reportedly was more than one-half completed at an estimated cost of $47 million. The program was to increase capacity from 50,000 to 132,000 tons per year by 1986.

Italy.—The Italian state-owned aluminum company, Ente Participazione Finanziamento Industria Manifattura, closed its 22,000-ton-per-year smelter at Mori and a major fabricating plant near Genoa reportedly because of severe financial problems.

Japan.—Showa Light Metal Co. Ltd. was reorganized as an Australian-Japanese joint venture equally owned by Conzinc Riotinto of Australia Ltd. (CRA) and Japan's Showa Denko K.K. CRA purchased the 50% interest for $104 million at the end of 1982. Showa Light Metal had a total capacity of 84,000 tons per year but was operating at a rate of 22,000 tons per year when the venture was finalized.

Mitsubishi Light Metal separated its aluminum smelting operations into a new company called Ryoka Light Metal Industries. Ryoka was to operate the 84,000-ton-per-year Sakaide smelter at a rate of 44,000 tons per year in place of Mitsubishi Light Metal, which was to concentrate on aluminum fabricating activities.

Nippon Light Metal Co. Ltd. reportedly was to separate its Tomakomai smelter operation as an independent company. The 79,000-ton-per-year smelter was operating at a rate of about 17,000 tons per year.

Philippines.—Plans of Reynolds and the Philippine Government, as equal partners, to build a $400 million aluminum smelter complex were deferred.

South Africa, Republic of.—Alusaf Pty. Ltd. completed a $257 million expansion of its smelter at Richards Bay by doubling capacity to 190,000 tons per year. Alusaf purchased two potlines from Nippon Light Metal when the Japanese company closed its smelter at Niigata, Japan, in 1980. The potlines were dismantled and shipped to Richards Bay in 1981.

Spain.—Péchiney and the Spanish state-owned industrial group, Instituto Nacional de Industria (INI) reportedly signed an agreement wherein, by yearend, INI would replace Péchiney as the majority shareholder in the primary aluminum producer, Alúminio de Galicia S.A. (Alugasa). Péchiney's share was reduced from a 67.2% interest in Alugasa to 37%. A separate agreement between Alcan and INI reduced Alcan's share of Empresa Nacional del Alúminio S.A. from 42.5% to 36%.

United Kingdom.—British Alcan Aluminium Ltd., the company formed in 1982 from British Aluminium and Alcan (UK), consolidated operations of the two former companies. British Alcan closed rolling mill operations at Falkirk, an alloy extrusion plant and rolling mill at Rogerstone, and foil mills at Kitts Green and Wembley. Production by High Duty Alloy Extrusions, a subsidiary of British Alcan, with plants at Distington, Cumbria, and Latchford, was increased.

Alcoa Manufacturing (GB) Ltd., Swansea, Wales, the only can stock manufacturer in the United Kingdom, announced that production of can stock would be terminated in January 1984. The high cost of aluminum was reportedly uncompetitive with tinplate, which was receiving state subsidies.

Kawecki-Billiton ceased production of aluminum master alloys ingots at its 1,500-ton-per-year Darley Dale, Derbyshire, plant.

Zaire.—The Aluzaire consortium, led by Alusuisse, was seeking $650 million in external financing to construct a 231,000-ton-per-year aluminum smelter at Banana. Total cost of the project was estimated at $1 billion. Alusuisse held a 20% share of the consortium; Zaire, 15%; VAW, Norsk-Hydro AS, Aluminio Italia, Energoinvest, and Yoshida Kogya, 10% each; and Alumined Beheer, 5%. Ten percent remained unallocated following the withdrawal of Sumitomo Chemical Co. Ltd. A feasibility study for the smelter was completed by Alusuisse.

Table 15.—Aluminum: World production,[1] by country

(Thousand short tons)

Country	1979	1980	1981	1982[p]	1983[e]
Argentina	131	147	148	152	150
Australia	297	335	418	420	[2]524
Austria	102	104	104	104	104
Bahrain	139	139	156	188	188
Brazil	263	287	283	330	442
Cameroon	48	48	41	[e]41	40
Canada	[r]904	[r]1,177	1,230	1,174	[2]1,203
China[e]	400	400	400	410	420
Czechoslovakia	41	42	36	37	37
Egypt	[r]112	132	148	155	165
France	436	476	480	430	[2]398
German Democratic Republic[e]	66	66	66	[r]64	66
Germany, Federal Republic of	817	806	804	797	805
Ghana	186	207	210	192	[2]47
Greece	155	161	[e]162	[r][e]149	154
Hungary	79	81	82	82	82
Iceland	80	81	82	85	86
India	233	204	235	239	225
Indonesia	--	--	--	34	128
Iran[e]	15	11	6	[r]40	40
Italy	297	299	298	298	[2]216
Japan[3]	1,114	1,203	849	387	282
Korea, North[e]	11	11	11	11	11
Korea, Republic of	24	[r]19	19	17	[2]14
Mexico	48	47	48	45	44
Netherlands	284	285	289	277	260
New Zealand	170	171	170	184	[2]261
Norway	732	720	698	702	[2]789
Poland[4]	106	105	73	[e]47	46
Romania[5]	239	266	267	229	230
South Africa, Republic of	95	95	96	118	180
Spain	286	426	437	404	394
Suriname[6]	71	51	35	66	55
Sweden	90	90	91	87	[2]91
Switzerland	91	95	91	83	[2]84
Taiwan	62	70	34	[e]11	[2]--
Turkey	35	[r]37	44	40	32
U.S.S.R.[e]	1,930	1,940	1,980	2,070	2,200
United Arab Emirates: Dubai	--	28	117	[r][e]160	127
United Kingdom	396	413	374	265	275
United States	5,023	5,130	4,948	3,609	[2]3,696
Venezuela	251	[r]361	346	[r]297	380
Yugoslavia	185	178	190	272	[2]313
Total	[r]16,044	[r]16,944	16,596	14,802	15,284

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

[1]Output of primary unalloyed ingot unless otherwise specified. Table includes data available through May 23, 1984.

[2]Reported figure.

[3]Includes high-purity aluminum containing 99.95% or more as follows, in short tons: 1979—4,238 (revised); 1980—4,691 (revised); 1981—6,859 (revised); 1982—4,790 (revised); and 1983—2,953.

[4]Includes secondary unalloyed ingot.

[5]Includes primary alloyed ingot.

[6]Data represent exports.

Table 16.—Aluminum: World capacity, by continent and country[1]

(Thousand short tons)

Continent and country	1981	1982	1983
North America:			
Canada	1,299	1,360	1,360
Mexico	50	50	50
United States	5,467	r5,498	5,513
South America:			
Argentina	154	154	154
Brazil	306	r446	462
Suriname	r66	r66	66
Venezuela	446	446	446
Europe:			
Austria	101	101	101
Czechoslovakia	66	66	66
France	r434	r434	417
German Democratic Republic	94	94	94
Germany, Federal Republic of	804	832	833
Greece	160	160	160
Hungary	84	84	84
Iceland	95	95	95
Italy	315	304	304
Netherlands	293	293	293
Norway	777	r881	882
Poland	61	61	61
Romania	275	275	275
Spain	439	439	439
Sweden	90	90	90
Switzerland	95	95	95
U.S.S.R	r2,535	r2,547	2,557
United Kingdom	421	309	309
Yugoslavia	349	349	394
Africa:			
Cameroon	88	88	88
Egypt	r147	r147	183
Ghana	220	220	220
South Africa, Republic of	94	145	190
Asia:			
Bahrain	187	187	187
China	r377	r421	421
India	386	397	402
Indonesia	--	83	165
Iran	55	55	55
Japan	1,252	r785	785
Korea, North	22	22	22
Korea, Republic of	20	20	20
Taiwan	92	r55	55
Turkey	66	66	66
United Arab Emirates: Dubai	149	r164	164
Oceania:			
Australia	410	524	645
New Zealand	172	269	269
Total	r19,013	r19,177	19,537

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 1980-87 and sources of energy and aluminum raw materials for foreign and domestic primary aluminum plants, including those in centrally planned economies. Part 2 summarizes production capacities for 1980-87 by smelter and country.

TECHNOLOGY

A review of developments in aluminum electrowinning described worldwide modernization of aluminum smelters, evaluated the optimum composition of the bath, and described new materials for anodes, cathodes and cell linings.[10] An overview of the aluminum industry presented brief descriptions of new developments of electrodes, cell automation, and pollution controls for the Hall-Heroult process, and of alternative smelting processes.[11]

Twenty-five papers reporting investigations and developments on aluminum reduction technology were published.[12] One study used a mathematical model to evaluate the effects of various designs and operational changes of the Hall-Heroult cells.[13] A novel cell design was suggested that would minimize the effect of horizontal currents on the flatness of the interface between the molten aluminum and molten cryolite, thus possibly improving cell performance. The new design suggested the use of two vertical bus connectors through the bottom of the cell to the cathode collector base. The normal connection is made at the outermost ends of the cathode collector bars.

Ardal og Sunndal Verk AS reported the results of potline operation with 220,000-ampere reduction pots in its Hoyanger, Norway, aluminum smelter.[14] The potline consisted of 80 side-by-side pots with prebaked anodes. The major advantages of operations with larger pots were reduced capital investments and lower operating costs. Other advantages included a decrease in net relative heat losses and less gas exhaust per ton of metal.

Intalco reported a 2% improvement in current efficiency and a 3.2% decline in power consumption during a 4-year test of a potline using a lithium modified bath.[15] Lithium carbonate additions to the cells decreased bath temperatures by about 10° C, and, reportedly, decreased the resistivity of the anode, cathode, and bus. The effects of different types of alumina on the lithium modified bath were discussed.

Bench-scale oxygen blast furnaces were operated with bauxite to study the feasibility of smelting aluminum directly from ore.[16] The blast furnace process would utilize the heat of combustion of a carbonaceous fuel as a heat source in a carbothermal reduction system. Materials containing iron and silicon were added, and an alloy product was formed during reduction. Oxygen rather than air was required to avoid the formation of nitrides of aluminum. Low yields of aluminum were obtained during the tests because of high volatization of the aluminum in the hot raceway. Bridging occurred across the top of the load because of volatization of the metal and silicon compounds. Further studies were continuing.

A review of new materials for use in the Hall-Heroult electrolytic aluminum process was made by Alcoa Laboratories.[17] The electromagnetic forces and anode gas agitation on the molten aluminum metal cathode surface could be reduced by maintaining a thin metal layer on a wettable electrode, such as titanium diboride, thus reducing the anode-cathode separation and resulting in lower cell voltages. Sidewalls fabricated from inert materials could be exposed to molten cryolite ending the requirement to maintain a delicate heat balance to form a frozen layer of cryolite to protect the carbonaceous material used in the sidewall construction of present-day pots. Heat exchangers could be incorporated in sidewalls to utilize heat loss.

Basic studies on the fundamentals of aluminum electrolysis were continued. The wettability of carbon electrodes by molten salts were shown to be different when the electrodes are polarized than when not polarized.[18] Current densities influenced the wettability of carbon electrodes. Wettability increased at a carbon cathode as the current density was increased. At a carbon anode, wettability increased up to a current density of 0.8 ampere per square centimeter, then it decreased. Increased alumina concentrations increased both anode and cathode wettability about 10%.

The influence of impurities introduced into the aluminum cryolite electrolyte by the main bath components and bath additives were grouped and investigated according to their reactions and behavior in the electrolytic process.[19] All impurities had a deleterious effect on the operation of the cell, the quality of the aluminum, or the life of the cell components. The increase in the amount of impurities introduced into the bath from using dry scrubber alumina as feed material for the cell was discussed.

Several short reports described metallurgical research of aluminum material.[20] The use of hot isostatic pressure was suggested as a method to eliminate pores and microcavities in age-hardened high-strength cast aluminum alloys. A relationship expressed in the form of empirical equations was established between cast aluminum alloys solidified under defined conditions and the mechanical properties of tensile strength and elongation at the break point.

Péchiney developed an aluminum purification process that eliminated hydrogen, nonmetallic inclusions, sodium, lithium, and calcium in molten aluminum.[21] A flow of gas injected into the molten metal by means of a patented injector during casting of aluminum eliminated possible defects at the foundry stage. High-quality aluminum reportedly was obtained that was suitable for aluminum foil and aircraft components by use of this process.

Showa Denko and Riken Corp. jointly developed a high-silicon aluminum alloy, which was reportedly as strong and as wear resistant as some steel alloys, by applying the rapid solidification aluminum powder metallurgy process.[22] The alloy powder, containing about 80% aluminum and 20% silicon, was cooled at a rate of 100° C per second compared with the conventional cooling rate of 0.01° to 0.1° C per second, producing a better crystal formation of the metal. The material was expected to find application in pistons, cylinders, and other automotive and aircraft parts.

A review of new technologies for developing novel aluminum materials characterized by unconventional compositions reported the advantages of the proper use of thermomechanical processing and the possibilities offered by high solidification rates.[23] Mechanical alloying and formation of fiber reinforced aluminum materials were also discussed.

The Bureau of Mines developed a method to solder aluminum and aluminum alloys with conventional "soft" tin-lead solders.[24] The three-step process was used to form joints equivalent in strength and durability to soft solder joints formed on copper, brass, and other materials. Aluminum surfaces to be joined were cleaned and coated with a thin layer of zinc applied to the aluminum by swabbing with or dipping into a electroless zincate solution. A nickel-copper (Ni-Cu) alloy coating was then electrolytically coated on the zinc layer using either electrolytic cell or brush-coating techniques. Aluminum with Ni-Cu-coated surfaces were then soft-soldered using conventional solders and fluxes. The process could have wide application in the aluminum automotive radiator field, in heat-transfer and air conditioning systems, and in electrical connections.

A Bureau of Mines evaluation of used aluminum smelter potlining determined that it can be successfully used as a substitute for fluorspar in cupola ironmelting and in basic oxygen steelmaking. Reports described the effects of used inner carbonaceous lining of smelting pots[25] and the used outer fire brick or alumina refractory lining of the pot[26] on the iron furnace performance, the metal and slag chemistry, and the mechanical properties of the iron product.

A technique for separating a mix of cast and wrought aluminum alloy scrap was developed by the Bureau of Mines.[27] Tests showed that a cast alloy loses strength and ductility at 520° to 560° C and can be fragmentized for easy separation by screening.

A glossary described many of the common terms associated with the aluminum process.[28]

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[1]Physical scientist, Division of Nonferrous Metals.
[2]Statistical assistant, Division of Nonferrous Metals.
[3]National Association of Recycling Industries Inc. Third Annual Aluminum Can Recycling Survey, 1983.
[4]Chandler, W. U. Materials Recycling: The Virtue of Necessity Progress Made in Aluminum Recycling. Recycl. Today, v. 21, No. 12, Dec. 1983, pp. 59-66.
[5]Work cited in footnote 3.
[6]Yafie, R. C. Aluminum Beverage Bottle is Being Test Marketed. Am. Met. Mark., v. 91, No. 138, July 18, 1983, p. 20.
[7]———. Alcoa, Continental Plan Two-Piece Can Project. Am. Met. Mark., v. 91, No. 25, Feb. 4, 1983, p. 1.
[8]Light Metal Age. FDA Clears Way for Retortable Pouch. V. 41, Nos. 1 and 2, Feb. 1983, p. 31.
[9]Federal Register. V. 44, No. 241, Dec. 13, 1979, p. 72496.
[10]Duby, P. Review of Development in Electrometallurgy in 1983. J. Met., v. 36, No. 4, Apr. 1984, pp. 56-60.
[11]Jarrett, N. Aluminum Extractive Metallurgy in 1983. J. Met., v. 36, No. 4, Apr. 1984, pp. 71-74.
[12]Adkins, E. M. (ed.). Light Metals 1983. (Proc. AIME Annu. Meeting, Atlanta, GA, Mar. 6-10, 1983). Metall. Soc., AIME, Warrendale, PA, 1983, 1,254 pp.
[13]Lympany, S. D., D. P. Ziegler, and J. Evans. The Hall-Heroult Cell: Some Design Alternatives Examined by a Mathematical Model. Paper in Light Metals 1983, ed. by E. M. Adkins (AIME Annu. Meeting, Atlanta, GA, Mar. 6-10, 1983). Metall. Soc., AIME, Warrendale, PA, 1983, pp. 507-517.
[14]Jordal, P., H. Kvanda, O. E. Jacobsen, and S. J. Hove. Modernization of Hoyanger Works. Economical Advantage of Large Reduction Pots. Paper in Light Metals 1983, ed. by E. M. Adkins (AIME Annu. Meeting, Atlanta, GA, Mar. 6-10, 1983). Metall. Soc., AIME, Warrendale, PA, 1983, pp. 587-594.
[15]Cheney, R. G. Potline Operation With Lithium-Modified Bath. J. Met., v. 35, No. 12, Dec. 1983, pp. 47-51; Light Metals 1983, Metall. Soc., AIME, Warrendale, PA, 1983, pp. 519-536.
[16]Dokiya, M., M. Fujishige, T. Kameyama, H. Yokokawa, S. Ujiie, K. Fukuda, and A. Motoe. Aluminum Blast Furnace. Paper in Light Metals 1983, ed. by E. M. Adkins (AIME Annu. Meeting, Atlanta, GA, Mar. 6-10, 1983). Metall. Soc., AIME, Warrendale, PA, 1983, pp. 651-670.
[17]Keller, R., and N. Jarrett. New Materials—New Approaches in Aluminum Electrolysis: Aluminium (Duesseldorf), v. 59, No. 6, June 1983, pp. 436-437 (Engl. Suppl.).
[18]Zhu-xian, Q., W. Qing-bin, and Y. Kwan-tsung. Studies on Wettability of Carbon Electrodes in Aluminum Electrolysis. Aluminium (Duesseldorf), v. 59, No. 9, Sept. 1983, pp. E281-E284.
[19]Grjotheim, K., and K. Matiasovsky. Impurities in the Aluminum Electrolyte. Aluminium (Duesseldorf), v. 59, No. 9, Sept. 1983, pp. E298-E303.
[20]Aluminium (Duesseldorf). V. 59, No. 8, Aug. 1983, pp. E238-E239.
[21]Engineering and Mining Journal. V. 184, No. 4, Apr. 1983, p. 83.
[22]Furukawa, T. Showa Denko, Riken Develop High-Silicon Aluminum Alloy. Am. Met. Mark., v. 91, No. 174, Sept. 7, 1983, p. 7.
[23]Furrer, P. Modern Trends in Aluminum Alloy Development. Aluminium (Duesseldorf), v. 59, No. 12, Dec. 1983, pp. E515-E518.
[24]Falke, W. L., A. Y. Lee, and L. A. Neumeir. Development of a Soft-Soldering System for Aluminum. BuMines RI 8747, 1983, 15 pp.
[25]Spironello, V. R., and I. D. Shah. An Evaluation of Used Aluminum Smelter Potlining as a Substitute for Fluorspar in Basic Oxygen Steelmaking. BuMines RI 8699, 1982, 11 pp.
[26]Spironello, V. R. An Evaluation of Used Aluminum Smelter Potlining as a Substitute for Fluorspar in Cupola Ironmaking and Basic Oxygen Steelmaking. BuMines RI 8775, 1983, 18 pp.
[27]Ambrose, F., R. D. Brown Jr., D. Montagna, and H. V. Makar. Hot-Crush Technique for Separation of Cast- and Wrought-Aluminum Alloy Scrap. Conserv. and Recycl., v. 6, Nos. 1 and 2, 1983, pp. 63-69.
[28]Grjotheim, K. and B. Welch. Glossary of Aluminum Electrolysis. Aluminium (Duesseldorf), v. 59, No. 9, Sept 1983, pp. E315-E318.

Antimony

By Patricia A. Plunkert[1]

The production and consumption of primary antimony increased compared with that of 1982 as a result of increasing demand. With the return of Sunshine Mining Co. to full production levels, mine production during 1983 increased significantly over that of 1982. During the year, one primary antimony producer closed its operation and two other primary production facilities were sold. The General Services Administration (GSA) completed its sale of antimony metal from the National Defense Stockpile that was excess to the goal.

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 11 operations to which a survey request was sent, 10 responded, representing an estimated 90% of the smelter production shown in table 1 and the primary antimony production shown in table 3. Production for the one nonrespondent was estimated using reported prior year production levels adjusted by trends in production and other guidelines.

Table 1.—Salient antimony statistics

(Short tons unless otherwise specified)

	1979	1980	1981	1982	1983
United States:					
Production:					
Primary:					
Mine (recoverable antimony)	722	343	646	503	838
Smelter[1]	15,062	16,062	17,844	12,282	15,017
Secondary (antimony content)	24,155	19,893	19,856	16,596	14,204
Exports of metal and alloys	485	453	324	830	304
Imports for consumption (antimony content)	22,141	17,996	17,970	13,387	12,885
Reported industrial consumption, primary antimony[1]	11,753	11,239	11,592	9,414	10,873
Stocks: Primary antimony, all classes (antimony content), Dec. 31	7,144	8,411	9,158	5,973	3,935
Price: Average, cents per pound[2]	140.7	150.8	135.5	107.2	91.3
World: Mine production	[r]69,534	[r]70,020	63,124	[p]59,277	[e]53,301

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

[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.—The Environmental Protection Agency announced that it had accepted a testing program sponsored by the Antimony Oxide Industry Association (AOIA) rather than initiating rulemaking under section 4(a) of the Toxic Substances Control Act to determine the effect that antimony metal, antimony trioxide, and antimony sulfide may have on health and the environment. The AOIA program would monitor and control occupational exposure and environmental release, perform medical surveillance, continue epidemiological studies on exposed workers, and perform testing to characterize any health effects and environmental consequences of these antimony substances.[2]

The Omnibus Budget Reconciliation Act of 1981 (Public Law 97-35) authorized the disposal of a total of 3,000 short tons of antimony metal from the National Defense

Stockpile at the rate of 1,000 tons per fiscal year. Sales of antimony authorized by this program were completed in October 1983. Total sales of antimony metal from the stockpile during calendar year 1983 amounted to 1,863 tons. Total sales from the 3-year program were 1,884 tons of antimony metal.

GSA reported that at yearend the Government stocks of antimony metal in the National Defense Stockpile totaled 38,840 tons of stockpile-grade material. The stockpile goal remained at 36,000 tons.

DOMESTIC PRODUCTION

MINE PRODUCTION

Two companies accounted for all of the domestic mine production, and the total output increased significantly compared with that of 1982. Most of the increase can be attributed to the return of Sunshine Mining to full production levels in 1983 following the temporary shutdown of its operation, which occurred during the latter half of 1982 and was attributed to depressed silver prices. The Sunshine Mine produced 585 tons of antimony in 1983 compared with 294 tons in 1982. The antimony was produced 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. The United States Antimony Corp. (USAC) produced antimony from stibnite mined at Thompson Falls, MT. USAC produced 253 tons of antimony compared with 209 tons in 1982.

Antimony was also produced as a byproduct of the smelting of some primary lead ores.

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

(Short tons of recoverable antimony)

Year	Produced	Shipped
1979	722	701
1980	343	382
1981	646	590
1982	503	365
1983	838	878

SMELTER PRODUCTION

Primary.—Production of primary antimony products increased compared with that of 1982 owing to an increase in demand caused by the continued strengthening of the economy. A total of 11 plants produced primary antimony products.

In July, Antimony Processors Inc. announced that it had closed its plant located in Moscow, TN. This plant produced sodium antimonate.

Harshaw Chemical Co. announced the sale of its Gloucester City, NJ, facility to Amspec Chemical Corp. Amspec reported that the plant would continue to produce antimony oxide along with organometallic compounds and some specialty chemicals.

PPG Industries Inc. announced the sale of its antimony oxide plant in La Porte, TX, to Laurel Industries Inc. of Cleveland, OH. Included in the sale was PPG's 25% interest in Antimony Products Ltd. of the Republic of South Africa, which supplied raw materials to the plant. Laurel Industries agreed to continue supplying antimony oxide to PPG's Stockertown, PA, plant, which produced flame-retardant plastics and concentrates.

The other producers of antimony products were Anzon America Inc., Laredo, TX; ASARCO Incorporated, Omaha, NE, and El Paso, TX; Chemet Co., Moscow, TN; 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: Metal	Oxide	Residues	Byproduct antimonial lead	Total
1979	2,642	12,141	--	279	15,062
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	743	W	15,017

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
1979	3,750	208	71	20	299	8.0
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

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 is 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)

	1982	1983
KIND OF SCRAP		
New scrap:		
Lead-base	1,661	1,446
Tin-base	2	1
Total	1,663	1,447
Old scrap:		
Lead-base	14,928	12,753
Tin-base	5	4
Total	14,933	12,757
Grand total	16,596	14,204
FORM OF RECOVERY		
In antimonial lead	14,603	12,664
In other lead alloys	1,987	1,523
In tin-base alloys	6	17
Total	16,596	14,204
Value (millions)	$66.4	$56.8

CONSUMPTION AND USES

Domestic consumption of primary antimony increased compared with that of 1982. In recent years, improved technology has lowered the average antimony content of the antimonial lead alloy used in the manufacture of starting-lighting-ignition (SLI) batteries. In 1983, the Battery Council International reported a 7% increase in the total shipments of replacement and original equipment automotive SLI batteries in the United States. Antimony alloyed with lead was also used in industrial chemical pumps and pipes, tank linings, roofing sheets, and cable sheaths. In these alloys, antimony increases strength and inhibits chemical corrosion.

Antimony compounds were used in plastics both as stabilizers and as flame retardants. The use of antimony oxide as a flame retardant increased owing primarily to increased demand in the transportation and construction industries. Antimony oxide in an organic solvent was used to make fabrics, plastics, and other combustibles flame retardant. Flames accompanying initial combustion are restricted or extinguished by chemicals released by heat from the treated materials. 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						Total
	Ore and concentrate	Metal	Oxide	Sulfide	Residues	Byproduct antimonial lead	
1979	15	1,899	9,528	32	--	279	11,753
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	738	W	10,873

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	1979	1980	1981	1982	1983
Metal products:					
Ammunition	253	362	409	294	175
Antimonial lead	1,300	748	1,257	793	921
Bearing metal and bearings	235	223	206	143	143
Cable covering	16	31	24	25	31
Castings	14	10	11	9	9
Collapsible tubes and foil	24	18	9	1	W
Sheet and pipe	36	29	36	26	43
Solder	199	134	105	124	154
Type metal	37	21	19	11	10
Other	99	74	69	67	71
Total	2,213	1,650	2,145	1,493	1,557
Nonmetal products:					
Ammunition primers	23	20	25	20	16
Fireworks	6	4	4	6	4
Ceramics and glass	1,127	1,303	782	1,358	1,252
Pigments	399	499	341	330	198
Plastics	1,580	1,636	1,551	1,050	1,453
Rubber products	182	325	232	221	70
Other	140	107	111	103	119
Total	3,457	3,894	3,046	3,088	3,112
Flame-retardant:					
Plastics	4,262	3,874	4,509	3,312	4,441
Pigments	35	56	40	25	14
Rubber	146	189	174	104	220
Adhesives	302	461	585	179	184
Textiles	1,143	942	962	1,110	1,212
Paper	195	173	131	103	133
Total	6,083	5,695	6,401	4,833	6,204
Grand total	11,753	11,239	11,592	9,414	10,873

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

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

(Short tons of antimony content)

Stocks	1979	1980	1981	1982	1983
Ore and concentrate	1,757	2,743	2,529	532	44
Metal	1,184	680	916	556	80
Oxide	3,398	3,855	4,707	4,711	2,61
Sulfide	17	13	25	24	1
Residues and slags	730	1,116	864	150	5
Antimonial lead[1]	58	4	117	W	W
Total	7,144	8,411	9,158	5,973	3,93

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 \$0.93 to \$0.98 per pound at the beginning of the year. The price fluctuated during the first part of the year and reached a low of \$0.78 to \$0.82 per pound in September. The price then increased steadily and by yearend was listed at \$1.25 to \$1.35 per pound.

Asarco's published price for high-tint antimony trioxide in lots of 40,000 pounds was \$1.20 per pound at the beginning of the year. The price was reduced several times during the first half of the year and reached a low of \$1 per pound in May. The price remained at this level until late October when it was gradually increased so that by yearend Asarco's published price for antimony trioxide was \$1.16 per pound. Other domestic producers adjusted their prices during the year to remain competitive with Asarco's price and generally lower priced imported material.

The Metal Bulletin published European price quotations for various grades of antimony ore and concentrates. At yearend, the quotations were as follows: sulfide ore concentrates, 50% to 55% antimony content, nominal; clean sulfide concentrates, 60% antimony content, \$16.50 to \$17.25 per metric ton unit (equivalent to \$15.00 to \$15.65 per short ton unit); and lump sulfide ore, 60% antimony content, \$16.75 to \$17.50 per metric ton unit (equivalent to \$15.20 to \$15.90 per short ton unit).

Table 9.—Antimony price ranges in 1983, by type

Type	Price per pound
Domestic metal[1]	\$2.00
Foreign metal[2]	\$0.78- 1.35
Antimony trioxide[3]	1.00- 1.20

[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, alloys, and scrap decreased dramatically from the unusually high level of exports in 1982. Canada, the United Kingdom, Thailand, and the Republic of Korea, in descending order of receipts, received approximately 60% of the total exports; the balance was shipped in small parcels to 19 countries. Exports of antimony oxide increased to 440 tons (gross weight). Approximately 70% of the total oxide, in decreasing order of receipts, was shipped to the Federal Republic of Germany, Canada, Italy, and Mexico; the balance was divided among 18 other countries.

Table 10.—U.S. import duties for antimony

Item	TSUS No.	Most favored nation (MFN)		Non-MFN
		January 1, 1983	January 1, 1984	January 1, 1983
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	.5 cent per pound	.4 cent per pound	2 cents per pound.
Antimony oxide	417.50	.1 cent per pound	.1 cent per pound	Do.

Table 11.—U.S. imports for consumption of antimony, by class and country

Class and country	1982 Gross weight (short tons)	1982 Value (thousands)	1983 Gross weight (short tons)	1983 Value (thousands)
Antimony metal:				
Belgium-Luxembourg	93	$184	74	$126
Bolivia	504	961	194	286
Brazil	28	255	--	--
Canada	1	205	2	204
Chile	56	109	--	--
China	1,157	2,116	639	1,043
Germany, Federal Republic of	(1)	2	(1)	22
Japan	(1)	4	(1)	3
Mexico	39	17	257	178
Peru	--	--	65	74
U.S.S.R	--	--	20	33
United Kingdom	(1)	(1)	31	18
Yugoslavia	22	40	--	--
Total	1,900	3,893	1,282	1,987
Antimony oxide:				
Belgium-Luxembourg	230	561	308	608
Bolivia	2,272	3,807	2,690	3,683
Brazil	2	5	132	227
Canada	21	15	25	4
Chile	--	--	220	275
China	2,058	5,190	1,222	2,107
France	1,582	4,520	1,652	3,602
Germany, Federal Republic of	87	456	102	636
Hong Kong	--	--	20	36
Italy	--	--	88	152
Japan	(1)	2	(1)	9
Netherlands	22	58	42	100
South Africa, Republic of	3,200	745	3,816	991
United Kingdom	959	2,686	287	888
Total	10,433	18,045	10,604	13,318
Antimony sulfide:[2]				
Belgium-Luxembourg	30	85	19	46
Canada	--	--	25	3
China	48	68	--	--
France	10	27	3	5
Germany, Federal Republic of	(1)	1	--	--
Japan	(1)	2	--	--
United Kingdom	(1)	5	(1)	4
Total	88	188	47	58

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

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

Country	1982 Gross weight (short tons)	1982 Antimony content (short tons)	1982 Value (thousands)	1983 Gross weight (short tons)	1983 Antimony content (short tons)	1983 Value (thousands)
Bolivia	2,498	1,683	$2,724	1,815	1,196	$1,158
Canada	680	427	622	5	3	4
Chile	--	--	--	33	22	20
Mexico	2,162	485	597	2,678	632	400
South Africa, Republic of	110	71	125	846	444	146
Thailand	--	--	--	923	471	598
United Kingdom	41	31	99	5	2	9
Zimbabwe	116	72	122	--	--	--
Total	5,607	2,769	4,289	6,305	2,770	2,335

Table 13.—U.S. imports for consumption of antimony

Year	Antimony ore and concentrate			Antimony sulfide[1]			Antimony metal[2]		Antimony oxide		
	Gross weight (short tons)	Antimony content (short tons)	Value (thousands)	Gross weight (short tons)	Antimony content (short tons)	Value (thousands)	Gross weight (short tons)	Value (thousands)	Gross weight (short tons)	Antimony content (short tons)	Value (thousands)
1981	10,813	5,168	$9,095	106	70	$249	2,631	$6,569	12,170	10,101	$19,922
1982	5,607	2,769	4,289	88	59	188	1,900	3,893	10,433	8,659	18,045
1983	6,305	2,770	2,335	47	32	58	1,282	1,987	10,604	8,801	13,318

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

WORLD REVIEW

Bolivia.—Corporación Minera de Bolivia (COMIBOL) and Empresa Nacional de Fundiciones (ENAF) announced that test smelting was expected to begin in September 1983 at the new lead and silver smelter in Karachipampa, Potosi. This joint venture between COMIBOL and ENAF reportedly will operate under the corporation name of Sociedad del Complejo Metalúrgico de Karachipampa. The plant was expected to process 56,000 tons of lead concentrates per year for an annual production of 24,000 tons of lead, 220 tons of silver, and 2,000 tons of byproduct antimony, along with additional byproducts of zinc, copper, and bismuth.[3]

Empresa Minera Unificada S.A. (EMUSA) announced the closure of its Caracota Mine for maintenance work. The closure was expected to last a minimum of 3 months. The Caracota Mine accounted for 40% of EMUSA's antimony ore output.[4]

Brazil.—In January, Cia. Industrial Amazonese and Best Metais e Soldas announced the opening of a new antimony smelter located at Manaus. The plant was expected to treat oxide ores, imported principally from Thailand, to produce antimony metal, but the plant also has the capability to treat sulfide ores. Annual capacity was reported to be 1,300 tons of antimony metal.[5]

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

(Short tons)

Country	1979	1980	1981	1982[p]	1983[e]
Australia[2]	[r]1,696	[r]1,531	1,246	1,326	1,300
Austria	629	730	665	735	660
Bolivia	14,351	17,047	16,866	15,408	11,600
Brazil	80	51	297	298	330
Burma	750	485	[e]110	--	--
Canada[e 3]	3,256	2,600	1,560	--	--
China[e]	11,000	11,000	11,000	11,000	11,000
Czechoslovakia	584	639	551	551	550
France	--	--	344	340	330
Guatemala	728	613	563	[e]550	500
Honduras	51	25	[e]22	[e]11	11
Italy	1,047	786	767	374	400
Malaysia (Sarawak)	338	147	211	419	440
Mexico[4]	3,166	2,399	1,984	1,725	1,700
Morocco	2,175	606	556	998	1,100
Pakistan	7	11	11	56	55
Peru (recoverable)	602	379	755	814	770
South Africa, Republic of	12,815	14,413	10,748	[5]10,070	[5]6,947
Spain	552	689	712	506	550
Thailand	3,235	3,214	1,322	734	1,300
Turkey	309	[r]1,068	924	1,189	1,200
U.S.S.R.[e]	9,100	9,300	9,500	9,900	10,000
United States[6]	722	343	646	503	[7]838
Yugoslavia	2,245	1,852	1,604	1,543	1,500
Zimbabwe	[r]96	[r]92	160	227	220
Total	[r]69,534	[r]70,020	63,124	59,277	53,301

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through May 16, 1984.
[2]Antimony content of antimony ore and concentrates, lead concentrates, and lead and zinc middlings.
[3]Partly estimated on the basis of reported value of total production.
[4]Antimony content of ores for export plus antimony content of antimonial lead and other smelter products produced.
[5]Reported figure from Consolidated Murchison Ltd. 1983 Annual Report.
[6]Production from antimony mines; excludes amount produced as a byproduct of domestic lead ores.
[7]Reported figure.

TECHNOLOGY

A modified transpiration apparatus was devised by the Bureau of Mines to permit rapid and accurate measurement of the vapor transport and vapor diffusion coefficients of antimony sulfide (Sb_2S_3) and other compounds at temperatures up to 1,045° Kelvin.[6]

Phillips Petroleum Co. marketed an additive that ties up heavy metals to maintain catalyst activity during the refining of crude oil and helps to prevent a shift in the reaction equilibrium to gas and coke at the expense of gasoline. The additive, called Phil-Ad CA, presumably is antimony oxide or a compound that converts to antimony oxide on calcination.[7]

[1]Physical scientist, Division of Nonferrous Metals.
[2]Federal Register. Antimony Metal, Antimony Trioxide, and Antimony Sulfide; Decision To Accept Negotiated Testing Program. V. 48, No. 172, Sept. 2, 1983, pp. 39979-39982.
[3]Mining Journal (London). Bolivian Lead-Silver Smelter. V. 300, No. 7714, June 24, 1983, p. 431.
[4]———. Emusa Mine Shutdown. V. 301, No. 7716, July 8, 1983, p. 30.
[5]Metal Bulletin (London). Brazilian Antimony Is Rolling. No. 6821, Sept. 16, 1983, p. 19.
[6]Madsen, B. W., A. Adams, and P. A. Romans. Determining Vapor Density and Gaseous Diffusion Coefficients of Sb_2S_3 Using a Modified Transpiration Apparatus. BuMines RI 8812, 1983, 14 pp.
[7]Chemical Week. More Motor Fuels From Dirtier Crudes. V. 133, No. 4, July 27, 1983, pp. 21-22.

Asbestos

By R. A. Clifton[1]

U.S. apparent consumption of asbestos continued to decline in 1983 because of its unfavorable public ecological image. U.S. apparent consumption was 88% of that in 1982 and 27% of the alltime high of 1973. Shipments from domestic mines, all chrysotile, increased 10%, and imports decreased 19%. The Manville Corp., formerly Johns-Manville Inc., the largest producer of asbestos in the market economy countries and the largest U.S. manufacturer of asbestos products, ceased all asbestos mining and product manufacturing. Manville's Canadian mine, the world's largest, was purchased by a Canadian group and production was expected to continue.

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 collection request was made, all responded, representing 100% of the total production data shown in table 1.

Table 1.—Salient asbestos statistics

	1979	1980	1981	1982	1983
United States:					
Production (sales) metric tons	93,354	80,079	75,618	63,515	69,906
Value thousands	$28,925	$30,599	$30,685	$24,917	$27,866
Exports and reexports (unmanufactured) metric tons	43,291	48,671	64,419	58,771	54,634
Value thousands	$17,381	$21,067	$21,508	$19,713	$19,683
Exports and reexports of asbestos products (value) do	$137,690	$141,653	$145,130	$127,867	$129,582
Imports for consumption (unmanufactured) metric tons	513,084	327,296	337,618	241,737	196,387
Value thousands	$135,210	$91,809	$103,893	$64,925	$57,956
Released from stockpile (unmanufactured) metric tons	1	--	--	--	--
Consumption do	560,600	358,700	348,800	246,500	217,000
World: Production do	[r]4,758,022	[r]4,699,300	4,337,140	[p]4,080,314	[e]4,157,256

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

Legislation and Government Programs.—The Occupational Safety and Health Administration (OSHA) published in the Federal Register of November 4 its Emergency Temporary Standard (ETS), which lowers, by a factor of four, the permissible level of workplace exposure to asbestos. The ETS was challenged in the Fifth Circuit Court of Appeals by the asbestos industry and, on November 23, was stayed pending judicial review.

On July 27, in testimony before the Senate Subcommittee on Toxic Substances and Environmental Oversight, the Environmental Protection Agency (EPA) testified that within 1 year it would propose a ban on certain asbestos products. The products to be covered by the proposed ban are saturated asbestos roofing felt, unsaturated roofing felt, asbestos flooring felt, asbestos sheet flooring, vinyl-asbestos floor tile, and asbestos-cement pipe. It was EPA's intention to propose another rule in October 1984, which would set production ceilings for remaining asbestos products. These limits would decline until all products containing asbestos would be eventually phased out.

The Consumer Products Safety Commission (CPSC) published its final report of the Chronic Hazard Advisory Panel on Asbestos. Copies of the report are available from the Office of the Secretary, Consumer Products Safety Commission, Washington, DC 20207. Copies may also be obtained by calling the Office of the Secretary at (301) 492-6800.

In July, EPA, CPSC, and OSHA set up a formal task force on asbestos. The group was to develop a coordinated Federal approach to protect the public from health hazards of asbestos in the workplace, during use of a product, or from disposal practices. The group's goals include assessing available data on asbestos health hazards, coordinating scientific research, identifying control measures, and developing a uniform approach to issuing regulations.

Environmental Impact.—The mortality rate of Reserve Mining Co.'s employees exposed to asbestos-containing taconite dust was the subject of a medical journal article.[2] It was found that men employed by Reserve from 1952 to 1976 had a mortality rate significantly lower than that expected for white males in the State of Minnesota and that deaths from malignant diseases were marginally below those expected for the State.

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

(Metric tons)

	Stockpile goals	Total inventories 1981	Total inventories 1982	Total inventories 1983
Amosite	15,422	38,587	38,587	38,591
Chrysotile	2,722	9,034	9,034	9,753
Crocidolite	--	r2,163	754	754
Total	18,144	r49,784	48,375	49,098

rRevised.

DOMESTIC PRODUCTION

Mines in the United States shipped about 10% more asbestos than in 1982, and the value increased 12%. 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. 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.

Table 3.—Asbestos producers in the United States in 1983

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

Employment in U.S. asbestos mines and mills remained at about 400 persons.

Miners at the Asbestos Group's mine in Vermont went on strike in October and were still out at yearend. Despite this, the management was optimistic about the future. A foreclosure suit had been dismissed, and there was sufficient inventory at the mine to meet shipments for some time.

CONSUMPTION AND USES

Total U.S. asbestos consumption decreased 12%; of the total, 97% was chrysotile and 3% was crocidolite. Small amounts of amosite were reported used. One percent of the chrysotile used was spinning grades 1, 2, or 3. Grade 7's were the most used, 76%, followed by grades 4 and 6, 8% each, and grade 5's, 7%.

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

(Thousand metric tons)

End use	Chrysotile							Cro-cido-lite	Amo-site	Total asbes-tos
	Grades 1 and 2	Grade 3	Grade 4	Grade 5	Grade 6	Grade 7	Total			
1982 total	--	2.3	18.4	15.0	18.8	175.3	229.8	16.0	0.7	246.5
1983:										
Asbestos-cement pipe	--	--	14.4	4.6	.9	--	19.9	6.2	--	26.1
Asbestos-cement sheet	--	--	.2	.9	6.7	2.2	10.0	--	--	10.0
Coatings and compounds	--	--	--	--	--	22.8	22.8	--	--	22.8
Flooring products	--	--	--	--	--	44.6	44.6	--	--	44.6
Friction products	--	--	.9	7.3	6.2	33.9	48.3	--	--	48.3
Insulation:										
Thermal	--	--	--	--	--	--	--	--	.1	.1
Electrical	--	--	--	--	--	.6	.6	--	--	.6
Packing and gaskets	--	--	.4	.5	.7	10.8	12.4	--	--	12.4
Paper	--	--	--	.1	--	1.4	1.5	--	--	1.5
Plastics	0.2	--	--	.2	--	.2	.6	--	--	.6
Proofing products	--	--	--	--	2.8	3.7	6.5	--	--	6.5
Textiles	.2	1.1	--	--	--	--	1.3	--	--	1.3
Other	--	1.1	1.1	.3	.1	39.1	41.7	--	.5	42.2
Total	.4	2.2	17.0	13.9	17.4	159.3	210.2	6.2	.6	217.0

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, $360 per metric ton, represented a 7% increase.

Table 5.—Customs unit values of imported asbestos

(Dollars per metric ton)

	1979	1980	1981	1982	1983
Canada:					
Chrysotile:					
Cement	238	251	272	234	257
Crude	201	158	---	380	199
Spinning	868	843	927	917	932
Other	292	296	373	334	384
South Africa, Republic of:					
Amosite	499	1,611	728	771	840
Crocidolite	711	686	676	646	629

FOREIGN TRADE

There was a 1% increase in the total value of asbestos fibers and asbestos products exported from the United States; of this, the fiber portion remained at 13%. Canada remained the largest recipient of U.S. exports, accounting for 51% of the value, followed by Japan, 8%; Saudi Arabia, 7%; and Mexico, 6%.

Canada provided 94% of the asbestos fiber imported into the United States, and the Republic of South Africa provided 6%. Several countries provided minor amounts. Chrysotile again dominated the imported types with 97% of the total. The value of imported fiber was only 89% of that of 1982.

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

(Thousand dollars)

Country	1982			1983		
	Unmanufactured fibers	Manufactured products	Total[1]	Unmanufactured fibers	Manufactured products	Total[1]
Australia	145	5,034	5,179	19	2,107	2,126
Brazil	242	367	609	221	1,432	1,653
Canada	1,144	43,714	44,858	1,539	73,739	75,278
Germany, Federal Republic of	980	2,417	3,397	985	2,367	3,352
Japan	3,933	6,475	10,408	3,787	8,036	11,823
Korea, Republic of	730	2,367	3,098	550	781	1,331
Kuwait	--	1,114	1,114	--	1,380	1,380
Mexico	4,902	9,837	14,739	4,649	3,565	8,214
Saudi Arabia	17	15,291	15,308	13	10,339	10,352
Thailand	1,199	325	1,524	2,599	189	2,788
Turkey	--	334	334	497	913	1,410
United Kingdom	178	2,761	2,939	204	2,116	2,320
Venezuela	259	5,747	6,006	329	1,773	2,102
Other	r5,815	r30,920	r36,735	4,005	19,846	23,851
Total[1]	19,543	126,704	146,247	19,398	128,584	147,981

[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	1981		1982		1983	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
EXPORTS						
Unmanufactured:						
Crudes, fibers, stucco ... metric tons	50,131	$17,328	42,342	$14,752	40,476	$14,879
Sand and refuse ... do	13,995	4,021	16,183	4,791	13,760	4,519
Total ... do	64,126	21,349	58,525	19,543	54,236	19,398
Products:						
Asbestos fibers ... do	3,840	9,544	2,538	8,119	1,537	5,198
Shingles and clapboard ... do	21,771	3,686	4,011	3,235	3,082	1,935
Other articles of asbestos ... do	17,504	14,292	17,639	13,444	4,953	5,593
Gaskets ... do	451	4,144	358	3,020	337	2,196
Packing and seals ... do	1,598	18,179	1,311	15,309	1,015	10,174
Insulation ... do	NA	8,185	NA	6,799	NA	3,270
Other articles, n.s.p.f ... do	NA	23,660	NA	17,047	NA	9,477
Brake linings and disk brake pads ... do	NA	50,058	NA	42,852	NA	70,456
Clutch facings and linings ... number	NA	12,783	NA	16,879	NA	20,285
Total	XX	144,531	XX	126,704	XX	128,584
REEXPORTS						
Unmanufactured:						
Crudes and fibers ... metric tons	240	150	246	170	333	271
Sand and refuse ... do	53	9	XX	XX	65	14
Total ... do	293	159	246	170	398	285
Products:						
Asbestos fibers ... do	6	34	66	203	3	7
Shingles and clapboard ... do	34	20	--	--	--	--
Gaskets ... do	1	7	--	1	(1)	117
Packing and seals ... do	1	2	5	22	1	10
Insulation ... do	NA	17	--	--	NA	10
Other articles, n.s.p.f ... do	NA	120	NA	9	NA	166
Brake linings and disk brake pads ... do	NA	149	NA	539	NA	318
Clutch facings and linings ... number	NA	234	NA	309	NA	167
Other articles of asbestos ... metric tons	1	16	27	80	59	203
Total	XX	599	XX	1,163	XX	998

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		South Africa, Republic of		Other		Total	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
1981	318,367	$90,828	17,112	$10,846	2,139	$2,219	337,618	$103,893
1982:								
Chrysotile:								
Crude	36	14	--	--	8	1	44	15
Spinning fibers	1,328	1,218	904	453	202	283	2,434	1,954
All other	227,715	55,482	2,193	1,341	1,058	728	230,966	57,551
Crocidolite (blue)	--	--	7,904	5,105	--	--	7,904	5,105
Amosite	--	--	389	300	--	--	389	300
Total	229,079	56,714	11,390	7,199	1,268	1,012	241,737	64,925
1983:								
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
Amosite	--	--	609	512	--	--	609	512
Total	184,303	49,733	11,754	7,740	330	483	196,387	57,956

WORLD REVIEW

The market economy countries' asbestos industries suffered the same state of oversupply, reduced demand, mine layoffs, and general economic problems that characterized 1982. Increased demand in the last quarter did little more than reduce some of the high fiber inventories.

Canada.—Manville concluded the sale of the Jeffrey Mine at Asbestos in September. The purchasers included a number of former Manville executives headed by the president of their former auditing firm. J. M. Asbestos Inc., the new owner, promised to continue production of fine chrysotile fibers and provide technical services.

Preliminary figures were cited that showed a continued downturn of Quebec's fiber production.[3] The volume, estimated at 717,000 tons, was 4% below that for 1982, but the value, Can$316 million, increased 6%.

According to a published report, Asbestos Corp. planned to close its Asbestos Hill Mine for 1 year.[4] Inventory shortfalls caused by the closing were to be made up by increased production from its Thetford Mine. A closure of Asbestos Hill might cause a temporary shutdown of Asbestos Corp.'s mill in Nordenham, Federal Republic of Germany, which currently processes the concentrated ore.

Italy.—A mining periodical described the current operation of the Amiantifera Balangero S.p.A. Balangero Mine.[5] Asbestos was mined from a face 170 meters high by 700 meters long. The mine's annual capacity was rated at 3.1 million tons of ore yielding 150,000 tons of fiber. It was one of the few asbestos mines in the world with a salable byproduct. Nearly one-half million tons per year of high-quality crushed stone and sand have been sold from the Balangero Mine.

South Africa, Republic of.—A mining periodical detailed workings of a mine and mill that produced roughly one-half of the world's crocidolite in 1982.[6] The underground Pomfret Mine of the Griqualand Exploration and Finance Co. Ltd. was considered to be the premier crocidolite mine of the world. Ore selection at the face of grades not less than 6% was used to maintain an average ore grade of 12% to the mill. Except for a wash cycle to recover fibers, the mill process was dry. Pomfret's 2,400 employees live in the town of Pomfret, which is owned by the company.

Zimbabwe.—A weekly mining periodical painted a bleak picture for the country's asbestos industry.[7] Extrapolation of half-year production figures showed a 27% production decline from that of 1982, and a 56% production decline from that of 1976, its record year.

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

(Metric tons)

Country[2]	1979	1980	1981	1982[p]	1983[e]
Afghanistan	[e]4,000	--	--	NA	NA
Argentina	1,371	1,261	1,280	1,218	1,350
Australia	79,721	92,418	44,647	[r] [e]20,000	20,000
Brazil	138,457	169,173	138,420	[e]140,000	135,000
Bulgaria	600	700	400	600	600
Canada (shipments)	1,492,719	1,323,053	1,122,000	834,000	829,000
China[e]	[r]140,000	[r]131,700	106,000	110,000	110,000
Cyprus	35,472	34,535	24,440	18,952	18,000
Egypt	238	316	325	310	325
Greece	--	--	--	[e]100,000	100,000
India	32,094	31,253	24,515	26,761	25,000
Italy	143,931	157,794	137,086	116,410	120,000
Japan	3,502	3,897	3,950	4,135	4,000
Korea, Republic of	14,804	9,854	14,084	15,933	15,000
Mozambique	789	[e]800	[e]800	[e]800	800
South Africa, Republic of	249,187	277,734	235,943	211,860	220,000
Swaziland (exports)	34,294	32,833	35,264	26,413	[3]31,275
Taiwan	2,957	683	2,317	2,392	2,500
Turkey	[r]600	[r]18,162	3,860	958	4,000
U.S.S.R.[e]	2,020,000	2,070,000	2,105,000	2,180,000	2,250,000
United States (sold or used by producers)	93,354	80,079	75,618	63,515	[3]69,906
Yugoslavia	10,041	12,106	13,591	11,657	10,500
Zimbabwe	259,891	250,949	247,600	194,400	190,000
Total	[r]4,758,022	[r]4,699,300	4,337,140	4,080,314	4,157,256

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available.
[1]Table includes data available through Apr. 18, 1984.
[2]In addition to the countries listed, 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

The U.S. Navy tested shipboard transformers, with and without asbestos, to demonstrate the superior properties of asbestos electrical insulating papers and boards.[8] Among the tests conducted was one to establish failure temperature under various overloads. The transformer containing asbestos surpassed all others by nearly 300° F. Asbestos emission tests demonstrated that little, if any, asbestos fiber was emitted from any of the transformers under actual operating conditions and that the tremendous overload resistance of the asbestos insulating system permits transformers on board U.S. Navy warships to operate under the most severe combat conditions.

A neoprene spray process was developed for coating asbestos fibers to prevent their escape from construction components used in building interiors.[9] The process is designed to both penetrate and surface coat the asbestos and eventually cure the coating to form a tough elastic cocoon. Use of the process was claimed to eliminate or greatly reduce the very high fiber counts generated during the disassembly of buildings.

Substitutes.—A glass industry publication describes a new alkali-resistant glass fiber.[10] The Japanese National Institute for Research in Inorganic Chemicals applied for Japanese and U.S. patents on its glass fiber, claimed to be at least 10 times higher fiber produced by England's Pilkington Bros. The process mixture for the glass consists of 25% each of silica and alumina and 50% of an intermediate material used in producing yttrium.

Two organic fibers were identified as having comparable properties to asbestos in certain uses. These were an acrylic fiber presented by the Badische Corp.[11] and a polyvinyl alcohol fiber developed by Eternits, the Swiss asbestos cement manufacturer, and the Osaka-based Kuraray Co., as an asbestos substitute in cement products.[12]

[1]Physical scientist, Division of Industrial Minerals.
[2]Higgins, I. T. T., J. H. Glassman, M. S. Oh, and R. F. Cornell. Mortality of Reserve Mining Company Employees in Relation to Taconite Dust Exposure. Am. J. Epidemiol., v. 118, No. 5, May 1983, pp. 710-719.
[3]Remick, J., and M. Trottier. General Outlook. West. Miner, v. 57, No. 2, Feb. 1984, p. 31.
[4]Industrial Minerals (London). Canada: Asbestos Hill Closed. No. 195, Dec. 1983, p. 9.
[5]Mining Magazine. Balangero—Europe's Most Important Asbestos Producer. V. 149, No. 6, Dec. 1983, p. 427.
[6]———. Pomfret Asbestos Mine. V. 149, No. 3, Sept. 1983, pp. 153-159.
[7]Mining Journal (London). A Mixed Bag for Zimbabwe. V. 301, No. 7740, Dec. 23, 1983, p. 451.
[8]Love, D., J. Fitch, and C. Y. Lu. Performance of Asbestos Insulation Systems in Dry Type Transformers. Electri-Onics, v. 29, No. 7, July 1983, pp. 67-70.
[9]Pititto, J. Neoprene Spray Is Answer to Knotty Asbestos Problem. Chem. Mark. Rep., v. 223, No. 18, May 2, 1983, pp. 15-16.
[10]Glass Industry. Japanese Lab Develops Alkali-Resistant Glass. V. 65, No. 1, Jan. 1983, p. 13.
[11]Chemical Marketing Reporter. Acrylics Aim at Asbestos. V. 224, No. 23, June 13, 1983, pp. 7, 34.
[12]European Chemical News. Eternits, Kuraray Develop PVA Asbestos Substitute. V. 40, No. 1064, Jan. 3-10, 1983,

Barite

By Sarkis G. Ampian[1]

Domestic production of barite decreased significantly for the second successive year, down 59% to 754,000 short tons valued at $29 million as output was lowered to pre-1970 levels. Nevada, the leading producer, decreased output 58% to 663,000 tons. Production from Missouri, the second leading producer, decreased substantially. Imports for consumption of crude barite declined to 1.40 million tons, 40% below the record 1982 level, but led domestic production for the second successive year. This decline in barite imports was the first in nearly 10 years. The principal use for barite, as a weighting agent in oil- and gas-well-drilling fluids (muds), accounted for 96% of U.S. consumption.

Demand for barite continued the decline started in the second half of 1982 owing to an oil glut and economic downturn that resulted in lower oil- and gas-well-drilling activity accompanied by the drilling of shallower wells that used less barite per foot of well. 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 were developed by the Bureau of Mines from one voluntary survey of U.S. operations. Of the 103 operations to which a survey request was sent, 100% 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)

	1979	1980	1981	1982	1983
United States:					
Barite, primary:					
Sold or used by producers	2,112	2,245	2,849	1,845	754
Value	$53,581	$65,957	$102,439	$69,522	$29,203
Exports	109	97	62	49	23
Value	$10,861	$13,794	$9,947	$6,510	$3,514
Imports for consumption (crude)	1,489	1,850	1,932	2,320	1,396
Consumption (apparent)[1]	3,492	3,998	4,719	4,116	2,127
Crushed and ground (sold or used by processors)[2]	3,223	3,649	4,716	4,088	2,745
Value	$179,009	$365,632	$406,255	$322,700	$194,380
Barium chemicals (sold or used by processors)	50	40	34	25	22
Value	$26,063	$22,441	$20,670	$18,720	$16,860
World: Production	7,999	[r]8,302	9,036	[p]8,257	[e]6,348

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

DOMESTIC PRODUCTION

The term "primary barite" denotes the first marketable product and includes crude run-of-mine barite, flotation concentrates, and material concentrated by other beneficiation processes such as washing, jigging, or magnetic separation. Run-of-mine barite sold or used by producers represented 38% of total production compared with 36% in 1982; flotation concentrate was 13% of total 1983 production; and the balance was other beneficiated material.

Reported primary barite production decreased 59%. Nevada and Georgia were 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 NL Baroid/NL Industries Inc., with mines in Arkansas, Missouri, and Nevada; Dresser Minerals Div., Dresser Industries Inc., with mines in Missouri and Nevada; IMCO Services Div., Halliburton Co., 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., Chromalloy American Corp., Eisenman Chemical Co. (a subsidiary of Newpark Resources Inc.), FMC Corp., and Old Soldier Mining Co. DeSoto Mining Co. in Missouri and David Beck Co. in Washington also produced significant quantities of barite.

The domestic barite industry continued its downturn, which had started at midyear 1982. Production data revealed the full effect of the oil glut and economic slowdown, which resulted in lower oil- and gas-well-drilling activity. Prior to the downturn, 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 commitments to purchase foreign ore, and was followed by cutbacks in domestic mine production and grinding plant activities. This slowdown was exacerbated by the continuing decline in foreign ore prices because of world barite oversupply and lower ocean freight rates, in part owing to lower bunker fuel prices. These factors, coupled with increased domestic mining costs and higher rail rates, combined to make foreign barite more attractive than domestic ore. Although some larger producers were starting to use unit trains in collaboration with the railroads, thus lowering their rail rates to the U.S. gulf coast areas, many mining and grinding operations were either suspended or on minimal production schedules. Most of the additions to mining, milling, and/or grinding capacity had begun before the 1982 downturn. Many on-going and planned projects, including exploration programs, were being critically evaluated.

A major barite producer was promoting the use of a weighting agent containing barite with upwards of 20%, by weight, of the heavier iron oxide ore, specular hematite. This material was reportedly more cost effective in oil- and gas-well drilling than the pure barite agents. This blended material could spur the need for more lower grade domestic barite. The use of more economical unit train shipments from Nevada to the gulf coast could play a role in fostering increased domestic barite production.

NL Baroid/NL Industries placed its Lake Charles, LA, grinding plant on-stream. Eisenman improved its crude ore unloading system and expanded its packaging, storage, and warehouse operations at its Corpus Christi, TX, grinding facility. W. R. Grace & Co. and Hughes Tool Co. formed an equally owned partnership, Hughes Drilling Fluids, which combined the domestic operations of Hughes Drilling Fluids Div. and Drilling Mud Inc. FMC announced plans to close its barium and strontium chemicals production facilities in Modesto, CA, by mid-1984. The plant processed barite ore from its Mountain Springs, NV, mine. The company cited high production costs, increasing imports, and shrinking demand as the main reasons for its decision. This was the sixth barium or strontium chemical unit in North America to close since 1970. Chemical Products Corp. (CPC), Cartersville, GA, the sole surviving domestic producer of barium and strontium chemicals, started to expand its production capacity for these chemicals to meet the anticipated shortfall in these chemicals brought about by the closing of FMC's Modesto facility and to minimize the need for imports to satisfy domestic demand. CPC filed a petition with the U.S. International Trade Commission, which instituted preliminary antidumping investigations relating to imports of barium chloride and barium carbonate from China. The petition charged that material from China was being sold at prices substantially below those of domestically produced material.

Table 2.—Primary barite sold or used by producers in the United States, 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)
1982:									
Arkansas	2	--	--	W	W	W	W	W	W
Georgia	2	--	--	W	W	W	W	W	W
Illinois	1	--	--	W	W	--	--	W	W
Missouri	8	--	--	--	--	107	$5,703	107	$5,703
Montana	1	W	W	--	--	--	--	W	W
Nevada	17	633	$13,727	--	--	942	39,000	1,575	52,727
Tennessee	1	W	W	--	--	--	--	W	W
Washington	1	W	W	--	--	--	--	W	W
Total	33	668	16,481	82	$6,420	1,095	46,621	1,845	69,522
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

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 continued its second consecutive year of decline from the alltime high of 1981, decreasing 42% since 1981 to 2.7 million tons. The decline reflected a significant decrease in barite required for well drilling, which accounted for over 96% of total sales. The oil- and gas-well-drilling industry completed over 76,000 wells and drilled over 325 million feet of hole.[2] The figures indicated a decline in the number of wells and feet drilled of 11% and 8%, respectively.

Total well footage drilled exceeded 10 million feet in five States: Texas, 114.2 million feet; Oklahoma, 48.7 million feet; Louisiana, 28.5 million feet; Ohio, 21.8 million feet; and Arkansas, 21.0 million feet. Generally, the deeper a hole is drilled, the more barite is used per foot of drilling. Among the five leading States, Louisiana had the highest average well depth, over 6,300 feet, and Kansas, the lowest, had an average well depth of about 3,000 feet. The U.S. average remained at about 4,400 feet. A significant reason that barite consumption decreased is that the average consumption of barite per foot of drilling decreased to 16.3 pounds per foot compared with 20.4 pounds per foot in 1982. Another barometer of drilling activity, the Hughes Tool rig count, showed that the average number of operating drilling rigs declined for the second successive year from 3,105 to 2,232.[3] The estimated rig count during the year ranged from a low of 1,800 to a high of 2,700. The alltime high count of 3,969 occurred in 1981.

The total value of barium chemicals sold or used in 1983 decreased 10% to $16.9 million. This was the fifth successive year of decline, and total value had declined 35% since the 1979 record year.

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

State	1982 Number of plants	1982 Quantity (thousand short tons)	1982 Value (thousands)	1983 Number of plants	1983 Quantity (thousand short tons)	1983 Value (thousands)
Louisiana	13	1,585	$123,056	11	1,056	$77,680
Missouri	4	98	6,964	3	11	1,135
Nevada	7	588	29,686	11	635	26,019
Oklahoma	6	321	34,803	6	82	7,249
Texas	13	1,080	91,824	13	750	58,643
Utah	5	164	12,502	4	55	3,842
Other[2]	12	252	23,866	12	157	19,811
Total[3]	60	4,088	322,700	60	2,745	194,380

[1]Includes imports.
[2]Includes Arkansas, California, Georgia, Illinois, Kansas, Montana, and New York (1983).
[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]	1982 Quantity	1982 Value	1983 Quantity	1983 Value
Barium chemicals	31	3,152	40	3,703
Filler or extender[3]	58	8,825	57	12,030
Well drilling	3,999	310,721	2,648	178,647
Total	4,088	[4]322,700	2,745	194,380

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

Table 5.—Barium chemicals produced and sold or used by processors in the United States[1]

Barium chemical	1982 Plants[2]	1982 Production (short tons)	1982 Sold or used by processors: Quantity (short tons)	1982 Sold or used by processors: Value (thousands)	1983 Plants[2]	1983 Production (short tons)	1983 Sold or used by processors: Quantity (short tons)	1983 Sold or used by processors: Value (thousands)
Barium carbonate	3	18,770	16,330	$7,560	3	18,190	15,800	$7,470
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	3	9,370	8,970	11,160	2	5,050	5,880	9,390
Total	4	28,140	25,300	18,720	4	23,240	21,680	16,860

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			
1963	907	20.14	4.57	16.76	41.47	59.6	4,405	21.87
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

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

Source: American Petroleum Institute.

PRICES

Price quotations in trade publications for some grades of barite decreased slightly. 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, increased 1% to $38.73, f.o.b. plant. The average reported value per ton of ground barite from Texas and Louisiana was $75.88; the average value of that from California, Nevada, and Utah was $58.08 per ton. The average customs value of ground barite exported to Canada was about $233 per ton; the customs value of material exported to Mexico and Latin America was about $140 per ton.

Table 7.—Barite price quotations

Item	Price per short ton[1]	
	1982	1983
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	105.00	106.00
Water-ground, 95% $BaSO_4$, 325 mesh, 50-pound bags	$80.00-155.00	$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	87.00-120.00	80.00-115.00
Crude, imported, specific gravity 4.20 to 4.30, f.o.b. shipping point	65.00- 75.00	65.00- 75.00
Barium chemicals:[3]		
Barium carbonate:		
Precipitated, bulk, carlots, freight equalized (per pound)	.24	.24
Electronics-grade, bags	335.00	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	55.00
Barium sulfate:		
Blanc fixe, technical-grade, bags, carlots	430.00	430.00
USP, X-ray diagnosis-grade, powder, 25-kilogram bags, 10,000-kilogram lots (per pound)	.54	.59
Barium sulfide (black ash), drums, carlots, works	115.00-150.00	460.00

[1]Unless otherwise specified.
[2]Engineering and Mining Journal. V. 183, No. 12, Dec. 1982, p. 19, and v. 184, No. 12, Dec. 1983, p. 21.
[3]Chemical Marketing Reporter. V. 222, No. 26, Dec. 27, 1982, p. 25, and v. 224, No. 26, Dec. 26, 1983, p. 29.

FOREIGN TRADE

Exports of natural barium sulfate declined 53% to 23,000 tons. This represented the smallest amount of ground barite exported since 1969 when 20,000 tons was shipped. Export and import data provided by the Bureau of the Census indicated the grades of barite traded; however, based on the value of individual shipments, an estimated 90% of barite exports was ground-drilling-mud grade, and an estimated 10% was chemical, filler, or glass grade. No crude barite was exported during 1983. Mexico continued as the leading importer of U.S. ground barite, accounting for nearly 80% of total exports. Exports to Canada, traditionally the second largest importer of ground barite, declined about 20% to about 2,600 tons.

Imports of crude barite decreased 40% from 2.32 million tons, the record high, to 1.40 million tons, the least amount of crude barite imported since 1978. The average unit value of this material dropped about 5% to $48.02 per ton, indicating that prices of foreign ores were continuing 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 were China, $50.10; Morocco, $49.56; Peru, $44.26; and Mexico, $33.72. The costlier, higher quality barite, generally material with a specific gravity greater than 4.3, had usually been blended with lower grade ore, foreign or domestic, during grinding to meet the American Petroleum Institute specification for 4.2 drilling-mud-grade barite. Imports from all countries, except China, declined significantly.

Imports of ground barite declined 94% to about 1,300; of this, Canada, the Netherlands, the Federal Republic of Germany, and Mexico supplied approximately 90%. Ground barite imports generally had been limited to premium-quality pharmaceutical grade, unavailable domestically and averaging $300 to $500 per ton. The average value of the Mexican imports, about $46 per ton, suggests that this barite was probably drilling-grade material. The value of the imports from Thailand, about $163 per ton, suggests that these ground materials were probably destined for domestic filler and extender markets that in the past had been supplied domestically.

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 district in 1983 (1982) was New Orleans, LA, 51% (56%); Houston, TX, 28% (34%); Laredo, TX (port of Brownsville, TX), 12% (9%); Port Arthur, TX (port of Lake Charles, LA), 9% (1%); and El Paso, TX, none (1%).

Imports of barium chemicals increased 17% to about 28,000 tons valued at about $16 million. The Federal Republic of Germany, China, Japan, and Italy were the major suppliers.

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

Country	1982		1983	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Argentina	45	$19	238	$134
Australia	--	--	3	13
Barbados	519	.163	1,677	107
Canada	3,166	603	2,582	601
Chile	4	11	--	--
Colombia	3	2	26	19
Guatemala	7,676	935	--	--
Jamaica	335	44	4	1
Japan	42	74	--	--
Mexico	36,293	4,544	17,676	2,485
Philippines	6	6	56	21
Venezuela	75	48	45	21
Other	368	60	509	111
Total[1]	48,533	6,510	22,816	3,514

[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	1982 Quantity (short tons)	1982 Value[1] (thousands)	1983 Quantity (short tons)	1983 Value[1] (thousands)
Crude barite:				
Chile	331,876	$16,812	81,601	$4,163
China	780,497	44,534	777,955	38,974
India	169,126	6,705	24,251	1,221
Ireland	81,157	2,456	--	--
Italy	36,921	1,763	--	--
Mexico	143,619	5,000	131,467	4,433
Morocco	350,801	19,054	175,999	8,723
Peru	241,634	12,058	129,939	5,751
Thailand	152,005	6,575	48,005	2,213
Other[2]	32,605	1,929	26,745	1,556
Total	2,320,241	116,886	[3]1,395,964	67,034
Ground barite:				
Belgium-Luxembourg	12	5	56	21
Canada	534	243	579	163
France	--	--	40	12
Germany, Federal Republic of	177	53	160	55
India	22,487	3,197	--	--
Mexico	--	--	153	7
Netherlands	360	108	295	105
Spain	81	26	--	--
Thailand	--	--	43	7
Total	23,651	3,632	1,326	370

[1]C.i.f. value.
[2]Includes 32,605 tons valued at $1,929,198 in 1982 and 26,462 tons valued at $1,527,100 in 1983 from Taiwan, not believed to have originated in Taiwan.
[3]Data do not add to total shown because of independent rounding.

Source: Bureau of the Census.

Table 10.—U.S. imports for consumption of barium chemicals

Year	Lithopone Quantity (short tons)	Lithopone Value (thousands)	Blanc fixe (precipitated barium sulfate) Quantity (short tons)	Blanc fixe Value (thousands)	Barium chloride Quantity (short tons)	Barium chloride Value (thousands)	Barium hydroxide Quantity (short tons)	Barium hydroxide Value (thousands)
1979	1,535	$662	9,352	$4,152	6,839	$1,398	3,912	$2,009
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

Year	Barium nitrate Quantity (short tons)	Barium nitrate Value (thousands)	Barium carbonate, precipitated Quantity (short tons)	Barium carbonate, precipitated Value (thousands)	Other barium compounds Quantity (short tons)	Other barium compounds Value (thousands)
1979	517	$117	11,596	$2,770	1,540	$783
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

NA Not available.

Source: Bureau of the Census.

Table 11.—U.S. imports for consumption of crude, unground, and crushed or ground witherite[1]

Year	Crude, unground		Crushed or ground	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1979	5	$1	436	$105
1980	22,145	713	62	23
1981	7	2	92	85
1982	292	82	41	44
1983	1	4	49	12

[1]Barium carbonate.

Source: Bureau of the Census.

WORLD REVIEW

Estimated world production of barite decreased 23% to 6.3 million tons. The United States produced 12% of the world total and imported 22% of the world output.

Australia.—The first phase of redevelopment at Steetley Industries' Oraparinna barite mine, acquired from Australian Barytes Pty. Ltd. in 1981, involving construction of a drift to gain access to the richer barite-bearing levels, was completed.[4] Production in 1983 was about 5,000 tons. A second planned phase was to optimize a newly developed method to process the deeper ores.

Brazil.—Magcobar Minerals Div., Dresser Industries, entered into a joint venture with Cal Confiansa to mine and grind barite in Bahia and Salvador, respectively.[5]

Canada.—A new mill in St. Johns, Newfoundland, was put on-stream by Magcobar Dresser Canada Ltd. in a joint venture with Standard Manufacturing Co.[6] A new $1.5 million Raymond mill was to process about 20,000 tons per year of ore from East Coast Barite's reopened Collier Point Mine in the Trinity Bay area. The mill's entire production was targeted for the offshore drilling market. In Nova Scotia, Nystone Chemicals constructed a jigging plant at its mine near Brookfield and Novex Mining and Exploration Co. Ltd. reopened the old Yava flotation mill to process barite from a deposit near Pine Brook Cape, Breton Isle.[7]

China.—KCA International PLC, well established in China after constructing a 200,000-ton-per-year barite milling facility in Guangxi, announced an agreement in principal to acquire Berkeley Exploration and Production PLC's bid position offshore in the southern Yellow Sea.[8] A large readily accessible deposit, containing in excess of 20 million tons of barite ore, was found in the western mountainous areas of Fujian.[9] Development of another deposit, in Lifang, Dahu, Yong'an County, was to have an initial production of 160,000 tons per annum. Guangxi was the largest Chinese barite producer with total annual exports amounting to about 700,000 tons. The barite deposit in Xiangzhou was reported to have a verified reserve of over 5 million tons. Another deposit, in Yonfu County, was being developed with U.S. assistance. China's resources of barite are mainly in Fujian, Guangxi, Hubei, and Shandong. The barite output of over 1 million tons satisfied both domestic and export needs.

Finland.—Outokumpu Oy reported that barite concentration began at its Pyhasalmi copper-zinc-pyrite mine on a trial basis.[10] The ore contained about 4% barite, which in the past had not been recovered. Plans called for concentrating about 5,000 tons of barite to determine if the new recovery circuits warrant commercial production. About 30,000 tons of barite was contained in the annual output of ore from the mine.

Ireland.—The worldwide downturn in drilling activities was given as the reason for closing Milchem Minerals Ltd.'s barite mine at Dineen Bay, County Cork, but it was reported that another company was interested in taking it over.[11] Milchem, however, continued to recover barite from tailings at Tynagh, County Galway.

Italy.—A barite grinding plant with a production capacity of over 250 tons per day of drilling-mud-grade barite was put on-stream by Sveluppo Industriale Minière Sarde, a member of the Carlo Laviosa group of companies, at Villaspeciosa near Cagliari, Sardinia.[12] The parent company had a similar operation in Livorno. The company's production, about 200,000 tons per year, was used largely for offshore oil exploration in Italy, with about 30% exported for use in the Mediterranean Basin.

Mexico.—The new 2,000-ton-per-day open pit La Minita barite mine of the Pen Oles Group was reported encountering startup problems.[13]

Morocco.—Important barite prospects were discovered at Bou Ouzzel and Androus by the Bureau de Recherches et de Participations Minières.[14] The Bleida Mine, operating at reduced levels since 1981, was reportedly near its unspecified rated capacity.[15] Cie. Marocaine des Barytes (COMABAR) and Stè. de Developpment Industriel et Minière de le Haute Moulouya (SODIM) (equal joint owners with the Moroccan Government) both announced ambitious production plans for the near future. Plans called for barite output to reach approximately one-half million tons before 1990. COMABAR opened another mine at Zelmon with a production capacity of 100,000 tons per year.

Pakistan.—There are two major deposits of barite, one near Khuzdar and the other in Las Bela.[16] Open pit mines near Khuzdar were operated by a joint venture between the Baluchistan Development Authority and Pakistan Petroleum Ltd. The joint venture completed construction of a new crushing-grinding complex with a capacity of 25,000 tons per year adjacent to the minesites. Plans were to build a second complex to process additional barite for use in the Persian Gulf area.

Poland.—The Government announced that plant modernization and other efficiencies helped to raise barite output at its only barite mine by over 25% to about 100,000 tons per year.[17] The operation was capable of supplying the nation's demand for ground barite.

Turkey.—Barite deposits are present in the Paleozoic formations in the east-west trending southern Taurus and northern Pontic ranges.[18] The main southern deposits are around Konya-Beysehir, Antalya-Gazipasa, and in the vicinity of Giresun in the north. Large deposits in the east are in Mus Province. The privately owned Mayas Madencilik Co. mined barite in Beysehir and milled the ore at Eskisehir. Polbar Baryte Industries AS and Egemetal Madencilik, both barite producers, were planning joint ventures with foreign firms to expand their current production.

Zaire.—The results of a satellite survey published by Erts-Zaire indicated the possibility of barite deposits in western Bas-Zaïre Province, near the Atlantic Ocean.[19]

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

(Thousand short tons)

Country[2]	1979	1980	1981	1982[p]	1983[e]
Afghanistan[3]	3	[r]3	1	2	2
Algeria	113	108	98	112	120
Argentina	61	55	54	40	44
Australia	104	43	45	[e]44	44
Austria	([4])	([4])	--	--	--
Belgium[e]	--	33	44	44	44
Bolivia[5]	2	10	2	1	1
Brazil	119	115	128	[e]132	130
Burma[6]	44	44	[e]11	22	22
Canada[e]	83	105	88	33	31
Chile	250	249	286	322	331
China[e]	550	750	880	990	1,102
Colombia	4	4	4	[e]4	4
Czechoslovakia	75	67	[e]67	[e]67	67
Egypt	2	5	2	[e]3	4
France	187	261	210	172	165
German Democratic Republic[e]	39	39	39	39	39
Germany, Federal Republic of	178	193	182	399	276
Greece[7]	53	53	52	52	51
Guatemala	4	5	6	2	2
India	541	478	390	359	331
Iran[e]	198	165	83	88	94
Ireland	362	287	[e]287	[e]287	240
Italy	237	224	195	198	165
Japan	61	62	62	66	77
Kenya	([4])	7	[e]7	([8])	--
Korea, North[e]	120	120	110	--	--
Korea, Republic of	1	([4])	--	--	--
Malaysia	2	--	21	[r] [e]28	22
Mexico	167	297	350	401	386
Morocco	316	353	513	593	303

See footnotes at end of table.

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

(Thousand short tons)

Country[2]	1979	1980	1981	1982[p]	1983[e]
Pakistan	38	15	26	29	31
Peru	490	457	451	413	180
Philippines	7	6	2	[e]10	2
Poland	106	106	94	[e]88	110
Portugal	1	1	1	[e]1	1
Romania	90	88	[e]87	[e]86	86
South Africa, Republic of	3	3	3	4	[9]7
Spain	82	66	58	55	55
Thailand	417	336	338	365	[9]207
Tunisia	16	30	27	34	[9]22
Turkey	110	[r]141	205	118	88
U.S.S.R.[e]	550	560	560	570	570
United Kingdom	50	60	69	89	94
United States[10]	2,112	2,245	2,849	1,845	[9]754
Yugoslavia	51	53	49	[e]50	44
Zimbabwe	(4)	(4)	--	--	--
Total	7,999	[r]8,302	9,036	8,257	6,348

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through May 30, 1984.
[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]Barite concentrates.
[8]Revised to zero.
[9]Reported figure.
[10]Sold or used by producers.

TECHNOLOGY

A technically oriented review of the past, present, and future of barite and other weighting materials used in oil- and gas-well drilling was published.[20] The article stressed the technology, output, production flowsheets, and specifications for drilling-mud-grade barite and other similarly used agents such as hematite and ilmenite. The article also stressed the fact that oil-well-drilling activities consume over 90% of the world's barite supply in drilling-mud formulations. Another review article described the industrial minerals used in the drilling industry.[21] The paper, featuring barite, highlighted both how industrial minerals were consumed by the industry and how the physical and chemical properties of these minerals were exploited to obtain the desired drilling fluid characteristics.

An in-depth review was published on the open pit barite mining at Ballynoe, Ireland.[22] The review covered the exploration, production history, geology, and open pit mining of these deposits. The article also discussed the operations of two U.S. companies presently mining in the Ballynoe area. Another comprehensive paper featuring barite was published in a treatise on the industrial minerals of India.[23] The paper detailed the barite geology, mineralogy, mining, and production methods in India along with estimates of reserves for the companies currently in production.[24] A profile of the activities of a leading Turkish barite producer was highlighted in another work. The work included discussions on the mining and milling of drilling-grade barite for use in the Middle East and Eastern Europe.

An overview of barite explorations in the United States was published.[25] The paper lists the three types of deposits in which barite is found—bedded, residual, and vein—and the sophisticated techniques and tools employed to locate them. The bedded deposits are of most interest because of their relatively large size. The paper also highlights the history of barite explorations in the United States and the geology of the known deposits along with their genesis. A discussion on modern prospecting tools, including geochemical, gravity, seismic, induced polarization, and electromagnetics as applied to barite prospecting, was also included.

[1]Physical scientist, Division of Industrial Minerals.

[2]American Petroleum Institute. Quarterly Review of Drilling Statistics for the United States. 4th Quarter, 1983, and Annual Summary, 1983. V. 17, No. 4, Feb. 1984, 39 pp.

[3]Hughes Tool Co. 1983 Annual Report. P. 14.

[4]Industrial Minerals (London). Company News and Mineral Notes. No. 186, Mar. 1983, p. 63.

[5]Castelli, A. V. Barite. Eng. and Min. J., v. 185, No. 3, Mar. 1984, pp. 92-93.

[6]Engineering and Mining Journal. This Month in Mining. In Canada-Newfoundland. V. 184, No. 7, July 1983, p. 84.

[7]Work cited in footnote 6.

[8]Industrial Minerals (London). Company News and Mineral Notes. No. 192, Sept. 1983, p. 77.

[9]Chin, E. Far East-China. Art. in Mining Annual Review 1983. Min. J. (London), June 1983, pp. 349-357.

[10]Mining Journal (London). Production: Finnish Barytes. V. 301, No. 7729, Oct. 7, 1983, p. 266.

[11]O'Meara. M. Republic of Ireland. Art. in Mining Annual Review 1983. Min. J. (London), June 1983, pp. 489-493.

[12]Industrial Minerals (London). World Minerals: Italy-Laviosa Offers Barytes Grinding Capacity. No. 186, Mar. 1983, p. 11.

[13]Mining Journal (London). Mining Annual Review 1983. North America-Mexico. June 1983, pp. 302-303.

[14]World Mining Yearbook. Worldwide Survey: Africa-Morocco. V. 36, No. 8, Aug. 1983, p. 120.

[15]Mew, M. Morocco. Art. in Mining Annual Review 1983. Min. J. (London), June 1983, pp. 441-443.

[16]U.S. Embassy, Islamabad, Pakistan. State Dep. Airgram A-012, May 5, 1983, 15 pp.

[17]Industrial Minerals (London). Company News and Mineral Notes. No. 194, Nov. 1983, p. 63.

[18]Mining Journal (London). Mining Annual Review 1983. North Africa and Middle East. June 1983, pp. 443-445.

[19]Industrial Minerals (London). Company News and Mineral Notes. No. 187, Apr. 1983, p. 68.

[20]Castelli, A. V. Past, Present, and Future of Barite and Other Weighting Materials. Pres. at Soc. Min. Eng. AIME Annual Meeting, Atlanta, GA, Mar. 6-10, 1983. Soc. Min. Eng. AIME preprint 83-67, 6 pp.

[21]Miles, W. J., and R. E. Blair. Industrial Minerals Uses in the Drilling Industry. Min. Eng., v. 35, No. 10, Oct. 1983, pp. 1397-1400.

[22]Mining Magazine (London). Open Pit Barytes Mining at Ballynoe, Ireland. V. 148, No. 3, Mar. 1983, pp. 194-199.

[23]Clarke, G. M. The Industrial Minerals of India. Ind. Miner. (London), No. 191, Aug. 1983, pp. 21-52.

[24]Watson, I. Bastas Doubles Barytes Capacity at Antalya. Ind. Miner. (London), No. 186, Mar. 1983, pp. 55-57.

[25]Fields, R. A. Barite Exploration in the United States. Pres. at Soc. Min. Eng. AIME Annual Meeting, Atlanta, GA, Mar. 6-10, 1983. Soc. Min. Eng. AIME preprint 83-94, 7 pp.

Bauxite and Alumina

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

The world aluminum industry began to recover in the second quarter of 1983 as demand for the metal increased and aluminum prices rose sharply. However, domestic bauxite and alumina production declined in 1983 with respect to 1982 levels. World bauxite production was also lower, although world alumina output registered a small increase over that of 1982.

The discovery of an 82-million-metric-ton[3] bauxite deposit averaging 42.5% alumina was reported in the Kalihandi area of Orissa State, India. In Brazil, Cia. Brasileira de Alumínio reported the discovery of a 60-million-ton bauxite deposit at Cataguases, Minas Gerais.

Kaiser Aluminum & Chemical Corp. closed its alumina plant at Baton Rouge, LA, in March, and Reynolds Metals Co. permanently shut down its Hurricane Creek alumina plant in August.

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 17 operations to which a survey form was sent, all responded, representing 100% of domestic 1983 bauxite production as shown in tables 1, 2, and 18.

Table 1.—Salient bauxite statistics

(Thousand metric tons and thousand dollars)

	1979	1980	1981	1982	1983
United States:					
Production: Crude ore (dry equivalent)	1,821	1,559	1,510	732	679
Value	$24,875	$22,353	$26,489	$12,334	$11,309
Exports (as shipped)	15	21	20	49	74
Imports for consumption[1]	13,780	14,087	12,802	10,122	7,601
Consumption (dry equivalent)	15,697	15,962	13,525	9,217	8,966
World: Production	[r]85,522	[r]89,215	85,523	[p]77,793	[e]76,016

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Excludes calcined bauxite. Includes bauxite imported to the U.S. Virgin Islands.

Legislation and Government Programs.—National Defense Stockpile goals for metal-grade bauxite remained at 21.3 million tons of Jamaica-type ore and 6.2 million tons of Suriname-type ore. The goal for calcined refractory-grade bauxite was 1.4 million tons, while the goal for calcined abrasive-grade bauxite was increased from 762,000 tons to 1 million tons.

General Services Administration (GSA) agreed to acquire 2 million tons of metal-grade bauxite from Jamaica during the fiscal years 1983 and 1984. Payment for the first half of the Government stockpile acquisition was to be by cash and the balance through the exchange of U.S. surplus agricultural products. Delivery of the ore to stockpile sites in Texas and Louisiana began in July 1983 and was expected to be completed in 1984. The GSA inventory for December 31, 1983, reported 203,000 tons of calcined refractory-grade bauxite, 10.6 million tons of Jamaica-type metal-grade bauxite, and 5.4 million tons of Suriname-type metal-grade bauxite.

DOMESTIC PRODUCTION

For the first time since bauxite mining began in the United States in 1889, virtually no domestic bauxite was mined for use in the production of aluminum metal. The ore was used to produce special grades of aluminas or for chemical, refractory, or other nonalumina uses. Of the three companies in Arkansas involved in processing bauxite, only two, the Aluminum Co. of America (Alcoa) and American Cyanamid Co., mined local bauxite. Porocel Corp. produced activated bauxite from purchased ore. Bauxite mined in Alabama and Georgia by A. P. Green Refractories Co., Harbison-Walker Refractories Co., and Mullite Co. of America was shipped to the chemical and refractory industries. A small quantity of the bauxite produced in Alabama and Arkansas was calcined for use in the production of oil and gas well proppants.

By yearend, only six of the nine U.S. Bayer alumina plants, including the St. Croix, U.S. Virgin Islands, refinery, were operating to produce alumina for the aluminum industry. Alcoa's Mobile, AL, plant closed in 1982, Kaiser closed its Baton Rouge, LA, Bayer plant in March 1983, and Reynolds shut down its Bayer operations at Hurricane Creek, AR, in August 1983. Both the Kaiser and the Reynolds plants were continuing to produce special grades of alumina products. Lower domestic production was offset by an increase in alumina imports, which exceeded domestic output for the first time since the United States began importing substantial quantities of alumina in 1967.

Domestic refineries shipped an estimated 3.32 million tons of calcined alumina to U.S. primary aluminum plants in 1983. Shipments of calcined alumina to the abrasive, ceramic, chemical, and refractory industries and alumina exports accounted for the balance of the total 3.54 million tons of calcined alumina produced.

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)

State	Mine production			Shipments from mines and processing plants to consumers[1]		
	Crude	Dry equivalent	Value[2]	As shipped	Dry equivalent	Value[2]
1981:						
Alabama and Georgia	342	268	4,303	389	442	17,670
Arkansas	1,505	1,242	22,185	1,429	1,221	26,358
Total[3]	1,847	1,510	26,489	1,819	1,663	44,028
1982:						
Alabama and Georgia	W	W	W	197	203	10,180
Arkansas	W	W	W	1,214	[r]1,044	25,142
Total	896	732	12,334	1,411	[r]1,247	35,322
1983:						
Alabama and Georgia	W	W	W	W	W	W
Arkansas	W	W	W	W	W	W
Total	826	679	11,309	977	913	26,370

[r]Revised. W Withheld to avoid disclosing company proprietary data.
[1]May exclude some bauxite mixed in clay products.
[2]Computed from values assigned by producers and from estimates of the Bureau of Mines.
[3]Data may not add to totals shown because of independent rounding.

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
1982	234	120	[r]184
1983	293	140	225

[r]Revised.
[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)	1979	1980	1981	1982	1983
Less than 8	1	--	--	--	--
From 8 to 15	55	62	65	63	W
More than 15	44	38	35	37	W

W Withheld to avoid disclosing company proprietary data.

Table 5.—Production and shipments of alumina in the United States

(Thousand metric tons)

Year	Calcined alumina	Other alumina[2]	Total[1]	
			As produced or shipped[3]	Calcined equivalent
Production:[e]				
1979	5,950	700	6,650	6,450
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
Shipments:[e]				
1979	5,970	710	6,680	6,480
1980	6,160	720	6,880	6,660
1981	5,610	715	6,320	6,085
1982	3,780	420	4,150	4,020
1983	3,480	670	4,150	3,945

[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	1982	1983
Aluminum Co. of America:		
Bauxite, AR	340	340
Mobile, AL	800	800
Point Comfort, TX	1,400	1,400
Total	2,540	2,540
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	650	--
Corpus Christi, TX	1,400	1,700
Total	2,050	1,700
Grand total	7,495	7,145

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

CONSUMPTION AND USES

During the year, 91% of the total 9.1 million tons of bauxite consumed by U.S. industry was refined to various forms of alumina. The production of 1 ton of calcined alumina required an average of 2.01 tons (dry basis) of bauxite. Only one of the nine domestic alumina plants processed domestic bauxite. Metal-grade bauxite from three previous sources, the Dominican Republic, Haiti, and Suriname, was not imported in 1983.

Consumption data include quantities of bauxite consumed by the Canadian abrasives industry for subsequent use in U.S. plants for the manufacture of abrasive end products. Consumption of other special grades included bauxite used for cement, petroleum refining, and the steel industry.

Alcoa joined Norton Co. in a joint venture at Fort Smith, AR, to produce sintered bauxite proppants for use in propping open rock strata in deep oil and gas wells. Alcoa's mines at Bauxite, AR, supplied the low-iron bauxite. The high-strength spherical beads are pumped into fractures in the producing formation and enhance well flow by increasing permeability. A proppant plant owned by the General Abrasives Div. of Dresser Industries Inc. was nearing completion at Eufaula, AL, and was scheduled to start production in June 1984. The world market for proppants was estimated at 100,000 tons per year.

Because of its good flame retardant characteristics and relatively low cost, demand for hydrated alumina, the uncalcined Bayer plant product, increased in 1983 as a filler for rigid and flexible plastic products and as a carpet backing. New markets for special grades of alumina were being developed in the ceramics, abrasives, and refractories industries.

Consumption of calcined alumina by the 29 operating domestic primary aluminum plants was approximately 5.86 million tons. The primary aluminum industry also consumed aluminum fluoride and synthetic cryolite made from alumina.

Table 7.—Bauxite consumed in the United States, by industry

(Thousand metric tons, dry equivalent)

Industry	Domestic	Foreign	Total[1]
1982:			
Alumina	559	7,984	8,543
Abrasive[2]	--	149	149
Chemical	[3]47	[3]192	169
Refractory	100	186	286
Other	W	W	71
Total[1] [2]	706	8,511	9,217
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

W Withheld to avoid disclosing company proprietary data; included with "Chemical."
[1]Data may not add to totals shown because of independent rounding.
[2]Includes consumption by Canadian abrasive industry.
[3]Includes "Other."

Table 8.—Crude and processed bauxite consumed in the United States

(Thousand metric tons, dry equivalent)

Type	Domestic origin	Foreign origin	Total
1982:			
Crude and dried	564	8,180	8,744
Calcined and activated	142	330	[1]473
Total	706	[1]8,511	9,217
1983:			
Crude and dried	570	7,867	8,437
Calcined and activated	154	375	529
Total	724	8,242	8,966

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

Table 9.—Production and shipments of selected aluminum salts in the United States, in 1982

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)	63	1,046	977	$136,223
Iron-free (17% Al_2O_3)	13	70	55	7,315
Aluminum chloride:				
Liquid and crystal (32° Bé)	3	W	W	W
Anhydrous (100% $AlCl_3$)	5	47	W	W
Aluminum fluoride, technical	5	76	80	64,418
Aluminum hydroxide, trihydrate (100% $Al_2O_3 \cdot 3H_2O$)	7	423	423	101,475
Other inorganic aluminum compounds[1]	XX	XX	XX	22,630

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	1982	1983
Producers and processors	[r]614	548
Consumers	[r]6,548	4,991
Government	16,326	16,326
Total	[r]23,488	21,865

[r]Revised.
[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	1982	1983
Producers[e]	244	265
Primary aluminum plants	[r]1,116	1,161
Total[e]	[r]1,360	1,426

[e]Estimated. [r]Revised.
[1]Excludes consumers' stocks other than those at primary aluminum plants.

PRICES

Because of the vertically integrated nature of the aluminum industry, bauxite and alumina are rarely traded on open world markets. Both commodities are normally traded under long-term contracts or through intracompany transfers. With the exception of spot sales and specialty forms and grades, prices are not listed in trade journals.

The average 1983 value for domestic crude bauxite shipments, f.o.b. mine or plant, was estimated by the Bureau of Mines to be $13.67 per ton. An average value of $88.76 per ton was estimated for domestic calcined bauxite shipments.

Monthly prices for imported, calcined, refractory-grade bauxite from Guyana were published in the Engineering and Mining Journal. Quoted prices, per ton, in carload lots, delivered f.o.b. Baltimore, MD, Mobile, AL, or Burnside, LA, were as follows:

Jan. 1983	Feb.-Apr. 1983	May-June 1983	July-Nov. 1983	Dec. 1983
$198.72	$198.14	$175.01	$174.59	$168.28

The estimated average value for domestic shipments of calcined alumina in 1983 was $244.21 per ton. Based on trade data of the Bureau of Census, imported alumina had an average value of $201.25 per ton, f.a.s. at port of shipment and $213.42 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	1982 Port of shipment (f.a.s.)	1982 Delivered to U.S. ports (c.i.f.)	1983 Port of shipment (f.a.s.)	1983 Delivered to U.S. ports (c.i.f.)
To U.S. mainland:				
Brazil	$29.47	$40.46	$30.82	$43.48
Dominican Republic	37.05	45.60	--	--
Guinea	27.50	38.05	26.49	35.89
Guyana	37.52	52.75	39.13	52.67
Haiti	32.54	38.34	--	--
Jamaica	35.43	39.91	29.19	36.04
Suriname	46.89	59.72	42.96	52.95
Weighted average	32.62	40.42	28.71	37.36

[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. 3, 1983	Jan. 2, 1984
Alumina, calcined	$228.18	$418.88
Alumina, hydrated, heavy	203.93	209.44
Alumina, activated, granular, works	352.74	905.00
Aluminum sulfate, commercial, ground (17% Al_2O_3)	259.04	259.04
Aluminum sulfate, iron-free, dry (17% Al_2O_3)	$270.06-382.50	439.82

Source: Chemical Marketing Reporter.

FOREIGN TRADE

The United States exported 54,000 tons of calcined bauxite and 20,000 tons of dried bauxite, or a total of 104,000 tons expressed as dry equivalent. Mexico received 97% of the calcined bauxite and Canada 96% of the dried bauxite. Other exports included 14,000 tons of aluminum sulfate, 11,000 tons of aluminum oxide abrasives, and 50,000 tons of other aluminum compounds, such as aluminum fluoride and synthetic cryolite. Import duties on bauxite and alumina were suspended in 1971 by Public Law 92-151.

Calcined abrasive-grade bauxite from Australia, China, Guinea, Guyana, and Suriname was processed in 1983 in Canada into fused crude aluminum oxide that was subsequently shipped to U.S. plants for use in 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	1981		1982		1983	
	Quantity	Value	Quantity	Value	Quantity	Value
Argentina	1	501	1	460	([2])	387
Australia	[r]1	1,234	([2])	342	([2])	306
Belgium-Luxembourg	[r]([2])	1,570	1	2,129	1	3,115
Brazil	2	1,363	1	1,128	21	5,750
Canada	[r]200	63,940	[r]102	37,106	19	13,874
France	[r]2	3,010	[r]2	2,583	2	1,836
Germany, Federal Republic of	3	6,514	3	6,403	3	5,171
Ghana	76	13,862	160	29,222	19	3,173
Japan	3	10,454	3	7,769	2	4,482
Mexico	[r]124	35,657	[r]84	23,976	99	29,517
Netherlands	1	1,392	1	1,878	1	1,170
Norway	141	21,364	145	38,086	265	59,776
Poland	([2])	26	([2])	102	([2])	117
Spain	20	4,349	([2])	152	([2])	141
Sweden	15	4,358	27	6,174	98	13,370
U.S.S.R.	36	8,570	([2])	14	--	--
United Kingdom	[r]5	6,284	6	6,962	4	3,750
Venezuela	94	25,695	[r]22	7,308	52	12,218
Other	[r]6	8,497	5	7,490	6	9,374
Total	[r]730	218,640	[r]563	179,284	[3]591	167,527

[r]Revised.
[1]Includes exports of alumina from the U.S. Virgin Islands to foreign countries. Includes exports of aluminum hydroxide (calcined equivalent) as follows: 1981—12,500 tons; 1982—7,600 tons; and 1983—8,100 tons.
[2]Less than 1/2 unit.
[3]Data do not add to total shown because of independent rounding.

Table 15.—U.S. imports for consumption of bauxite, crude and dried,[1] by country

(Thousand metric tons)

Country	1981	1982	1983
Brazil	1,265	512	555
Dominican Republic[2]	449	163	--
Guinea	3,546	4,198	3,600
Guyana	463	239	167
Haiti	529	500	--
Jamaica[2]	5,352	4,080	3,036
Sierra Leone	108	--	--
Suriname	1,079	409	239
Other	11	21	4
Total	12,802	10,122	7,601

[1]Includes bauxite imported to the U.S. Virgin Islands from foreign countries.
[2]Dry equivalent of shipments to the United States.

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: 1981—13,856,826 tons; 1982—11,049,685 tons; and 1983—7,903,202 tons.

Table 16.—U.S. imports for consumption of calcined bauxite, by country

(Thousand metric tons and thousand dollars)

Country	1982				1983			
	Refractory grade		Other grade		Refractory grade		Other grade	
	Quantity	Value[1]	Quantity	Value[1]	Quantity	Value[1]	Quantity	Value[1]
Australia	--	--	10	967	--	--	8	1,116
China	55	6,264	18	2,064	51	4,498	14	2,188
Guyana	52	9,225	17	1,443	66	9,230	22	2,531
Suriname	22	1,658	14	1,126	--	--	47	3,940
Other	2	306	([2])	22	--	--	1	78
Total	131	17,453	59	5,622	117	13,728	92	[3]9,852

[1]Value at foreign port of shipment as reported to U.S. Customs Service.
[2]Less than 1/2 unit.
[3]Data do not add to total 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	1981		1982		1983	
	Quantity	Value[2]	Quantity	Value[2]	Quantity	Value[2]
Australia	2,955	574,688	[r]2,707	[r]598,685	3,049	544,322
Brazil	(3)	142	11	3,511	3	1,565
Canada	34	10,222	[r]130	51,334	159	67,762
France	4	13,479	5	13,183	6	10,982
Germany, Federal Republic of	8	9,469	[r]11	14,341	13	15,797
Guinea	--	--	--	--	13	1,851
Guyana	4	613	--	--	--	--
Jamaica	523	124,180	196	49,651	399	87,973
Japan	1	1,639	1	1,243	25	7,927
Suriname	448	102,486	117	27,387	318	59,225
Venezuela	--	--	--	--	35	4,394
Other	[r](3)	1,014	[r]5	[r]11,109	11	9,222
Total[4]	3,978	837,932	[r]3,182	770,444	4,030	811,021

[r]Revised.
[1]Includes imports of aluminum hydroxide. For 1982 and 1983, imports of crude and refined and ground aluminum oxide are included.
[2]Value at foreign port of shipment as reported to U.S. Customs Service.
[3]Less than 1/2 unit.
[4]Data may not add to totals shown because of independent rounding.

WORLD REVIEW

World markets for metal-grade bauxite remained depressed through yearend. By midyear, some alumina plant capacity had been reactivated in response to increased smelter requirements, but the oversupply of alumina reportedly held alumina prices down to marginally economic levels. World alumina capacity increased by 1.8 million tons per year with the startup of new plants in Ireland and Venezuela and the expansion of some existing plants. The International Bauxite Association invited India to join the bauxite producers group, restoring to 11 the number of member countries, following the resignation of Haiti in December 1982.

Australia.—In Queensland, the annual capacity of the Queensland Alumina Ltd. refinery at Gladstone, the world's largest alumina plant, was expanded by 370,000 tons to 2.4 million tons and was to reach 2.7 million tons by mid-1984. Comalco Pty. Ltd. entered the world proppant market in 1983 with sintered abrasive-grade bauxite produced from ore mined at Weipa, Queensland. Both production and shipments of metal-grade bauxite at Weipa declined from 1982 levels. This was largely due to slack demand, although a recurrence of the 1982 maritime dispute over manning of a bauxite ore carrier forced Comalco to reduce bauxite production in the second quarter. In Western Australia, Alcoa of Australia Ltd. raised alumina production in mid-1983 at its Kwinana and Pinjarra refineries from 85% to 95% of capacity. Alcoa announced that its 500,000-ton-per-year Wagerup refinery, completed in mid-1982, was to start production in February 1984. Startup of a second new Western Australia alumina plant at Worsley was also delayed. The Worsley alumina project, owned by Reynolds Australia Alumina Ltd. (40%), Shell Co. of Australia Ltd. (30%), BHP Minerals Ltd. (20%), and Kobe Alumina Associates (Australia) Pty. Ltd. (10%), was expected to start alumina production by the second quarter of 1984, although the bauxite mine to supply the plant began operating in 1983. The designed annual capacity of the refinery was 1 million tons. Reynolds' 400,000-ton share of alumina from the Worsley plant was expected to replace, in part, the 650,000 tons of annual alumina capacity lost when Reynolds closed the Hurricane Creek refinery in Arkansas.

Brazil.—Mineração Rio do Norte S.A. (MRN), Brazil's only bauxite exporter, revised its original plan to increase the annual capacity of the Trombetas mine from 3.3 million tons to 6.4 million tons and opted for a capacity increase to 4 million tons. More than 600,000 tons of Trombetas bauxite was consumed by U.S. alumina plants in 1983. Much of the increased bauxite production in 1984 was expected to go to supply MRN's first Brazilian customer, the Alumínio do

Maranhão S.A. (Alumar) alumina-smelter complex at São Luis, Maranhão State. Alumar, a $1,300 million joint venture between Alcoa Alumínio S.A. (60%) and Billiton International Metals BV (40%), planned to start up a 500,000-ton-per-year alumina plant and a 100,000-ton-per-year primary aluminum plant in the second half of 1984. Another major project in northern Brazil, Consorcio del Construcão Albras/Alunorte (CONSUAL S.A.), formerly known as the Albras-Alunorte project, remained on an indefintely suspended status. The project, to include an 800,000-ton-per-year alumina plant and a 320,000-ton-per-year smelter located on the Amazon River near Belem, Pará State, was planned by Cia. Vale do Rio Doce (51%) and a group of 27 Japanese companies (49%).

Greece.—After years of planning and negotiating, the Governments of Greece and the Soviet Union agreed to proceed with the joint construction of a $450 million alumina plant designed to produce 600,000 tons per year of alumina from local Greek bauxite deposits. The U.S.S.R. and Bulgaria were to purchase annually 400,000 tons and 200,000 tons, respectively. Construction was to start in 1985.

Guinea.—Compagnie des Bauxites de Guinée (CBG), the operating company for the Sangaredi bauxite mine, the largest in Guinea, was owned by Halco (Mining) Inc., 51%, and the Government of Guinea, 49%. Billiton BV of the Royal Dutch/Shell Group, Netherlands, purchased a 6% interest in Halco through Martin Marietta Aluminum Co.'s sale of part of its 20% interest in Halco. Other companies in the Halco consortium were Aluminum Co. of Canada Ltd. (Alcan) 27%, Alcoa 27%, Péchiney S.A. 10%, Vereinigte Aluminum-Werke AG 10%, and Montecatini Edison S.p.A. 6%.

Guyana.—A Government proposal in June 1983 to reduce the workweek from 5 to 3 days and a drastic retrenchment in September of the Guyana Mining Enterprise Ltd. work force led to a 6-week labor strike and a loss in production during the year. A contract with Green Construction Co., Iowa, for overburden removal and bauxite mining at the East Montgomery Mine was extended throughout the year. Recommendations by consultants—Kaiser Aluminum Technical Services on repairing the alumina plant, and USS Engineers & Consultants Inc., a United States Steel Corp. subsidiary, on improving management of the operation—were reviewed by the state-owned Bauxite Industrial Development Corp. Production of calcined abrasive-grade bauxite, produced from 1937 to 1970, was resumed in 1983 to take advantage of markets previously supplied by the Suriname Aluminum Co. (Suralco). The 355,000-ton-per-year alumina plant at Linden remained closed during the year.

Hungary.—According to Hungaropress, the Hungarian news agency, an agreement to supply the U.S.S.R. with 530,000 tons of alumina and 5,000 tons of semifinished aluminum products annually was extended to 1990 with an option for further extension to the year 2000. Hungary was to receive, in exchange, annual deliveries of 205,000 tons of primary aluminum ingot. The barter arrangement allows the U.S.S.R. to benefit from Hungarian bauxite reserves, while the latter benefits from the relatively lower Soviet smelter costs that result from hydroelectric power sources. Hungary was developing a new 650,000-ton-per-year bauxite mine at Fenyoefoe that was expected to start producing ore by mid-1984. Bauxite production was started early in 1983 at the Bito-2 Mine in County Fejer. Output from the 1.3 million-ton-per-year-capacity mine was expected to reach 400,000 tons by yearend.

Ireland.—The newly constructed Aughinish Alumina Ltd. refinery owned by Alcan (40%), Billiton (35%), and Anaconda Ireland Co. (25%) started production in September. The refinery had a designed annual capacity of 800,000 tons of alumina and was scheduled to consume about 1.6 million tons annually of bauxite imported from CBG in Guinea.

Jamaica.—Production and exports by the five companies operating bauxite mining and refining plants remained at very low levels. Because Jamaica derives more than 65% of its export earnings through sales of these commodities, the economic impact of the depressed market was severe. In March, the Government signed an agreement to supply 1 million tons of metal-grade bauxite for the U.S. National Defense Stockpile. A second agreement, signed in November, increased the quantity to be supplied to 2 million tons. The first million tons was sold by cash transaction at $33.46 per dry ton, f.o.b. Jamaican ports.[4] The price of the second million tons was the same; however, payment by the United States was to be in the form of dairy products. Bauxite shipments to U.S. stockpile sites began in July and were expected to be completed by yearend 1984. Jamaica signed a contract in the first quarter of 1983 to sell annually to the U.S.S.R., 1 million tons of bauxite starting in 1984. A trial shipment of 200,000 tons was exported under this contract in 1983. The new bauxite contract replaced an earlier sales contract to supply the Soviet Union annually with 250,000 tons of alumina. Jamaica was to receive machinery and other merchandise from the U.S.S.R. in partial payment for the bauxite. The bauxite production levy agreement between the Government and the five North American bauxite and alumina producers expired at yearend 1983. Negotiations between the Government and the companies to draft a 5-year levy agreement were complicated by a devaluation that lowered the value of the Jamaican dollar by 43%, and no agreement had been reached by yearend.

Suriname.—Shipments of bauxite and alumina continued at low levels in 1983 as a result of weak demand, and output was further reduced by a December labor strike that closed down the bauxite mines, alumina refinery, primary aluminum smelter, and the hydroelectric powerplant. News was announced in August that NV Billiton Maatschappij Suriname, a wholly owned subsidiary of Billiton, would buy a 45% interest in the Suralco 1.4 million-ton-per-year alumina plant located at Paranam. This would end a tolling arrangement whereby part of Billiton's bauxite production was refined to alumina in the Suralco (wholly owned subsidiary of Alcoa) plant. Suralco suspended its exports of metal-grade bauxite and closed down its refractory-grade bauxite calcining facilities early in the year. In November, the abrasive-grade bauxite calciners were also shut down. The company cited high production costs, low market prices, and diminishing reserves as reasons for ending calcined bauxite production. Withdrawal of Suralco, the world's second largest abrasive-grade bauxite producer, left the market to Australia, China, Guinea, and Guyana.

United Kingdom.—British Alcan Aluminium Ltd. announced that its Burntisland alumina plant in Scotland was to be modified and the capacity expanded in 1984. Approximately $1.7 million was to be spent to increase the capacity for fine-particulate hydrated alumina. The Burntisland facility was one of the leading European alumina chemicals producers.

Venezuela.—The first unit of the Interamericana de Alúmina C.A. (INTERALÚMINA) refinery began producing alumina in February, and the second unit started up in September, bringing the plant to its designed annual capacity of 1 million tons. Startup was reported to have gone smoothly, and by yearend, a total of 560,000 tons of alumina had been produced with about 140,000 tons exported to Canada, Norway, and the United States. The balance was sold to Venezuela's state-owned primary aluminum smelters, Venezolana de Alúminio and Aluminio del Caroni S.A. Bauxite feed for INTERALÚMINA was imported from Brazil, Sierra Leone, and Suriname. In July, the Government budgeted funds for the Bauxitas Venezolanas C.A. (Bauxiven) project to proceed with engineering studies to develop the Los Pijiguaos bauxite deposits in Bolivar State. Bauxiven's objectives were to design a mining operation and an Orinoco River barge transport system to start delivery of ore to the INTERALÚMINA refinery in 1986.

Table 18.—Bauxite: World production, by country[1]

(Thousand metric tons)

Country	1979	1980	1981	1982[p]	1983[e]
Australia	27,583	27,178	25,541	23,625	24,500
Brazil	2,388	5,538	5,770	6,289	7,000
China[e]	1,500	1,500	1,500	1,500	1,500
Dominican Republic[2]	[r]635	[r]606	457	141	--
France	1,969	1,921	1,824	1,662	1,716
Germany, Federal Republic of	(3)	(3)	(3)	(3)	(3)
Ghana	214	225	181	64	63
Greece	2,812	3,286	3,216	2,853	2,900
Guinea[4]	11,326	11,862	11,112	11,827	[5]11,080
Guyana[2]	2,312	1,844	1,681	1,430	[5]1,791
Haiti[6]	584	312	427	377	--
Hungary	2,976	2,950	2,914	2,627	[5]2,917
India	1,952	1,785	1,923	1,854	[5]1,923
Indonesia	1,052	1,249	1,203	700	750
Italy	26	23	19	24	24

See footnotes at end of table.

Table 18.—Bauxite: World production, by country[1] —Continued

(Thousand metric tons)

Country	1979	1980	1981	1982[p]	1983[e]
Jamaica[7]	11,618	12,054	11,682	8,361	7,300
Malaysia	387	920	701	589	460
Pakistan	2	2	2	[r e]1	1
Romania	708	710	[e]712	[e]680	650
Sierra Leone	672	766	[e]610	606	600
Spain	8	4	9	8	8
Suriname	5,010	4,646	4,100	3,059	1,750
Turkey	[e]350	533	575	508	[5]296
U.S.S.R.[e 8]	4,600	4,600	4,600	4,600	4,600
United States[2]	1,821	1,559	1,510	732	[5]679
Yugoslavia	3,012	3,138	3,249	3,668	[5]3,500
Zimbabwe	5	4	5	8	8
Total	[r]85,522	[r]89,215	85,523	77,793	76,016

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through June 27, 1984.
[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: 1979—2,500; 1980—2,500; 1981—2,500; 1982—2,500, and 1983—2,500. Estimated alunite ore production was as follows in thousand metric tons: 1979—600; 1980—600; 1981—605 (revised); 1982—610 (revised); and 1983—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]	1979	1980	1981	1982[p]	1983[e]
Australia	7,415	7,246	7,079	6,631	7,100
Brazil	449	493	497	606	580
Canada	953	1,202	1,208	1,127	[4]1,116
China[e]	750	750	750	800	800
Czechoslovakia[e]	100	100	100	100	100
France	1,069	1,173	1,095	960	853
German Democratic Republic	41	43	43	40	46
Germany, Federal Republic of	1,539	1,608	1,651	1,510	1,500
Greece	495	494	490	420	450
Guinea	660	708	608	549	600
Guyana[5]	200	231	170	73	--
Hungary	788	805	792	710	[4]836
India[e]	[4]493	500	500	500	450
Ireland	--	--	--	--	70
Italy	854	900	786	698	700
Jamaica	2,094	2,456	2,556	1,758	[4]1,907
Japan	1,545	1,936	1,344	959	[4]1,065
Romania[e]	502	534	540	[r]514	500
Spain	--	58	695	673	650
Suriname	1,325	1,316	1,200	1,172	1,200
Taiwan[e]	[r]113	[r]128	[r]62	[r]21	--
Turkey	70	138	131	84	[4]57
U.S.S.R.[e]	2,600	2,700	2,800	3,000	3,200
United Kingdom	88	102	90	88	90
United States[e]	6,450	6,810	5,960	4,130	[4]4,000
Venezuela	--	--	--	--	560
Yugoslavia	836	1,058	1,037	1,072	1,100
Total	[r]31,429	[r]33,489	32,184	28,195	29,530

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Figures presented generally represent calcined alumina; exceptions are noted individually.
[2]Table includes data available through June 27, 1984.
[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.

Table 20.—World annual alumina capacity, by country

(Thousand metric tons, yearend)

Country	1981	1982	1983
Australia	7,340	7,840	7,910
Brazil	540	540	540
Canada	1,225	1,225	1,225
China	650	650	650
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
Italy	920	920	920
Jamaica	2,825	2,825	2,825
Japan	2,615	2,615	2,615
Poland	([1])	--	--
Romania	540	540	540
Spain	800	800	800
Suriname	1,350	1,350	1,350
Taiwan	140	160	160
Turkey	200	200	200
U.S.S.R.[e]	4,500	4,500	4,500
United Kingdom	140	140	140
United States	7,420	7,495	7,145
Venezuela	--	--	1,000
Yugoslavia	1,635	1,635	1,635
Total	39,195	39,790	41,310

[e]Estimated.
[1]Revised to zero.

TECHNOLOGY

Alcoa and ARCO Metals Co. announced a joint research project to perfect the technology for production of primary aluminum from kaolinitic clay. ARCO was to contribute its expertise in producing aluminum chloride from clay, while Alcoa would provide smelter technology for converting the chloride to aluminum. This alternative to the conventional Bayer-Hall processes, based on bauxite as the raw material, promised significant savings in energy requirements and could draw on very large domestic resources of clay.[5]

Toth Aluminum Corp. planned to open a new plant at Vacherie, LA, in the first quarter of 1984 to produce aluminum chloride and other metal chlorides from clay. The plant was to use a proprietary carbochlorination process in conjunction with a boron trichloride catalyst to treat kaolin clay supplied from Georgia. The company expected this first commercial plant to recover alumina from clay to produce annually about 8,000 tons of aluminum chloride for conversion to high-purity alumina for the abrasives and ceramic markets.[6]

At Red Mountain, CO, Earth Sciences Inc. was exploring an alunite (potassium aluminum sulfate) deposit as a possible alternate source of alumina. The company reported drilling out more than 54 million tons of alunite, which, when pure, contains 37% alumina. The proposed project was economically enhanced by a plan to produce potash and sulfuric acid as coproducts.[7]

The Bureau of Mines reviewed the state-of-the-art technology for producing aluminum chloride from kaolinitic clay. The important chemical problems in producing anhydrous aluminum chloride of acceptable purity for the production of aluminum metal were identified and discussed.[8] Preliminary studies were completed at the Bureau of Mines Tuscaloosa Research Center on the dewatering of the red mud waste of alumina plants. High-molecular-weight polyacrylamides were found to be the most effective flocculants for red mud generated from Jamaican bauxite. Slurries containing approximately 10% solids were dewatered to about 25% solids using a baffled, rotating drum mixer to mix a commercial flocculant with the mud and a trommel screen to provide dewatering.

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[1]Physical scientist, Division of Nonferrous Metals.
[2]Statistical assistant, Division of Nonferrous Metals.
[3]All quantities in this chapter are given in metric tons unless otherwise specified.
[4]Contract price was $34 per long dry ton of bauxite.
[5]American Metal Market. V. 91, No. 215, Nov. 3, 1983, pp. 1, 8.
[6]———. No. 220, Nov. 10, 1983, p. 6.
[7]Industrial Minerals (London). May 1983, p. 15.
[8]Landsberg, A. Aluminum From Domestic Clay Via a Chloride Process. BuMines IC 8923, 1983, 15 pp.

Beryllium

By James F. Carlin, Jr.,[1] and Benjamin Petkof[1]

The domestic beryllium industry continued to convert domestic and imported beryllium ore concentrates to beryllia, metal, and alloys. Imports of beryl declined moderately. Exports of beryllium materials declined sharply from those of 1982. Beryllium concentrate consumption increased as numerous end-use markets rebounded in 1983.

World beryl production declined slightly in 1983.

Domestic Data Coverage.—Domestic production data for beryllium were developed by the Bureau of Mines from separate, voluntary surveys of U.S. operations. Typical of these surveys was the Beryllium Mineral Concentrate and Beryllium Ore survey. All 18 operations to which a survey request was sent responded. Four of these operations accounted for 100% of the total production in 1983. Production data were withheld in table 1 to avoid disclosing company proprietary data.

Table 1.—Salient beryllium mineral statistics

(Short tons unless otherwise specified)

	1979	1980	1981	1982	1983
United States:					
Beryllium mineral concentrates:					
Shipped from mines[1]	W	W	W	W	W
Imports for consumption	1,037	1,703	2,138	2,652	2,194
Consumption[1]	9,518	8,508	8,141	5,387	6,989
Price, approximate, per short ton unit BeO, imported cobbed beryl at port of exportation	$47	$69	$94	$121	$126
Yearend stocks[1]	835	1,350	2,223	5,112	7,037
World production of beryl	2,642	2,823	3,198	[p]3,414	[e]3,189

[e]Estimated. [p]Preliminary. W Withheld to avoid disclosing company proprietary data.
[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 1982: 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 beryllium materials remained at 18,000 tons, 7,900 tons, and 400 tons, respectively. The General Services Administration awarded a contract to Brush Wellman Inc. to sell the Government 30 tons of beryllium metal by December 12, 1984, for inclusion in the National Defense Stockpile.

Beryllium occupational and health standards promulgated in 1975 by the Occupational Safety and Health Administration were still pending in 1983.

Federal income tax laws provided a depletion allowance of 22% for domestic production and 14% for U.S. companies producing from foreign sources.

DOMESTIC PRODUCTION

Brush Wellman remained the only major commercial producer of beryllium concentrates. Brush Wellman mined low-grade bertrandite ore at Spor Mountain, UT, and processed it into beryllium hydroxide. A small quantity of beryl was also mined domestically.

Brush Wellman converted beryllium concentrates to beryllium hydroxide at its processing plant near Delta, UT, and began operation of a new furnace designed to process beryl ore with lower beryllia concentration, containing a minimum of 7% beryllium oxide. The firm also completed a major expansion of its Elmore, OH, plant for making beryllium-copper alloy rods and tubes.

The Cabot Berylco Div. of the Cabot Corp. continued to produce beryllium-copper and other beryllium alloys at its plant in Reading, PA, from imported and domestic ores that were converted to beryllium hydroxide. Cabot started rolling beryllium-copper alloy strip products at its High Technology Materials Div. in Kokomo, IN, and also continued rolling operations at its Reading, PA, plant. Cabot started construction on a new facility in Elkhart, IN, to further process some strip products.

Domestic production of beryllium metal declined significantly, but production of beryllium-copper master alloys and beryllium oxide ceramics increased.

CONSUMPTION AND USES

Consumption of beryl ore increased from that of 1982, but remained below levels of recent years, as several markets experienced greater demand.

Copper-based beryllium alloys were the most widely used beryllium-containing products and demand increased in 1983. The addition of about 2% beryllium to copper provides a commercial copper alloy with physical properties that permit the alloy's use in a wide range of applications in cast and wrought forms. Often the alloy was used in the form of a thin strip or small-diameter rod. The alloy was then used to fabricate items such as connectors, springs, sockets, switches, bushings, bearings, noncorrosive and nonmagnetic housings, and temperature- and pressure-sensing devices for the aircraft, automotive, electronic, and well-drilling industries.

Beryllium oxide ceramics found increasing use in electronics and electrical industries because of its high thermal conductivity, mechanical hardness and strength, electrical insulation, and low dielectric constant. It was used in the production of lasers, microwave tubes, semiconductors, electronic substrates, microprocessors, aerospace and communications equipment, home appliances, and other equipment.

Beryllium metal with its high stiffness-to-weight ratio, light weight, excellent thermal conduction properties, and nuclear reflection and absorption properties was used in inertial guidance systems, military and commercial satellite and space vehicle structures, instrumentation, space optics, and special nuclear applications.

PRICES AND SPECIFICATIONS

From the beginning of 1983 until late July, Metals Week quoted the price range for beryl ore at $110 to $135 per short ton unit; for the balance of the year, the price range was quoted at $110 to $120 per short ton unit.

At yearend, the American Metal Market quoted the following prices for beryllium materials in dollars per pound:

Vacuum cast ingot, 97% pure		$206
Metal powder, in 5,000-pound lots and 97% pure		178
Beryllium-copper master alloy		130
Beryllium-copper casting alloy	$4.39-	5.30
Beryllium-copper in rod, bar, wire		7.20
Beryllium-copper in strip		7.10
Beryllium-aluminum alloy, in 100,000-pound lots		215
Beryllium oxide powder		49.60

FOREIGN TRADE

Exports declined sharply, especially to Switzerland, reflecting the erratic pattern of yearly exports in recent years. France was the major destination.

Beryl was the only beryllium mineral ore imported into the United States. The average value of imported ore increased from $1,212.29 per ton in 1982 to $1,255.70 per ton in 1983. Brazil and China together supplied about 82% of total imports of beryl. In addition to the imports of beryl, 18,346 pounds of wrought, unwrought, and waste and scrap beryllium metal valued at $110,975 was imported from the Federal Republic of Germany, Mexico, and the United Kingdom.

Starting January 1, 1983, the U.S. import duties for beryllium were as follows: beryllium ore and concentrates (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), 8.3% 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), 4.4% 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	1982		1983	
	Quantity (pounds)	Value (thousands)	Quantity (pounds)	Value (thousands)
Belgium-Luxembourg	--	--	487	$5
Canada	804	$130	1,129	384
China	476	8	--	--
Costa Rica	--	--	5,130	9
Czechoslovakia	9	1	55	6
Finland	20	2	196	20
France	4,229	1,298	13,289	1,246
Germany, Federal Republic of	542	140	1,261	310
Hong Kong	345	16	--	--
Ireland	--	--	48	2
Italy	57	6	343	7
Japan	9,649	751	5,137	378
Korea, Republic of	2,951	40	2,561	83
Mexico	50	1	231	3
Netherlands	28	53	9	23
Portugal	--	--	150	1
Spain	8,962	16	--	--
Sweden	7,478	88	--	--
Switzerland	98,556	1,126	4,886	126
United Kingdom	347	22	2,553	137
Other	r10	r3	12	3
Total	134,013	3,696	37,477	2,693

rRevised.

[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	1982 Quantity (short tons)	1982 Value (thousands)	1983 Quantity (short tons)	1983 Value (thousands)
Argentina	31	$32	--	--
Australia	2	3	14	$26
Belgium-Luxembourg	44	38	--	--
Brazil	945	1,262	1,006	1,217
China	975	1,041	788	1,030
Hong Kong	127	159	32	40
Japan	60	74	--	--
Madagascar	--	--	33	22
Portugal	22	33	--	--
Rwanda	22	19	--	--
South Africa, Republic of	227	298	128	188
Switzerland	118	156	165	200
Taiwan	31	34	--	--
United Kingdom	10	9	--	--
Zaire	--	--	9	11
Zimbabwe	38	57	19	21
Total	2,652	3,215	2,194	2,755

WORLD REVIEW

Brazil and the U.S.S.R. remained the major producers of beryl. China was also a substantial producer, but production data were unavailable.

Brazil.—Beryl was mined in six States: Minas Gerais, Bahia, Rio Grande do Norte, Paraíba, Ceará, and Alagoas. The principal areas of production were in the northeast sector of Minas Gerais in the Jequitinhonha and Rio Doce Valleys. Here, mining was characteristically carried on by a large number of producers operating on a small scale. After beneficiation, beryl was exported, mainly to the United States.

U.S.S.R.—Most beryl deposits were in the Kola Peninsula, Kazakhstan, the Urals, Altay, Transbaikal, the Soviet Far East, and western Ukraine. Recovery of beryllium from the Dzhidinsk tungsten and molybdenum ores in Buryat, A.S.S.R., was planned.

[1]Physical scientist, Division of Nonferrous Metals.

Table 4.—Beryl: World production, by country[1]

(Short tons)

Country	1979	1980	1981	1982[p]	1983[e]
Argentina	13	34	8	7	8
Brazil (exports)	498	606	894	1,161	882
Madagascar	11	11	11	11	11
Mozambique	31	22	20	17	17
Portugal	6	21	20	21	20
Rwanda	51	119	65	76	77
South Africa, Republic of	1	(2)	134	64	19
U.S.S.R.[e]	2,000	2,000	2,000	2,000	2,100
United States[3]	W	W	W	W	W
Zimbabwe	31	10	46	57	55
Total	2,642	2,823	3,198	3,414	3,189

[e]Estimated. [p]Preliminary. W Withheld to avoid disclosing company proprietary data.

[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. 4, 1984.

[2]Less than 1/2 unit.

[3]Primarily bertrandite ore.

Bismuth

By James F. Carlin, Jr.[1]

Domestic production of bismuth was derived by processing lead ores and 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 pharmaceutical, chemical, cosmetic, steel, and aluminum industries were major users.

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)

	1979	1980	1981	1982	1983
United States:					
Consumption	2,727	2,289	2,393	1,876	2,285
Exports[1]	428	129	79	53	306
Imports, general	2,167	2,217	2,436	2,026	1,972
Producer price, average per pound (ton lots)	$3.01	(2)	(2)	(2)	(2)
Consumer stocks, Dec. 31	630	674	509	542	577
World: Production[3]	[r]7,548	[r]7,954	8,130	[p]8,799	[e]8,935

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

Bismuth was produced from the treatment of lead ores and bullion of both foreign and domestic origin. 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 1983, and most consumption categories shared in the increase. The sharpest increase occurred in metallurgical additives, where usage was stimulated by increased demand for capital goods as the general economy rebounded.

Table 2.—Bismuth metal consumed in the United States, by use

(Thousand pounds)

Use	1982	1983
Fusible alloys	572	623
Metallurgical additives	125	523
Other alloys	21	20
Pharmaceuticals[1]	1,145	1,104
Experimental	([2])	2
Other	13	13
Total	1,876	2,285

[1]Includes industrial and laboratory chemicals and cosmetics.
[2]Less than 1/2 unit.

PRICES

Asarco continued suspension of its producer list price throughout the year. The published price of a major foreign producer remained at $2.30 per pound throughout the year. Dealer quotations were $1.35 to $1.40 per pound at the beginning of 1983 and were raised throughout the year to finish at $1.75 to $1.80 per pound.

FOREIGN TRADE

Exports of bismuth increased sharply to the highest level in 4 years.

Starting January 1, 1983, 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), 7.3% ad valorem for MFN and 45% ad valorem for non-MFN; and compounds (TSUS 418.00 and 423.80), 10.5% ad valorem for MFN and 35% ad valorem for non-MFN.

The recent pattern of import sources continued, with Mexico and Peru being the major suppliers.

Table 3.—U.S. exports of bismuth, bismuth alloys, and waste and scrap, by country

Country	1982		1983	
	Quantity (pounds)	Value (thousands)	Quantity (pounds)	Value (thousands)
Argentina	--	--	148	$1
Australia	108	$1	26	3
Bahrain	278	1	--	--
Bermuda	382	1	--	--
Brazil	905	15	813	3
Canada	11,794	88	24,950	102
China	--	--	38,486	83
Colombia	506	1	--	--
France	28	6	7	2
Germany, Federal Republic of	1,387	21	137	1
Greece	1,000	3	4,000	11
Hong Kong	25	5	--	--
India	3,451	25	--	--
Ireland	--	--	410	2
Israel	4	1	165	2
Italy	1,983	26	429	7
Japan	5,142	46	7,407	59
Korea, Republic of	10	2	9	1
Malaysia	244	1	100	2
Mexico	--	--	641	9
Netherlands	--	--	64,567	172
Peru	204	2	--	--
Portugal	767	1	--	--
Singapore	1,128	6	891	8
South Africa, Republic of	811	5	69	2
Spain	2,840	10	1,464	12
Sweden	267	5	--	--
Switzerland	400	3	30,110	66
Taiwan	--	--	1,258	55
Thailand	382	7	--	--

Table 3.—U.S. exports of bismuth, bismuth alloys, and waste and scrap, by country—Continued

Country	1982 Quantity (pounds)	1982 Value (thousands)	1983 Quantity (pounds)	1983 Value (thousands)
Trinidad	528	$6	--	--
United Kingdom	16,841	59	129,940	$93
Venezuela	1,099	21	--	--
Other	244	3	101	7
Total	52,758	371	306,128	703

Table 4.—U.S. general imports[1] of metallic bismuth, by country

Country	1982 Quantity (pounds)	1982 Value (thousands)	1983 Quantity (pounds)	1983 Value (thousands)
Belgium-Luxembourg	908	$3	16,095	$24
Canada	50,290	82	178,633	346
Germany, Federal Republic of	118,571	253	32,783	78
Japan	41,361	73	68,281	102
Korea, Republic of	13,412	15	55,112	83
Mexico	699,547	913	706,572	959
Peru	864,100	1,319	653,720	949
Poland	--	--	10	2
United Kingdom	238,056	548	260,750	578
Total	2,026,245	3,206	1,971,956	3,121

[1]General imports and imports for consumption were the same in 1982 and 1983.

WORLD REVIEW

World production of bismuth rose slightly in response to increased demand in many end-use markets. Australia remained the major producer of bismuth at the mining level.

Table 5.—Bismuth: World mine production, by country[1]

(Thousand pounds)

Country[2]	1979	1980	1981	1982[p]	1983[e]
Australia (in concentrates)	[e]2,200	[r] [e]2,650	2,579	3,395	3,310
Bolivia (in concentrates)	22	24	24	11	10
Canada[3]	306	377	370	417	[4]445
China (in ore)[e]	570	570	570	570	570
Germany, Federal Republic of (in ore)[e]	22	([5])	([5])	([5])	--
Japan (metal)	1,010	745	1,054	1,071	1,260
Korea, Republic of (metal)	192	271	220	209	200
Mexico[6]	1,662	1,698	1,446	1,336	1,320
Peru[6]	1,162	1,096	1,409	1,332	1,350
Romania (in ore)[e]	180	180	180	180	180
Uganda (in ore)[e]	11	NA	NA	NA	NA
U.S.S.R. (metal)[e 7]	160	160	170	170	180
United States (in ore)	W	W	W	W	W
Yugoslavia (metal)[3]	[r]51	183	108	108	110
Total	[r]7,548	[r]7,954	8,130	8,799	8,935

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available. W Withheld to avoid disclosing company proprietary data; excluded from total.
[1]Table includes data available through Apr. 4, 1984.
[2]In addition to the countries listed, Brazil, Bulgaria, France, the German Democratic Republic, and Namibia are believed to have produced bismuth, but available information is inadequate for formulation of reliable estimates of output levels.
[3]Refined metal and bullion plus recoverable bismuth content of exported concentrate.
[4]Reported figure.
[5]Revised to zero.
[6]Bismuth content of refined metal, bullion, and alloys produced indigenously plus recoverable bismuth content of ores and concentrates exported for processing.
[7]Output reported is at the smelter stage of production.

TECHNOLOGY

In the United States, a lower temperature wave soldering process was developed, using an eutectic alloy of tin and bismuth with a melting point of 138° C compared with 183° C for the conventional tin-lead solder alloy. The process of immersion wave soldering was being increasingly used in the electronics field and involved passing printed circuit boards through a flux and then over the submerged solder wave; the process permitted rapid soldering with minimal solder waste. Researchers claimed the new process allowed more uniform fluxing, more controllable solder deposition, reduced thermal stress, elimination of solder splatter and drossing, and easier post-solder cleaning of the printed circuit boards.[2]

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[1]Physical scientist, Division of Nonferrous Metals.
[2]Tin International. V. 56, No. 8, Aug. 1983, p. 300.

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, which were 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 were developed by the Bureau of Mines from three 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 data 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. In addition, the two producers of refined borates supplied data on exports of refined borates shown in tables 1 and 5.

Table 1.—Salient statistics of boron minerals and compounds

(Thousand short tons and thousand dollars)

	1979	1980	1981	1982	1983
United States:					
Sold or used by producers:					
Quantity:					
Gross weight[1]	1,590	1,545	1,481	1,234	1,303
Boron oxide (B_2O_3) content	799	783	740	607	637
Value	$310,211	$366,760	$435,387	$384,597	$439,181
Exports:					
Sodium borates (refined):[2]					
Quantity	332	325	228	227	225
Value[e]	$94,000	$65,000	$58,000	$59,000	$51,000
Boric acid:[3]					
Quantity	42	47	46	35	38
Value	$22,938	$23,735	$24,602	$19,082	$20,688
Imports for consumption:					
Colemanite:[4]					
Quantity	89	69	98	39	40
Value	$10,946	$6,218	$15,202	$6,386	$8,309
Boric acid:					
Quantity	8	10	1	4	8
Value	$4,267	$6,393	$763	$1,903	$3,456
Consumption: Boron oxide (B_2O_3) content[5]	410	384	373	266	341
World: Production	[r]2,777	[r]2,877	2,820	[p]2,503	[e]2,450

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

[1]Minerals and compounds sold or used by producers, including both actual mine production and a marketable equivalent of brine products.

[2]Comparable quantities of crude sodium borates are exported also; however, export data are not available.

[3]Includes orthoboric and anhydrous boric acid.

[4]Reported value includes approximately 11,000 tons of ulexite in 1979, 5,500 tons in 1980, 44,000 tons in 1981, and 35,000 tons in 1982. No data available for 1983.

[5]See table 2.

Legislation and Government Programs.—The U.S. Department of Justice terminated a 37-year-old consent decree against 7 companies and 11 individuals engaged in mining, processing, manufacturing, selling, and distributing crude borates, borax, and boric acid. The decree required Borax Consolidated Group defendants to sell the Western Borax Mine property and the Thompson properties and to give the United States a quitclaim deed to the Little Placer Claim. At the time of the termination, the Western Borax Mine property and the Little Placer Claim were owned by Kerr-McGee Chemical Corp. The Western Borax Mine had been depleted of mineral resources, but the Little Placer contained an estimated 2.5 million tons of recoverable borate ore. Both of the claims were adjacent to the U.S. Borax & Chemical Corp. mine at Boron, CA. U.S. Borax estimated that an additional 27 million tons of borate ore from the Boron Mine could be extracted by gaining surface access to the Kerr-McGee property.[2] The termination was finalized in the Federal court for the northern district of California on August 31. On September 8, the Bureau of Land Management allowed the Little Placer leases to be transferred to U.S. Borax for an undisclosed fee.

A suit filed by Kerr-McGee against the U.S. Department of the Interior was dismissed by the Ninth U.S. Court of Appeals because of a lack of demonstrated harm to Kerr-McGee's operations at Searles Lake from a Federal recommendation to place Death Valley National Monument under the strictest pollution control standards. The judge cited the 1977 Clear Air Act Amendments that required the Federal Government to determine if stricter pollution controls were needed.

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 of ore and 130,000 short tons of salable product. Colemanite was ground and processed at the washing and calcining plant at Amargosa, NV. Previously referred to as Lathrop Wells, the town incorporated during 1983 to Amargosa. The mill had a monthly capacity of 6,300 tons 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 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 distill water that was recycled for boiler feed water in the coal-fired generator. The Westend plant curtailed 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.

U.S. Borax, 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. New equipment to improve the recovery of borax from the tailings was being constructed. Centrifuges were to separate clay matter from borax in water solution, which would be evaporated in solar ponds. The process was expected to increase borax recovery by 6% to a total of 91%.

A second plant at Boron produced technical-grade boric acid and sodium sulfate as waste by a proprietary process using 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.

In 1983, 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. discontinued a pilot project designed to produce boric acid from solution-mined colemanite. Pilot plant-size solar ponds had been constructed.

Anaconda Copper Co. and Leslie Salt Co. formed a joint venture to buy the Searles Lake leases of Occidental Petroleum Corp. Leslie produced salt from the solar ponds during the year. Anaconda planned to develop the property at some future date for production of other minerals, including borates.

CONSUMPTION AND USES

U.S. consumption of borates rebounded significantly from its 1982 7-year low. Glass fiber insulation and glass fiber reinforcement plastics continued to be the largest consuming industries.

The improved market for thermal insulation in construction increased demand for borax pentahydrate and ulexite-probertite for use in the manufacture of glass fiber insulation, 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, anhydrous borax, orthoboric acid, and Turkish colemanite 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. Fiber optic material used borosilicate glass cladding.

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.

Table 2.—U.S. consumption of boron minerals and compounds, by end use

(Short tons of boron oxide content)[1]

End use	1982	1983
Glass fiber insulation	57,800	91,400
Fire retardants:		
Cellulosic insulation	31,100	30,200
Other	1,900	1,300
Textile-grade glass fibers	31,600	58,800
Borosilicate glasses	30,600	34,600
Soaps and detergents	27,000	30,400
Enamels, frits, glazes	11,400	11,200
Agriculture	10,800	14,200
Metallurgy	3,400	3,800
Nuclear applications	700	1,100
Miscellaneous uses	21,900	24,200
Sold to distributors, end use unknown	38,000	39,500
Total	[2]266,100	340,700

[1]Includes imports of boric acid, colemanite, and ulexite.
[2]Data do not add to total shown because of independent rounding.

Table 3.—U.S. consumption of orthoboric acid, by end use

(Short tons of boron oxide content)

End use	1982	1983
Fire retardants:		
Cellulosic insulation	11,790	7,915
Other	1,218	1,299
Textile-grade glass fibers	7,379	9,659
Insulation-grade glass fibers	50	--
Borosilicate glasses	6,591	6,984
Metallurgy	696	792
Soaps and detergents	210	336
Enamels, frits, glazes	1,129	371
Nuclear applications	511	754
Agriculture	155	194
Miscellaneous uses	13,454	10,572
Sold to distributors, end use unknown	10,313	12,710
Total	53,496	51,586

PRICES

Prices for basic boron compounds remained at 1982 levels. This was the first time in more than a decade that the price had not risen because of energy and/or labor costs.

Table 4.—Borate prices per short ton[1]

Product	Price, Dec. 31, 1983 (rounded dollars)
Borax, technical, anhydrous, 99%, bulk, carlots, works[2]	564
Borax, technical, granular, pentahydrate, 99.5%, bulk, carlots, works[2]	201
Borax, technical, granular, decahydrate, 99.5%, bulk, carlots, works[2]	175
Boric acid, technical, granular, 99.9%, bulk, carlots, works[2]	552
Boric acid, technical, granular, 99.9%, bags, carlots, works[2]	597
Boric acid, U.S. Borax & Chemical Corp., high-purity anhydrous, 97% B_2O_3, 100-pound bags, carlots, Boron, CA	2,161
Colemanite, American Borate Co., calcined and screened, minus 70-mesh, 42% B_2O_3, bulk, carlots, Dunn, CA	468
Colemanite, American Borate Co., flotation concentrate (uncalcined), 37% B_2O_3, bulk, carlots, Dunn, CA	318
Colemanite, Turkish, 40%-42% B_2O_3, crude, lump, f.o.b. railcars, U.S. east coast port	400
Ulexite-probertite, American Borate Co., screened, minus 7-mesh, 20% B_2O_3, bulk, carlots, Dunn, CA	56
Ulexite-probertite, American Borate Co., minus 200-mesh, 20% B_2O_3	116

[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. 224, No. 26, Dec. 26, 1983, p. 29.

FOREIGN TRADE

Exports of boric acid increased 10% in quantity and 8% in value. Data for crude sodium borates were withheld because there was only one producer for export. Exports of refined sodium borates, as reported by the producers, decreased slightly.

Owens-Corning, through its American Borate subsidiary, imported colemanite, ulexite, and boric acid from Turkey, principally for use in textile-grade and insulation-grade glass fibers. Brokers also imported Turkish colemanite. Imports of boric acid nearly doubled, according to the Bureau of the Census.

Table 5.—U.S. exports of boric acid and refined sodium borate compounds, by country

Country	1982 Boric acid[1] Quantity (short tons)	1982 Boric acid[1] Value (thousands)	1982 Refined sodium borates[2] (short tons)	1983 Boric acid[1] Quantity (short tons)	1983 Boric acid[1] Value (thousands)	1983 Refined sodium borates[2] (short tons)
Argentina	22	$25	--	--	--	1
Australia	2,435	1,101	7,734	2,916	$1,450	6,296
Austria	--	--	417	--	--	308
Belgium-Luxembourg	--	--	3,608	--	--	5,703
Brazil	353	216	6,120	744	358	2,822
Canada	7,831	3,809	55,153	5,053	2,450	43,671
Chile	15	16	28	2	4	--
Colombia	131	94	834	209	136	1,607
Costa Rica	10	11	44	12	6	415
Czechoslovakia	--	--	755	--	--	515
Denmark	169	102	693	325	77	516
Ecuador	9	8	148	3	4	530
El Salvador	--	--	--	--	--	58
Egypt	246	244	--	--	--	11
Finland	21	13	308	--	--	623
France	6	451	14,660	2	1	14,042
German Democratic Republic	--	--	1,391	--	--	752
Germany, Federal Republic of	--	--	11,195	(3)	1	13,243
Greece	--	--	44	--	--	17
Guatemala	4	4	35	2	2	--
Haiti	--	--	--	32	12	--
Honduras	25	8	--	44	17	--
Hong Kong	178	109	2,518	268	160	3,389
Hungary	--	--	805	--	--	552
India	--	--	--	6	2	2
Indonesia	143	89	2,146	100	57	2,515
Ireland	3	1	1,213	--	--	22
Israel	31	25	216	40	30	654
Italy	--	--	3,385	--	--	2,856
Ivory Coast	--	--	803	--	--	988
Jamaica	--	--	--	1	2	--
Japan	15,435	8,511	54,244	18,708	11,259	59,198
Kenya	--	--	--	--	--	39
Korea, Republic of	559	376	6,628	1,565	297	6,030
Leeward Island	--	--	--	3	2	--
Liberia	--	--	--	6	3	--
Malaysia	90	62	1,558	53	46	2,607
Mexico	3,382	1,631	19,452	5,093	2,372	19,860
Morocco	--	--	--	--	--	357
Netherlands	254	174	2,546	--	--	2,757
New Zealand	754	413	4,500	651	376	2,959
Nicaragua	--	--	47	--	--	485
Norway	--	--	699	--	--	280
Pakistan	--	--	285	--	--	301
Panama	--	--	--	2	3	--
Papua New Guinea	323	172	132	--	--	56
Peru	--	--	--	3	2	34
Philippines	604	244	1,561	564	353	1,476
Portugal	--	--	486	--	--	134
Puerto Rico	--	--	67	--	--	103
Saudi Arabia	11	4	344	--	--	246
Senegal	--	--	--	--	--	731
Singapore	186	107	375	244	119	822
South Africa, Republic of	31	30	4,622	4	10	4,163
Spain	--	--	813	--	--	1,123
Sri Lanka	18	11	19	15	8	63
Sudan	--	--	--	--	--	6
Sweden	--	--	1,933	21	17	1,731
Switzerland	--	--	266	2	4	403
Taiwan	1,086	596	5,720	1,291	727	8,494
Thailand	162	119	554	199	137	965
Tunisia	--	--	--	--	--	42
United Kingdom	11	12	4,525	46	20	5,188
Uruguay	6	4	66	7	3	14
Venezuela	356	233	1,189	259	167	743
Yugoslavia	--	--	151	--	--	559
Zambia	--	--	--	--	--	33
Zimbabwe	--	--	--	--	--	562
Other[4]	[r]130	[r]60	[r]368	--	--	--
Total[5]	35,030	19,082	227,404	38,498	20,688	224,672

[r]Revised.
[1]Bureau of the Census.
[2]U.S. exporters of sodium borates.
[3]Less than 1/2 unit.
[4]Includes China, Madagascar, Malawi, Nigeria, and the United Arab Emirates.
[5]Data may not add to totals shown because of independent rounding.

Table 6.—U.S. imports for consumption of boric acid, by country

Country	1982 Quantity (short tons)	1982 Value[1] (thousands)	1983 Quantity (short tons)	1983 Value[1] (thousands)
Argentina	734	$264	1,286	$485
Canada	(2)	1	--	--
France	52	40	139	105
Germany, Federal Republic of	(2)	3	(2)	4
Italy	470	203	956	408
Sweden	20	4	--	--
Turkey	3,086	1,389	5,500	2,453
United Kingdom	--	--	(2)	1
Total	4,362	[3]1,903	7,881	3,456

[1]U.S. Customs declared values.
[2]Less than 1/2 unit.
[3]Data do not add to total shown because of independent rounding.

Source: Bureau of the Census.

WORLD REVIEW

Argentina.—On the Tincalayú salt flats in the Salta Province of the Salar del Hombre Muerto Basin, Boroquímica S.A.M.I.C.A.F., a subsidiary of Borax Holdings Ltd., continued to operate South America's largest mine which had a capacity of about 150,000 tons per year of tincal, a sodium borate mineral. The Tertiary Age deposit was located at an altitude of 14,000 feet in a remote location near Arequipa. The ore was refined at Campo Quijano, which had a capacity to produce 30,000 tons of boron oxide. Exports of boron minerals and compounds in 1982 included 4,000 tons of processed borates, 46 tons of colemanite, 327 tons of calcium and magnesium borates, and 102 tons of sodium borates.

Bolivia.—A field team, including geologists from the U.S. Geological Survey, discovered industrial minerals in the Salar de Uyuni. Exploration of the deposit continued. The salar is a playa-type deposit containing boron reserves estimated at 3.5 million tons.

Canada.—Borates were discovered in conjunction with halite, sylvite, anhydrite, and red mudstone of the Windsor Group of Mississippian Age in New Brunswick. This was the first discovery of borates in Canada.

Chile.—Corporación de Fomento de la Producción (CORFO), a Government-controlled company, continued to seek international tenders to develop potassium salts and boric acid at Salar de Atacama. CORFO planned a 31,000-ton-per-year plant to produce boric acid as a byproduct of potash production.

China.—About 25,000 tons per year of boron minerals had been produced in Qinghai and Liaoning Provinces. It was reported that boron production during 1981 was unable to meet immediate local demand.

Table 7.—Boron minerals: World production, by country[1]

(Thousand short tons)

Country	1979	1980	1981	1982[p]	1983[e]
Argentina	[r]146	172	138	136	153
Chile	3	[r]4	4	(2)	(2)
China[e]	30	30	30	30	30
Peru[e]	13	23	18	15	14
Turkey	775	883	929	868	730
U.S.S.R.[e]	220	220	220	220	220
United States[3]	1,590	1,545	1,481	1,234	[4]1,303
Total	[r]2,777	[r]2,877	2,820	2,503	2,450

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through May 2, 1984.
[2]Less than 1/2 unit.
[3]Minerals and compounds sold or used by producers, including both actual mine production and a marketable equivalent of brine products.
[4]Reported figure.

Mexico.—Drilling to define boron mineral reserves continued at Material Primas Magdalena, a joint venture between Vitro Corp. and U.S. Borax.

Turkey.—A new mining law became effective on June 13. Private sector boron operations had 18 months from that date to sell their remaining stockpiles, after which Etibank was to become the sole supplier of Turkish boron minerals. During 1982, 655,000 tons of concentrates was sold. Production capacity was 1.5 million tons per year of concentrates. Production of boron minerals had decreased by 23% since 1981, the record high year. During 1982, 460,000 tons of various boron ores and compounds was exported, and exports of boron minerals and products to the United States was valued at $8 million. Borate exports during 1983 included colemanite, tincal, ulexite, decahydrate and pentahydrate borates, anhydrous borax, boric acid, and sodium perborate. Etibank proceeded to form distributorships to supply the world market, but announced plans to remain open to direct negotiations with major customers. Etibank estimated reserves of 990 million tons of borate ore.

Etibank planned to begin operating a 160,000-ton-per-year pentahydrate borax and a 60,000-ton-per-year anhydrous borax plant at Kirka. Plans to build a borax research facility at Kirka during 1984 were announced. A 100,000-ton-per-year boric acid plant was under construction at Bandirma and was to be in operation by yearend 1984.

Infrastructure improvements during 1983 for transportation of borates included a loading facility at Degirmenozu (Kirka), special railway cars, and a wharf at Bandirma. The port had a facility for simultaneous loading bulk or bags for two 20,000-deadweight-ton-vessels at a rate of 400 tons per hour.[3]

U.S.S.R.—Western Kazakhstan was the only region in the U.S.S.R. where significant reserves of boron and potassium had been discovered alongside large phosphate reserves. Expansion of production of the borate ores was planned during the 11th 5-year plan beginning in 1981. A significant increase in borate fertilizers was planned.[4]

During 1983, a process was developed for boron extraction from brine of the Volgograd salt-bearing zone of the Gulf of Kara-Bagaz-Gol and the Sivash (lagoon). A byproduct of the process was chloromagnesium brine which was processed into high-purity magnesium oxide for metallurgical uses.

TECHNOLOGY

Refined tetraborates, such as borax, were used to convert inorganic ammonium salts to ammonium pentaborate tetrahydrate (AB5) and methanol. The ammonium triborate, which forms as an intermediate during the process, passed the Consumer Product Safety Commission's regulations for use on cellulosic insulation and was proven to be noncorrosive to copper, steel, and aluminum. The ammonium triborate reacted with moisture in the air to release ammonia and methanol. A different one-step process reacted tetraborate ore in methanol with aqueous ammonia and aqueous sulfuric acid to produce an AB5-sodium sulfate mixture. The AB5 produced by the one-step process was expected to sell for 33% to 50% less than the current market price of $1,420 per ton for granular AB5. AB5 can be hot sprayed onto a variety of substrates or used in combination with other chemicals as flame retardants for plastics and natural and synthetic fibers and fabrics. Thermtron Inc. planned to license the patented technology.[5]

General Motors Corp. announced a rare-earth compound that could replace ferrite magnets in starter motors of 1986 model year automobiles. The new material contained a rare earth (R), iron (Fe), and boron (B) substance in the molar ratio $R_2Fe_{14}B$. Neodymium and praseodymium produced magnets with the highest energy. The search for a new magnetic material had begun in 1978 when the price of cobalt rose during a temporary supply interruption.[6]

The U.S. Electric Power Research Institute awarded contracts for research on transformer core materials. Allied Chemical Corp.'s Metglas Products Div. was awarded a 5-year, $8 million contract to study an economic process to produce Metglas. Metglas is a mixture of iron, carbon, and boron or silicon that becomes amorphous when rapidly cooled. A common composition is 92% iron, 3% boron, and 5% silicon by weight. Metglas requires less energy to become magnetized than conventional steels. The Osaka Transformer Co. Ltd. of Japan demonstrated a 67% decrease in core losses, and aging tests demonstrated that the amorphous metal core could be expected to exceed the life of other transformer core materials. Westinghouse Electric Corp. was awarded a $1.2 million contract to design, build, and evaluate transformer cores, including an amorphous metal transformer core.[7]

Ulvac Coating Corp. developed a boron fiber with a tensile strength higher than that of carbon fibers. The boron fiber was produced by coating a fine tungsten wire. The process was in production.[8]

Colemanite was added as coarse aggregate to concrete for nuclear shielding. Boron was also added as a frit formed by the fusion of boric acid, limestone, silicate, and aluminum oxide. It was determined that use of polymer coating on the boron additive, to reduce solubility, allowed the boron content of the concrete to be increased by a factor of four.[9]

Glass fiber-based mattress ticking, bedspreads, draperies, pillows, and wall coverings were used in a model fire-resistant motel room. The added protection increased costs by about 10% over those of conventional materials. The material could prolong the time from ignition to flashover by a factor of five.[10]

PPG Industries developed a titanium diboride ceramic powder trade named Sintrium. A process to fabricate the powder into dense electrically conductive shapes was available for licensing.[11]

Semiconductor layers of P-type amorphous silicon carbide and boron were developed for use in solar cells. The layers were produced in plasma furnaces on glass substrates with indium- and tin-oxide electrodes. The solar cells contained three different types of semiconductor layers that produced conversion efficiencies of 12%. The development was a joint effort of Mr. Yoshihiro Hamagawa and Kanegafuchi Chemical Industry Co. of Japan.[12]

Triphenylboron (TPB) was used as an intermediate in preparing an organoboron compound and as a mild phenylating agent and had potential for use in preparing fuel additives. Commercial quantities of TPB were offered by E. I. du Pont de Nemours & Co. Inc.[13]

Iron borides were being studied as catalysts for the production of high-octane aliphatics and alcohols.[14]

A corrosion-inhibiting solution containing boric acid was developed for use in a closed-loop heat exchanger. The boric acid reduced alkalinity by forming a boric acid-borate buffer with a pH of 8.3. No pitting or signs of corrosion were detected on copper, bronze, or Muntz metal. Samples of stainless steel, aluminum, and steel were also tested.[15]

The Japanese National Research Institute on Inorganic Materials of the Office of Science and Technology used a strontium catalyst to produce a 2.2-millimeter-diameter cubic boron nitride crystal. Cubic boron nitride, which is comparable to diamond in hardness, was used for grinding hardened steel or abrasive cutting. The quantity of cubic boron nitride consumed worldwide was reportedly about 2 tons per year, or about one-tenth that of diamonds.[16]

Boron-containing compounds were studied for their effectiveness in facilitating destruction of tumors by neutron bombardment therapy. Boron cannot easily penetrate a normal cell wall, but can enter tumorous tissue. A purified boron-containing substance was found to be capable of attaching itself to tumor proteins. The substance is injected one-half day before the neutron therapy. After 5 years, 33% of the patients without previous treatment who received the boron compound treatment were alive.[17]

Commercial glass requires 10 to 20 different oxides in relative quantities that must be closely controlled to reach the desired end product. A computer programed with a raw material data base was used to consider both physical and chemical properties of raw materials for optimum glass formulation. Pentahydrate borax was the highest unit- and fractional-cost material, representing 28% of the $71.88-per-ton cost for batch glass.[18]

Glass fiber brushes proved to be an economical and efficient tool for polishing metals. Each brush consisted of 2,000 tiny filament tips.[19]

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[1]Physical scientist, Division of Industrial Minerals.
[2]U.S. Department of Justice. Press Release. May 26, 1983, 4 pp.
[3]Industrial Minerals (London). Borates in Turkey—An Interview With Muammer Ocal, General Director of Etibank, 29 September 1983. No. 195, Dec. 1983, pp. 63-65.
[4]Miletskiy, B. Improvement of Kazakh Mining Industry Suggested. Sots. Ind., Moscow, June 2, 1983, p. 2.
[5]Chemical & Engineering News. Technology. V. 62, No. 8, Feb. 20, 1984, pp. 36-37.
[6]Science News. APS-Rare Earth Magnets Attract Attention. V. 125, No. 14, Apr. 7, 1984, p. 212.
[7]Rosenfelder, W. J. Industrial Development of Amorphous Metal. Chem. & Ind. (London), v. 16, Aug. 15, 1983, pp. 639-641.
[8]European Chemical News. Technology. V. 40, No. 1,078, Apr. 18, 1983, p. 19.
[9]Gunduz, G. Colemanite-Baryte Frit and Polymer Impregnated Concrete as Shielding Materials. Nucl. Eng. and Des., v. 72, 1982, pp. 439-447.

[10]Engineering News-Record. Glass-Fiber Fabrics Enhance Fire Safety. V. 210, No. 19, May 12, 1983, pp. 13-14.

[11]Industrial Minerals (London). Company News & Mineral Notes. No. 194, Nov. 1983, p. 65.

[12]Chemical Engineering. Currents. V. 90, No. 6, Mar. 21, 1983, p. 23.

[13]Chemical Week. Wrap-up. V. 132, No. 21, May 25, 1983, p. 17.

[14]Bartholomew, C. H. Metal-Boride Catalyst for Indirect Liquefaction (U.S. DOE contract DE-FG22-82PC50816, Brigham Young Univer.). Dec. 15, 1982, 24 pp.

[15]Taylor, P. A. Development of a Silicate-Nitride Borate Corrosion Inhibitor (U.S. DOE contract W-7405-eng-26, Union Carbide Corp.). Y-2283, Nov. 29, 1983, 13 pp.

[16]U.S. Embassy, Tokyo, Japan. Advanced Materials. State Dep. Airgram A-23, Apr. 20, 1983, 2 pp.

[17]Technology Review. Trends. V. 87, No. 1, Jan. 1984, pp. 65, 67.

[18]Lehman, R. L. A Method for Improving Glass Batch Formulation. Glass Ind., v. 64, No. 12, Dec. 10, 1983, pp. 24-38, 35.

[19]Ceramic Bulletin. News Notes. V. 62, No. 3, Mar. 1983, p. 290.

Bromine

By Phyllis A. Lyday[1]

Domestic production of bromine sold or used during 1983 was estimated at 370 million pounds valued at $91 million. The largest single use for bromine was in the manufacture of ethylene dibromide (EDB), much of which was used as a scavenger for lead in gasoline. During the year, the Environmental Protection Agency (EPA) set new regulations for the use of EDB as a soil and space fumigant. The Federal Trade Commission (FTC) and Great Lakes Chemical Corp. reached a tentative agreement on the acquisition of Velsicol Chemical Corp. by Great Lakes.

Domestic Data Coverage.—Domestic production data for bromine are developed by the Bureau of Mines from a voluntary domestic survey of U.S. operations. Of the nine operations to which a survey request was sent, one responded, representing an

Table 1.—Salient bromine and bromine compound statistics

(Thousand pounds and thousand dollars)

	1979	1980	1981	1982	1983
United States:					
Bromine sold:[1]					
Quantity	67,600	52,192	60,790	(2)	(2)
Value	$15,100	$12,500	$11,000	(2)	(2)
Bromine used:					
Quantity	429,700	325,978	316,307	(2)	(2)
Value	$98,200	$83,100	$75,100	(2)	(2)
Exports:					
Elemental bromine:					
Quantity	[3]10,100	[3]8,100	[3]W	NA	[4]4,500
Value	[3]$2,100	[3]$1,700	[3]W	NA	[4]$1,000
Bromine compounds:					
Gross weight	92,800	85,400	67,500	[5]55,600	[5]61,300
Contained bromine	77,600	70,400	56,000	[5]47,200	[5]52,000
Value	$35,500	$35,900	$33,100	[5]$21,100	[5]$21,600
Imports:[4]					
Elemental bromine:					
Quantity	34	1	(6)	(6)	(6)
Value	$5	$5	(6)	(6)	(6)
Ethylene dibromide:					
Quantity	193	861	644	--	16
Value	$33	$165	$139	--	$11
Potassium bromide:					
Quantity	794	667	107	281	436
Value	$536	$457	$80	$204	$303
Sodium bromide:					
Quantity	2,190	310	20	645	2,534
Value	$1,056	$201	$12	$423	$971
World: Production	888,785	[r]756,105	758,306	[p]826,963	[e]795,770

[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, and 370 million pounds in 1983, valued at $91 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. During 1981 and 1982, 165,000 and 390,000 pounds of potassium bromate were reported, respectively.

[6]Negligible amount.

estimated 1% of the total production shown in tables 1 and 5. Production for the eight nonrespondents was estimated using reported prior year production levels adjusted by trends in employment and other guidelines.

Legislation and Government Programs.—On September 18, EPA suspended registration of EDB as a soil fumigant. Soil fumigants account for 95% of the use of EDB as a pesticide. Of the 105 million pounds of EDB produced annually, about 20 million pounds was used as a pesticide; the balance was used as an antiknock additive in gasoline.[2] EDB was approved in the 1940's as a pesticide, but recent tests have found the substance to be a potential rodent carcinogen and to be responsible for reproductive disorders in test animals. Exposure to EDB has been found to result in damage to the kidneys, liver, spleen, eyes, and skin, as well as the nervous, circulatory, and respiratory systems. Dibromochloropropane (DBCP) and EDB became controversial in 1975 when a National Cancer Institute study indicated that the pesticide induced cancer in laboratory animals. Later studies showed EDB to be a mutagen.[3] EDB was used as a control of nematodes in soil. EPA also announced the cancellation of the use of EDB for disinfecting grain milling machinery, for controlling pests in stored grain, and for the fumigation of fruit and other agricultural produce. It appeared that the cancellation could be delayed for public hearings, but the suspension would remain in effect during the appeal proceedings. Quarantine fumigations of citrus fruits and vegetables with EDB were to be canceled effective September 1, 1984.

Florida suspended the use of EDB at the end of July after traces of EDB were found in ground water.[4] Industry sources cited the contaminations from spills and misuse, not from soil fumigation.[5] Of 300 wells tested in Hawaii, 5 showed suspected detectable traces of EDB from spills or nonagricultural uses. California suspended the use of EDB in four counties when ground water contamination was suspected. None of these wells have had EDB traces confirmed at present.

The EPA standard of 1.10 grams of lead per gallon of leaded gasoline went into effect July 1. Small refineries were on a sliding scale that took effect in February.

An exemption for methyl bromide used to control blueberry maggots and plum curculios on blueberries was granted by EPA. Provisions require a maximum rate of 32 grams per cubic meter for 2.5 hours at 72° F. Treated blueberries are required to be aerated for a 24-hour period.[6]

EPA announced that 34 pesticides including Bromophenoxim are facing possible suspension because of invalid health effects testing.[7] EPA also proposed that 70 chemicals, including carbon tetrabromide and brominated methanes, having a potential to produce polychlorinated biphenyls (PCB) would be covered by PCB criteria regulation.[8]

The Consumer Product Safety Commission (CPSC) voted not to require exported products to meet U.S. flammability standards. CPSC interpreted that the Flammable Fabrics Act (1978) intended that the decision to implement standards lies with the importing government. Although the interpretation did not cause direct damage to the brominated flame retardants industry, it did limit a potential growth area for bromine.

The Occupational Safety and Health Administration (OSHA) proposed standards to protect workers exposed to EDB. OSHA proposed reducing the maximum worker exposure limit for EDB from 20 parts per million to 0.1 part per million averaged over 8 hours. A short-term exposure limit of 0.5 part per million over 15 minutes was also proposed. OSHA proposed an action level of 0.05 part per million for the level at which monitoring and medical surveillance would be required. The use of respirators and worker training and education would also be required. The OSHA decision was the result of a Teamsters Union petition for an emergency standard at the time small amounts of EDB were being used to control the spread of the Mediterranean fruit fly. Rather than issue an emergency standard, OSHA initiated regular rulemaking procedures to produce new permanent standards for EDB.[9] Industry epidemiology data showed the incidence of cancer for workers exposed to EDB to be less than for the general populace.[10]

DOMESTIC PRODUCTION

Domestic production of elemental bromine decreased approximately 8%. Five companies operated nine plants in two States. A slight production increase in the leading State of Arkansas was attributed to increased demand for brominated flame retardants, which counteracted the ban on EDB. Michigan experienced a decrease in production of bromine.

Ethyl Corp. increased its capacity to produce decabromodiphenyl oxide (DBDPO) at Magnolia, AR, by 50%. DBDPO, a major flame retardant, is used as an additive in high-impact polystyrene and formulations of polypropylene, polyethylene, engineering plastics, and industrial fabrics. In January, Ethyl completed a 40% production capacity increase for calcium bromide. A sodium bromide plant was completed in April. A 15-million-pound-per-year tetrabromobisphenol-A facility was due to be completed in early 1984.

Great Lakes produced a key brominated intermediate for the pyrethroid compound Fenvalerate developed by Sumitomo Chemical Co. and marketed by Shell Chemical Co. Photostable pyrethroids are examples of natural-product-based insecticides that are safe to mammals and act against a range of pests. The pyrethroid is protected against interfering with the metabolism process of plants but on soil is readily broken down by microorganisms to harmless products. The brominated intermediate is projected to be a high-profit growth area for bromine. Great Lakes moved its methyl bromide formulating and blending facility from Irvine, in the Los Angeles area, to Bakersfield, CA. In July, Great Lakes completed an expansion of the manufacturing facilities for DE-60F, a proprietary brominate flame retardant used in standard and polyester-based flexible polyurethane foams.

Great Lakes and FTC reached a tentative agreement concerning the Velsicol facilities acquired by Great Lakes during 1981. The tentative agreement would prohibit 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 order would also require that Great Lakes grant PPG Industries Inc. all the latest technology and know-how on brominated flame retardants acquired from Velsicol.

Great Lakes would be required by FTC to enter into a different agreement that would govern the operation and ownership rights of Arkansas Chemicals Inc., a 50-50 joint venture facility 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 all brominated compounds, including flame retardants; and require Great Lakes to purchase a specified amount of bromine from Arkansas Chemicals annually.[11] PPG discontinued production of EDB at its antiknock production unit at Beaumont, TX, during the first quarter of 1983.

The Dow Chemical Co. announced plans to construct a calcium bromine plant by 1985. Six former Occidental Chemical Co. workers were awarded $5 million in damages against Dow because of Dow's failure to inform the workers of the potential health effect of DBCP. DBCP had been banned in 1979 because of significant sperm count abnormalities.[12]

Table 2.—Bromine-producing plants in the United States in 1983

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 Chemical Co	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 less demand for leaded gasoline and as a consequence of the regulation of lead levels in gasoline that became effective in 1982. Methyl tertiary butyl ether was cited as a potential substitute for lead but at nine times the cost.[13] The ban on EDB as a space and soil fumigant was expected to further decrease the demand for EDB by approximately 20 million pounds during 1984.

In 1982, it was estimated that approximately 25 million pounds of additive chlorinated and brominated phosphate esters and approximately 20 million pounds of additive brominated chemicals were used in flame retardants. Bromine compounds slow or stop flame generation by interfering with the chain reaction mechanism of combustion. Antimony trioxide, antimony pentoxide, and zinc borate have a synergistic effect in combination with brominated flame retardants.[14]

Hydrocarbon well drilling was estimated as 89% of the 1982 record, but brominated derivatives used in oil and gas drilling were not as severely affected as clay and barite.

PRICES

Ethyl announced increases for bromine effective January 1, 1984, to 33 cents per pound. Calcium bromide solution from Ethyl increased to 25 cents per pound at yearend 1983. The price increases were attributed to increases in the price of chlorine and higher operating costs.

Ameribrom Inc., the major importer of brominated compounds, announced price increases for food-grade sodium bromate and powdered potassium bromate to $1.75 per pound. Prices for ammonium bromide increased to $1.27 per pound.

Table 3.—Yearend 1983 prices for elemental bromine and selected compounds

Product	Value per pound (cents)
Ammonium bromide, national formulary (N.F.), granular, drums, carlots, truckloads, freight equalized	125 -127
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	112
Calcium bromide, bulk, 14.2 pounds per gallon at 60° F, f.o.b. works[2]	20.0 - 23.5
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. 224, No. 26, Dec. 26, 1983, pp. 28-34.

FOREIGN TRADE

Exports of bromine-containing compounds increased during the year. The majority of these exports was EDB. Other compounds exported included those for use in well completions, flame retardants, and agriculture.

Approximately 84% of imports of bromine and bromine compounds reported by the Bureau of the Census was from Israel. The closer proximity of Israel to overseas markets gave Israeli bromine an advantage in transportation costs compared with U.S. exports. Other countries from which bromine and bromine compounds were imported by the United States were the United Kingdom, 9%; and France, 5%. These imports included sodium bromide, 69%; potassium bromate, 19%; potassium bromide, 12%; and negligible amounts of elemental bromine and EDB. Because imported bromine compounds are contained in many products, some of the compounds are not easily identified through Census data.

Israel was given Generalized System of Preference eligibility status with de minimis waiver for potassium and sodium bromide. The de minimis provision allows the President to waive the 50% competitive need limit in cases where total U.S. imports of an item in 1982 did not exceed $1.3 million.

WORLD REVIEW

Canada.—The Canadian Government announced plans to set lower levels of lead in gasoline. The 1983 lead content limit was 0.77 gram per liter. The decrease in lead would adversely affect U.S. EDB exports to Canada for use in leaded gasoline.

Israel.—Bromine and bromine compounds were produced by Bromine Compounds Ltd., a 50-50 venture between Dead Sea Works Ltd. (DSW) and Dead Sea Bromine Co. Ltd. (DBC). DBC was 100% owned by DSW. DSW was 89% owned by Israel Chemicals Ltd. (ICL) and 11% by public stock. The ICL directors were actively involved in management of the whole group. The bromine companies had been unprofitable because of technical and managerial reasons despite Government assistance through tax rebates, grants, preferential financing, and regional development aid. Custom-designed bromine-isotank containers, additional plant capacity, new administrative facilities, and research on new manufacturing and production processes required large capital investments.[15] Substantial salary expenses had been incurred for employees called for temporary military duty.[16] Bromine production in Israel is as a byproduct of potash, chlorine, and caustic soda. The bromine portion of the group had 200 personnel working a 3-shift day, 7 days per week.[17] The bromine compounds plant was located at Ramat Hovav and began operating in 1982. Equipment was still being transferred from the old plant at Beersheba. The new plant accounted for 50% to 55% of world trade in bromine compounds. At completion, the new plant was expected to triple the capacity for production of bromine compounds.[18] DBC completed a 1-million-pound-per-year expansion of its sodium and potassium bromate electrolysis plant to a total capacity of 10 million pounds.[19] An expansion to 220 million pounds of bromine compounds was to be completed by 1984.

Jordan.—Jordan began production of potash from Dead Sea brines at the Arab potash project near Amman. The brines contained 0.48% by weight magnesium bromine. Future projects include plans for a 60-million-pound-per-year bromine and bromine derivatives plant.[20]

United Kingdom.—The British Government announced a switch to lead-free gasoline by 1990. This decision adversely affects Associated Octel Co. Ltd., which produces EDB for use in Europe and employs about 2,700 workers. European Economic Community (EEC) guidelines did not allow the banning of leaded gasoline in Europe. Europe had been slow to reduce lead in gasoline. Lead contents of 0.40 gram per liter had been normal, and some countries had lead rates as high as 0.64 gram per liter. EEC was expected to institute new guidelines on lead-free gasoline by April 1984. Eight countries accounting for 60% of gasoline consumption in Europe were expected to be at the 0.15-gram-per-liter minimum by 1986.

Table 4.—World bromine plant capacities and sources

Country and company	Location	Capacity (million pounds)	Source
Australia:			
NA	Adelaide	NA	Seawater.
China:			
NA	Iksaydam	NA	Underground brines.
France:			
Ato Chem France	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]	1979	1980	1981	1982[p]	1983[e]
France	41,888	36,332	[e]36,000	[r] [e]20,000	22,000
Germany, Federal Republic of	8,862	[r]8,832	7,864	6,775	6,700
India	660	736	[e]770	[e]770	770
Israel	101,000	97,133	97,047	[e]154,000	154,000
Italy[e]	1,300	1,300	1,280	1,320	1,100
Japan[e]	26,500	26,500	26,500	26,500	26,500
Spain[e]	900	900	900	800	700
U.S.S.R.[e]	146,000	148,000	150,000	150,000	150,000
United Kingdom	64,375	58,202	60,848	65,698	64,000
United States[3]	497,300	378,170	377,097	401,100	370,000
Total	888,785	[r]756,105	758,306	826,963	795,770

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through Apr. 25, 1984.
[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]Sold or used by producers.

TECHNOLOGY

In November, Duke Power Co. began using an experimental battery, with an aqueous zinc bromine electrolyte, to supply a small portion of electrical demand at the corporate headquarters in Raleigh, NC. The experimental system consisted of 40 battery modules with a capacity of 20 kilowatts. The system can generate 80 kilowatt hours over a 4-hour period. The energy-per-unit weight capacity of the new system is up to three times that of conventional lead-acid batteries. The battery was developed by GEL Inc. and was being marketed by Synergy Research Corp., both of Durham, NC. This load-leveling system offers advantages of few moving parts and the ability to handle heavy discharges while continuously cycling without damage.[21]

Guidelines were suggested for investigators studying bromine as an indicator of lead in the atmosphere. Although lead had been added to gasoline in approximately equal proportions at different locations, exhaust particulates were known to react with acid sulfates and nitrates to form gaseous hydrogen bromide that could not be retained on filters and the apparent bromine-to-lead ratios could not be determined. Bromine losses were also known to occur during storage and preparation of the samples.[22]

Gas-phase bromine occurrences in arctic air between February and May exceeded levels measured during the rest of the year. Some of the measurements were 10 times higher than levels found in other parts of the world. Particulate bromine levels increased from 5 to 133 parts per trillion. Suggested sources for the increased bromine levels were man-made pollution from the Eurasian continent and naturally occurring red benthic algae. The primary significance is that the synergistic interaction of the bromine and chlorine chains in the atmosphere could allow bromine to participate in the destruction of ozone at lower altitudes under conditions of less light than with chlorine alone.[23]

Investigations conducted on ozone used in water treatment demonstrated that ozone oxidized the bromide ion to produce hypobromous acid (HOBr). In the presence of organic matter, HOBr reacts to form bromoorganics; more bromoform was produced with humic acid at a pH of 6.1 than at a pH of 8.8. The range of conditions conducive to haloform formation was narrower for bromination than for chlorination.[24]

Studies comparing bromine chloride, chlorine dioxide, and iodine with chlorine as a virucidal agent found bromine chloride to be the most active on a molar basis. Bromine chloride was found to be the most effective and its activity peaked at a pH of 5. Ammonia inhibited the effect of bromine chloride.[25]

Nyacol Products Inc. announced a new bromine-antimony liquid flame retardant (Nyacol HA-9). The bromine component is pentabromo diphenyloxide, which is nonreactive with the resin in liquid application systems. The product produces maximum flame retardant properties for liquid systems such as urethane and foam.[26]

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[1]Physical scientist, Division of Industrial Minerals.

[2]Federal Register. U.S. Environmental Protection Agency. Ethylene Dibromide. V. 48, No. 197, Oct. 11, 1983, pp. 46228-46248.

[3]Lipsett, M. J., D. Carmelli, A. Winship-Ball, and B. P. Eynon. Qualitative Cancer Risk Assessment for Occupational Exposure to Ethylene Dibromide. (U.S. OSHA contract 211-82-0014, Stanford Res. Inst. Int.); NTIS PB 83-184325, June 1982, 39 pp.

[4]Chemical Week. Wrap-Up. V. 133, No. 7, Aug. 17, 1983, p. 19.

[5]———. A Passel of Troubles for EDB. V. 133, No. 10, Sept. 7, 1983, pp. 13-14.

[6]Pesticide & Toxic Chemical News. Section 18 Exemptions Granted for Methyl Bromide and Alachlor. V. 11, No. 42, Aug. 31, 1983, p. 18.

[7]Chemical and Engineering News. Audit of IBT Tests: 34 Pesticides Would Face Suspension. V. 61, No. 29, July 18, 1983, p. 4.

[8]Pesticide & Toxic Chemical News. Third and Final Rule To Be Proposed by EPA Within a Few Days. V. 12, No. 4, Dec. 7, 1983, pp. 17-23.

[9]The Washington Post. Ethylene Dibromide—OSHA Wants To Tighten Grip on Risky Chemicals. Sept. 30, 1983, p. A15.

[10]Great Lakes Chemical Corp. News From Great Lakes Chemical Corp. Oct. 3, 1983, 3 pp.

[11]Federal Register. Federal Trade Commission. Great Lakes Chemical Corp. and Northwest Industries, Inc., et. al.; Proposed Consent Agreements with Analysis to Aid Public Comment. V. 49, Mar. 12, 1984, pp. 9220-9234.

[12]Chemical and Engineering News. Pesticide Suit Hits Dow: Six Workers Awarded $5 Million. V. 61, No. 17, Apr. 25, 1983, p. 4.

[13]———. Lead in Gasoline in Europe Heads for Possible Phaseout. V. 61, No. 14, Apr. 4, 1983, pp. 7-13.

[14]Dixon, T. Flame Retardants—Legislation Needed To Fire Markets. Ind. Miner. (London), No. 191, Aug. 1983, pp. 89-94.

[15]Phosphorus & Potassium. A Review of the Fertilizer and Chemicals Industry of Israel. Part 1, No. 130, Mar.-Apr. 1984, pp. 18-23.

[16]Ackerman, E. B. (Ameribrom Inc.). Written communication submitted to U.S. International Trade Commission, Apr. 11, 1984, 23 pp; available on request from the Office of the Secretary, U.S. International Trade Commission, Washington, DC.

[17]U.S. Embassy, Tel Aviv, Israel. State Dep. Airgram A-72, Nov. 24, 1980, 7 pp.

[18]Work cited in footnote 16.

[19]Chemical Marketing Reporter. Drugs & Fine Chemicals. V. 4, No. 7, Aug. 15, 1983, p. 20.

[20]Phosphorus & Potassium. Jordan: APC's First Step Into the Potash Market. No. 125, May-June 1983, pp. 10-23.

[21]Advanced Battery Technology. Zinc Bromine Battery Under Test at Duke Power Co. V. 20, No. 4, Apr. 1984, pp. 3-4.

[22]Harrison, R. M., and W. T. Sturges. The Measurement and Interpretation of Br/Pb Ratios in Airborne Particles. J. Atmos. Environ., v. 17, No. 2, 1983, pp. 311-328.

[23]Chemical and Engineering News. Bromine in Arctic Air: Spring Peak May Destroy Ozone Layer. V. 61, No. 34, Aug. 22, 1983, p. 6.

[24]Haag, W. R., and J. Holgne. Ozonation of Bromine-Containing Water: Kinetics of Formation of Hypobromous Acid and Bromate. Environ. Sci. Technol., v. 17, No. 5, 1983, pp. 261-267.

[25]Taylor, G. R., and M. Butler. A Comparison of the Virucidal Properties of Chlorine, Chlorine Dioxide, Bromine Chloride and Iodine. J. Hyg. (Cambridge), v. 89, May 12, 1982, pp. 321-328.

[26]Nyacol Products Inc. Colloidal Antimony Oxide. Company communication, Feb. 24, 1983, 1 p.; available on request from P. A. Lyday, BuMines, Washington, DC.

Cadmium

By Patricia A. Plunkert[1]

Increased production and withdrawals from stocks compensated for a decrease in net imports during 1983, and apparent consumption remained at a level comparable to that of 1982. The producer price of cadmium during 1983 increased from $1 per pound at the beginning of the year to $1.25 per pound by yearend.

Domestic Data Coverage.—Domestic production data for cadmium sulfide, cadmium lithopone, and cadmium sulfoselenide are developed by the Bureau of Mines from a voluntary survey of U.S. operations. Of the seven operations to which a survey request was sent, six responded, representing an estimated 99% of the total production shown in table 4. Production for the remaining nonrespondent was estimated using prior year industry production levels.

Table 1.—Salient cadmium statistics

	1979	1980	1981	1982	1983
United States:					
Production[1] metric tons	1,823	1,578	1,603	1,007	1,052
Shipments by producers[2] do.	2,468	1,271	1,382	1,832	1,495
Value thousands	$9,498	$5,219	$3,838	$2,628	$1,786
Exports metric tons	211	236	239	11	170
Imports for consumption, metal do.	2,572	2,617	3,090	2,305	2,196
Apparent consumption do.	5,099	3,534	4,378	[r]3,728	3,763
Price: Average per pound[3]	$2.76	$2.84	$1.93	$1.11	$1.13
World: Production metric tons	[r]18,679	[r]18,231	17,364	[p]16,452	[e]17,244

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

[1]Primary and secondary cadmium metal. Includes equivalent metal content of cadmium sponge used directly in production of compounds.

[2]Includes metal consumed at producer plants.

[3]Average quoted price for cadmium sticks and balls in lots of 1 to 5 tons.

Legislation and Government Programs.—On July 15, 1983, the Environmental Protection Agency (EPA) issued final regulations under the Clean Water Act that limit the pollutants that electroplating and metal-finishing facilities may discharge into waters of the United States or into publicly owned treatment works. Cadmium is one of seven metals for which specific daily and monthly average maximum effluent limits have been set. As guidance to dischargers and control authorities, a long-term concentration average of 0.13 milligram of cadmium per liter of effluent was found to be attainable by the technology that EPA assessed.[2]

Under the Clean Water Act, EPA also proposed new regulations to limit the discharge of pollutants into navigable waters and into publicly owned treatment works by existing and potential new sources that manufacture certain inorganic compounds. Cadmium pigments and salts is one of six subcategories for which EPA proposed effluent limitations guidelines. After considering comments received in response to this proposal, EPA was expected to promulgate a final rule.[3]

The strategic stockpile goal remained at 5,307 metric tons of cadmium metal. No inventory acquisitions or sales were made during the year, and as of December 31, 1983, the stockpile inventory was 2,871 tons of cadmium metal.

DOMESTIC PRODUCTION

Domestic production of cadmium metal increased slightly in 1983 despite the closure of ASARCO Incorporated's zinc smelter in Corpus Christi, TX. This plant had been closed since the end of October 1982, but company officials announced that the signing of a new labor agreement with refinery workers should enable the plant to be back in operation in 1984. The production of cadmium compounds also increased compared with 1982 levels. Cadmium sulfide, cadmium lithopone, and cadmium sulfoselenide production increased approximately 80% over that of 1982 owing to increased demand.

Table 2.—Primary cadmium producers in the United States in 1983

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)
1979	912
1980	826
1981	885
1982	971
1983	1,024

[1]Includes plating salts and oxide.

Table 4.—Cadmium sulfide[1] produced in the United States

(Metric tons)

Year	Quantity (cadmium content)
1979	813
1980	801
1981	527
1982	374
1983	670

[1]Includes cadmium lithopone and cadmium sulfoselenide.

CONSUMPTION AND USES

Apparent consumption of cadmium increased slightly compared with that of 1982. Cadmium continued to be used in the following categories: coating and plating, batteries, pigments, plastic and synthetic products, and alloys. The largest users of products from these categories continued to be the transportation and defense industries.

Table 5.—Supply and apparent consumption of cadmium

(Metric tons)

	1981	1982	1983
Stocks, Jan. 1	1,768	1,844	1,417
Production	1,603	1,007	1,052
Imports, metal	3,090	2,305	2,196
Total supply	6,461	5,156	4,665
Exports	239	11	170
Stocks, Dec. 31	1,844	[r]1,417	732
Apparent consumption[1]	4,378	[r]3,728	3,763

[r]Revised.
[1]Total supply minus exports and yearend stocks.

STOCKS

Total inventories of cadmium decreased to a level that was approximately one-half that of 1982. Total stocks at the end of 1983 were at their lowest level in over 30 years. Metal stocks showed the most dramatic decrease, dropping to a level that was less than 40% of that at the end of 1982 owing in part to the increased demand for cadmium metal to produce cadmium compounds. Inventories of cadmium in compounds were at their lowest level since 1975.

Table 6.—Industry stocks, December 31

(Metric tons)

	1982		1983	
	Cadmium metal	Cadmium in compounds	Cadmium metal	Cadmium in compounds
Metal producers	635	W	209	W
Compound manufacturers	167	r460	49	378
Distributors	150	r5	91	5
Total	952	r465	349	383

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

PRICES

AMAX Inc. was the only domestic producer with a published price for cadmium metal during 1983. At the beginning of the year, AMAX listed a price of $1 per pound for cadmium metal, which was raised to $1.15 per pound in mid-May. In late August, AMAX announced a further price increase to $1.25 per pound. The published producer price remained at this level through yearend.

Dealer prices in January were listed at $0.65 to $0.70 per pound for cadmium metal. They fluctuated throughout the year and reached a high of $0.90 to $0.97 per pound in late September. At yearend, the dealer prices were listed at $0.90 to $0.95 per pound.

FOREIGN TRADE

Exports of cadmium metal and cadmium in alloys, dross, flue dust, residues, and scrap increased dramatically over the unusually small amount of material exported in 1982 but remained below the average for the 1978-81 period. The three largest recipients in 1983, in descending order of receipts, France, the United Kingdom, and Belgium-Luxembourg, received over 80% of U.S. cadmium exports.

Cadmium metal imports for consumption decreased slightly, continuing a 3-year trend of decreasing metal imports. The principal supplying countries were Canada, Australia, Peru, and Mexico.

The U.S. Department of Commerce conducted an administrative review of the antidumping findings on cadmium from Japan. As a result, Commerce determined that a cash deposit of estimated antidumping duties would no longer be required on any shipment of Japanese cadmium imported, or withdrawn from warehouse, for consumption on or after September 9, 1983. This finding would be in effect until the next administrative review, which Commerce planned to begin immediately.[4]

Imports of metal and flue dust from most favored nations (MFN) and imports of flue dust from non-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)
1981	239	$332
1982	11	126
1983	170	351

Table 8.—U.S. imports for consumption[1] of cadmium metal, by country

Country	1982 Quantity (metric tons)	1982 Value (thousands)	1983 Quantity (metric tons)	1983 Value (thousands)
Australia	446	$951	713	$1,160
Belgium-Luxembourg	78	185	15	54
Canada	375	890	[2]938	1,877
China	161	515	--	--
Finland	95	173	67	87
France	83	174	43	79
Germany, Federal Republic of	241	340	21	34
Japan	--	--	(3)	(3)
Korea, Republic of	110	225	50	77
Mexico	171	248	126	163
Netherlands	113	226	17	23
Norway	5	11	35	58
Peru	[2]306	482	154	206
Spain	40	95	--	--
United Kingdom	81	169	17	24
Total	[2 4]2,305	4,684	[2]2,196	3,842

[1]General imports and imports for consumption were the same in 1982; general imports in 1983 were 2,191 metric tons.
[2]Includes waste and scrap (gross weight).
[3]Less than 1/2 unit.
[4]Does not include 11 metric tons of cadmium contained in flue dust from Canada.

WORLD REVIEW

The European Economic Community (EEC) agreed to limit the amount of cadmium that factories can emit into public waters. Installations built after 1985 would have to keep their cadmium emissions below 0.2 milligram per liter. Existing plants must reduce their emissions to 0.5 milligram per liter by 1986 and to 0.2 milligram per liter by 1989.[5]

Germany, Federal Republic of.—A major lead and zinc smelter, Ruhr-Zinc GmbH, obtained about one-third of its raw material needs from steelmaking dusts and sludges that contain high volumes of nonferrous metals. About 30 to 40 tons per year of cadmium was obtained from this material, containing from 0.003% to 0.2% cadmium.[6]

India.—A new lead-zinc deposit was discovered in the Rampura-Agucha area of Rajasthan State. The total in situ ore reserves was estimated at 61 million tons averaging 1.57% lead, 13.48% zinc, and 9.58% iron. The cadmium content reportedly varied between 250 and 780 parts per million. The deposit was said to be amenable to open pit mining methods.[7] Based on this deposit, Hindustan Zinc Ltd. proposed the establishment of a new zinc-lead smelter complex near Chittorgarh in Rajasthan. The proposed complex would have an annual capacity of 70,000 tons of zinc, 35,000 tons of lead, 160,000 tons of sulfuric acid, 235 tons of cadmium, and 50 tons of silver.[8]

Italy.—Two metal producers, state-owned Società per Azioni Minero-Metallurgiche (SAMIM) and privately owned Alessandro Tonolli, planned to combine their operations to form a new company to be known as Sameton. The new company planned to have a total metal capacity of 455,000 tons per year, including a capacity of 500 tons per year of cadmium.[9]

United Kingdom.—Chloride Alcad sold its nickel-cadmium batteries division in the United Kingdom and its wholly owned U.S. subsidiary, Chloride Inc., to the Marathon Battery Co., Waco, TX.[10]

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

(Metric tons)

Country	1979	1980	1981	1982[p]	1983[e]
Algeria	64	60	[e]65	[e]65	65
Argentina	36	18	--	21	19
Australia (refined)	804	1,012	1,031	1,010	1,000
Austria	34	36	55	48	50
Belgium	1,440	[r]1,527	1,176	1,001	1,100
Brazil	21	41	45	[e]70	60
Bulgaria[e]	210	[r]200	[r]200	[r]200	200
Canada (refined)	1,455	[r]1,303	1,298	809	1,107
China[e]	[r]250	[r]250	[r]270	[r]300	300
Finland	590	581	621	566	566
France	689	789	663	803	790
German Democratic Republic[e]	15	16	16	16	16
Germany, Federal Republic of	1,266	1,194	1,192	1,030	1,000
India	166	89	113	131	115
Italy	527	568	482	515	500
Japan	2,597	2,173	1,977	2,034	2,200
Korea, North[e]	150	[r]140	[r]140	[r]100	100
Korea, Republic of	50	365	300	320	300
Mexico (refined)	830	778	590	607	900
Namibia	81	69	--	110	25
Netherlands	416	455	518	485	480
Norway	115	130	117	104	104
Peru	190	172	307	421	400
Poland	773	698	580	570	570
Romania[e]	90	85	85	80	80
Spain	222	309	303	289	280
U.S.S.R.[e]	2,850	2,850	2,900	2,900	3,000
United Kingdom	424	375	278	354	380
United States[2]	1,823	1,578	1,603	1,007	[3]1,052
Yugoslavia	289	201	208	[e]205	200
Zaire	212	168	[2]230	281	285
Zambia	--	1	1	--	--
Total	[r]18,679	[r]18,231	17,364	16,452	17,244

[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 Mar. 7, 1984.
[2]Includes secondary.
[3]Reported figure.

TECHNOLOGY

Energy Research Corp., under contract to the Bureau of Mines, developed a new 15-ampere-hour capacity miners' caplamp battery. The new battery uses nickel-cadmium technology, a roll-bonded electrode structure, and offers significant improvements in performance with reduced size and weight. The new caplamp battery, weighing 2-1/2 pounds, is over 2 pounds lighter than the presently used lead-acid caplamp battery. A report described the design and fabrication of the nickel-cadmium battery.[11]

The Bureau of Mines reported on two investigations of the thermodynamic properties of cadmium oxysulfate ($2CdO \bullet CdSO_4$). The first investigation established the standard enthalpy of formation for cadmium oxysulfate using hydrochloric acid solution colorimetry.[12] The second determined the standard Gibbs energy of formation of cadmium oxysulfate and manganese sulfate using high-temperature galvanic cells that contained stabilized zirconia (ZrO_2) as the solid electrolyte.[13]

Developments in cadmium technology were abstracted in Cadmium Abstracts, a quarterly publication available through the Cadmium Association, 34 Berkeley Square, London W1X 6AJ, England.

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[1]Physical scientist, Division of Nonferrous Metals.
[2]Federal Register. Electroplating and Metal Finishing Point Source Categories; Effluent Limitations Guidelines, Pretreatment Standards. V. 48, No. 137, July 15, 1983, pp. 32462-32488.
[3]———. Inorganic Chemicals Manufacturing Point Source Category; Effluent Limitations Guidelines, Pretreatment Standards, and New Source Performance Standards. V. 48, No. 207, Oct. 25, 1983, pp. 49408-49436.
[4]———. Cadmium From Japan; Final Results of Administrative Review of Antidumping Finding. V. 48, No. 176, Sept. 9, 1983, pp. 40759-40760.
[5]Metal Bulletin (London). No. 6797, June 21, 1983, p. 15.
[6]American Metal Market. Steel Sludges Supply Smelter. V. 91, No. 78, Apr. 21, 1983, p. 10A.

[7]Gandhi, S. M. Rampura-Agucha Lead/Zinc Deposit. Min. Mag. (London), v. 149, No. 5, Nov. 1983, pp. 315-321.

[8]Page 298 of work cited in footnote 7.

[9]Metals Week. SAMIM and Tonolli To Form New Company. V. 54, No. 33, Aug. 15, 1983, p. 6.

[10]Metal Bulletin (London). No. 6762, Feb. 11, 1983, p. 13.

[11]Lewis, W. H., and E. Ferreira. New Developments in Personal Lighting Systems for Miners. BuMines IC 8938, 1983, 10 pp.

[12]Ko, H. C., and R. R. Brown. Enthalpy of Formation of $2CdO \cdot CdSO_4$. BuMines RI 8751, 1983, 4 pp.

[13]Schaefer, S. C. Electrochemical Determination of Thermodynamic Properties of Manganese Sulfate and Cadmium Oxysulfate. BuMines RI 8809, 1983, 20 pp.

Calcium and Calcium Compounds

By Lawrence Pelham[1]

Calcium, the fifth most abundant element in the Earth's crust, is very active, and therefore 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 10 operations to which a survey request was sent, 8 responded, representing an estimated 27% of the total production shown in table 1. Production for the two nonrespondents was estimated using prior year production levels adjusted by economic trends and other guidelines.

DOMESTIC PRODUCTION

Pfizer Inc. continued to produce 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 continued to account 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, an 80% calcium-20% magnesium alloy, and other calcium alloys. Elkem Metal Co., a Norwegian-owned company at Niagara Falls, NY, continued to produce calcium alloys, 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 continued to produce calcium alloys. Pesses Co. continued to produce 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. continued to produce calcium chloride from dry-lake brine wells in San Bernardino County, CA. Total output in California increased by 43%. The Dow Chemical Co. and Wilkinson Chemical Corp. continued to recover calcium chloride from brines in Lapeer, Mason, and Midland Counties, MI. Total output in Michigan increased by 7%. Natural calcium chloride production is much greater in Michigan than in California, and therefore total production increased only 8%.

Allied Chemical Corp. continued to recover 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 decreased by 19%.

Calcium hypochlorite was produced by two U.S. companies: Olin Corp. and PPG Industries Inc. PPG began operating a new calcium hypochlorite plant at Natrium, WV, with a design capacity of 100 tons per day. Total U.S. capacity for producing calcium hypochlorite was 115,000 tons per year.

W. R. Grace & Co. began operating a calcium nitrite plant in Wilmington, NC. The plant is the first of its kind in North America.

Table 1.—Production of calcium chloride (75% $CaCl_2$ equivalent) in the United States

Year	Natural		Synthetic		Total	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1979	719,709	$51,884	261,052	$22,566	980,761	$74,450
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

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 has 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 most rapidly growing end use for calcium chloride and calcium bromide has been in well completion fluids in oil and gas recovery.

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 is used in conjunction with rock salt for maximum effectiveness and economy.

Calcium hypochlorite was used to disinfect swimming pools 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 and to accelerate setting time.

Calcium carbide and calcium silicon 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

During 1983, calcium metal crowns remained at the $3.05 per pound price for quantities greater than 20,000 pounds, reached on October 15, 1981, when it had increased from $2.78 per pound. The per pound price of redistilled calcium metal, for quantities greater than 20,000 pounds, continued to range from approximately $10 to $15. The price of calcium-silicon alloy increased on July 1, 1983, from $0.66 to $0.72 per pound. The former price had been in effect since August 1, 1982. Yearend published prices and specifications were as follows:

	Value per pound	
	1982	1983
Calcium metal, 1-ton lots, 50-pound full crowns, 10 by 18 inches, Ca+Mg 99.5%, Mg 0.7%	$3.05	$3.05
Calcium-silicon alloy, 32% calcium, carload lots, f.o.b. shipping point	.66	.72

Source: Metals Week. V. 53, No. 52, Dec. 27, 1982, p. 5; Metals Week. V. 55, No. 1, Jan. 2, 1984, p. 5.

Calcium metal is 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 is at least 98%. Higher purity metal is obtained by redistillation.

Calcium metal is usually shipped in polyethylene bags under argon in an airtight 55-gallon steel drum.

Calcium chloride is 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	$145.00
100-pound bags, carload, same basis	196.00
Anhydrous, 94% to 97%, flake or pellet, bulk, carload, same basis	207.00
80-pound bags, carload, same basis	271.00
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, truck load, freight equalized	1,800.00

Source: Chemical Marketing Reporter. V. 224, No. 26, Dec. 26, 1983, p. 29.

FOREIGN TRADE

Exports of calcium chloride to 47 countries in 1983, decreased 26% in quantity and 14% in value.

Exports of calcium phosphates were 48,000 tons valued at $32.6 million compared with 61,000 tons valued at $36.5 million in 1982. The leading destinations were Venezuela, Colombia, and Mexico, with material being sent to a total of 57 countries.

Exports of other calcium compounds, including precipitated calcium carbonate, totaled 20,000 tons valued at $13.7 million in 1983 compared with 31,000 tons and $15.6 million in 1982. Material in this category was sent to 70 countries, mainly Canada, Mexico, and the United Kingdom.

Crude calcium chloride imports decreased about 77%, to 13,580 tons valued at $652,000, mainly from Canada and Mexico. Other calcium chloride imports amounted to 204 tons valued at $641,000, mainly from Canada.

Imports of other calcium compounds included 155,000 tons of calcium nitrate valued at $11.1 million, mainly from Norway; 13,500 tons of calcium carbide valued at $4.6 million from Canada; 5,500 tons of calcium hypochlorite valued at $6.0 million, mainly from Japan; 375,000 tons of crude calcium carbonate chalk valued at $943,000, mainly from the Bahamas; 9,500 tons of calcium carbonate chalk whiting valued at $958,000, mainly from France; and 7,600 tons of precipitated calcium carbonate valued at $2.2 million, mainly from France and the United Kingdom.

Calcium metal was imported from three countries. Canada supplied 103,363 pounds; China, 229,279 pounds; and France, 192 pounds. China increased its exports to the United States by 20%, replacing a decrease of 13% by Canada and 99% by France. 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 other nations.

Table 2.—U.S. exports of calcium chloride, by country

Country	1982		1983	
	Short tons	Value	Short tons	Value
Angola	19,232	$1,046,846	--	--
Brazil	698	243,840	461	$149,985
Cameroon	1,685	601,926	3,768	623,076
Canada	9,555	1,951,557	18,382	2,435,362
Mexico	2,428	528,077	454	138,009
Netherlands	85	11,981	1,660	1,742,495
Saudi Arabia	3,024	2,189,317	4,922	921,967
Sweden	648	135,021	37	16,873
Switzerland	1,043	174,801	51	5,355
Trinidad and Tobago	1,342	270,134	1,104	483,107
United Arab Emirates	5,472	2,155,333	4,916	1,764,269
United Kingdom	245	63,083	751	159,687
Venezuela	2,448	744,073	2,619	373,233
Other	[r]7,152	[r]949,411	1,472	736,909
Total	55,057	11,065,400	40,597	9,550,327

[r]Revised.

Table 3.—U.S. imports for consumption of calcium and calcium chloride

Year	Calcium		Calcium chloride	
	Pounds	Value[1]	Short tons	Value[1]
1979	717,726	$1,015,183	58,091	$3,018,443
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	1,292,662

[1]U.S. Customs import value, generally representing value in foreign country, and, therefore, excluding U.S. import duties, freight, insurance, and other charges incurred in shipping merchandise to the United States.

Table 4.—U.S. imports for consumption of calcium chloride, by country

Country	1982		1983	
	Short tons	Value[1]	Short tons	Value[1]
Canada	22,509	$1,062,599	9,099	$603,754
Germany, Federal Republic of	55	56,422	67	60,455
Mexico	37,939	1,482,344	4,584	156,713
Other	120	408,847	34	471,740
Total	60,623	3,010,212	13,784	1,292,662

[1]U.S. Customs import value, generally representing value in foreign country, and, therefore, excluding U.S. import duties, freight, insurance, and other charges incurred in shipping merchandise to the United States.

WORLD REVIEW

Calcium metal was produced in Canada, China, France, Japan, and the U.S.S.R., in addition to the United States. The market economy country production of calcium metal was estimated to be about 1,500 tons. Total world production was an estimated 2,000 tons.

[1]Physical scientist, Division of Industrial Minerals.

Cement

By Lawrence L. Davis[1] and Wilton Johnson[2]

U.S. cement production and consumption in 1983 increased, reflecting increased activity by the construction industry and improvement of the U.S. economy. According to a U.S. Department of Commerce report, the value of U.S. construction put in place increased 13% to $263 billion. Housing starts increased 60% to 1.70 million units.

Imports, a sensitive indicator of domestic cement demand, increased 45% to 4.2 million tons and accounted for 6% of consumption. Clinker imports were 24% of the total.

Shipments of portland and masonry cement from U.S. plants, excluding Puerto Rico, increased 11% to 71 million tons. Shipments increased to all geographical regions. The following regions had the largest consumption gains: Atlantic, 18%; Mountain, 15%; and Pacific, 13%.

Plant expansions and modernizations in California and Texas added 1.5 million tons to domestic cement production capacity. Despite these additions, total U.S. portland cement production capacity remained about the same because of plant closures in North Carolina and Tennessee, which effectively retired 1.5 million tons of grinding capacity.

Foreign ownership of U.S. cement production capacity continued to increase. By yearend, approximately 35% of clinker production capacity and 39% of finishing grinding capacity had been acquired by foreign interests.

Domestic Data Coverage.—Domestic production and consumption data for cement were developed by means of the portland and masonry cement voluntary survey. Of the 154 cement manufacturing plants to which an annual survey collection request was made, 100% responded, representing 100% of the cement production and consumption data shown in table 1.

Table 1.—Salient cement statistics

(Thousand short tons unless otherwise specified)

	1979	1980	1981	1982	1983
United States:[1]					
Production[2]	84,491	75,224	71,710	63,355	70,420
Shipments from mills[2 3]	85,747	76,242	71,748	64,066	70,934
Value[2 3 4] thousands	$3,991,580	$3,886,488	$3,723,095	$3,263,585	$3,534,324
Average value per ton[2 3 4]	$46.55	$50.98	$51.89	[r]$50.94	$49.95
Stocks at mills,[2] Dec. 31	6,600	6,825	7,372	6,753	6,711
Exports	149	186	300	201	118
Imports for consumption	9,393	5,244	3,963	2,911	4,221
Consumption, apparent[5 6]	87,799	77,599	73,321	65,623	73,539
World: Production	[r]961,595	[r]973,849	979,296	[p]969,338	[e]1,020,346

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Excludes Puerto Rico and the Virgin Islands.
[2]Portland and masonry cement only.
[3]Includes imported cement shipped by domestic producers.
[4]Value received, f.o.b. mill, excluding cost of containers.
[5]Quantity shipped, plus imports, minus exports.
[6]Adjusted to eliminate duplication of imported clinker and cement shipped by domestic cement manufacturers.

DOMESTIC PRODUCTION

One State agency and 48 companies operated 145 plants in 40 States. In addition, two companies operated two plants in Puerto Rico, manufacturing one or more kinds of hydraulic cement.

Some of the data are arranged by State or by groups of States that form cement districts. A cement district may represent a group of States or a portion of a State. The States of California, New York, and Pennsylvania 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 San Luis Obispo and Kern Counties and the western borders of Inyo and Mono Counties.

California, Southern.—All other counties in California.

New York, Western.—All counties west of a dividing line following the eastern boundaries of St. Lawrence, Lewis, Oneida, Madison, Chenango, and Broome 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 Westchester, Rockland, Suffolk, and Nassau Counties.

Pennsylvania, Eastern.—All counties east of the eastern boundaries of Potter, Clinton, Centre, Huntingdon, and Franklin Counties.

Pennsylvania, Western.—All other counties in Pennsylvania.

PORTLAND CEMENT

Clinker production in the United States, excluding Puerto Rico, increased 7% to 63.6 million tons, and clinker imports reported by U.S. cement producers increased 45% to 762,000 tons. A total of 67.5 million tons of portland cement was ground in the United States. Stocks at mills decreased by 77,000 tons to 6.3 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 12.4% to 0.30%. The 5 largest producers provided 36% of total clinker production; the 10 largest producers provided a combined 57%. The 10 largest companies, in terms of clinker production, were Lone Star Industries Inc., General Portland Inc., Ideal Basic Industries Inc., Lehigh Portland Cement Co., Gifford-Hill & Co., Kaiser Cement Corp., Dundee Cement Co., Texas Industries Inc., National Gypsum Co., and Southwestern Portland Cement Co. Martin Marietta Corp., fourth largest in 1982, dropped out of the top 10 as a result of its decision to sell its cement facilities and exit the industry. General Portland, third largest in 1982, became second largest in 1983.

At yearend, 269 kilns located at 128 plants were being operated by 44 companies and 1 State agency in the United States, excluding Puerto Rico. Annual clinker production capacity at yearend was 87.6 million tons. An average of 44 days downtime was reported for kiln maintenance and replacing refractory brick. The industry operated at 73% of its apparent capacity. Average annual clinker capacity of U.S. kilns was 326,000 tons, average plant capacity was 684,000 tons, and average company capacity was about 1.9 million tons. Three plants produced white cement. In addition, 10 plants operated grinding mills using only imported or purchased clinker, or interplant transfers of clinker. Of these, five produced portland cement only, and five ground clinker for both masonry and portland cement. Based on the fineness necessary to grind Types I and II cements and allowing for downtime for maintenance, the U.S. cement industry's estimated annual grinding capacity increased about 0.5% to 105 million tons.

Clinker was produced by wet-process kilns at 57 plants and by dry-process kilns at 66 plants; 5 additional plants operated both wet and dry kilns. Most new plants that came on-stream and those currently under construction were dry-process, preheater- or precalciner-equipped, single-kiln systems with annual capacities in excess of 500,000 tons of clinker. The yearend totals of 55 suspension and 20 grate preheaters were unchanged.

Capacity Added in 1983.—Centex Corp. doubled the annual capacity of its Texas Cement Co. plant in Buda, TX, to 1.1 million tons. Fuller Co. designed and supplied the production equipment.

Capitol Aggregates Inc. added a 500,000-ton-per-year, dry-process line to its cement plant at San Antonio, TX.

Kaiser Cement had completed a $150 million expansion and conversion from wet to dry process of its Cushenbury plant at Lucerne Valley, CA, in late 1982. The plant, expanded from 1.0- to 1.6-million-ton-per-year capacity, went into full production in 1983.

Capacity Additions Scheduled To Be Completed in 1984.—Gifford-Hill planned to modify the preheater kiln system at its Harleyville plant in South Carolina to increase capacity by about 45,000 tons. Projects to precalcine and fire the crusher air dryer with coal rather than oil or gas were planned for completion.

Southwestern Portland Cement remained on schedule with the $100 million expansion and modernization of its Victorville, CA, plant. The expansion, scheduled for completion in September 1984, was designed to increase annual clinker capacity from 1.1 to 1.4 million tons.

Capacity Additions Scheduled To Be Completed After 1984.—Beehive Cement Co. was seeking financing for a new 550,000-ton-per-year cement plant at Santaquin, UT.

Dal-Tex Cement Corp. began construction of a 1-million-ton-per-year cement plant near Midlothian, TX. Construction was delayed while Dal-Tex sought a new contractor.

Florida Crushed Stone Co. continued planning for construction of a 600,000-ton-per-year cement plant in Brooksville, FL. Start of construction, originally scheduled for 1983, was delayed until early 1984.

Gifford-Hill continued to evaluate plans for a 2-million-ton-per-year capacity expansion of its Oro Grande, CA, cement plant. Plans included new secondary crushing facilities, preblending, raw mill, homogenizing silos, preheater, precalciner kiln, clinker storage, and cement mill. The company was also planning an expansion of its Clarksdale, AZ, plant.

Las Vegas Portland Cement Inc. continued to seek financing for construction of a 1-million-ton-per-year, $100 million cement plant at Jean, NV. The plant had originally been scheduled to go into production in 1983 at a cost of $90 million and with a capacity of 650,000 tons per year.

Mineral Reserves Inc. again postponed construction of a 600,000-ton-per-year cement plant near Pueblo, CO. High interest rates were reported to be the cause for the delay.

Monolith Portland Cement Co. began engineering work on its planned expansion and conversion from wet to dry processing at its Monolith, CA, plant. The expansion would double plant capacity to 1.0 million tons per year.

Plant Closings.—Genstar Cement and Lime Co.'s San Andreas, CA, cement plant remained closed throughout the year. Plans for a $50 million expansion and modernization program were postponed indefinitely.

Ideal Basic closed its plant at Castle Hayne, NC, after attempting, unsuccessfully, to find a buyer.

Moore McCormack Cement Inc. closed its Kingsport, TN, plant and began dismantling its plant at Richard City, TN.

Corporate Changes.—Continental Cement Co. sold a 50% interest in its cement terminals at Port Everglades and Cape Canaveral, FL, to Atlantic Cement Co. Inc.

Cianbro Corp. sold its Thomaston, ME, cement plant to Passamaquoddy Properties. Cianbro had purchased the plant earlier in the year from Martin Marietta. Cianbro continued to operate the plant under lease.

Ideal Basic sold its Tijeras, NM, cement facilities to General Electric Credit Corp. but continued to operate the plant under a leaseback arrangement.

Lone Star sold its 600,000-ton-per-year cement plant at Dixon, IL, to Dixon Marquette Cement Inc., a subsidiary of Prairie Materials Sales Inc.

Louisville Cement Co. sold its Bessemer, PA, cement plant to SME Bessemer Cement Co., a subsidiary of Standard Machine and Equipment Co.

Martin Marietta sold most of its cement operations. Its plants at Calera, AL; Atlanta, GA; and Tulsa, OK, were sold to Blue Circle Industries PLC of the United Kingdom, and its plant at Buffalo, IA, was sold to Davenport Cement Co., a subsidiary of Cementia Holdings A.G. of Zurich, Switzerland. Martin Marietta also sold its Martinsburg, WV, plant to Capital Cement Corp., a subsidiary of Riverton Corp., and its Thomaston, ME, plant to Cianbro. Remaining plants at Lyons, CO, and Leamington, UT, were on the market but had not been sold by yearend.

Moore McCormack purchased from Ideal Basic a 550,000-ton-per-year cement plant at Knoxville, TN; cement terminals at Castle Hayne and Statesville, NC, and Gray Station, TN; and a cement bulk transfer facility in Wilmington, NC.

Table 2.—Portland cement production, capacity, and stocks in the United States, by district[1]

District	1982					1983				
	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	7	3,054	4,584	66.6	266	6	2,914	4,018	72.5	293
Pennsylvania, eastern	10	3,750	5,401	69.4	395	8	4,103	4,848	84.6	351
Pennsylvania, western	4	1,008	2,403	41.9	145	4	997	2,441	40.8	119
Maryland, Virginia, West Virginia	5	W	W	W	W	5	3,025	3,610	83.8	335
Ohio	6	1,381	2,506	55.1	158	6	1,630	2,603	62.6	212
Michigan and Wisconsin	8	W	W	W	W	7	3,814	7,096	53.7	348
Indiana and Kentucky	5	W	W	W	W	5	2,581	3,862	66.8	282
Illinois	4	1,544	2,644	58.4	198	4	1,889	2,640	71.6	229
Georgia and Tennessee	6	W	W	W	W	4	1,809	2,690	67.2	145
North Carolina and South Carolina	4	W	W	W	W	4	1,976	4,278	46.2	114
Florida	6	2,641	4,364	60.5	213	6	3,344	4,553	73.4	214
Alabama	6	2,677	4,927	54.3	360	6	3,195	5,661	56.4	367
Arkansas, Louisiana, Mississippi	4	W	W	W	W	4	2,327	2,790	83.4	128
South Dakota	1	523	1,806	28.9	66	1	593	1,806	32.8	56
Iowa	4	1,461	3,001	48.6	270	4	1,675	3,001	55.8	307
Missouri	5	3,104	4,925	63.0	357	5	3,541	4,950	71.5	444
Kansas and Nebraska	7	W	W	W	W	7	2,394	4,114	58.2	394
Oklahoma	3	W	W	W	W	3	1,705	2,180	78.2	165
Texas, northern	9	4,581	5,246	87.3	357	9	4,872	5,542	87.9	313
Texas, southern	11	4,867	7,150	68.0	300	10	4,780	7,132	67.0	243
Idaho, Montana, Utah	6	1,327	2,410	55.0	253	6	1,480	2,381	62.2	241
Colorado and Wyoming	4	1,619	2,600	62.2	136	3	1,437	3,112	46.2	103
Oregon and Washington	6	W	W	W	W	5	1,719	2,750	62.5	242
Arizona, Nevada, New Mexico	4	W	W	W	W	4	1,970	3,083	63.9	126
California, northern	4	2,099	3,797	55.2	286	3	2,124	3,937	53.9	166
California, southern	8	4,408	8,174	53.9	292	8	5,386	8,893	60.6	305
Hawaii	2	223	560	39.7	44	2	210	560	37.5	38
Other	--	20,804	37,544	55.4	2,261	--	--	--	--	--
Total or average	149	61,071	104,042	58.7	6,357	139	67,490	104,531	64.6	6,280
Puerto Rico	2	986	2,210	44.6	36	2	927	2,210	41.9	32

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

[1]Includes Puerto Rico. Includes data for white cement facilities (3 in 1983 and 5 in 1982) as follows: California (1); Pennsylvania (1 in 1983 and 2 in 1982); and Texas (1 in 1983 and 2 in 1982). Includes data for grinding plants (10 in 1983 and 9 in 1982) as follows: Florida (1); Illinois (1 in 1983 only); Michigan (2); New York (1); Oregon (1 in 1982 only); Pennsylvania (1); Texas (3 in 1983 and 1 in 1982); and Wisconsin (1 in 1983 and 2 in 1982).

[2]Includes cement produced from imported clinker (1982—525,000 tons; 1983—762,000 tons).

[3]Grinding capacity based on fineness necessary to grind Types I and II cement, making allowance for downtime required for maintenance.

[4]Includes imported cement. Source of imports withheld to avoid disclosing company proprietary data.

Table 3.—Clinker capacity and production in the United States,[1] by district, as of December 31, 1983

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	11.8	46	3,766	2,790	74.0
Pennsylvania, eastern	2	5	--	7	16	14.7	46	4,685	3,933	83.9
Pennsylvania, western	3	1	--	4	8	6.0	61	1,826	988	54.1
Maryland, Virginia, West Virginia	2	3	--	5	15	11.7	50	3,682	2,960	80.4
Ohio	2	3	1	6	10	7.9	60	2,407	1,601	66.5
Michigan and Wisconsin	2	2	--	4	9	15.7	42	5,074	3,384	66.7
Indiana and Kentucky	2	3	--	5	10	11.7	25	3,975	2,437	61.3
Illinois	--	3	--	3	8	8.6	31	2,873	1,778	61.9
Georgia and Tennessee	1	2	1	4	7	6.9	33	2,293	1,786	77.9
North Carolina and South Carolina	2	1	--	3	7	7.6	56	2,351	1,965	83.6
Florida	4	1	--	5	10	12.0	41	3,894	2,955	75.9
Alabama	1	5	--	6	8	13.7	49	4,332	3,091	71.4
Arkansas, Louisiana, Mississippi	4	--	--	4	8	7.7	47	2,446	2,248	91.9
South Dakota	--	--	1	1	4	3.3	40	1,074	536	49.9
Iowa	1	3	--	4	8	9.4	43	3,023	1,545	51.1
Missouri	2	3	--	5	7	14.4	55	4,458	3,722	83.5
Kansas and Nebraska	4	3	--	7	19	11.0	58	3,381	2,336	69.1
Oklahoma	1	2	--	3	7	5.5	41	1,783	1,662	93.2
Texas, northern	5	3	1	9	25	15.4	36	5,072	4,737	93.3
Texas, southern	3	4	--	7	8	13.7	39	4,466	3,661	82.0
Idaho, Montana, Utah	5	1	--	6	10	6.9	47	2,192	1,439	65.6
Colorado and Wyoming	2	1	--	3	7	6.7	32	2,228	1,429	64.1
Oregon and Washington	3	2	--	5	8	5.3	37	1,736	1,564	90.1
Arizona, Nevada, New Mexico	--	4	--	4	11	7.9	43	2,544	1,897	74.6
California, northern	--	3	--	3	3	11.3	50	3,562	2,035	57.1
California, southern	1	6	1	8	28	24.2	38	7,918	4,926	62.2
Hawaii	1	1	--	2	2	1.8	62	545	215	39.4
Total or average	57	66	5	128	269	272.8	44	87,586	63,620	72.6
Puerto Rico	2	--	--	2	9	7.4	75	2,147	869	40.5

[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
1982:				
Less than 600	2	3	900	0.3
600 to 1,150	24	41	20,601	7.3
1,150 to 1,700	33	63	46,621	16.5
1,700 to 2,300	30	60	56,984	20.1
2,300 to 2,800	25	55	65,731	23.2
2,800 and over	24	78	92,346	32.6
Total	138	300	283,183	100.0
1983:				
Less than 600	2	3	900	0.3
600 to 1,150	21	34	18,307	6.5
1,150 to 1,700	33	63	49,075	17.5
1,700 to 2,300	25	50	51,952	18.6
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

[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	1981	1982	1983
Calcareous:			
Limestone (includes aragonite, marble, chalk)	73,026	71,307	73,075
Cement rock (includes marl)	26,627	18,593	21,644
Oystershell and coral	3,090	1,773	2,030
Argillaceous:			
Clay	5,742	5,007	5,736
Shale	3,649	3,282	3,011
Other (includes staurolite, bauxite, aluminum dross, pumice, alumina, volcanic material, other)	212	209	118
Siliceous:			
Sand and calcium silicate	1,794	1,568	1,669
Sandstone, quartzite, other	734	508	691
Ferrous: Iron ore, pyrites, millscale, other iron-bearing material	1,144	958	1,058
Other:			
Gypsum and anhydrite	3,600	3,148	3,474
Blast furnace slag	95	69	49
Fly ash	757	550	870
Other, n.e.c	162	108	103
Total	120,632	107,080	113,528

[1]Includes Puerto Rico.

MASONRY CEMENT

Production of masonry cement increased 28% to 2.9 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	1982 Plants active during year	1982 Production (thousand short tons)	1982 Stocks[1] at mills, Dec. 31 (thousand short tons)	1983 Plants active during year	1983 Production (thousand short tons)	1983 Stocks[1] at mills, Dec. 31 (thousand short tons)
New York and Maine	3	61	11	4	66	11
Pennsylvania, eastern	7	180	26	6	205	35
Pennsylvania, western	4	71	12	3	68	12
Maryland, Virginia, West Virginia	6	W	W	5	256	27
Ohio	4	79	20	4	98	21
Michigan and Wisconsin	4	W	W	5	165	43
Indiana and Kentucky	4	W	W	4	343	58
Illinois	1	W	W	1	W	W
Georgia and Tennessee	4	W	W	4	150	21
North Carolina and South Carolina	3	W	W	3	256	22
Florida	5	218	17	5	305	24
Alabama	5	146	23	5	205	28
Arkansas, Louisiana, Mississippi	4	W	W	4	99	12
South Dakota	1	6	4	1	2	1
Iowa	1	W	W	3	32	9
Missouri	3	75	10	3	137	18
Kansas and Nebraska	7	W	W	6	70	32
Oklahoma	3	W	W	3	46	5
Texas, northern	7	158	14	7	214	17
Texas, southern	6	60	8	5	67	10
Idaho, Montana, Utah	4	6	5	3	6	5
Colorado and Wyoming	2	W	W	2	W	W
Oregon and Washington	2	W	W	3	5	4
Arizona, Nevada, New Mexico	3	63	5	3	85	5
California, southern	1	W	W	1	W	W
Hawaii	2	6	3	2	6	2
Other	--	1,155	238	--	44	9
Total	96	[2]2,284	396	95	[3]2,930	431

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes imported cement.
[2]Includes 2,018,000 tons produced from clinker and 266,000 tons produced from cement.
[3]Includes 2,641,000 tons produced from clinker and 289,000 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 was 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 new or modernized plants featuring coal-burning and dry-process systems with preheaters and precalciners to promote efficiency in fuel consumption.

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 2% to 4.9 million British thermal units (Btu).

The average consumption of electrical energy decreased 3% to 142.1 kilowatt hours per ton. Assuming a 40% energy efficiency in conversion of fuel to electrical energy, this represents a fuel equivalent of 1.2 million Btu per ton. Thus, average fuel consumption for kiln firing plus electrical energy, primarily for finish grinding, was approximately 6.1 million Btu per ton.

Average fuel consumption in kiln firing in wet-process plants, 5.4 million Btu per ton, was 26% higher than average fuel consumption in dry-process plants, 4.3 million Btu per ton. Approximately 56% of clinker production was by the dry process.

Kilns without preheaters averaged 5.2 million Btu per ton of clinker produced; those with suspension preheaters averaged 3.8 million Btu per ton, and those with grate-type preheaters averaged 4.9 million

Btu per ton.

Coal accounted for 92% of kiln fuel consumption, natural gas accounted for 5%, and oil accounted for the remainder.

Interest continued in the use of energy-saving additives such as fly ash and iron and steel slag. The use of fly ash in cements increased 58% to 870,000 tons. However, the use of slags declined 29% to 49,000 tons.

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)
1982:						
Coal	24	11,637	19.3	2,495	--	--
Oil	2	928	1.5	--	976	--
Natural gas	3	761	1.3	--	--	7,607,179
Coal and oil	29	11,912	19.8	2,160	376	--
Coal and natural gas	54	22,334	37.1	4,354	--	11,285,363
Oil and natural gas	3	505	.8	--	152	2,569,257
Coal, oil, natural gas	24	12,177	20.2	2,062	536	4,903,188
Total	139	60,254	100.0	11,071	2,040	26,364,987
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

[1]Includes Puerto Rico.
[2]Includes 0.6% anthracite, 96.3% bituminous, 3.1% petroleum coke in 1982; 95.8% bituminous and 4.2% petroleum coke in 1983.

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)
1982:						
Wet	64	25,207	41.8	5,186	1,204	14,974,907
Dry	69	31,981	53.1	5,318	810	8,564,900
Both	6	3,066	5.1	567	26	2,825,180
Total	139	60,254	100.0	11,071	2,040	26,364,987
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

[1]Includes Puerto Rico.
[2]Includes 0.6% anthracite, 96.3% bituminous, and 3.1% petroleum coke in 1982; 95.8% bituminous and 4.2% petroleum coke in 1983.

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: 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)
1982:								
Wet	--	--	67	3,551	3,551	39.1	26,711	132.9
Dry[2]	4	316	78	4,723	5,039	55.5	32,338	155.8
Both	--	--	6	489	489	5.4	3,010	162.5
Total or average	4	316	151	8,763	9,079	100.0	[3]62,057	146.3
Percent of total electric energy used	--	3.5	--	96.5	--	--	--	--
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	--	--	--	--

[1]Includes Puerto Rico. Includes grinding plants and white cement facilities.
[2]Includes data for grinding plants.
[3]Data do not add to total shown because of independent rounding.

TRANSPORTATION

U.S. shipments of portland cement to consumers were primarily in bulk, 94%; by truck, 94%; and made directly from cement manufacturing plants, 72%, rather than 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, 46%, and waterways, 38%. Transportation by truck accounted for 13%. Cement used at producing plants accounted for the remaining 3%.

Table 10.—Shipments of portland cement from mills in the United States,[1] in bulk and in containers, by type of carrier

(Thousand short tons)

Type of carrier	Shipments from plant to terminal		Shipments to ultimate consumer: From terminal to consumer		Shipments to ultimate consumer: From plant to consumer		Total shipments
	In bulk	In containers	In bulk	In containers	In bulk	In containers	
1982:							
Railroad	7,688	116	226	--	3,207	57	3,490
Truck	1,379	100	16,307	569	38,101	3,310	58,287
Barge and boat	7,182	84	64	2	260	13	339
Unspecified[2]	507	--	216	5	321	13	555
Total	16,756	300	16,813	576	41,889	3,393	[3] [4]62,672
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

[1]Includes Puerto Rico.
[2]Includes cement used at plant.
[3]Bulk shipments were 93.7%, and container (bag) shipments were 6.3%.
[4]Data do not add to total shown because of independent rounding.

CONSUMPTION AND USES

Cement consumption in the United States, excluding Puerto Rico, increased 12% to 73.5 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 11% to 70.9 million tons. This included 1.6 million tons of cement and clinker imported and sold or used by domestic producers. Additional imports of 1.0 million tons net of cement imported by certain other importers accounted for the difference between consumption and domestic shipments.

Domestic cement shipments to all regions of the United States increased. Regions registering the largest increases were Atlantic, 18%; Mountain, 15%; and Pacific, 13%. Increases in shipments to all other regions ranged from 6% to 9%.

The end-use distribution pattern for portland cement did not differ significantly from that of recent years. Ready-mix concrete producers were the primary consumers, accounting for 69% of the total quantity shipped by domestic producers. Manufacturers of concrete products used 12% 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 13% to \$263 billion.[3] Of this total value, 42% was in private housing; 23% was in private industrial and commercial building, including farms; 7%

was in public buildings; 5% was in highways; and the remainder was in other public construction.

Total private construction put in place increased 17% to $212 billion. The value of residential units put in place increased 48% to $111 billion, and industrial-commercial construction put in place decreased 2% to $101 billion. Total public construction put in place decreased 1% to $50 billion; of which, public buildings remained unchanged at $17 billion, highway construction increased 5% to $14 billion, and other public construction decreased 8% to $19 billion.

Housing starts increased 60% to 1.70 million units, consisting of 1.07 million single units and 635,000 multiunits, according to the U.S. Department of Commerce. Single-housing starts increased 61%. On a regional basis, housing starts increased 58% in the South to 935,000 units, 44% in the Northeast to 168,000 units, 86% in the West to 382,000 units, and 46% in the North Central region to 218,000 units.

Table 11.—Portland cement shipped by producers in the United States, by district[1]

District	1982			1983		
	Quantity (thousand short tons)	Value (thousands)	Average per ton	Quantity (thousand short tons)	Value (thousands)	Average per ton
New York and Maine	3,057	$119,238	$39.00	2,889	$117,300	$40.60
Pennsylvania, eastern	3,771	170,217	45.14	4,107	176,752	43.04
Pennsylvania, western	1,029	42,729	41.52	1,046	41,787	39.95
Maryland, Virginia, West Virginia	W	W	W	3,015	136,833	45.38
Ohio	1,326	59,598	44.95	1,575	71,599	45.46
Michigan and Wisconsin	W	W	W	3,680	165,924	45.09
Indiana and Kentucky	W	W	W	2,061	80,523	39.07
Illinois	1,757	78,444	44.65	1,857	74,975	40.37
Georgia and Tennessee	W	W	W	2,036	85,370	41.93
North Carolina and South Carolina	W	W	W	1,986	83,734	42.16
Florida	2,651	136,190	51.37	3,329	164,048	49.28
Alabama	2,558	104,461	40.84	3,279	150,255	45.82
Arkansas, Louisiana, Mississippi	W	W	W	2,314	119,342	51.57
South Dakota	520	27,978	53.80	603	37,435	62.08
Iowa	1,622	82,225	50.69	1,644	87,836	53.43
Missouri	3,205	120,339	37.55	3,499	157,249	44.94
Kansas and Nebraska	W	W	W	2,298	119,112	51.83
Oklahoma	W	W	W	1,719	83,685	48.68
Texas, northern	4,795	295,515	61.63	5,084	310,839	61.14
Texas, southern	4,937	250,164	50.67	4,676	223,460	47.79
Idaho, Montana, Utah	1,259	74,291	59.01	1,504	79,060	52.57
Colorado and Wyoming	1,566	97,461	62.24	1,470	90,376	61.48
Oregon and Washington	W	W	W	1,675	92,570	55.27
Arizona, Nevada, New Mexico	W	W	W	2,053	124,006	60.40
California, northern	2,039	117,990	57.87	2,281	117,660	51.58
California, southern	4,425	283,893	64.16	5,286	303,289	57.38
Hawaii	227	18,122	79.83	216	20,673	95.71
Other	20,334	1,005,584	49.45	--	--	--
Total or average[2] [3]	61,080	3,084,439	50.50	67,183	3,315,690	49.35
Foreign imports[4]	605	32,574	53.84	827	41,317	49.96
Puerto Rico	986	81,822	82.98	931	82,509	88.62
Grand total or average[3]	62,672	3,198,835	51.04	68,942	3,439,516	49.89

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

[1]Includes Puerto Rico. Includes data for white cement facilities (3 in 1983 and 5 in 1982) as follows: California (1); Pennsylvania (1 in 1983 and 2 in 1982); and Texas (1 in 1983 and 2 in 1982). Includes data for grinding plants (10 in 1983 and 9 in 1982) as follows: Florida (1); Illinois (1 in 1983 only); Michigan (2); New York (1); Oregon (1 in 1982 only); Pennsylvania (1); Texas (3 in 1983 and 1 in 1982); and Wisconsin (1 in 1983 and 2 in 1982).

[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	1981			1982		
	Quantity (thousand short tons)	Value (thousands)	Average per ton	Quantity (thousand short tons)	Value (thousands)	Average per ton
New York and Maine	66	$4,104	$62.18	69	$4,597	$66.62
Pennsylvania, eastern	182	10,800	59.34	198	12,298	62.11
Pennsylvania, western	74	3,248	43.89	64	4,797	74.95
Maryland, Virginia, West Virginia	W	W	W	246	16,974	69.00
Ohio	86	6,170	71.74	97	7,454	76.85
Michigan and Wisconsin	W	W	W	170	9,807	57.69
Indiana and Kentucky	W	W	W	331	17,522	52.94
Illinois	W	W	W	W	W	W
Georgia and Tennessee	W	W	W	160	10,459	65.37
North Carolina and South Carolina	W	W	W	234	14,182	60.61
Florida	231	16,267	70.42	313	19,557	62.48
Alabama	150	9,086	60.57	210	13,417	63.89
Arkansas, Louisiana, Mississippi	W	W	W	100	6,409	64.09
South Dakota	4	383	95.75	4	359	89.75
Iowa	W	W	W	37	3,425	92.57
Missouri	88	4,855	55.17	146	7,339	50.27
Kansas and Nebraska	W	W	W	71	3,778	53.21
Oklahoma	W	W	W	45	3,074	68.31
Texas, northern	160	10,833	67.71	196	14,184	72.37
Texas, southern	75	5,607	74.76	80	5,520	69.00
Idaho, Montana, Utah	5	412	82.40	5	424	84.80
Colorado and Wyoming	W	W	W	W	W	W
Oregon and Washington	W	W	W	6	598	99.67
Arizona, Nevada, New Mexico	64	5,137	80.27	85	5,999	70.58
California, southern	W	W	W	W	W	W
Hawaii	6	554	92.33	6	641	106.83
Other	1,173	67,715	57.73	45	3,425	76.11
Total or average[2]	2,364	145,172	61.41	2,921	186,240	63.76
Foreign imports[3]	17	1,400	82.35	2	77	38.50
Grand total or average	2,381	146,572	61.56	2,923	186,317	63.74

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Does not include quantities produced on the job by masons.
[2]Data may not add to totals shown because of independent rounding.
[3]Cement imported and distributed by domestic producers only. Source of imports withheld to avoid disclosing company proprietary data.

Table 13.—Cement shipments, by destination and origin[1]

(Thousand short tons)

Destination and origin	Portland cement[2]			Masonry cement		
	1981	1982	1983	1981	1982	1983
Destination:						
Alabama	988	930	1,088	76	64	85
Alaska[3]	137	171	180	--	W	W
Arizona	1,479	1,245	1,645	W	W	W
Arkansas	668	553	655	39	31	41
California, northern	2,535	2,170	2,608	--	(4)	--
California, southern	4,733	3,864	4,427	--	--	W
Colorado	1,532	1,464	1,478	27	24	26
Connecticut[3]	590	611	626	16	13	15
Delaware[3]	124	154	145	6	7	9
District of Columbia[3]	116	139	116	2	2	1
Florida	5,335	4,081	4,866	389	317	396
Georgia	1,882	1,775	2,256	151	145	189
Hawaii	302	229	216	10	6	6
Idaho	311	241	268	2	1	1
Illinois	2,323	2,309	2,241	70	54	64
Indiana	1,146	1,015	1,148	71	61	68

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		
	1981	1982	1983	1981	1982	1983
Destination —Continued						
Iowa	1,147	1,158	1,147	16	12	12
Kansas	1,086	956	983	22	18	21
Kentucky	915	888	813	75	66	76
Louisiana	2,597	2,453	2,490	70	67	74
Maine	227	198	223	9	8	8
Maryland	1,165	1,069	1,266	97	89	113
Massachusetts[3]	997	991	1,077	36	32	34
Michigan	1,729	1,313	1,457	86	58	70
Minnesota	1,238	1,112	1,124	38	33	38
Mississippi	841	673	716	51	39	51
Missouri	1,426	1,249	1,383	34	29	37
Montana	300	228	264	2	1	2
Nebraska	667	678	715	12	9	11
Nevada	574	405	459	--	--	--
New Hampshire[3]	242	288	260	10	9	8
New Jersey[3]	1,267	1,235	1,337	57	53	56
New Mexico	661	543	598	11	10	12
New York, eastern	542	447	366	24	20	22
New York, western	809	753	746	34	32	36
New York, metropolitan[3]	1,061	1,072	1,312	36	38	51
North Carolina	1,455	1,379	1,472	173	153	196
North Dakota[3]	318	266	317	6	6	6
Ohio	2,334	2,040	2,311	124	99	116
Oklahoma	1,827	1,857	1,758	55	55	66
Oregon	626	573	553	1	1	1
Pennsylvania, eastern	1,458	1,391	1,481	48	44	54
Pennsylvania, western	832	816	828	64	59	54
Rhode Island[3]	118	129	147	4	4	3
South Carolina	905	755	858	89	81	106
South Dakota	239	194	274	4	3	4
Tennessee	1,192	1,055	1,207	108	99	127
Texas	9,202	9,185	10,074	219	243	285
Utah	699	598	792	2	1	1
Vermont[3]	125	110	133	5	4	4
Virginia	1,531	1,357	1,646	130	108	147
Washington	1,292	1,016	1,077	8	6	6
West Virginia	478	457	444	34	30	29
Wisconsin	1,331	1,048	1,247	41	32	36
Wyoming	503	403	380	3	2	2
U.S. total	70,157	63,289	69,698	2,697	2,378	2,876
Foreign countries[5]	593	363	231	84	60	91
Puerto Rico	1,151	950	920	--	--	--
Total shipments	71,901	64,602	70,849	2,781	2,438	2,967
Origin:						
United States[6]	68,197	61,080	67,183	2,738	2,364	2,921
Puerto Rico	1,226	986	931	--	--	--
Foreign:[7]						
Domestic producers	805	605	827	8	17	2
Others	1,673	1,931	1,908	35	57	44
Total shipments	71,901	64,602	70,849	2,781	2,438	2,967

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 (1981—192,000 tons; 1982—158,000 tons; and 1983—211,000 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. Origin of imports withheld to avoid disclosing company proprietary data.

Table 14.—Cement shipments,[1] by region and subregion

Region and subregion[2]	Portland cement				Masonry cement			
	Thousand short tons		Percent of total		Thousand short tons		Percent of total	
	1982	1983	1982	1983	1982	1983	1982	1983
Northeast:								
New England	2,327	2,466	3.7	3.5	70	72	2.9	2.5
Middle Atlantic	5,714	6,069	9.0	8.7	246	273	10.4	9.5
Total	8,041	8,535	12.7	12.2	316	345	13.3	12.0
South:								
Atlantic	11,166	13,070	17.6	18.7	932	1,186	39.2	41.2
East Central	3,546	3,824	5.6	5.5	268	339	11.3	11.8
West Central	14,048	14,977	22.2	21.5	396	466	16.6	16.2
Total	28,760	31,871	45.4	45.7	1,596	1,991	67.1	69.2
North Central:								
East	7,725	8,404	12.2	12.1	304	354	12.8	12.3
West	5,613	5,943	8.9	8.5	110	129	4.6	4.5
Total	13,338	14,347	21.1	20.6	414	483	17.4	16.8
West:								
Mountain	5,127	5,884	8.1	8.5	39	44	1.6	1.5
Pacific	8,023	9,061	12.7	13.0	13	13	.6	.5
Total	13,150	14,945	20.8	21.5	52	57	2.2	2.0
Grand total	63,289	69,698	100.0	100.0	2,378	2,876	100.0	100.0

[1]Includes imported cement shipped by domestic and Canadian cement manufacturers and other importers.
[2]Geographic regions designated by the U.S. Department of Commerce, Bureau of the Census.

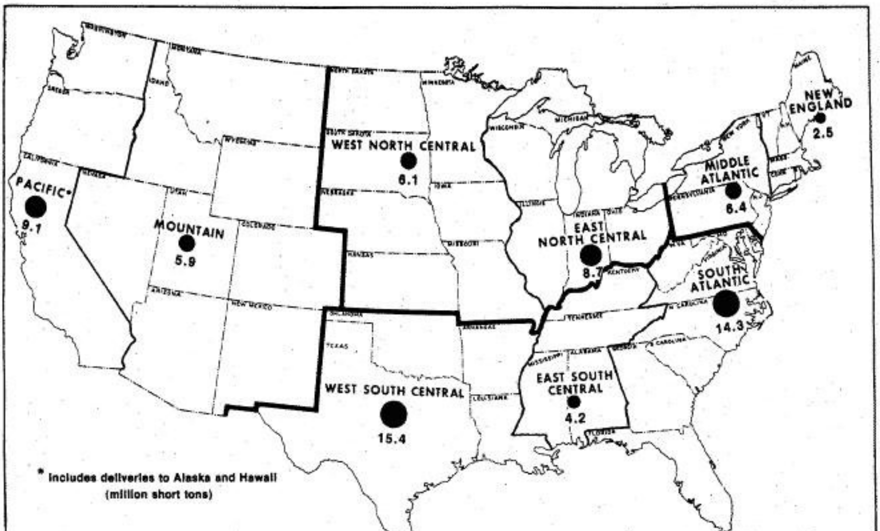

Figure 1.—Shipments of cement by geographic region of destination in 1983.

Table 15.—Portland cement shipments in 1983, by district of origin and type of customer[1]

District of origin	Building material dealers		Concrete product manufacturers		Ready-mixed concrete		Highway contractors		Other contractors		Federal, State, and other government agencies		Miscellaneous including own use		Total[2] (thousand short tons)
	Quantity (thousand short tons)	Percent	Quantity (thousand short tons)	Percent	Quantity (thousand short tons)	Percent	Quantity (thousand short tons)	Percent	Quantity (thousand short tons)	Percent	Quantity (thousand short tons)	Percent	Quantity (thousand short tons)	Percent	
New York and Maine	130	4.5	434	15.0	2,069	71.6	138	4.8	104	3.6	2	0.1	12	0.4	2,889
Pennsylvania, eastern	342	8.3	928	22.6	2,699	65.7	23	.6	61	1.5	--	--	54	1.3	4,107
Pennsylvania, western	121	11.6	138	13.2	686	65.6	32	3.0	68	6.5	--	--	1	.1	1,046
Maryland, Virginia, West Virginia	214	7.1	412	13.7	2,196	72.8	69	2.3	74	2.4	3	.1	48	1.6	3,015
Ohio	92	5.9	254	16.1	1,144	72.6	79	5.0	3	.2	--	--	3	.2	1,575
Michigan and Wisconsin	127	3.5	492	13.4	2,824	76.7	148	4.0	68	1.9	7	.2	13	.4	3,680
Indiana and Kentucky	116	5.6	272	13.2	1,526	74.1	91	4.4	29	1.4	2	.1	25	1.2	2,061
Illinois	50	2.7	185	10.0	1,442	77.6	98	5.3	40	2.1	--	--	43	2.3	1,857
Georgia and Tennessee	146	7.2	342	16.8	1,236	60.7	200	9.8	81	4.0	11	.5	20	1.0	2,036
North Carolina and South Carolina	58	2.9	345	17.4	1,454	73.2	59	3.0	31	1.6	18	.9	20	1.0	1,986
Florida	483	14.5	378	11.4	2,239	67.3	120	3.6	91	2.7	11	.3	7	.2	3,329
Alabama	247	7.5	459	14.0	2,180	66.5	201	6.1	122	3.7	21	.7	49	1.5	3,279
Arkansas, Louisiana, Mississippi	146	6.3	214	9.2	1,375	59.4	206	8.9	235	10.2	34	1.5	103	4.5	2,314
South Dakota	10	1.6	34	5.6	291	48.2	120	19.9	101	16.7	--	--	48	8.0	603
Iowa	35	2.1	291	17.7	1,049	63.8	211	12.8	47	2.9	1	.1	10	.6	1,644
Missouri	59	1.7	347	9.9	2,081	59.4	707	20.2	209	6.0	--	--	97	2.8	3,499
Kansas and Nebraska	78	3.4	152	6.6	1,644	71.5	218	9.5	182	7.9	1	(3)	24	1.0	2,298
Oklahoma	217	12.6	70	4.1	1,075	62.5	58	3.4	276	16.1	6	.3	17	1.0	1,719
Texas, northern	374	7.4	352	6.9	2,782	54.7	249	4.9	1,169	23.0	20	.4	138	2.7	5,084
Texas, southern	205	4.4	318	6.8	3,237	69.2	149	3.2	550	11.8	25	.5	193	4.1	4,676
Idaho, Montana, Utah	53	3.5	97	6.5	1,076	71.5	86	5.7	189	12.6	1	.1	1	.1	1,504
Colorado and Wyoming	48	3.3	111	7.6	1,165	79.2	49	3.3	89	6.0	--	--	9	.6	1,470
Oregon and Washington	50	3.0	134	8.0	1,313	78.4	104	6.2	45	2.7	3	.2	25	1.5	1,675
Arizona, Nevada, New Mexico	78	3.8	260	12.7	1,392	67.8	54	2.6	136	6.7	2	.1	130	6.3	2,053
California, northern	156	6.9	252	11.1	1,729	75.8	23	1.0	91	4.0	5	.2	23	1.0	2,281
California, southern	412	7.8	704	13.3	3,782	71.5	20	.4	314	5.9	2	(3)	52	1.0	5,286
Hawaii	16	7.4	30	13.9	159	73.6	--	--	10	4.6	--	--	1	.5	216
Imports[4]	50	6.0	23	2.8	755	91.2	--	--	--	--	--	--	--	--	827
Total[2] or average	4,113	6.0	8,028	11.8	46,600	68.5	3,512	5.2	4,415	6.5	175	.3	1,166	1.7	68,011
Puerto Rico	475	51.0	70	7.5	359	38.6	--	--	12	1.3	1	.1	14	1.5	931

[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	1982 Quantity (thousand short tons)	1982 Value[2] (thousands)	1982 Average per ton	1983 Quantity (thousand short tons)	1983 Value[2] (thousands)	1983 Average per ton
General use and moderate heat (Types I and II)	56,191	$2,788,208	$49.62	62,549	$3,044,691	$48.68
High-early-strength (Type III)	2,171	115,931	53.40	2,331	120,251	51.59
Sulfate-resisting (Type V)	247	14,715	59.57	423	22,065	52.16
Oil well	2,539	165,733	65.27	1,993	136,411	68.45
White	285	36,947	129.64	249	38,172	153.30
Portland slag and portland pozzolan	673	36,085	53.62	691	35,312	51.10
Expansive	29	2,147	74.03	45	3,316	73.69
Miscellaneous[3]	536	39,069	72.89	662	39,299	59.36
Total[4] or average	62,672	3,198,835	51.04	68,942	3,439,516	49.89

[1]Includes Puerto Rico.
[2]Mill value is the actual value of sales to customers, f.o.b. plant, less all discounts and allowances, less all freight charges to customer, less all freight charges from producing plant to distribution terminal if any, less total cost of operating terminal if any, less cost of paper bags and pallets.
[3]Includes waterproof, low-heat (Type IV), and regulated fast-setting cement.
[4]Data may not add to totals shown because of independent rounding.

PRICES

The average reported unit mill value of all types of portland cement decreased 2%, the second consecutive year of decline following a 6% average annual rate of increase from 1979 to 1981. The average reported unit mill value of masonry cement prepared at cement plants increased 4%, following a 4% average annual rate of increase from 1979 to 1982.

According to Engineering News-Record (ENR), yearend prices of bulk portland cement for 20 U.S. cities averaged $61.78 per ton.[4] This was 22% above the average reported mill value obtained from the Bureau of Mines canvass of cement producers. The lowest ENR quotation was $54.03 per ton for St. Louis, MO, and the highest was $78.30 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
1979	$46.24	$54.59	$46.61
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

[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 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.
[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 42%. Of the 118,000 tons exported, 90% was shipped to Canada, 5% to Mexico, and 5% to 47 other countries. These exports accounted for 0.16% of total shipments from U.S. and Puerto Rican mills.

Imports of hydraulic cement and clinker increased 46% to 4.3 million tons; of this, 24% was clinker. Canada supplied 52% of the total, followed by Mexico, 19%; Spain, 17%; France, 4%; and 18 other countries, 8%. U.S. net import reliance, excluding Puerto Rico and the Virgin Islands, was 6% of apparent consumption.

Imports of white nonstaining portland cement increased 78% to 160,000 tons. Five countries—Belgium-Luxembourg, Canada, Denmark, Mexico, and Spain—accounted for 97% of white cement imports.

Table 18.—U.S. exports of hydraulic cement and cement clinker, by country

Country	1981 Quantity (short tons)	1981 Value (thousands)	1982 Quantity (short tons)	1982 Value (thousands)	1983 Quantity (short tons)	1983 Value (thousands)
Bahamas	3,126	$300	515	$70	220	$43
Canada	208,278	18,251	134,340	18,748	106,011	12,183
Ecuador	517	210	751	177	141	56
Haiti	346	37	576	52	19	7
Leeward and Windward Islands	1,422	160	1,906	199	112	13
Mexico	69,968	7,374	54,878	5,145	6,121	2,921
Peru	1,575	347	428	79	24	34
Saudi Arabia	4,157	1,429	2,336	877	1,343	570
Venezuela	2,528	699	4,027	1,143	912	167
Other[1]	[r]10,860	[r]2,757	3,609	966	3,491	1,365
Total[2]	302,777	31,564	203,366	27,456	118,393	17,360

[r]Revised.
[1]Includes 53 countries in 1981; 50, in 1982; and 40, in 1983.
[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	1981			1982			1983		
	Quantity	Value		Quantity	Value		Quantity	Value	
		Customs	C.i.f.[1]		Customs	C.i.f.[1]		Customs	C.i.f.[1]
Australia	67	2,158	3,223	116	4,027	5,833	46	1,340	1,905
Bahamas	4	195	223	57	2,245	2,666	--	--	--
Canada	2,338	83,660	97,390	2,074	76,798	82,432	2,201	86,198	92,851
Denmark	52	1,997	2,517	52	1,629	2,232	42	2,748	3,338
France	239	12,614	13,351	131	6,058	6,296	153	6,435	7,507
Japan	569	20,944	26,032	87	3,153	4,519	(2)	100	118
Korea, Republic of	--	--	--	19	748	757	69	3,228	4,144
Mexico	83	4,623	4,625	132	6,154	6,228	826	30,844	33,539
Spain	322	12,357	15,800	245	8,626	11,891	737	23,833	29,303
Other	323	12,692	16,098	16	1,448	2,059	193	6,713	8,820
Total[3]	3,997	151,240	179,259	2,929	110,886	124,912	4,268	161,439	181,525

[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 20.—U.S. imports for consumption of clinker, by country

(Thousand short tons and thousand dollars)

Country	1981			1982			1983		
	Quantity	Value		Quantity	Value		Quantity	Value	
		Customs	C.i.f.[1]		Customs	C.i.f.[1]		Customs	C.i.f.[1]
Canada	578	19,421	21,570	320	11,326	12,621	446	14,786	16,534
France	239	12,605	13,336	130	6,057	6,296	152	6,389	7,439
Japan	374	12,938	16,442	--	--	--	--	--	--
Mexico	--	--	--	20	995	995	192	6,899	7,373
Spain	34	1,152	1,359	--	--	--	214	5,559	6,437
Other	1	331	435	(2)	7	8	--	--	--
Total[3]	1,226	46,447	53,142	470	18,385	19,920	1,005	33,633	37,784

[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	1982			1983		
	Quantity	Value		Quantity	Value	
		Customs	C.i.f.[1]		Customs	C.i.f.[1]
Anchorage: Canada	45	2,011	2,346	36	1,871	2,302
Baltimore:						
Netherlands	--	--	--	(2)	(2)	(2)
United Kingdom	--	--	--	(2)	5	6
Total	--	--	--	(2)	5	6
Bridgeport: Canada	(2)	3	3	--	--	--
Buffalo: Canada	643	23,691	25,849	650	26,635	30,207
Chicago:						
Canada	(2)	(2)	1	(2)	4	4
Germany, Federal Republic of	(2)	1	1	--	--	--
Japan	--	--	--	(2)	12	15
Total	(2)	1	2	(2)	16	19
Cleveland: Canada	(2)	(2)	1	--	--	--
Detroit:						
Belgium-Luxembourg	--	--	--	(2)	12	15
Canada	239	11,957	12,582	314	16,339	17,095
Total[3]	239	11,957	12,582	314	16,350	17,110
Duluth: Canada	86	2,921	3,285	92	3,200	3,654
El Paso: Mexico	22	1,129	1,129	173	7,660	7,660
Great Falls: Canada	5	414	414	3	290	290
Honolulu: Korea, Republic of	--	--	--	37	2,398	2,824
Houston:						
China	--	--	--	1	102	152
Colombia	--	--	--	4	141	180
Germany, Federal Republic of	(2)	24	26	--	--	--
Mexico	--	--	--	86	2,442	2,870
Spain	--	--	--	164	4,074	4,864
Sweden	--	--	--	(2)	5	7
Yugoslavia	--	--	--	(2)	59	74
Total[3]	(2)	24	26	255	6,822	8,147
Laredo:						
China	(2)	7	8	--	--	--
Mexico	83	3,773	3,795	81	2,926	2,926
Total	83	3,780	3,803	81	2,926	2,926
Los Angeles:						
Australia	116	W	W	46	W	W
Germany, Federal Republic of	(2)	W	W	--	--	--
Spain	(2)	W	W	39	W	W
Yugoslavia	2	W	W	1	W	W
Total[3]	118	4,639	6,000	87	2,727	3,903
Miami:						
Bahamas	38	1,502	1,805	--	--	--
Belgium-Luxembourg	4	257	420	3	223	371
Colombia	--	--	--	39	1,050	1,397
Costa Rica	--	--	--	(2)	1	2
Denmark	52	1,627	2,232	23	792	995
France	--	--	--	(2)	1	1
Mexico	6	217	245	175	5,565	6,574
Spain	146	4,229	6,036	146	3,690	4,819
Venezuela	--	--	--	57	1,550	1,951
Total[3]	246	7,832	10,738	443	12,871	16,111
Milwaukee: Canada	21	661	715	94	2,909	3,361
Mobile: Colombia	--	--	--	5	175	222
New Orleans:						
Canada	20	666	972	21	1,083	1,463
Hong Kong	(2)	52	53	--	--	--
Mexico	--	--	--	29	820	967
Total[3]	20	718	1,025	50	1,902	2,430

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	1982			1983		
	Quantity	Value		Quantity	Value	
		Customs	C.i.f.[1]		Customs	C.i.f.[1]
New York City:						
Germany, Federal Republic of	--	--	--	([2])	2	2
Norway	--	--	--	24	605	788
Spain	--	--	--	184	4,842	6,137
Total[3]	--	--	--	208	5,448	6,927
Nogales: Mexico	([2])	10	10	50	2,162	2,162
Norfolk:						
Canada	([2])	4	4	--	--	--
France	24	2,439	2,503	26	2,739	3,536
Germany, Federal Republic of	([2])	4	5	([2])	3	6
Mexico	--	--	--	([2])	1	1
Total[3]	24	2,447	2,512	26	2,743	3,544
Ogdensburg: Canada	163	5,043	5,043	246	7,918	7,918
Pembina: Canada	54	2,827	2,827	46	2,340	2,340
Portland, ME: Canada	10	337	337	10	329	329
Portland, OR:						
Japan	--	--	--	([2])	36	37
Yugoslavia	--	--	--	([2])	5	10
Total[3]	--	--	--	([2])	40	47
St. Albans: Canada	468	14,112	14,112	582	18,567	18,570
San Diego:						
Japan	70	2,583	3,672	--	--	--
Korea, Republic of	--	--	--	32	830	1,320
Mexico	15	824	824	159	7,043	7,751
Total	85	3,407	4,496	191	7,873	9,071
San Francisco:						
Japan	18	569	838	([2])	46	55
Korea, Republic of	19	748	757	--	--	--
Total	37	1,317	1,595	([2])	46	55
San Juan, PR:						
Belgium-Luxembourg	6	593	910	8	665	1,013
Canada	5	521	880	3	454	558
Colombia	1	65	74	1	23	28
Costa Rica	--	--	--	15	638	711
France	--	--	--	([2])	1	2
Spain	3	249	395	12	830	1,107
Venezuela	--	--	--	3	155	187
Total[3]	15	1,428	2,259	42	2,767	3,607
Savannah: Italy	--	--	--	1	153	157
Seattle:						
Canada	78	3,194	3,670	78	3,206	3,691
Japan	([2])	6	9	([2])	6	11
United Kingdom	--	--	--	([2])	1	2
Yugoslavia	--	--	--	([2])	14	24
Total[3]	78	3,200	3,679	79	3,227	3,727
Tampa:						
Bahamas	19	741	861	--	--	--
Canada	165	7,715	9,328	25	1,053	1,071
Colombia	--	--	--	25	765	975
Denmark	--	--	--	19	1,956	2,342
France	107	W	W	127	W	W
Mexico	6	206	233	74	2,226	2,629
Spain	96	W	W	192	W	W
United Kingdom	70	39	54	--	--	--
Total[3]	463	16,652	19,674	462	18,812	21,596

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	1982			1983		
	Quantity	Value		Quantity	Value	
		Customs	C.i.f.[1]		Customs	C.i.f.[1]
Virgin Islands of the United States:						
Dominican Republic	1	157	233	--	--	--
French West Indies	3	168	217	--	--	--
Leeward and Windward Islands	--	--	--	5	255	305
Total	4	325	450	5	255	305
Grand total[3]	2,929	110,886	124,912	4,268	161,439	181,525

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 the 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)
1979	4,664	165,258	4,668	131,873	81	5,227	9,413	302,358
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

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

Source: Bureau of the Census.

WORLD REVIEW

World cement production increased 5%. A number of the major cement-producing countries, especially Brazil, China, the Republic of Korea, India, Taiwan, and the United States, recorded strong gains. Production decreased 14% in Turkey and 13% in Mexico. Competition among exporting countries remained strong as many countries tried to find new markets for surplus cement. Despite this, a number of countries, particularly Brazil, Egypt, India, Mexico, and Turkey, continued with projects to increase cement capacity.

Rock Products magazine published its annual international cement review covering significant worldwide activities in the cement industry.[5]

Argentina.—Although many cement plants operated at only 70% of capacity, the industry brought two new plants into operation. Cementera Santa Cruz S.A. began production from its 1,900-ton-per-day cement plant in Santa Cruz Province, and Cementos N.O.A.'s 689,000-ton-per-year Rio Juramento plant near Salta went into operation. Calera Avellaneda S.A. was converting a preheater kiln line at its Olavarrio cement plant to raw meal precalcination. At completion, now scheduled for late 1984, production was expected to be increased from 440 to 770 tons per day.

Brazil.—Although cement production was only about two-thirds of existing capacity, cement companies continued to expand their production capacity. Capacity was expected to increase from 35 million tons per year in 1983 to 59 million tons per year in 1987. Cia. de Cimento Atol doubled the capacity of its Sao Miguel dos Campos plant to 1,000 tons per day, Ciminas Cimento Nacional de Minas S.A. completed expansion of its Pedro Leopoldo plant to 1.1 million tons per year, and Cia. Cimento Portland Itau finished expansion of its Itau de Minas plant. Cia. de Cemento Itambe continued its work to increase the Campo Largo plant clinker capacity from 1,400 to 2,200 tons per day, and Cimento Portland Mato Grasso S.A. was developing plans for a 660,000-ton-per-year plant near Nobres.

Canada.—Portland cement producers suffered through a second consecutive year of unusually low demand. Plant closures for extended periods were common as producers adjusted to the poor market conditions. Exports of cement and clinker remained about the same as in 1982.[6]

China.—Cement production increased 15% to 119 million tons. China National Technical Import Corp. was constructing a 1.4-million-ton-per-year, dry-process plant at Ningguo.

France.—Ciments LaFarge (France) continued to modify its plant at Saint-Pierre-la-Cour. The plant was to be converted to coal firing and a five-stage preheater added. Capacity was to be increased from 1,800 to 4,200 tons per day. Capacity at Cimento LaFarge's Lexos plant was increased 24%, and the plant was made capable of burning coal shales, petroleum coke, and coal with up to 30% ash content.

Germany, Federal Republic of.—After declining for 4-years straight, cement production in 1983 was about the same as in 1982. Although construction activity increased, cement production was only 60% of capacity and one plant closed during the year.

Greece.—Cement exports increased an estimated 10% while production increased 16%. Exports went mainly to Saudi Arabia, Nigeria, Libya, Egypt, and Persian Gulf countries. Halkis Cement Co. was adding precalcining systems and expected to increase capacity to over 3.3 million tons per year. The company was also converting three kilns to coal firing to reduce energy costs.

India.—The cement industry continued its aggressive program of modernization and expansion of existing plants and construction of new plants. Cement Corp. of India continued construction of its 1.1-million-ton-per-year plant at Tandur. The plant was expected to go into production in 1985 and to be the most modern in India. The company was also planning a 1.1-million-ton-per-year expansion of its Neemuch plant. The Indian Rayon Corp. was constructing a 1,650-ton-per-day, dry-process plant at Rayon. The plant was designed to operate on low-Btu Indian coal. Work continued on the Century Spinning and Manufacturing Co. Manikgarh Cement Div.'s new 1.1-million-ton-per-year, dry-process plant at Chandrapur and Coromandel Fertilizers Ltd.'s 3,600-ton-per-day plant near Chilamkur. Both were scheduled for completion in 1984. Several other companies were planning future expansions and new plants.

Japan.—Cement exports rose 27%, to 16 million tons, mainly because of increased sales to Southeast Asia and the Middle East. The Middle East received 60% of Japan's cement exports. Domestic demand continued to decrease because of a recession in public and private construction. In August, the cement industry formed a cartel, and domestic producers agreed to reduce production and sales. No new kilns were installed during the year.

Korea, Republic of.—Cement production increased, but exports declined 16% as a result of lower construction activity, particularly in the Middle East. A price cartel, maintained for the last 12 years by the six major Korean cement producers, was dissolved. The Republic of Korea continued to explore new markets in the United States.

Mexico.—Cementos Guadalajara S.A. began operating a new 2,500-ton-per-day line at its Guadalajara plant. Grupo Cementos Tolteca, an associate of Blue Circle Industries, continued a 1-million-ton-per-year expansion of its Tolteca cement plant.

Turkey.—Turkiye Cimento Sanayii TAS started operation of two new cement plants and continued construction of five other plants. The two new plants, at Samsun and Adiyaman, had a combined clinker capacity of 1.2 million tons per year. The five plants under construction, at Diyarbakir, Siirt, Urfa, Edirne, and Denizli, were expected to add about 2.9 million tons per year to Turkey's cement capacity. In addition, the Ankana, Erzurum, and Gaziantep plants increased capacity by 175,000, 170,000, and 175,000 tons per year, respectively, by adding new cement mills.

United Kingdom.—As part of a major 5-year program to modernize its cement manufacturing and distribution operations, Blue Circle Industries continued conversion of the present three-kiln, semidry process at its Cauldron plant to a single precalciner kiln operation. Capacity was not changed, but energy and labor costs were reduced. A similar conversion was planned for the Dunbar works at East Lothian. The company also announced plans to close wet-process plants at Cambridge and Snodland.

Yugoslavia.—An expansion of the Kosjeric plant continued on schedule. A new 2,400-ton-per-day production line was expected to be completed in 1984. In the planning stage were a 900,000-ton-per-year clinker grinding plant at Podruta and new plants at Bela Palanka and Golubac.

Table 23.—Hydraulic cement: World production, by country[1]

(Thousand short tons)

Country	1979	1980	1981	1982[p]	1983[e]
Afghanistan[e 2]	[3]155	55	[r]105	[r e]132	165
Albania [e]	930	1,100	1,200	1,200	1,200
Algeria	[r]4,154	[r]4,581	4,916	[r e]5,071	5,512
Angola[e]	440	265	[r]276	[r]331	331
Argentina	7,349	7,863	7,331	6,151	[3]6,223
Australia	5,779	[r]5,938	6,554	6,100	6,614
Austria	6,185	6,013	5,829	5,525	[3]5,411
Bahamas	496	520	32	71	110
Bangladesh[4]	355	[r]369	380	359	[3]338
Belgium	8,491	8,247	7,376	6,968	5,963
Bolivia	277	[r]326	413	358	331
Brazil	27,419	29,975	28,716	28,268	[3]42,136
Bulgaria	5,954	5,907	5,989	6,188	[3]6,221
Burma	431	[r]425	419	374	[3]371
Cameroon	540	[r]560	569	584	551
Canada	12,969	11,571	11,183	9,288	[3]8,629
Cape Verde Islands	(5)	(5)	(5)	(5)	--
Chile	1,491	[r]1,745	2,054	1,190	992
China	81,461	88,030	92,594	103,697	119,325
Colombia	4,693	4,796	5,732	5,546	5,749
Costa Rica	582	610	765	827	827
Cuba	2,879	3,121	3,629	3,487	3,748
Cyprus	1,251	1,359	1,141	[e]1,100	[3]1,039
Czechoslovakia	11,307	11,624	11,735	11,381	[3]11,572
Denmark	2,659	2,113	1,766	[e]1,760	1,543
Dominican Republic	977	1,119	1,048	[e]1,000	992
Ecuador	1,211	1,531	1,599	[r e]1,543	1,488
Egypt	3,260	3,338	[r e]3,858	4,696	6,614
El Salvador	[r]651	573	505	461	353
Ethiopia[e]	[3]103	121	[r]143	[r]154	165
Fiji	106	93	101	[e]105	105
Finland	1,928	1,976	1,970	1,978	1,984
France	31,774	32,082	31,117	28,815	[3]27,011
Gabon	101	121	165	[r e]193	198
German Democratic Republic	13,529	[r]13,713	13,453	12,920	13,228
Germany, Federal Republic of	[r]40,825	[r]39,585	36,224	34,357	34,172
Ghana	298	265	437	[r e]322	298
Greece	13,336	[r]13,977	14,721	7,619	8,818
Guatemala	632	627	626	[r e]595	584
Haiti	261	268	252	[e]254	243
Honduras	255	[r]491	248	276	331
Hong Kong	1,410	1,641	1,672	1,583	[3]1,893
Hungary	5,354	5,137	5,115	4,816	[3]4,667
Iceland	139	134	134	[r e]132	132
India	20,133	19,511	22,884	24,800	27,558
Indonesia	5,179	6,417	7,544	8,268	9,370
Iran	9,921	8,818	8,818	10,472	11,023
Iraq	5,622	6,063	6,173	[e]6,170	6,173
Ireland	2,278	2,059	2,136	[r e]2,094	2,094
Israel	2,116	2,302	2,603	2,404	2,269
Italy	43,309	46,046	45,804	43,791	[3]43,229
Jamaica	249	159	182	233	243
Japan	[r]96,786	[r]96,957	93,511	88,941	[3]88,901
Jordan	[r]687	[r]1,006	1,063	876	1,401
Kenya	938	1,402	1,475	1,474	1,433
Korea, North[e]	8,818	8,818	[r]8,818	[r]8,818	8,818
Korea, Republic of	18,092	[r]17,208	17,215	19,717	[3]23,459
Kuwait	1,146	1,441	1,707	1,712	1,720
Lebanon	[r]2,339	1,636	2,636	1,984	1,102
Liberia	150	117	95	87	66
Libya[e]	3,527	3,527	3,530	[r]4,409	5,512
Luxembourg	351	358	377	379	375
Madagascar	77	66	[r e]71	[r e]72	72
Malawi	114	101	86	58	77
Malaysia	2,497	2,589	3,123	3,443	3,527
Mali	29	22	[e]22	30	22

See footnotes at end of table.

Table 23.—Hydraulic cement: World production, by country[1] —Continued

(Thousand short tons)

Country	1979	1980	1981	1982[p]	1983[e]
Mexico	16,731	17,924	19,914	21,272	18,574
Mongolia	202	196	231	386	370
Morocco	3,611	3,915	3,975	4,097	4,189
Mozambique	301	[r, 6]260	[6]232	288	331
Nepal	24	34	34	[e]28	[3]51
Netherlands	4,080	4,128	3,655	3,420	3,285
New Caledonia	62	62	55	58	66
New Zealand	[r]829	[r]794	837	861	[3]838
Nicaragua	95	170	[e]110	[e]110	110
Niger	42	45	41	42	44
Nigeria	1,918	[r]2,646	2,976	[r, e]3,968	3,968
Norway	2,422	2,307	1,964	1,879	1,874
Pakistan	3,768	3,677	3,900	4,031	4,189
Panama	562	623	573	386	386
Paraguay	171	195	177	121	110
Peru	2,643	2,391	3,395	2,855	2,535
Philippines[6]	4,354	[r]4,939	4,508	4,850	4,850
Poland	21,138	20,330	15,680	17,676	[3]17,817
Portugal	5,664	6,336	6,280	6,577	6,504
Qatar	[r]261	230	284	288	292
Romania	17,194	17,208	16,255	16,529	16,535
Saudi Arabia	2,425	3,858	5,512	[e]6,600	7,716
Senegal	420	[r]425	410	400	408
Singapore	[e]1,488	2,152	2,484	[e]2,200	2,971
South Africa, Republic of	7,606	7,937	8,923	8,830	[3]8,677
Spain (including Canary Islands)[7]	30,768	[r]30,876	31,494	[r, e]31,967	[3]33,767
Sri Lanka	653	629	708	[r, e]717	[3]558
Sudan	203	204	165	202	220
Suriname	68	76	78	[e]80	80
Sweden	2,631	[r]2,695	2,555	2,538	2,535
Switzerland	4,336	4,687	4,795	4,518	[3]4,564
Syria	2,036	2,199	2,458	3,142	[3]3,142
Taiwan	[r]13,114	15,501	15,809	14,806	[3]16,325
Tanzania	309	[r, 6]311	[6]433	[r, e]551	551
Thailand	5,793	5,883	6,904	7,285	[3]8,006
Trinidad and Tobago	236	[r]205	153	208	209
Tunisia	1,524	1,962	2,227	[e]2,200	2,756
Turkey	[r]15,193	[r]14,191	16,582	17,392	[3]14,987
Uganda	55	11	22	[e]33	44
U.S.S.R	135,605	137,843	140,180	136,335	141,096
United Arab Emirates	1,400	1,896	2,447	[e]3,300	3,968
United Kingdom	17,791	16,323	14,140	14,288	[3]14,767
United States (including Puerto Rico)	85,904	76,709	72,932	64,341	[3]71,347
Uruguay	[r]757	[r]755	761	607	617
Venezuela	4,386	5,338	5,401	6,166	[3]4,571
Vietnam[e]	804	[r]707	[r]601	880	[3]1,023
Yemen Arab Republic	99	89	90	261	276
Yugoslavia	10,011	10,268	10,781	10,712	[3]10,573
Zaire	496	[r]488	450	[e]440	441
Zambia	220	176	154	170	[3]171
Zimbabwe	437	[r]517	606	[e]440	441
Total	[r]961,595	[r]973,849	979,296	969,338	1,020,346

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through June 20, 1984.
[2]Year beginning Mar. 21 of that stated.
[3]Reported figure.
[4]Data are for the year ending June 30 of that stated.
[5]Revised to zero.
[6]Converted from officially reported data provided in terms of 94-pound cement bags.
[7]Excludes natural cement.

TECHNOLOGY

Cement.—A new precalcining process using a recirculating fluid-bed technique was installed at Ciments LaFarge's Port-La-Nouvelle plant in France. Industrial-scale tests were performed to evaluate the efficiency of the technique and a second series of tests involving adaptation of existing equipment to optimize the economics of the new system was scheduled.[7]

Researchers at the Israel Institute of Technology studied the effect of added gypsum on the compressive strength of portland cement samples that were wetted and allowed to set.[8] The samples were made from the same clinker, with and without added gypsum, and had initial porosities of 28.8% to 34.4%. Porosity, degree of hydration, average density of the hydration products, and compressive strength were determined for each of four initial porosities and curing times of 1, 3, 7, and 28 days. Addition of gypsum increased compressive strength, particularly in the first 3 days. The increased strength was attributed to increased average density of the hydration products formed in the presence of gypsum, and the increased density was attributed to the pressure generated when ettringite was formed.

Concrete.—The Bureau of Mines completed underground testing of steel-fiber-reinforced concrete mine support cribbing.[9] Previous studies had indicated that steel-fiber-reinforced concrete cribbing was superior in performance and cost to the wood cribbing usually used for support in underground coal mines.[10] The latest tests were conducted to verify and demonstrate the effectiveness of the concrete cribbing and to establish design guidelines for their use. The test results supported the superior performance and indicated favorable economics. The new material was accepted enthusiastically by the mining industry.

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[1]Physical scientist, Division of Industrial Minerals.

[2]Mineral specialist, Division of Industrial Minerals.

[3]International Trade Administration (U.S. Department of Commerce). Construction Review. V. 30, No. 2, Mar.-Apr. 1984, pp. 18-25.

[4]Engineering News-Record. ENR Materials Prices. V. 212, No. 1, Jan. 5, 1984, p. 51.

[5]Rock Products. International Cement Review. V. 87, No. 4, Apr. 1984, pp. 47-80.

[6]Stonehouse, D. H. Canadian Mineral Surveys, 1983. Can. Dep. Energy, Mines and Resour., pp. 61-62.

[7]Page 49 of work cited in footnote 5.

[8]Soroka, I., and M. Relis. Effect of Added Gypsum on Compressive Strength of Portland Cement Clinker. Am. Ceram. Soc. Bull., v. 62, No. 6, June 1983, pp. 695-703.

[9]Smelser, T. W., and L. N. Henton. Concrete Crib Design and Field Testing. BuMines RI 8804, 1983, 41 pp.

[10]Anderson, G. L., and T. W. Smelser. Development Testing and Analysis of Steel-Fiber-Reinforced Concrete Mine Support Members. Support System Design and Results of Laboratory Investigation and Full-Scale Testing. BuMines RI 8412, 1980, 38 pp.

Chromium

By John F. Papp[1]

In 1983, reported chromium consumption was 305,000 short tons, a strong increase over that of 1982. The reported consumption of chromium by refractory and chemical consumers declined marginally, while that of metallurgical consumers increased significantly. This increase in chromium consumption reflects increased demand for steel. Stainless steel production increased by 42% compared with that of 1982; shipments increased by 27%.

Imports for consumption of chromite continued to decline, while those of ferrochromium increased. The decline in chromite imports reflects the marginal decline in refractory and chemical industry chromite consumption. Metallurgical industry chromite consumption decreased by more than a factor of 7, while net production of chromium ferroalloys, metal, and other materials dropped by a factor of about 3. The concurrent decline in acquisition of chromium in the form of chromite and increase in its acquisition via ferrochromium is a trend that started about 1970. This trend reflects the steel industry's greater use of foreign-produced ferrochromium compared with that produced domestically.

Domestic Data Coverage.—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 operations, listed in table 3, represent 100% of domestic production shown in table 4. Eighty-three percent of those operations responded to both the Chromite Ore and Chromium Products and the Ferroalloys surveys.

Table 1.—Salient chromium statistics

(Thousand short tons)

	1979	1980	1981	1982	1983
CHROMITE					
United States:					
Exports	27	6	71	8	11
Reexports	28	44	67	57	5
Imports for consumption	1,024	982	898	507	190
Consumption	1,214	977	889	545	325
Stocks, Dec. 31: Consumer	907	675	728	545	450
World: Production	r10,277	r10,438	9,660	p8,770	e8,921
CHROMIUM FERROALLOYS[1]					
United States:					
Production	273	[2]239	[2]226	[2]119	[2]36
Exports	15	32	14	5	4
Reexports	1	1	1	(3)	2
Imports for consumption	242	302	440	148	282
Consumption	528	412	423	262	388
Stocks, Dec. 31: Consumer	56	58	54	26	26
World: Production	3,458	r3,507	3,315	p3,030	e2,841

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.—Two legislative studies on chromium were published: (1) U.S. Mineral Dependence on South Africa by the Senate Foreign Relations Committee (SFRC) and (2) Strategic and Critical Nonfuel Minerals: Problems and Policy Alternatives by the Congressional Budget Office. The SFRC report recommended preservation of the domestic ferrochromium industry to permit a flexible foreign policy.

Countervailing duties imposed on chromium materials imported from countries that offer bounties or grants on the manufacture, production, or exportation of such materials are covered under section 303 of the Tariff Act of 1930 and the Trade Agreements Act of 1979. Complaints by domestic producers have resulted in countervailing duties applied against high-carbon ferrochromium from the Republic of South Africa and ferrochromium from Spain. The countervailing duty assessment is periodically reviewed. Reviews of countervailing duties on high-carbon ferrochromium from the Republic of South Africa and on ferrochromium from Spain were completed in 1983 and preliminary findings were published. As a result of an administrative review, the International Trade Administration (ITA), U.S. Department of Commerce, found the grant to high-carbon ferrochromium from the Republic of South Africa between April 11, 1981, and December 31, 1981, to be less than one-half of 1% of the f.o.b. value. Consequently, Commerce ordered the U.S. Customs Service to refund countervailing duties collected for material imported during the subject period, with 16% interest, and to cease duty collection on this material.

With regard to ferroalloys from Spain, ITA determined the amount of net subsidy to be 2.14% of the f.o.b. invoice price for calendar year 1980, 2.61% for 1981, and 2.15% for 1982. As a result of this finding, in 1983, Commerce directed the Customs Service to collect deposits of 1.53% in countervailing duties on shipments of ferrochromium from Spain.

As a result of the President's endorsement of upgrading of stockpile chromium ore to ferrochromium, an interagency committee including Commerce, the General Services Administration (GSA), and the Federal Emergency Management Agency, was formed. GSA announced a stockpiling plan in May, and a conversion contract for about 122,000 tons of chromium ore was awarded in December to Macalloy Inc.

The Environmental Protection Agency (EPA) measures the extraction procedure toxicity for chromium as total chromium. In 1980, EPA proposed to change the extraction procedure toxicity for chromium to a measure of hexavalent chromium, and reopened that proposal for further comments in 1983. EPA announced availability of the "Health Assessment Document for Chromium (Review Draft)," in order to conduct a comprehensive review of the scientific aspects of this health assessment document, which summarized the current scientific information regarding the effects of chromium on humans and the environment.

The U.S. International Trade Commission (USITC) determined that there was a violation of section 337 of the Tariff Act of 1930 in the importation of certain silica-coated lead chromate pigments and ordered their exclusion from entry. USITC published a report on chromium ferroalloys providing information on product use, domestic industry, U.S. consumption, production, and trade.[2]

Table 2.—U.S. Government stockpile goals and yearend inventories for chromium in 1983

(Thousand short tons)

Material	Stockpile goals	Physical inventory: Stockpile-grade	Physical inventory: Nonstockpile-grade	Physical inventory: Total
Chromite, metallurgical	3,200	1,957	531	2,488
Chromite, chemical	675	242	--	242
Chromite, refractory	850	391	--	391
Low-carbon ferrochromium	75	300	19	319
High-carbon ferrochromium	185	402	1	403
Ferrochromium-silicon	90	57	1	58
Chromium metal	20	4	--	4

The Office of Strategic Resources, U.S. Department of Commerce, published two studies regarding the importance of chromium as used in the aerospace and steel industries.[3]

The Trade and Development Program (TDP), U.S. Department of State, held a briefing on the potential for chromium ore mine development potential in the Philippines. The TDP is currently analyzing the chromium ore mine development potential in Turkey.

DOMESTIC PRODUCTION

The major marketplace products of chromium are chromium ore, alloys, chemicals, and metal. In 1983, the United States produced chromium alloys, chemicals, and metal from imported chromium ore. No chromium ore was mined domestically.

A hearing was sponsored by the U.S. Forest Service and Del Norte County, CA, to gather comments on a draft Environmental Impact Statement on California Nickel Corp.'s Gasquet Mountain project in California. California Nickel purchased property near its deposit for the purpose of constructing a pilot plant.

Chromium alloy and metal production was 44,930 tons. The United Auto Workers struck the SKW Alloys Inc., Calvert City, KY, plant in September after agreement could not be reached on across-the-board concessions sought by the company. The United Steelworkers of America struck the Foote Mineral Co., Graham, WV, plant in October because of a disagreement over company-requested concessions. By yearend, the strike against Foote was settled; however, the strike against SKW continued. Macalloy Inc., Charleston, SC, was awarded a contract to convert chromium ore in the national stockpile to ferrochromium. The award was valued at $23 million.

E. I. du Pont de Nemours & Co. Inc. completed its plant capacity increase for chromium dioxide production that was started in 1982 and has embarked on yet another plant expansion to double capacity by 1984.

Table 3.—Principal producers of chromium products in 1983, by industry

Industry and company	Plant
Metallurgical:	
Elkem AS, Elkem Metals Co	Marietta, OH, and Alloy, WV.
Interlake Inc., Globe Metallurgical Div	Beverly, OH.
Macalloy Inc	Charleston, SC.
Metallurg Inc., Shieldalloy Corp	Newfield, NJ.
SKW Alloys Inc	Calvert City, KY, and Niagara Falls, NY.
Satralloy Corp	Steubenville, OH.
Refractory:	
Basic Inc	Maple Grove, OH.
Corhart Refractories Co. Inc	Pascagoula, MS.
Davis Refractories Inc	Jackson, OH.
General Refractories Co	Baltimore, MD, and 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 metal in the United States

(Short tons)

	Net production		Net shipments	Producer stocks, Dec. 31
	Gross weight	Chromium content		
1982:				
Low-carbon ferrochromium; High-carbon ferrochromium	91,905	55,900	82,353	W
Ferrochromium-silicon; Other[1]	27,380	13,561	36,961	63,631
Total	119,285	69,461	119,314	63,631
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

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes chromium metal, exothermic chromium additives, and other miscellaneous chromium alloys.

CONSUMPTION AND USES

Domestic consumption of chromite ores and concentrates was 325,000 tons in 1983. Of the total chromite consumed, the chemical industry used 58%; the refractory industry, 22%; and the metallurgical industry, 20%. The metallurgical industry consumed 64,000 tons of chromite in the process of producing 45,000 tons of chromium ferroalloys, metal, and other chromium-containing materials.

Chromium has a wide range of uses in the three primary consumer groups. In the metallurgical industry, its principal use was in stainless steel. Of the 392,000 tons of chromium ferroalloys, metal, and other chromium-containing materials reported consumed, stainless steel accounted for 81%; full-alloy steel, 9%; superalloys, 3%; and other end uses accounted for the remainder. Chromium ferroalloy, metal, and other chromium material consumption increased 36% compared with that of 1982.

The primary use of chromium in the refractory industry was in the form of chromite to make refractory bricks to line metallurgical furnaces. Chromite consumption by the refractory industry decreased 10% compared with that of 1982.

The chemical industry consumed chromite for manufacturing chromates, chromic acid, and pigments. Sodium and potassium chromate and bichromate are base materials used to make a wide range of chromium chemicals. Chromite consumed by the chemical industry decreased by 3% compared with that of 1982.

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 (thousand short tons)	Average Cr_2O_3 (percent)	Gross weight (thousand short tons)	Average Cr_2O_3 (percent)	Gross weight (thousand short tons)	Average Cr_2O_3 (percent)	Gross weight (thousand short tons)	Average Cr_2O_3 (percent)
1979	774	38.4	198	35.4	242	44.9	1,214	39.2
1980	577	35.9	160	35.8	240	45.8	977	38.4
1981	503	35.7	148	37.3	238	42.6	889	37.9
1982	270	35.1	80	36.4	195	44.9	545	38.8
1983	64	39.3	72	36.9	189	44.7	325	41.9

Table 6.—U.S. consumption of chromium ferroalloys and metal in 1983, by end use

(Short tons, gross weight, unless otherwise specified)

End use	Low-carbon ferrochromium	High-carbon ferrochromium	Ferrochromium silicon	Other	Total
Steel:					
Carbon	2,935	4,160	472	--	7,567
Stainless and heat-resisting	9,422	295,830	12,153	422	317,827
Full-alloy	7,638	24,884	1,759	70	34,351
High-strength, low-alloy and electric	2,688	2,113	1,740	145	6,686
Tool	277	3,508	W	1	3,786
Cast irons	558	5,659	34	174	6,425
Superalloys	3,430	3,857	W	2,537	9,824
Welding materials (structural and hard-facing)	361	839	W	143	1,343
Other alloys[1]	1,136	730	6	1,100	2,972
Miscellaneous and unspecified	1,107	82	262	117	1,568
Total	29,552	341,662	16,426	[2]4,709	392,349
Chromium content	19,519	199,620	6,149	4,045	229,333
Stocks, Dec. 31	3,474	20,948	1,294	[3]954	26,670

W Withheld to avoid disclosing company proprietary data; included with "Miscellaneous and unspecified."
[1]Includes magnetic and nonferrous alloys.
[2]Includes 3,572 short tons of chromium metal.
[3]Includes 740 short tons of chromium metal.

STOCKS

Reported consumer stocks of chromite declined from 545,000 tons in 1982 to 450,000 tons in 1983. Metallurgical industry stocks increased, while refractory and chemical industry stocks declined. Producer stocks of chromium ferroalloys, metal, and other materials declined from 64,000 tons in 1982 to 47,000 tons in 1983, while consumer stocks declined from 29,000 tons in 1982 to 27,000 tons. At the 1983 annual rate of chromium ferroalloy and metal consumption, producer plus consumer stocks represented a 2-month supply, while consumer stocks alone represented a 1-month supply. Stocks of chromium chemicals (sodium bichromate equivalent) at producer plants increased from 18,421 tons in 1982 to 24,277 tons in 1983.

Table 7.—U.S. consumer stocks of chromite, December 31, by industry

(Thousand short tons)

Industry	1979	1980	1981	1982	1983
Metallurgical	416	219	230	120	140
Refractory	161	134	128	112	76
Chemical	330	322	370	313	234
Total	907	675	728	545	450

Table 8.—U.S. consumer stocks of chromium ferroalloys and metal, December 31, by product

(Short tons, gross weight)

Product	1979	1980	1981	1982	1983
Low-carbon ferrochromium	6,683	5,432	5,198	3,459	3,474
High-carbon ferrochromium	45,465	50,258	46,601	21,793	20,948
Ferrochromium-silicon	3,701	2,578	1,801	1,237	1,294
Other[1]	2,465	1,935	2,468	2,593	954
Total	58,314	60,203	56,068	29,082	26,670

[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 varied, while the price of low-carbon ferrochromium and ferrochromium-silicon remained unchanged. The price of imported 50% to 55% high-carbon ferrochromium dropped from \$0.36 to \$0.37 per pound in January to a low of \$0.355 to \$0.365 in September, then rose to \$0.39 to \$0.40 per pound at yearend. The price of domestic 50% to 55% high-carbon ferrochromium rose from \$0.38 per pound to \$0.40 to \$0.43 per pound at yearend. The price of imported 60% to 65% high-carbon ferrochromium dropped from \$0.41 to \$0.42 per pound to \$0.38 to \$0.39 per pound in September, then rose to \$0.41 to \$0.42 per pound at yearend. The price of domestic 66% to 70% high-carbon ferrochromium rose from \$0.43 per pound to \$0.42 to \$0.54 per pound in February, 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 1983

Material	January	December
	Cents per pound of chromium	
U.S. charge chromium (50%-55% chromium)	38	40-43
Imported charge chromium (50%-55% chromium)	36	39-40
Imported charge chromium (60%-65% chromium)	41	41-42
U.S. charge chromium (66%-70% chromium)	43	42-54
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	34.5

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 11,032 tons, valued at \$1.87 million. Mexico (61%) and Canada (38%) were the major recipients of these exports.

Exports of chromium ferroalloys and ferrochromium-silicon totaled 4,247 tons, contained 2,589 tons of chromium, and were valued at \$4,822,250. Canada (66%) and India (17%) were the major recipients of these exports.

Exports of chromium metal, wrought and unwrought, waste and scrap, totaled 238 tons, valued at \$2,555,476. Canada (24%) and Japan (24%) were the major recipients of these exports.

Exports of potassium chromate and dichromate totaled 11 tons, valued at \$[illegible]8,031. The major recipient of these exports was Canada (45%).

Exports of sodium chromate and dichromate totaled 14,174 tons, valued at \$8,401,423. The major recipients of these exports were the Republic of Korea (19%) and China (18%).

Exports of chromic acid totaled 3,927 tons, valued at \$5,932,392. The major recipients of these exports were Canada (19%), Japan (16%), China (13%), the Republic of Korea (13%), and Taiwan (12%).

Exports of pigments containing chromium totaled 2,551 tons, valued at \$8,832,162. The major recipients of these exports were Canada (17%) and Japan (17%).

Imports of ferrochromium-silicon totaled 1,438 tons, contained 579 tons of chromium, and were valued at \$669,540. These imports came from Zimbabwe (99.6%) and Canada (0.4%).

Imports of chromium metal, wrought and unwrought, waste and scrap, totaled 3,359 tons, and were valued at $13,686,617. These imports came primarily from the United Kingdom (39%) and Japan (32%).

Imports of potassium chromate and dichromate totaled 347 tons, valued at $329,921. These imports were supplied primarily by the U.S.S.R. (70%).

Imports of sodium chromate and dichromate totaled 8,933 tons, valued at $6,093,556. These imports were supplied primarily by Romania (24%), the U.S.S.R. (16%), and Belgium (15%).

Imports of chromium carbide totaled 237 tons, valued at $1,628,510. These imports were supplied primarily by the Federal Republic of Germany (70%).

Imports of chromic acid totaled 3,267 tons, valued at $4,826,756. These imports were supplied primarily by Italy (46%).

Imports of pigments included 21 tons of chrome green, valued at $49,090; 1,933 tons of chrome yellow, valued at $3,274,467; 1,997 tons of chromium oxide green, valued at $4,067,637; 2 tons of hydrated chromium oxide green, valued at $24,819; 738 tons of molybdenum orange, valued at $1,840,914; 165 tons of strontium chromate, valued at $347,535; and 1,381 tons of zinc yellow, valued at $1,806,869.

Table 10.—U.S. exports and reexports of chromite ores and concentrates

(Thousand short tons and thousand dollars)

Year	Exports		Reexports	
	Quantity	Value	Quantity	Value
1979	27	2,514	28	2,860
1980	6	1,447	44	8,544
1981	71	5,893	67	9,575
1982	8	1,574	57	9,172
1983	11	1,874	5	1,350

Table 11.—U.S. import duties for chromium-containing materials

Item	TSUS No.	Most favored nation (MFN)		Non-MFN
		Jan. 1, 1983	Jan. 1, 1987	Jan. 1, 1983
Ore:				
Chrome ore and concentrate	601.15	Free	No target duty	Free.
Metal and alloys:				
Low-carbon ferrochromium	606.22	3.7% 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	4.4% ad valorem	3.7% ad valorem	30% ad valorem.
Chemicals:				
Potassium chromate and dichromate	420.08	1.6% ad valorem	1.5% ad valorem	3.5% ad valorem.
Sodium chromate and dichromate	420.98	2.7% ad valorem	2.4% ad valorem	8.5% ad valorem.
Chromium carbide	422.92	5.1% ad valorem	4.2% ad valorem	25% ad valorem.
Chromic acid	423.0092	4.4% ad valorem	3.7% ad valorem	Do.
Pigments:				
Chrome green	473.10	do	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

(Thousand short tons and thousand dollars)

Country	Less 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	Cr_2O_3 content	Value	Gross weight	Cr_2O_3 content	Value	Gross weight	Cr_2O_3 content	Value	Gross weight	Cr_2O_3 content	Value
1982:												
Albania	4	2	299	--	--	--	--	--	--	4	2	299
Finland	33	9	1,490	12	5	716	--	--	--	45	14	2,206
Madagascar	--	--	--	29	13	2,002	12	6	681	41	19	2,683
Pakistan	--	--	--	--	--	--	3	2	330	3	2	330
Philippines	66	21	5,375	4	2	444	--	--	--	70	23	5,819
South Africa, Republic of	23	9	1,143	204	91	10,701	50	23	2,822	277	123	14,666
Turkey	16	6	794	8	3	455	8	4	788	32	13	2,037
U.S.S.R	34	13	1,629	--	--	--	--	--	--	34	13	1,629
Total[1]	176	59	10,731	256	115	14,318	74	35	4,621	507	209	29,670
1983:												
Albania	6	2	422	--	--	--	--	--	--	6	2	422
Canada	6	2	327	--	--	--	--	--	--	6	2	327
Madagascar	--	--	--	--	--	--	21	10	1,362	21	10	1,362
Philippines	13	4	1,328	--	--	--	--	--	--	13	4	1,328
South Africa, Republic of	8	3	541	63	30	3,193	73	34	3,210	144	67	6,944
U.S.S.R	--	--	--	--	--	--	(2)	(2)	7	(2)	(2)	7
Total[1]	33	12	2,619	63	30	3,193	95	45	4,578	190	86	10,390

[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)
1982:						
Brazil	--	--	--	17,196	9,219	$6,932
Canada	451	311	$240	--	--	--
China	18	11	13	5,489	3,602	2,659
Germany, Federal Republic of	3,532	2,473	3,694	218	149	232
Italy	465	346	607	--	--	--
Japan	148	101	266	97	64	81
Norway	84	55	110	--	--	--
Philippines	--	--	--	19	12	11
South Africa, Republic of	8,316	5,205	6,987	47,004	24,628	19,343
Sweden	4,210	3,045	4,954	--	--	--
Turkey	--	--	--	5,934	3,809	2,910
United Kingdom	20	15	22	--	--	--
Yugoslavia	--	--	--	15,583	10,153	8,144
Zimbabwe	5,576	3,855	4,806	26,951	17,721	15,484
Total[1]	22,819	15,417	21,699	118,491	69,357	55,796
1983:						
Albania	--	--	--	3,881	2,445	1,424
Belgium	--	--	--	1	1	(2)
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[1]	16,757	11,713	15,274	263,546	151,285	93,738

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

WORLD REVIEW

World chromite production increased to 8.9 from 8.8 million tons in 1982. Ferrochromium production decreased to 2,841 tons from 3,030 tons in 1982. Predictions of increased steel production, particularly stainless steel production, in 1983 resulted in increased chromite and ferrochromium production at yearend.

A chromium chemical plant was completed in Argentina. New ferrochromium plant production was reported in Greece, India (two plants), and the Philippines. Construction of a ferrochromium plant in Turkey continued. Finland announced plans to increase its chromite and ferrochromium production capacity.

In April, the European Commission announced its duty-free import quotas for material classified as not less than 6% and not less than 4% carbon-ferrochromium to be 66,400 tons of the 6% material and 3,310 tons of the 4% material, with 62,000 tons of the 6% material allocated and 4,400 tons held in reserve; and 3,200 tons of the 4% material allocated and 110 tons held in reserve. Ferrochromium entering the European Economic Community (EEC) countries in excess of their allocated quota is subject to a tariff of about 8%, except for Greece, which sets its own tariff. Sweden, Turkey, Yugoslavia, and Zimbabwe export to EEC countries duty free. The duty-free quotas were increased in July to 153,000 tons of the 6% material and 3,700 tons of the 4% material, and further increased in November to 252,000 tons of the 6% material and 7,300 tons of the 4% material.

The European Commission set 1984 duty-free ferrochromium quotas in November at 127,000 tons, with 118,000 tons of 6% material allocated and 6,000 tons in reserve; and 3,200 tons of 4% material allocated and 100 tons in reserve.

The antidumping suit initiated by Electrowerke Weisweiler GmbH against ferrochromium producers from the Republic of South Africa, Sweden, Turkey, and Zimbabwe was terminated subject to minimum pricing agreements. The European Commission found that: The aforementioned producers had increased their EEC market share from 21% in 1979 to 39% in 1982; from 1979 to 1982, low-carbon ferrochromium consumption dropped 27% worldwide; EEC producers had been hit harder than EEC import sources; and the prices at which imported ferrochromium was sold caused material injury to community producers. The companies agreeing to confidential minimum prices were Middelburg Steel & Alloys Holdings (Pty.) Ltd. (MSA), Ferrolegeringar Trollhalterverken, Etibank, and Zimbabwe Alloys Ltd.

Afghanistan.—Soviet technicians evaluated substantial deposits of chromite in the south of Afghanistan near Pakistan at Herserak and Muhammed Agha Kulangar.

Albania.—Albania reported that the Todo Manco and Kalimash chromite mines produced during the year. Total chromite production reached a rate of 1 million tons per year for an unspecified time period: 830,000 tons of lump ore, 200,000 tons of concentrate, and 60,000 tons of natural fines. About 70,000 tons was consumed domestically; the remainder was exported, one-half to the centrally planned economy countries and the remainder to the market economy countries. The lump ore averages 42% Cr_2O_3; the concentrate averages 49% Cr_2O_3.

Albania reported increased production at the Burrel ferrochromium plant, estimated to have a capacity of about 25,000 tons per year. Albania's ferrochromium production target for the year was reported to be 20,000 to 28,000 tons and its export target to be 60,000 to 70,000 tons. Albanian ferrochromium is a charge chrome of about 65% Cr and 3% Si.

Albania's export organization, Mineralimpeke, pursued a chromium trade strategy of undercutting world prices and engaging in high-volume barter deals. Albania was accused of forcing both chrome ore and ferrochromium prices down. The sales strategy was effective in Japan where chrome ore imports from Albania were over 100,000 tons, exceeding the previous high of about 64,000 tons in 1975. In exchange for the chrome ore, Japan supplied steel pipe.

Albania signed a bilateral trade pact with China, the first such pact since 1978. Under the agreement, Albania was to supply 90,000 tons per year of chrome ore, which could increase in subsequent years, and an unspecified amount of ferrochromium in exchange for Chinese products.

Albania's trading position is shifting in the Japanese market to greater than world price for its chrome ore and a reluctance to barter in favor of currency exchange. In addition, Albania has reduced the chrome ore concentrates offered to Japanese buyers and is trying to increase lump sales.

Argentina.—Bayer Argentina S.A., a subsidiary of Bayer AG, announced completion of its new chrome tanning agent manufacturing plant located at Bayer's Zarate Complex near Buenos Aires. The plant has a capacity of 20,000 tons of tanning chemicals per year.

Brazil.—Cia. de Ferro-Ligas da Bahia S.A. converted two of its ferrochromium furnaces, one a 16 megavolt ampere (MVA) and the other a 7.5 MVA, to the production of ferrosilicon in the early part of the year.

Canada.—The Manitoba Department of Energy and Mines, in cooperation with the Geological Survey of Canada, continued to evaluate the extent of the chromite deposits in the Bird River area. Dynamic Mining Exploration Co. and Combustion Engineering Superheater Ltd. jointly evaluated the feasibility of creating an integrated stainless steel manufacturing facility using Dynamic's chromium deposits in the Bird River and Euclid Lake areas of Manitoba.

China.—The responsibility for exporting chromium ore, metal, and ferroalloy shifted from the China National Metals & Mineral Import & Export Corp. to the China Metallurgical Import and Export Corp., a trade unit of the Ministry of Metallurgical Industry.

Cuba.—Chromite deposit discoveries made by geologists from the German Democratic Republic, the U.S.S.R., and Czechoslovakia were reported to the Council for Mutual Economic Assistance.

Finland.—Outokumpu Oy and Etibank established a joint marketing company in Finland. This marketing cooperation followed previous cooperative activities in Turkey, including the construction of a high-carbon ferrochromium plant at Elazig and modernization and expansion of the chrome concentrator at Kefdag.

Outokumpu announced plans to expand production capacity at the Kemi chromite mine by installation of concentrator equipment with increased capacity to handle lump concentrate, and at the Tornio ferrochromium smelter by the installation of a 36-megawatt, 70,000-ton-per-year furnace. Completion of the concentrator is expected in 1984; the smelter, in 1986.

France.—Société Française d'Electrometallurgie (SOFREM) was considering plans for restructuring its operations. The restructuring plan included Cie. Universelle d'Acétylene et d'Electrométallurgie (CUAEM). Both SOFREM and CUAEM are under the joint management of Pechiney Ugine Kuhlmann (PUK). The reorganization called for the closing of one plant, the loss of 750 jobs, and the investment of $56 million[4] by PUK. In addition, PUK was negotiating with Electricite de France to obtain lower electrical rates.

Caisse Française des Matières Premières, the Government's stockpiling agency that purchases through Groupement des Importatieurs de Metaux, stopped purchasing chromium-containing materials for its stockpile, leaving the stockpile level at 3,000 tons of chromium and 10,000 to 17,000 tons of ferrochromium.

Greece.—Hellenic Ferroalloy S.A., a subsidiary of the state-controlled Hellenic Industrial Mining & Investment Co. (HIMIC), started ferrochromium production in February. The ferrochromium plant is located at Tsingeli near Volos. The plant capacity is 50,000 tons per year of high-carbon ferrochromium graded at 60% to 63% Cr, 6% to 8% C, and 3% to 5% Si. The plant is supplied by ore from the Skoumtsa Mine, which provides ore with 3:1 chromium-to-iron ratio. The Skoumtsa Mine produced 700 tons per day and was targeted for 1,000 tons per day in 1985. At 1,000 tons per day, the Skoumtsa Mine will be producing enough chromite to produce 40,000 to 50,000 tons per year of ferrochromium. Skoumtsa reserves are 3 to 4 million tons. In 1983, HIMIC was exploring for chromite ore at two sites near Volos and at two sites near Macedonia.

Development continued on a concentrator facility at Kozáni. The dressing plant, when completed, was to produce 70,000 tons per year of concentrate for ferrochromium production from 280,000 tons per year of chromite ore.

Greece's Institute of Geological and Mining Research proposed exploration for chromite as part of its next 5-year plan (1983-87). Tsvetmetproexport, U.S.S.R., and the Greek Bank for Industrial Development agreed to cooperate in the exploration for chromite in Greece.

India.—Two ferrochromium plants started production in India. Ferro Alloys Corp. Ltd. inaugurated its charge chrome plant in March. The plant, located at Randia in Balasore district, Orissa State, has a 45-MVA furnace, built by Tanabe Kokoki Co. Ltd. of Japan. The plant has a production capacity of 60,000 tons per year of 55% chromium content charge chrome, using Orissa State-supplied power and chrome ore from its captive mines at Kathpal and Boula. The charge chrome was to be exported through the Port of Paradip and marketed by Marc Rich and Co. for sale primarily in Japan and the United States. Production was initially limited, owing to a power shortage. Indian Metals and Ferroalloys Ltd. (IMFA) inaugurated its charge chrome plant in February. The plant, located at Therubali in Koraput district, Orissa State, has a 39-MVA furnace. The plant has a production capacity of 60,000 tons per year of charge chrome, using Orissa State-supplied power and a blend of domestic and Albanian ore. The charge chrome was to be exported, possibly through the Port of Vishakhapatnam, and marketed by Elkem AS of Norway.

In addition to the ferrochromium plants opened during the year, IMFA and the Orissa Mining Corp. (OMC) were in the process of constructing other ferrochromium plants. IMFA contracted with Elkem to construct a 60,000-ton-per-year ferrochromium plant at Chouduar, Cuttack district, Orissa State. This plant, scheduled to go into production in 1985, will probably export through the Port of Paradip. OMC secured financing from the European Asian Bank to construct a 60,000-ton-per-year, 55% to 58% chromium content charge chrome plant at Bamnipol, Keonjhar district, Orissa State. OMC was expected to start construction in 1984 and complete construction in 1985. This plant was to be constructed with technical assistance from Outokumpu of Finland and Voest-Alpine AG of Austria. The plant was to use chromite from its captive Sukrangi Mine. Export would probably be through the Port of Paradip and marketing by Klöckner & Co. of the Federal Republic of Germany.

In 1983, production capacity for steel produced by the argon oxygen decarburization process had yet to be installed in India owing to the low demand for stainless steel. As a result, virtually all charge chrome production in India was destined for export markets.

In February, the export duty on chromite was reduced from 10% to 5% ad valorem. In addition, there were export ceilings for chromite. Lump ore graded at less than 42% chromic oxide, and chromite fines and friable ore had ceilings that permitted exports.

Girnar Pratisthan Ltd. (GPL) finalized a technical agreement with Technimont of Italy. GPL was to receive production information on chrome salts for its Kalyani plant located near Calcutta.

Italy.—Montedison S.p.A., an Italian ferrochromium producer, reported record losses in 1982. Company restructuring and an increase in ferrochromium prices were expected to return the company to profitability in 1984. The company's ferroalloy division reported near-capacity ferrochromium production of 40,000 tons in 1983.

Japan.—The Ministry of International Trade and Industry (MITI) began a stockpiling program for chromium materials with the objective of developing a 60-day consumption volume over a 5-year period. MITI's stockpile system actually consisted of three separate stockpiles: (1) the national stockpile (Government financed, 25-day supply), (2) the joint stockpile (Government and private financed, 25-day supply), and (3) the private stockpile (privately financed, 10-day supply). MITI achieved a 5-day supply in the national and joint stockpiles in 1983 and was expected to add a 2-day supply to the national stockpile in 1984. MITI anticipated warehouse construction in 1984 for national stockpile storage. Finding that interest payments in 1983 on chromium materials in the private stockpile were increasing the value of the stockpiled material over the value of commercial material, the private stockpile holders requested that MITI intercede on industry's behalf with the Ministry of Finance to make the private stockpile interest payments tax deductible.

MITI set duty-free import quotas for ferrochromium and ferrochromium-silicon imported from developing countries. The duty-free quota for ferrochromium was 24,853 tons. This quota applied from April 1983 to March 1984. Ferrochromium imported above the duty-free quota was subject to 8% duty.

Despite increasing domestic ferrochromium consumption, ferrochromium production continued to decline. Showa Denko K.K. was to close its Toyama plant that had been idle since August. Awamura Metal Industry Co. Ltd. was planning to shut down one of two furnaces at its Uji plant. Japan Metals and Chemicals Co. announced plans to stop ferrochromium production at its Sakata plant in December, and Kobe Steel Ltd. planned to close its ferrochromium plant at Kochi in March 1984.

The Specific Industries Restructure Law, effective in June 1983 and replacing the Depressed Industries Law, covered ferrochromium producers. The law facilitated production capacity reduction in structurally depressed, material-producing industries. Ferrochromium producers had been unable to compete with imported materials. Electrical power cost represented a large fraction of ferrochromium production cost, requiring about 3,400 kilowatt hours per ton. Japan Ferroalloy Association had discussed reduced electric power rates with MITI for using off-peak power to produce ferrochromium.

Kawasaki Steel Corp.'s Chiba Works brought on-stream a 13,000-ton-per-month tin-free steel line. The chromium-coated steel produced is used in bicycles, office equipment, electric appliances, and building materials. Kawasaki Steel also announced its intention to build a demonstration plant for iron and ferrochromium production. The blast furnace operation was composed of two parts: a prereduction furnace and a smelting-reduction furnace.

According to MITI statistical data in 1983, Japan imported 710,874 tons of chrome ore and 269,918 tons of ferrochromium, produced 362,875 tons of ferrochromium and 11,978 tons of ferrochromium silicon, and exported 5,984 tons of ferrochromium.

New Caledonia.—Inco Metals Co. reported improving its spiral separation plant and reported reserves of 600,000 tons. Inco chromite concentrate graded at 51% to 54% Cr_2O_3, with 4% or less silica, was to be upgraded as a result of separation plant changes.

Norway.—Bjölvefossen AS, a ferrochromium producer, participated in merger talks with four other ferroalloy producers. Tinfos Jernverk AS, a high-carbon ferrochromium producer, did not participate. After several months, the merger talks were abandoned without resolution.

New pollution laws were causing Bjölvefossen to abandon ferrochromium production, owing to the high cost of compliance. Bjölvefossen was to have converted its ferrochromium furnaces to ferrosilicon furnaces.

Oman.—Oman made its first shipment of chrome ore during the year. The material was mined by the Oman Mining Co. in the Nakhl area north of the city of Sohar. Oman Mining had a capacity of about

20,000 tons per year of run-of-mine chromite. Oman had no beneficiation or smelting facilities and was seeking markets for its material.

Pakistan.—A mineral development program was established by the Baluchistan Development Authority (BDA). The program was to evaluate the potential for chromite and ferrochromium production. In 1983, BDA mined chromite in the Las Bela and Zhob districts and was encouraging additional exploration for chromite in the Las Bela district.

Papua New Guinea.—Development of the Ramu River chromite-nickel-cobalt deposit was pursued by Nord Resources Corp. The property was 69.5% owned by Nord Resources plus other U.S. companies. MIM Holdings Ltd., an Australian company, owned the balance. The deposit, located at Marum, has ore reserves of 248 million tons contained in three tiers. The top tier contains 81.5 million tons grading 8% to 9% chromite. A feasibility study found development to be uneconomic at the current price of chromite.

Philippines.—Acoje Mining Co. Inc., a metallurgical chromite producer, requested the Philippine Securities and Exchange Commission to place the company in receivership as protection against debt collection suits. Acoje was restructuring its debt. Benguet Corp., the leading refractory chromite producer, reported that it was taking advantage of the reduced demand by allocating resources to exploration and plant modernization. The silica content of ore produced at Benguet's Masinloc operation had been increasing to the dissatisfaction of its refractory customers. Benguet had improved its beneficiation and expected to bring new low-silica reserves into production in 1985. Benguet reduced the silica content of minus 10-mesh, grade A chromite from 4.5% to 3.95%. The Trade and Development Program, U.S. Department of State, as a result of studying chromite in the Philippines, found that a choice of joint-venture opportunities was available to U.S. companies desiring to enter or broaden the U.S. chromium production base in the Philippines.

Ferrochrome Philippines Inc. (FPI) started commercial production with a capacity of 61,000 tons per year. FPI produced a 61.5% chromium, 8% carbon, 2.9% silicon, 0.02% phosphorus, and sulfur high-carbon ferrochromium using ore from Acoje's chromite operation at Pangasinan. The FPI plant, located at Tagoloan, Misamis Oriental Province, Mindanao Island, used sintered preheated pellets as feed into a closed stationary submerged arc furnace. The ferrochromium is marketed by Voest-Alpine Intertrading. Difficulties were experienced with crushing and screening equipment late in the year.

Early in the year, both FPI and Ferro-Chemicals Inc. suffered power cutbacks of near 50% owing to low water levels at the Lake Lanao power station of the National Power Corp. By yearend, production was back up to 80%. A unification of power rates in the Philippines was being debated. Mindanao with its hydroelectric power had the lowest cost electricity.

Efforts by the Philippine Government to limit imports resulted in some difficulties for FPI, a ferrochromium producer. FPI could not get a permit to import foreign chromite for blending. The Government had also limited the amount of money foreign exchange banks can extend in letters of credit per day. The ferrochromium industry, as an export industry, was given special treatment.

Romania.—The Tulcea ferroalloy complex reportedly has a ferrochromium production capacity of 115,000 tons per year.

South Africa, Republic of.—Transvaal Consolidated Land and Exploration Co. Ltd., 59% owned by the Barlow Rand Group in 1983, closed its Milsell Mine while continuing to produce near capacity at Henry Gould Mine and near 50% of capacity at Winterveld. Mining Corp. Ltd. continued long-term development at Dilokong Mine in Lebowa, increasing capacity from 90,000 to 100,000 tons per year to 170,000 tons per year while filling orders from stocks.

South African Manganese Amcor Ltd. (Samancor) reopened its Bathlako Mine in Bophuthatswana at 50% of capacity. The mine, closed since 1982, produced low-silica ore for chemical and refractory use. Waterkloof Mine resumed operation in all of its mines. Lavino Mine moved to near-full-capacity operation. Mining Corp. Ltd. ran its washing plant briefly but continued to sell from stocks. Ucar Chrome's Jaglust Mine continued to sell from stock.

Western Platinum Ltd. continued development of the UG2 reef. A new concentrator, which started processing Merensky Reef ore in 1982, shifted to UG2 ore in 1983. Using a process developed by the South African Council for Mineral Technology (Mintek), the mine was to produce a chromite concentrate for smelting.

Based on low stainless steel stocks worldwide and the projection of increased stainless steel production, ferrochromium producers started increasing ferrochromium production in midyear and continued through yearend to meet steel industry demand.

MSA, a subsidiary of Barlow Rand Ltd., reopened one of two low-carbon ferrochromium furnaces at the Middelburg plant in July. Feralloys Ltd. moved the planned reopening date for the high-carbon ferrochromium furnace at Witbank (48 MVA, 30,000 tons per year) from April 1984 to January 1984 in response to increasing orders. Tubatse Ferrochrome (Pty.) Ltd., a subsidiary of General Mining Union Corp. Ltd. (Gencor) and Union Carbide Corp., reopened a charge chrome furnace in July and another in September 1983, bringing all three furnaces at its Steelport plant into production. Consolidated Metallurgical Industry Ltd. reopened its idle furnace in April, bringing both of its furnaces into production.

Gencor acquired controlling interest in Samancor. Gencor held a 7% share of Samancor directly and a 1.4% share through its affiliate, UC Investment Ltd. (now Gencor Investment Corp. Ltd.). Gencor obtained 50.25% of African Metals Ltd., which owned a 44% share of Samancor, from Iron Steel Industrial Corp. Ltd. The other major shareholder in Samancor was Anglo American Corp. of South Africa Ltd., holding between 30% and 32%. Gencor was the largest chrome ore producer, with a 1.7-million-ton capacity, and a large ferrochromium producer of 150,000-ton capacity.

Samancor was the largest ferrochromium producer, 200,000-ton capacity, and a large chrome ore producer, 390,000- to 400,000-ton capacity. Gencor's ferrochromium operation, Tubatse Ferrochrome was coowned on a 50% basis with Union Carbide. Samancor's ferrochromium operation, Ferrometals (Pty.) Ltd., was a wholly owned subsidiary. Gencor chromite mines, Tweenfontein, Groothoek, and Montrose, were owned through its subsidiary, Transvaal Mining and Finance Co. Ltd. Samancor owned the Ruighoek, Gasvally, and Mooinooi chromite mines. A new company, Chromore (Pty.) Ltd., was to unify the management of all six mine properties.

The worst drought in 30 years forced the Electricity Supply Commission (Escom), the state-owned electric utility, to consider rationing power. Escom requested the mining industry to evaluate the impact of various levels of power cuts.

Plasma ferrochromium production technology was being developed by Mintek, MSA, and Ferrometals (Pty.) Ltd. Samancor started operation of an 8-MVA transferred, arc-type plasma furnace at its Metalloys plant at Meyerton. It was to be used as a test furnace for ferrochromium production. MSA continued development of a plasma process for ferrochromium production. A 20-MVA furnace built by ASEA AB, Sweden, with a production capacity of 20,000 tons per year was being installed at its Palmiet plant in Krugersdorp. Converting traditional electric arc furnaces to this plasma arc process would double furnace capacity. This dc plasma arc process was being tested for its production efficiency and expansion potential.

Spain.—Ferroaleaciones Españolas S.A. brought its second ferrochromium furnace into production in May.

Ferrochromium from Spanish producers imported into the United States was assessed at 1.53 cents duty by the U.S. Department of Commerce.

Sweden.—Vargon Alloys AB reported producing charge chrome and other high-carbon ferrochromium at near capacity: 100,000 to 130,000 tons per year of charge chrome and 30,000 tons per year of other high-carbon ferrochromium. Vargon produced charge chrome with a 105-MVA furnace fitted with heat recovery systems, Finnish chromite, and inexpensive Swedish electricity. Other high-carbon ferrochromium was produced in a 24-MVA furnace.

ASEA Industrial Systems received a contract for one of its single-electrode dc arc furnaces for ferrochromium production. This ferrochromium furnace was built for a power input of 20 MVA and was to be charged with chromite ore fines fed directly into a dc arc plasma. The single-electrode design reduced electrode consumption, the second highest cost next to energy cost in ferrochromium production.

SKF Steel Engineering AB marketed its Plasmared direct-reduction process for application to ferrochromium production. SKF suggested Zimbabwe and Sweden as potential plant locations. SKF was studying the possibility of constructing an 86,000-ton-per-year plant near Malmö, Sweden. SKF was negotiating an arrangement with the Swedish energy ministry wherein plant waste heat was returned to the district heating system, thereby conserving energy.

SKF started construction of an 80,000-ton-per-year plant, using its proprietary Plasma Dust process, to recover chromium from steel melt shop dust. The plant, located at Landskrona, was expected to start commercial operation in 1985 under the company name of ScanDust AB.

Taiwan.—A new stainless steel plant was scheduled to start operation in 1983. As a result, Taiwan's consumption of ferrochromium was expected to rise by about 7,000 tons per year. No ferrochromium was produced domestically.

Turkey.—Outokumpu of Finland and Etibank were expanding and modernizing the chrome ore concentration facility at Kefdag. The Kefdag concentrator supplied chrome concentrates to the Elazig Ferrochrome Works, which had a 60,000-ton capacity. The concentrator expansion and modernization was expected to be completed in 1986. The Elazig Ferrochrome Works, being modernized by Outokumpu, was to have a capacity of 170,000 tons per year of high-carbon ferrochromium.

U.S.S.R.—The first output of ferrochromium-silicon was reported from the Chelyabinsk electrometallurgical plant.

United Kingdom.—The creation of a strategic materials stockpile was revealed in Parliament in February 1983. The Department of Trade and Industry, the national Government agency responsible for stockpiling, purchased chrome ore and chromium ferroalloys through a private trader, Brandeis-Intsel Ltd. of London. These stockpile purchases were the result of studies started in 1980 by the Institute of Geological Sciences, on the vulnerability of United Kingdom industry to material supply interruption, with a subsequent report by the House of Lords in October 1982, when chromium was identified as a strategic and critical material. The Department of Trade and Industry had been considering stockpiling at least since 1981 when Brandeis-Intsel reported to it on the mechanics of stockpiling. The major potential recipients of stockpiled chromium materials were British Chrome and Chemicals Ltd. and British Steel Corp.

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

(Thousand short tons)

Country[2]	1979	1980	1981	1982[p]	1983[e]
Albania[e 3]	[r]827	[r]838	[r]937	[r]965	990
Brazil[4]	[r]375	[r]345	260	304	310
Cuba[5]	31	32	23	30	35
Cyprus	17	18	11	[e]11	11
Egypt	([6])	--	--	--	--
Finland[5]	480	[r]399	454	380	375
Greece[e 7]	[8]50	47	47	46	45
India	342	[r]353	369	374	400
Iran[e]	150	90	35	45	55
Japan	13	15	12	12	[8]9
Madagascar	141	198	110	[e]100	100
New Caledonia	13	2	4	55	100
Pakistan	3	3	1	1	1
Philippines	613	547	484	391	365
South Africa, Republic of[5]	3,634	3,763	3,164	2,385	[8]2,460
Sudan	31	28	29	28	30
Thailand	([6])	--	--	--	--
Turkey	410	431	466	448	440
U.S.S.R.[9]	[r]2,535	[r]2,701	2,646	2,701	2,700
Vietnam[e]	15	17	17	[r]18	20
Yugoslavia	([6])	([6])	([6])	--	--
Zimbabwe	597	[r]611	591	476	475
Total	[r]10,277	[r]10,438	9,660	8,770	8,921

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

[1]Table includes data available through June 6, 1984.

[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]Estimated series revised to represent marketable ore rather than crude ore.

[4]Figures are sum of (1) crude ore sold directly for use and (2) concentrate output, both as reported in Brazilian sources. Data for 1979 and 1980 may include 45,000 to 55,000 short tons annually 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: 1979—983; 1980—919; 1981—1,021; 1982—736; and 1983—740 (estimated).

[5]Production of marketable product (direct-shipping lump ore plus concentrates and foundry sand).

[6]Less than 1/2 unit.

[7]Exports of direct-shipping ore plus production of concentrates.

[8]Reported figure.

[9]Series revised to reflect estimated marketable production; estimates based in part on officially reported output as follows in thousand short tons: 1979—3,500; 1980—3,800; 1981—3,600; 1982—3,800 (estimated); and 1983—3,800 (estimated). These figures, although regarded by the Soviets as "marketable," are not believed to represent marketable production in the sense normally used in market economy nations.

The United Kingdom had purchased 29,000 tons of high-carbon ferrochromium, 4,000 tons of low-carbon ferrochromium, an unspecified quantity of ferrochromium-silicon, and 39,000 tons of chemical-grade chrome ore. These materials were stored in Sheffield.

Zimbabwe.—Mineral Marketing Corp., the state-owned export marketing organization, started operation in March.

The Government loaned $5.7 million to Zimbabwe Alloys. The loan was for 5 years until January 1988, carried prime overdraft rate interest charges, carried the right of the Government to convert the debt into equity in the company up to 19.35%, and required repayment of the loan before payment of dividends.

TECHNOLOGY

As part of the Bureau of Mines program to assess domestic chromite deposits, the Bureau conducted a reconnaissance investigation into podiform chromite occurrences in the Caribou Mountain and Kanuti River areas of central Alaska[5] and studied the beneficiation of material from that deposit.[6] Alaskan surface samples confirmed the presence of chromite, and beneficiation tests produced high-chromium, high-iron, and high-aluminum chromite concentrates. The Bureau also studied the smelting of chromite concentrates from a Papua New Guinean laterite deposit to produce a high-carbon ferrochromium.[7] Submerged arc operations provided the most efficient smelting conditions, consuming quantities of energy comparable to commercial operations, and yielding a product of high phosphorus content.

As part of the Bureau's program to increase domestic chromium resource availability through recycling, research was conducted in several areas. The Bureau demonstrated a hydrometallurgical method to separate chromium from other metals by precipitation with benzoate ion when the chromium is contained in one of a variety of surface-finishing wastes. The resulting chromium salt may then be converted to hydroxide and the benzoate may be recycled. Chromium recoveries of 92% to 100% were obtained.[8] The economic evaluation of a Bureau-developed technique to regenerate chromic acid-sulfuric acid etching solutions found that a 1,000-gallon capacity regeneration cell could save $240 per day, resulting in a 10-month payback time.[9] The Bureau characterized the chromium content; the chemical, physical, and extraction procedure toxicity properties; and the chromium valence states of electric arc furnace steelmaking dust.[10] The identification of these properties will provide a basis for resource recovery decisions. A patent was granted to the Bureau for a recovery process wherein a superalloy scrap is converted to the sulfide to form a matte, which is fragmented and leached with chlorine under controlled conditions to extract the alloying elements.[11]

An investigation of 14 domestic dolomites was carried out by Bureau researchers to characterize these materials and their refractory properties as a substitute for chromite refractories.[12] Two new steels, a manganese-nickel-molybdenum and a manganese-molybdenum steel, were developed[13] to substitute for 8600 and 4100 standard grades in a broad range of end uses as substitutes for alloy steels that contain chromium.

The Bureau issued a report on raw material requirements for Japan's specialty steel industry.[14] Imports of chromium ore and ferroalloy from 1972 to 1981 were analyzed to determine supply trends and import dependence. Risk reduction measures were also described.

The U.S. Geological Survey studied the mechanism giving rise to geophysical signatures of chromite mineral deposits as a complement to mining company exploration in order to increase the probability of discovery and thus production of domestic chromite.[15] Laboratory petrophysical and petrographic studies of chromite occurrences were used to build a generic chromite deposit model that was field tested against a known chromite deposit. These studies identified collections of weak anomalies attributable to minerals associated with the chromite and thus served as a deposit indicator. Since no chromite-specific indicator was identified, the indicators found could be site specific.

The recovery and processing of chromium ore to ferrochromium in the Republic of South Africa was studied.[16] Beneficiation of MG-1 seam chromium ore from Marikana by tabling and spiral separation resulted in 85% chromite recovery for 44% Cr_2O_3 and 1% to 2% SiO_2 concentrate from natural fines. A grade containing 46% Cr_2O_3 and less than 1% SiO_2 could also be produced, but at lower chromite recovery. The prereduction and smelting characteristics of UG-

2 seam chromium ore were studied and compared with those of chromium ore from the Winterveld Mine. Mining of platinum-group metals from the UG-2 seam started in 1982 and resulted in chromite tailings containing 42% Cr_2O_3 at a chromium-to-iron ratio of 1.35.[17] High-carbon ferrochromium was produced from the UG-2 chromite concentrate at 48% to 50% chromium content and with a lower total energy required than for other ores. High-carbon ferrochromium is therefore likely to become a byproduct of this platinum-group metals extraction process. The UG-2 seam contains about 20% of the Republic of South Africa's chromium resources, and conversion of this chromium byproduct to ferrochromium represents a potential for 120,000 tons of ferrochromium per year. To make the ferrochromium marketable, blending or plasma production technology could be used to obtain a 50% to 55% grade,[18] or a new grade containing 45% to 50% chromium could be developed.[19]

The profitable mining and smelting of chromium ore into ferrochromium depends on many factors such as ore grade and characteristics, beneficiating techniques, blending, and the smelting process used. An efficient process requires careful balancing of various process parameters to optimize recovery and yield at minimum cost. Vertical integration of the mine-concentrator-smelter complex facilitates the optimization process. Such an optimization study was carried out for chromium ore from the Xerolivado Mine in Greece in the southern Mount Vourinos complex and other lower grade ores from the northern Mount Vourinos complex.[20]

Research to improve the energy efficiency of ferrochromium production resulted in a computer program for process evaluation that can generate a complete flow sheet for ferrochromium production from raw material drying to smelting, including up to 10 pretreatment and 2 smelting stages, and is based on equipment operational specifications.[21] SKF reported marketing efforts to apply its plasma process to ferrochromium production in Zimbabwe.[22] ASEA Industrial is applying its dc arc furnace to the production of ferrochromium through MSA. The dc arc furnace compared with the three-phase ac arc furnace offers reduced electrode consumption, less noise, better stirring and heat distribution, and comparable power consumption.[23] Used to produce ferrochromium, this single electrode dc arc system permits ore fines to be charged through the central bore in the electrode without prior agglomeration. Kawasaki Steel was planning a demonstration plant for its innovative iron-ferrochromium smelting process.[24] Pilot tests since 1970 showed the blast furnace application to ferrochromium production workable with controlled charge injection and hydrocarbon energy sources added to the air-oxygen blast gas. Hot gases resulting from the blast furnace operation are used to prereduce the ore to be smelted. A 50% energy saving in the production of ferrochromium was reported. One-third to one-half chromium ore is reduced in the prereduction state at about 1,000° C, and complete reduction is achieved in the smelting stage at about 1,550° C to 1,650° C. The 100-metric-ton plant will take 3 to 5 years to build.

Chromium as black chrome coating is a subject of research for solar collectors because of its useful optical properties.[25] Black chrome is currently used as a solar collector coating material; however, when used in industrial solar collectors, the coating suffered from a 10% efficiency loss as it aged. The cause of that loss has been related to the coating process, and the process has been improved to eliminate the aging problem.[26]

The U.S. Department of Energy has found chromium to be the most essential metal in energy systems.[27] As a result, the Department sponsors research on chromium-containing alloys in the areas of electronic structure, material properties, electrochemistry, and the role of chromium in oxidation resistance.

As a result of regulations by EPA on the chromium content of industrial waste water, much research and development has been carried out to remove chromium from waste water. Chromium removal achievements have reduced the volume of waste water, but the problem (waste heavy metals) is only "concentrated" and the waste is still dumped at high cost. Further processing by electrochemical, filtration, and biological processes can result in the recovery of chromium materials. These and other processes are being used or developed to recover chromium materials.[28]

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[1]Physical scientist, Division of Ferrous Metals.

[2]U.S. International Trade Commission. Ferroalloys. USITC Publ. 841, No. 6-2-45, Oct. 1983, 62 pp.

[3]U.S. Department of Commerce. Critical Materials Requirements of the U.S. Aerospace Industry. U.S. GPO, Washington, DC, Stock No. 003-000-00578-0, Oct. 1981, 310 pp.

———. Critical Materials Requirements of the U.S. Steel Industry. NTIS PB 83-235580, Mar. 1983, 259 pp.

[4]French francs (F) converted to U.S. dollars at the rate of F8.00 = US$1.00.

[5]Foley, J. Y., and M. M. McDermott. Podiform Chromite Occurrences in the Caribou Mountain and Lower Kanuti River Areas, Central Alaska. Part I: Reconnaissance Investigations. BuMines IC 8915, 1983, 27 pp.

[6]Dahlin, D. C., L. L. Brown, and J. J. Kinney. Podiform Chromite Occurrences in the Caribou Mountain and Lower Kanuti River Areas, Central Alaska. Part II: Beneficiation. BuMines IC 8916, 1983, 15 pp.

[7]Nafziger, R. H. Smelting Ferrochromium From a New Guinea Lateritic Chromite. Trans. Inst. Min. Metall., sec. C, v. 92, June 1983, pp. C73-C82.

[8]McDonald, H. O., and L. C. George. Recovery of Chromium From Surface-Finishing Wastes. BuMines RI 8760, 1983, 8 pp.

[9]Spotts, D. A. Economic Evaluation of a Method To Regenerate Waste Chromic Acid-Sulfuric Acid Etchants. BuMines IC 8931, 1983, 7 pp.

[10]Law, S. L., W. F. Lowry, J. G. Snyder, and G. W. Kramer. Characterization of Steelmaking Dusts From Electric Arc Furnaces. BuMines RI 8750, 1983, 26 pp.

[11]Thomas, J. A., D. L. Jones, and V. A. Ettel (assigned to U.S. Dep. Interior). Chromium Recovery from Superalloy Scrap by Selective Chlorine Leaching. U.S. Pat. 4,377,410, Mar. 22, 1983.

[12]Clancy, T. A. Dolomite Refractories and Their Potential as Substitutes for Imported Chromite. BuMines IC 8913, 1983, 18 pp.

[13]Keith, C. J., and V. K. Sharma. Development of Chromium-Free Grades of Constructional Alloy Steels. BuMines OFR 147-83, 1983, 60 pp.; NTIS PB 83-243873.

[14]Chin, E., J. C. Wu, L. Nahai, G. L. Kinney, and C. L. Kimbell. Selected Raw Material Requirements for Japan's Specialty Steel Industry. BuMines IC 8946, 1983, 34 pp.

[15]Wynn, J. C. Strategic Minerals Geophysical Research: The Chromite Example. Min. Eng., Mar. 1983, pp. 246-251.

[16]Brayshaw, M. D. The Beneficiation of Chromite Ore From The MG-1 Seam Near Marikana. Council Miner. Technol., Randburg, Republic of South Africa, Mintek Rep. No. M7D, Apr. 1983, 19 pp.

[17]Barnes, A. R., C. W. P. Finn, and S. H. Algie. The Prereduction and Smelting of Chromite Concentrate of Low Chromium-to-Iron Ratio. J. S. Afr. Inst. Min. Metall., Mar. 1983, pp. 49-54.

[18]Maske, K. U., and J. J. Moore. The Application of Plasma to High Temperature Reduction Metallurgy. High Temp. Technol., v. 1, No. 1, Aug. 1982, pp. 51-53.

[19]O'Shaughnessy, D. P. Potential for Low-Grade Chrome Ore Resources. Min. Mag. (London), Aug. 1983, pp. 112-115.

[20]Apostolides, G. A., and C. Papathanasiou. Technology and Economics of the Mining, Beneficiation and Smelting of Chromite Concentrates in an Integrated State-Owned Ferrochromium Complex. Min. Process. and Extr. Metall., Trans., sec. C, v. 92, Sept. 1983, pp. C117-C128.

[21]Curr, T. R., and F. M. Marjoribanks. Computer Programme for the Evaluation of Process Routes in the Production of Ferrochromium. Council Min. Technol., Randburg, Republic of South Africa, Mintek Rep. No. M56, 1983, 46 pp.

[22]Stundza, T. SKF to Intensify Marketing of Plasma-Arc. Am. Met. Mark., v. 91, No. 127, p. 7.

[23]Stenkvist, S.-E. The DC Arc Furnace. Proc., 41st Electric Furnace Conf., Detroit, MI, Dec. 6-9, 1983.

[24]Furukawa, T. Kawasaki Develops New "Smelting-Production Process." Am. Met. Mark., v. 91, No. 47, Mar. 9, 1983, p. 5.

World Mining. Ironmaking/Ferro Alloys Manufacturing Process Tested. V. 36, No. 5, May 1983, pp. 19-20.

[25]Svedlindh, P. Solar Radiation Absorbing Properties of Black Chrome. Rep. UPTEC-80102, Oct. 1980, 52 pp., Uppsala Univ., Sweden.

[26]Pettit, R. B. Black Chrome Solar Selective Coatings Optimized for High Temperature Applications. Sol. Energy Mater., v. 7, 1982, pp. 153-170.

———. Accelerated Temperature Aging of Black Chrome Solar Selective Coatings. Sol. Energy Mater., v. 8, 1983, pp. 349-361.

[27]McHargue, C. J. Chromium Substitution/Conservation in Alloys for Use in Energy Systems. J. Met., v. 35, No. 7, July 1983, pp. 30-36.

[28]Basta, N. Getting the Metal Out of Spent Plating Baths. Chem. Eng., v. 90, No. 10, May 16, 1983, pp. 22-25.

———. Total Metals Recycle is Metal Finishers' Goal. Chem. Eng., v. 90, No. 16, Aug. 8, 1983, pp. 16-19.

Parkinson, G. Liquid Membranes: Are They Ready? Chem. Eng., v. 90, No. 17, Aug. 22, 1983, pp. 22-27.

Clays

By Sarkis G. Ampian[1]

Total quantity of clays sold or used by domestic producers increased 16% in tonnage and 13% in value. Clays in one or more of six classification categories, ball clay, bentonite, common clay and shale, fire clay, or fuller's earth, were produced in 44 States and Puerto Rico during 1983. Clay production was not reported in Alaska, Delaware, the District of Columbia, Hawaii, Rhode Island, Vermont, or Wisconsin. Leading States were Georgia, Texas, Wyoming, North Carolina, Alabama, South Carolina, and California. Unpredictable shortages of natural gas and costs of fuels continued to cause considerable concern among clay producers and clay products manufacturers. Industrywide, efforts were made both to economize and to obtain standby fuels. Environmental restrictions and associated costs of installing environmental protection equipment, combined with rising capital costs, continued to adversely affect production.

Production of common clay and shale increased because of an upturn in construction that increased demand for clay building materials including brick, lightweight aggregate, vitrified pipe, floor and wall tile, etc. Increases in production of ball clay, fuller's earth, and kaolin were caused largely by an improvement in the economy. Production of bentonite and fire clay decreased.

Kaolin accounted for 18% of the clay production but 63% 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 1,374 operations covered by the survey, 1,151 responded, representing 84% of the total clay and shale production sold or used as shown in table 1. Production of the 223 nonrespondents was estimated using reported prior year production levels adjusted by trends in employment and other guidelines.

Table 1.—Salient U.S. clays and clay products statistics[1]

(Thousand short tons and thousand dollars)

	1979	1980	1981	1982	1983
Domestic clays sold or used by producers:					
Quantity	54,689	48,790	44,379	35,345	40,858
Value	$846,089	$898,947	$988,845	$825,064	$931,092
Exports:[2]					
Quantity	3,205	3,214	3,151	2,619	2,484
Value	$243,722	$263,147	$292,914	$267,700	$254,237
Imports for consumption:[2]					
Quantity	51	34	33	24	21
Value	$3,972	$6,688	$7,895	$4,514	$3,488
Clay refractories shipments:[2] Value	$580,257	$557,386	$609,949	$559,655	$595,299
Clay construction products shipments: Value	$1,179,058	$1,061,507	$971,824	$923,459	$1,160,543

[1]Excludes Puerto Rico.
[2]U.S. Department of Commerce.

Table 2.—Clays sold or used by producers in the United States in 1983, 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	1,624,734	137,232	--	101,269	[2]1,863,235	[2]$20,757,585
Arizona	--	32,316	118,815	--	2	1	151,134	1,424,645
Arkansas	--	--	769,217	--	--	109,476	878,693	9,955,645
California	--	88,092	1,683,153	W	--	44,367	[3]1,815,612	[3]18,255,415
Colorado	--	4,300	442,807	12,110	--	--	459,217	2,649,521
Connecticut	--	--	86,034	--	--	--	86,034	514,910
Florida	--	--	231,416	--	423,986	28,943	684,345	31,566,251
Georgia	--	--	1,280,809	--	692,431	5,885,746	7,858,986	560,005,491
Idaho	--	W	--	W	--	W	5,787	91,287
Illinois	--	--	716,580	--	W	--	[4]716,580	[4]3,359,537
Indiana	--	--	557,698	W	--	--	[3]557,698	[3]1,421,142
Iowa	--	--	576,251	--	--	--	576,251	3,257,649
Kansas	--	15,000	703,234	--	--	--	718,234	3,920,604
Kentucky	W	--	669,300	W	--	--	[3 5]669,300	[3 5]2,142,337
Louisiana	--	W	505,054	--	--	--	[2]505,054	10,792,807
Maine	--	--	43,488	--	--	--	43,488	92,522
Maryland	W	--	483,741	--	--	--	[5]483,741	[5]1,746,874
Massachusetts	--	--	236,993	--	--	--	236,993	1,298,295
Michigan	--	--	1,198,900	--	--	--	1,198,900	5,693,416
Minnesota	--	--	W	--	--	W	W	W
Mississippi	W	240,944	943,089	--	W	--	1,445,939	23,846,189
Missouri	--	--	1,003,755	310,675	W	103,118	[4]1,417,548	[4]11,848,263
Montana	--	179,068	15,226	188	--	--	194,482	6,205,294
Nebraska	--	--	163,651	--	--	--	163,651	500,951
Nevada	--	20,151	--	--	W	W	57,768	2,347,523
New Hampshire	--	--	W	--	--	--	W	W
New Jersey	--	--	50,000	12,018	--	--	62,018	596,000
New Mexico	--	--	47,609	2,251	--	--	49,860	114,506
New York	W	--	371,060	--	--	--	[5]371,060	[5]868,551
North Carolina	--	--	2,067,947	--	--	W	[6]2,067,947	[6]6,680,959
North Dakota	--	--	W	--	--	--	W	W
Ohio	--	--	1,468,285	248,055	--	--	1,716,340	8,060,857
Oklahoma	--	--	861,531	--	--	--	861,531	2,287,746
Oregon	--	--	188,222	--	--	--	188,222	275,397
Pennsylvania	--	--	854,687	61,537	--	W	[6]916,224	[6]4,310,929
Puerto Rico	--	--	125,259	--	--	--	125,259	251,204
South Carolina	--	--	1,052,666	18,302	W	742,178	[4]1,813,146	[4]34,830,474
South Dakota	--	W	122,576	--	--	--	[2]122,576	[2]353,105
Tennessee	507,744	W	433,221	--	W	W	1,066,060	26,515,819
Texas	15,600	74,756	3,714,421	43,508	W	W	3,955,354	22,575,292
Utah	--	6,230	220,222	622	W	--	[4]227,074	[4]1,568,645
Virginia	--	--	744,291	--	40,000	--	784,291	5,466,950
Washington	--	--	275,285	7,000	--	--	282,285	[3]1,714,671
West Virginia	--	--	248,571	W	--	--	[3]248,571	[3]531,990
Wyoming	--	1,938,499	201,263	--	--	--	2,139,762	49,058,676
Undistributed	223,467	287,514	90,934	189,576	755,215	187,606	[7]1,196,838	[7]41,584,074
Total	746,811	2,886,870	27,191,995	1,043,074	1,911,634	7,202,704	40,983,088	931,339,998

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 1983, by State[1]

State	Ball clay	Bentonite	Common clay and shale	Fire clay	Fuller's earth	Kaolin	Total
Alabama	--	1	24	7	--	13	45
Arizona	--	5	5	--	--	--	10
Arkansas	--	--	19	--	--	4	23
California	1	5	51	--	--	10	67
Colorado	--	14	28	8	--	--	50
Connecticut	--	--	2	--	--	--	2
Florida	--	--	4	--	4	1	9
Georgia	--	--	17	--	11	73	101
Idaho	--	1	2	1	--	1	5
Illinois	--	--	11	1	2	--	14
Indiana	--	--	19	--	--	--	19
Iowa	--	--	11	--	--	--	11
Kansas	--	1	20	--	--	--	21
Kentucky	6	--	11	2	--	--	19
Louisiana	--	2	8	--	--	--	10
Maine	--	--	4	--	--	--	4
Maryland	1	--	8	--	--	--	9
Massachusetts	--	--	3	--	--	--	3
Michigan	--	--	8	--	--	--	8
Minnesota	--	--	1	--	--	1	2
Mississippi	1	4	22	--	2	--	29
Missouri	--	--	12	51	2	15	80
Montana	--	11	5	1	--	--	17
Nebraska	--	--	5	--	--	--	5
Nevada	--	6	--	--	--	2	8
New Hampshire	--	--	1	--	--	--	1
New Jersey	--	--	2	1	--	--	3
New Mexico	--	--	4	2	--	--	6
New York	1	--	10	--	--	--	11
North Carolina	--	--	51	--	--	2	53
North Dakota	--	--	2	--	--	--	2
Ohio	--	--	56	19	--	--	75
Oklahoma	--	--	18	--	--	--	18
Oregon	--	--	7	--	--	--	7
Pennsylvania	--	--	37	34	--	1	72
South Carolina	--	--	28	--	1	20	49
South Dakota	--	1	3	--	--	--	4
Tennessee	19	--	12	--	1	--	32
Texas	2	11	70	2	1	1	87
Utah	--	3	10	1	1	1	16
Virginia	--	--	15	--	1	--	16
Washington	--	--	7	2	--	--	9
West Virginia	--	--	3	1	--	--	4
Wyoming	--	112	3	--	--	--	115
Total	31	177	639	133	26	145	1,151

[1]Includes both active and idle operations.

DOMESTIC PRODUCTION, PRICES, AND FOREIGN TRADE, BY TYPE OF CLAY

KAOLIN

Domestic production of kaolin increased 13%. The average unit value for all grades of kaolin increased 5% to $81.19 per short ton. Kaolin was produced in 15 States. Two States, Georgia and South Carolina, accounted for 92% of total production. Arkansas ranked third, and Missouri, fourth. Output increased in all States, except for North Carolina and Pennsylvania.

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.

Total domestic consumption of domestically produced kaolin increased 13%. Kaolin producers reported major end uses for their clay as follows: paper coating, 32%; paper filling, 14%; refractories, 5%; chemicals, 5%; common brick, rubber, and fiberglass, 4% each; and catalysts, 3%. Capacity increases that occurred during the early 1980's, in anticipation of a growth that was never realized, continued to cause both excess plant capacity and lower profit margins for the waterwashed kaolin producers. Kaolin sales for refractories use decreased. The refractory industry was undergoing long-range modifications brought about by changes in technology and imports.

A notable exception to the waterwashed kaolin capacity increases was a shortage of capacity for calcined grades. Demand for calcined grades for paper coating and filling had grown rapidly in recent years and it was anticipated that additional capacity would be brought on-stream during the mid-1980's to meet this need. Production of the paper-grade kaolins, low-temperature calcined, delaminated, and waterwashed, increased 20%, 18%, and 14%, respectively.

All Georgia waterwashed kaolin producers continued to modernize, instead of expand, to reduce drying and other energy-related costs. Particular emphasis was placed on heat recovery, improved filtration, and increased high-solids slurry shipments. J. M. Huber Corp.'s newly completed 40,000-ton-per-year calcining facility at its Huber, GA, plant was undergoing plant trials. J. M. Huber also took delivery of a new 84-inch magnetic separator at its Huber location and continued developing its Wilkinson County mining operation. Georgia Kaolin Co. moved its overseas shipping operation from Hutchinson Island in the Savannah River to a new closeby $30 million deepwater facility in the Port of Savannah. Thiele Kaolin Co. was completing its Ready Creek Div.'s $16 million expansion in Warren County, GA. A new 120,000-ton-per-year airfloat filler producer, Wilkinson Kaolin Associates, started operations near Gordon, GA. Another new company, Cascade Industrial Minerals Inc., was formed to develop the hydrothermally altered kaolin deposits near Eugene, OR. An Italian company, Ceramiche CISA S.p.A., announced construction plans for a ceramic tile production facility in the Macon, GA, area. The company's American subsidiary, CISA America Corp., planned to use Georgia kaolins in its manufacturing process.

Exports of kaolins, as reported by the U.S. Department of Commerce, increased 3% to 1.34 million tons valued at $158 million, despite a strong U.S. dollar. Kaolin, including calcined material, was exported to 59 countries. The major recipients were Japan, 31%; Canada, 18%; the Netherlands, 16%; Italy, 6%; and Mexico, 5%. Kaolin producers reported end uses for their exports as follows: paper coating, 73%; refractories, 10%; paper filling, 9%; rubber and paint, 3% each; and others, including ceramics, chemical manufacturing, medical, pharmaceutical and cosmetics, pesticides and related products, sanitary ware, graphite anodes, ink, and plastics, 2%.

Kaolin imports decreased 21% to about 7,500 tons valued at $754,000. The United Kingdom supplied about 96%. The unit price of kaolin imported from the United Kingdom increased 14%.

Kaolin prices quoted in the trade journals remained unchanged except for calcined grade, which advanced $37. Chemical Marketing Reporter, December 26, 1983, quoted prices as follows:

Waterwashed, 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, waterwashed, 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	1982		1983	
	Short tons	Value	Short tons	Value
Alabama	80,836	$4,906,151	101,269	$8,673,861
Arizona	--	--	1	W
Arkansas	85,197	5,659,147	109,476	8,393,582
California	25,392	1,157,344	44,367	1,163,999
Florida	26,332	W	28,943	2,165,080
Georgia	5,268,358	445,389,265	5,885,746	523,406,722
Missouri	84,298	1,970,887	103,118	2,652,195
South Carolina	615,746	25,068,174	742,178	31,409,140
Other[1]	176,044	8,459,198	187,606	6,887,309
Total	6,362,203	492,610,166	7,202,704	584,751,888

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes Idaho, Minnesota, Nevada, North Carolina, Pennsylvania, Tennessee, Texas, and data indicated by symbol W.

Table 5.—Kaolin sold or used by producers in the United States, by kind

Kind	1982		1983	
	Short tons	Value	Short tons	Value
Airfloat	910,134	$43,909,147	965,055	$54,678,774
Calcined[1]	915,196	109,675,506	1,006,616	138,276,614
Delaminated	612,591	56,251,295	722,128	68,527,254
Unprocessed	699,411	11,063,621	843,071	11,710,948
Waterwashed	3,224,871	271,710,597	3,665,834	311,558,298
Total	6,362,203	492,610,166	7,202,704	584,751,888

[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
1982				
Georgia	317,698	$29,256,516	410,044	$67,904,368
Other[1]	187,454	12,514,622	--	--
Total	505,152	41,771,138	410,044	67,904,368
1983				
Georgia and Alabama	423,682	40,677,908	[2]448,143	[2]86,765,361
Other[1]	[3]89,541	[3]7,861,746	[4]45,250	[4]2,971,599
Total	513,223	48,539,654	493,393	89,736,960

[1]Includes Alabama (1982), Arkansas, California, Idaho, Pennsylvania, and Texas.
[2]Excludes Alabama.
[3]Includes Arkansas, California, and Idaho.
[4]Includes Pennsylvania, Texas, and South Carolina.

Table 7.—Georgia kaolin sold or used by producers, by kind

Kind	1982		1983	
	Short tons	Value	Short tons	Value
Airfloat	467,922	$16,778,096	395,422	$21,359,864
Calcined[1]	727,742	97,160,884	770,556	118,769,408
Delaminated	612,591	56,251,295	722,128	68,527,254
Unprocessed	277,245	3,856,568	360,942	4,699,555
Waterwashed	3,182,858	271,342,422	3,636,698	310,050,641
Total	5,268,358	445,389,265	5,885,746	523,406,722

[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	1982				1983			
	Air-float	Unprocessed[1]	Water-washed[2]	Total	Air-float	Unprocessed[1]	Water-washed[2]	Total
Domestic:								
Adhesives	28,086	--	29,965	58,051	14,983	--	55,967	70,950
Alum (aluminum sulfate) and other chemicals	8,708	185,440	697	194,845	8,931	219,890	937	229,758
Animal feed	--	242	200	442	--	242	509	751
Asphalt tile and linoleum	3,433	--	--	3,433	3,635	--	--	3,635
Catalysts (oil-refining)	39,272	--	94,515	133,787	56,776	--	113,392	170,168
China and dinnerware; crockery and earthenware	15,675	4,574	1	20,250	14,570	3,740	--	18,310
Electrical porcelain	7,387	7,263	--	14,650	8,462	7,263	--	15,725
Face brick	--	16,000	29,842	45,842	45	19,801	--	19,846
Fiberglass and mineral wool	57,241	11,477	37,729	106,447	70,351	11,477	47,301	129,129
Firebrick, blocks, shapes	140	926	--	1,066	408	10,900	--	11,308
Floor and wall tile, ceramic	21,014	--	--	21,014	19,931	--	--	19,931
Flue linings and high-alumina brick, glazes, glass, enamels	38,548	--	--	38,548	29,042	--	--	29,042
Foundry sand	--	--	501	501	--	--	685	685
Grogs and crudes, refractory	2,970	213,917	--	216,887	1,245	215,043	--	216,288
Ink	W	--	W	13,163	W	--	--	W
Kiln furniture, mortar, cement	W	W	--	19,185	W	W	--	W
Medical, pharmaceutical, cosmetic	W	--	W	1,660	--	--	1,611	1,611
Paint	28,964	--	68,198	97,162	5,285	--	107,667	112,952
Paper coating	--	--	2,026,511	2,026,511	--	--	2,321,663	2,321,663
Paper filling	63,463	--	803,397	866,860	11,533	4,035	979,012	994,580
Plastics	1,158	--	34,733	35,891	499	26	38,088	38,613
Pottery	7,210	1,117	--	8,327	7,981	699	--	8,680
Roofing granules	6,265	7,316	--	13,581	6,308	7,316	--	13,624
Rubber	29,123	--	31,196	60,319	24,943	--	52,275	77,218
Sanitary ware	29,394	18,984	5,646	54,024	25,259	41,225	33	66,517
Miscellaneous, airfloat:								
Common brick, fertilizers, gypsum products, pesticides and related products, roofing and structural tile, other uses not specified	13,473	--	--	13,473	20,509	--	--	20,509
Miscellaneous, unprocessed:								
Fertilizers, pesticides and related products, other uses not specified (1983)	--	10,968	--	10,968	--	11,086	--	11,086

Miscellaneous, waterwashed:								
Gypsum products, pesticides and related products, waterproofing and sealing, fertilizers, other uses not specified	--	--	45,554	45,554	--	--	81,663	81,663
Undistributed	7,415	13,433	13,160	--	8,715	23,855	--	32,570
Total	408,939	491,657	3,221,845	4,122,441	339,411	576,598	3,800,803	4,716,812
Exports:								
Paint	--	--	31,256	31,256	4,352	--	29,403	33,755
Paper coating	26,396	--	833,430	859,826	41,543	--	840,559	882,102
Paper filling	9,437	--	87,299	96,736	887	--	106,974	107,861
Plastics	--	--	20,572	20,572	--	--	21,116	21,116
Refractories	19,821	103,286	--	123,107	8,535	106,757	--	115,292
Rubber	2,400	--	465	2,865	188	--	595	783
Undistributed	929	--	10,626	11,555	506	--	7,519	8,025
Total	58,983	103,286	983,648	1,145,917	56,011	106,757	1,006,166	1,168,934
Grand total	467,922	594,943	4,205,493	5,268,358	395,422	683,355	4,806,969	5,885,746

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	1982		1983	
	Short tons	Value	Short tons	Value
Airfloat[1]	441,694	$23,996,889	510,189	$29,976,858
Unprocessed	174,052	1,071,285	231,989	1,432,282
Total	615,746	25,068,174	742,178	31,409,140

[1]Includes waterwashed.

Table 10.—South Carolina kaolin sold or used by producers, by kind and use

(Short tons)

Kind and use	1982	1983
Airfloat:[1]		
Adhesives	12,522	17,693
Animal feed and pet waste absorbent	2,193	1,269
Ceramics[2]	27,477	5,453
Fertilizers	7,929	5,540
Fiberglass	76,969	100,099
Paint	410	1,671
Paper coating and filling	2,799	2,980
Pesticides and related products	14,424	15,741
Plastics	11,075	14,804
Rubber	158,819	196,452
Other refractories[3]	4,737	4,157
Other use[4]	81,708	106,914
Exports[5]	40,632	37,416
Total	441,694	510,189
Unprocessed: Face brick and other uses unknown	174,052	231,989
Grand total	615,746	742,178

[1]Includes waterwashed.
[2]Includes floor and wall tile, pottery, and roofing granules.
[3]Includes refractory grogs and crudes; refractory mortar and cement.
[4]Includes animal oil; catalyst (oil-refining); chemical manufacturing; electrical porcelain; face brick; firebrick, blocks, and shapes; high alumina refractories; ink; medical, pharmaceutical and cosmetic; roofing tile; sewer pipe; and other unknown uses.
[5]Includes ceramics, adhesives, paper filling, pesticides and related products, and rubber.

Table 11.—Kaolin sold or used by producers in the United States, by use

(Short tons)

Use	1982 Airfloat	1982 Unprocessed[1]	1982 Water-washed[2]	1982 Total	1983 Airfloat	1983 Unprocessed[1]	1983 Water-washed[2]	1983 Total
Domestic:								
Adhesives	41,736	--	29,965	71,701	33,804	--	57,967	91,771
Alum (aluminum sulfate) and other chemicals	24,788	288,359	5,477	318,624	24,913	329,826	4,122	358,861
Animal feed	2,250	242	3,076	5,568	1,326	242	4,552	6,120
Brick, common and face	24	222,672	29,842	252,538	229	305,750	--	305,979
Catalysts (oil- and gas-refining)	89,801	--	95,710	185,511	124,744	--	113,392	238,136
Cement, portland	--	38,417	--	38,417	--	46,507	--	46,507
China and dinnerware	20,064	4,463	1	24,528	20,104	1,399	855	22,358
Crockery and other earthenware	W	W	--	W	W	W	--	W
Electrical porcelain	17,282	10,608	--	27,890	20,083	7,263	366	27,712
Fertilizers[3]	9,350	6,015	1,195	16,560	7,011	6,015	2,818	15,844
Fiberglass; mineral wool and other insulation	147,250	11,477	37,729	196,456	183,209	11,477	61,538	256,224
Firebrick, blocks, shapes	140	83,990	2,390	86,520	1,951	10,900	--	12,851
Floor and wall tile, ceramic glazes, glass, enamel	35,641	5,773	--	41,414	32,253	2,826	3,974	39,053
Flue linings and high-alumina brick	38,548	57,453	--	96,001	29,564	81,254	--	110,818
Foundry sand	--	--	501	501	--	--	685	685
Grogs and crudes, refractory	6,542	213,917	--	220,459	4,884	324,599	--	329,483
Gypsum products	5,095	458	1,309	6,862	4,544	--	12,634	17,178
Ink	W	--	W	13,163	W	--	--	W
Kiln furniture, mortar and cement, refractory	6,917	14,548	--	21,465	9,234	23,855	2,000	35,089
Linoleum and asphalt tile	--	3,433	--	3,433	3,635	--	--	3,635
Medical, pharmaceutical, cosmetic	W	--	W	1,665	W	--	W	2,674
Paint	29,374	14,390	75,702	119,466	6,956	903	130,742	138,601
Paper coating	--	--	2,026,511	2,026,511	--	--	2,321,663	2,321,663
Paper filling	67,215	--	803,397	870,612	15,466	4,035	981,012	1,000,513
Pesticides and related products	14,699	12,615	2,631	29,945	16,069	171	1,438	17,678
Plastics	12,276	--	35,928	48,204	15,346	--	39,114	54,460
Pottery	10,850	6,896	--	17,746	11,632	699	1,658	13,989
Roofing granules	9,328	12,182	--	21,510	8,925	7,316	--	16,241
Roofing tile and structural tile	--	--	--	--	850	--	1,000	1,850
Rubber	190,404	--	31,196	221,600	223,857	--	55,232	279,089
Sanitary ware	29,854	51,248	5,646	86,748	33,299	41,225	33	74,557

See footnotes at end of table.

Table 11.—Kaolin sold or used by producers in the United States, by use —Continued

(Short tons)

Use	1982				1983			
	Airfloat	Unprocessed[1]	Water-washed[2]	Total	Airfloat	Unprocessed[1]	Water-washed[2]	Total
Domestic —Continued								
Waterproofing and sealing	--	--	W	W	--	--	W	W
Miscellaneous	26,425	35,026	48,767	[4]95,390	35,229	43,275	77,056	[4]152,886
Total	835,853	1,094,182	3,236,973	5,167,008	869,117	1,249,537	3,873,851	5,992,505
Exports:								
Ceramics	3,273	--	1,975	5,248	2,985	--	959	3,944
Foundry sand; grogs, crudes, other refractories	19,821	104,861	--	124,682	9,570	106,757	--	116,327
Paint	--	--	31,256	31,256	4,352	--	29,403	33,755
Paper coating	--	--	859,826	859,826	41,543	--	840,559	882,102
Paper filling	11,933	--	87,299	99,232	959	--	106,974	107,933
Plastics	--	--	20,572	20,572	--	--	21,116	21,116
Rubber	34,517	--	465	34,982	35,775	--	595	36,370
Other	4,737	5,520	9,140	19,397	754	--	7,898	8,652
Total	74,281	110,381	1,010,533	1,195,195	95,938	106,757	1,007,504	1,210,199
Grand total	910,134	1,204,563	4,247,506	6,362,203	965,055	1,356,294	4,881,355	7,202,704

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.

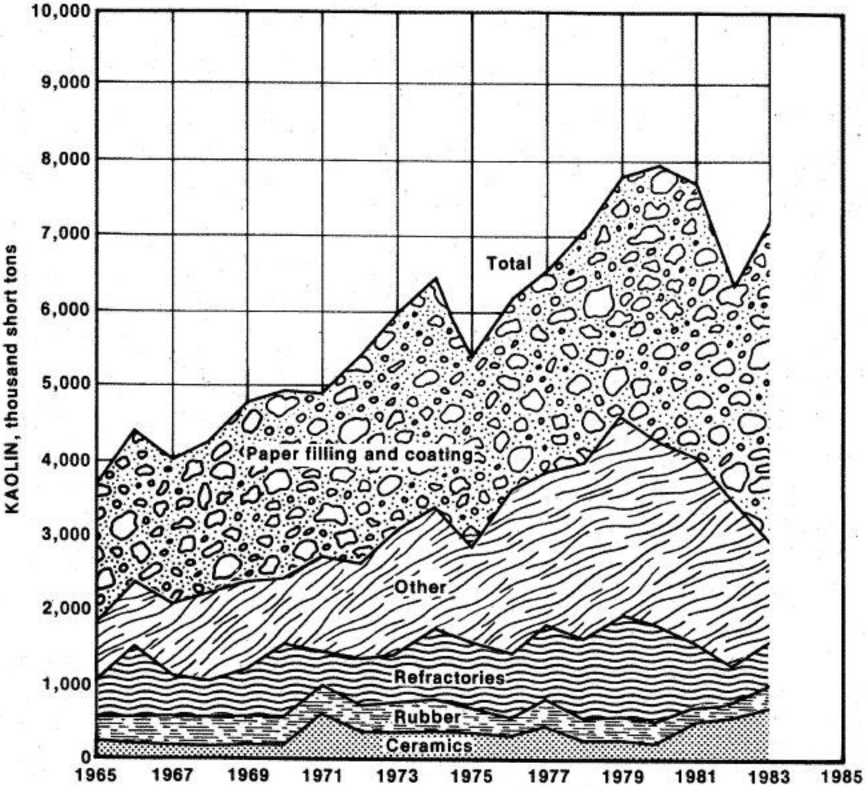

Figure 1.—Kaolin sold or used by domestic producers for specified uses.

BALL CLAY

Reported production of domestic ball clay increased 16% to 746,811 tons valued at $26 million. Tennessee provided 68% of the Nation's output, followed, in order of production, by Kentucky, Mississippi, Texas, Maryland, and New York.[2] Production increased in all States except Texas. The principal ball clay markets continued to be ceramics, mainly dinnerware, pottery, wall tile, and sanitary ware. Recovery of the construction industry and the overall economy during the year spurred the impressive ball clay production gains.

Ball clay is defined as a plastic, white-firing clay used principally for bonding in ceramic ware. The clays are of sedimentary origin and consist mainly of the clay mineral kaolinite and sericite micas.

Increased production capacities, modernization, and/or new plant construction continued cautiously during the year. Ball clay producers were also cautiously increasing their capabilities to produce water-slurried ball clay for sanitary ware, dinnerware, and tile markets or adopting this capability. At midyear, Ranchers Exploration and Development Corp. acquired Kentucky-Tennessee Clay Co. when it obtained more than 50% of its outstanding shares. Kentucky-Tennessee Clay is the largest domestic ball clay producer with multistate operations.

The average unit value for ball clay reported by domestic producers increased slightly to $35.08 per ton. Chemical Marketing Reporter, December 26, 1983, listed ball clay prices, revised upwards to reflect more realistic 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 slightly to 146,000 short tons valued at $4.8 million. Unit value decreased 8% to $33.07 per ton. Shipments were made to 24 countries. The major recipients were Mexico, 58%, and Canada, 37%. The large Mexican market was still being partially supplied by its domestic clays influenced by a lack of foreign capital caused by poor economic conditions and devaluation of the peso.

Ball clay imports, almost entirely from the United Kingdom, decreased 23% to 3,962 tons valued at $280,000. The unit value of these imports decreased slightly to $70.67 per ton.

Table 12.—Ball clay sold or used by producers in the United States, by State

State	Airfloat[1]		Unprocessed		Total	
	Short tons	Value	Short tons	Value	Short tons	Value
1982						
Tennessee	238,657	$9,111,952	181,900	$4,680,024	420,557	$13,791,976
Other	[2]189,827	[2]7,635,223	[3]32,107	[3]796,208	221,934	8,431,431
Total	428,484	16,747,175	214,007	5,476,232	642,491	22,223,407
1983						
Tennessee	315,937	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

[1]Includes water-slurried.
[2]Includes Kentucky, Maryland, Mississippi, and Texas (1983).
[3]Includes California (1982), Kentucky, Maryland, Mississippi, New York, and Texas (1982).

Table 13.—Ball clay sold or used by producers in the United States, by use

(Short tons)

Use	1982			1983		
	Airfloat[1]	Unprocessed	Total	Airfloat[1]	Unprocessed	Total
Adhesives	W	--	W	W	--	W
Animal feed	W	W	11,650	W	W	9,550
China and dinnerware	27,657	735	28,392	34,779	--	34,779
Crockery and other earthenware	W	--	W	W	--	W
Drilling mud	W	--	W	W	--	W
Electrical porcelain	9,790	5,450	15,240	12,545	6,908	19,453
Fiberglass and catalysts (oil-refining)	W	--	W	W	--	W
Firebrick, blocks, shapes	W	W	W	W	W	W
Glazes, glass, enamels	W	W	2,135	2,446	245	2,691
Grogs and crudes, high-alumina, mortar and cement refractories	69,804	6,487	76,291	81,175	8,207	89,382
Kiln furniture	2,001	--	2,001	1,786	--	1,786
Paper coating and filling	11,476	--	11,476	11,329	--	11,329
Pesticides and related products	--	W	W	--	W	W
Pottery	145,254	11,833	157,087	179,059	17,113	196,172
Rubber	--	W	W	--	W	W
Sanitary ware	44,119	78,249	122,368	43,584	93,627	137,211
Tile:						
Floor and wall	29,718	56,371	86,089	63,581	37,029	100,610
Other	--	--	--	--	1,607	1,607
Miscellaneous	34,544	24,628	[2]45,387	54,389	13,019	[2]57,858
Exports	54,121	30,254	84,375	57,404	26,979	84,383
Total	428,484	214,007	642,491	542,077	204,734	746,811

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 decreased 4% to 1.04 million tons valued at $16.4 million. Fire clay is defined as detrital material, either plastic or rocklike, containing low percentages of iron oxide, lime, magnesia, and alkalies to enable the material to withstand temperatures of 1,500° C or higher. It is basically kaolinite but usually contains other materials such as diaspore, ball clay, bauxite clay, and shale. Fire clays commonly occur as underclay below coal seams and are 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 slowed during the year. Most plants were closed for part of the year or placed on minimal production schedules. The refractory clay industry appeared to be entering a period of low production, reflecting lower demand by major consumers—steel, foundry, aluminum, and cement industries. In addition, these industries were switching to higher alumina-based refractories, either direct-fired or specialties, which contain less fire clay. An exception to the industry retrenchments was the $1.4 million expansion launched by Donoho Clay Co. at its Anniston, AL, plant. The company's unique high-silica clay was being widely used by the iron and steel industries in their cupolas and electric arc furnaces. Kaiser Aluminum was selling its refractory plants in Frostburg, MD, Plymouth Meeting, PA, and Gary, IN. The Frostburg plant, the only clay and high-alumina plant among the three, had been serving as a distribution point for the company's eastern markets.

Fire clay production was reported from mines in 17 States. Six States, Missouri, Ohio, West Virginia, Alabama, Pennsylvania, and Texas, in order of volume, accounted for 88% of the total domestic output. Production increased significantly in Alabama and Ohio and decreased significantly in Missouri and Pennsylvania.

Exports of fire clay decreased 8% to 165,000 tons valued at $13.5 million. The price of exported fire clay increased 8% to $81.68 per ton, suggesting a larger percentage of higher quality material shipped. Fire clay was exported to 22 countries. Belgium-Luxembourg received 31% and Japan received 30%, while Canada and Mexico received 12% and 11%, respectively. There were no imports of fire clay.

Unit value for fire clay, reported by producers, ranged from $5 to $26 per ton. The average unit value decreased 7% to $15.73 per ton.

Table 14.—Fire clay sold or used by producers in the United States, by State[1]

State	1982		1983	
	Short tons	Value	Short tons	Value
Alabama	89,500	$2,085,278	137,232	$3,595,800
Colorado	2,429	28,056	12,110	114,516
Illinois	10,464	131,323	--	--
Kentucky and West Virginia[2]	9,698	106,699	167,467	1,912,388
Missouri	447,668	8,832,909	310,675	5,479,963
Montana	546	W	188	W
New Jersey	12,143	212,240	12,018	211,000
New Mexico	W	W	2,251	20,282
Ohio	152,089	2,214,063	248,055	3,421,330
Pennsylvania	135,881	2,601,714	61,537	853,104
South Carolina	W	W	18,302	W
Texas	38,493	233,728	43,508	287,601
Utah	W	W	622	4,980
Washington	W	W	7,000	W
Other[3]	188,060	2,002,742	22,109	502,966
Total	1,086,971	18,448,752	1,043,074	16,403,930

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Refractory uses only.
[2]1982 data included Kentucky only.
[3]Includes California, Idaho, Indiana (1983), West Virginia (1982), and data indicated by symbol W.

BENTONITE

Bentonite production decreased 11% to 2.9 million tons valued at $81.7 million. A 19% decrease in production of swelling bentonite in Wyoming, the largest producing State, accounted for most of this decrease. Domestic consumption decreased for drilling mud, foundry sand, and pelletizing iron ore.

Bentonite was produced in 15 States. The high-swelling or sodium bentonites continued to be produced chiefly in Wyoming, Montana, and California. The calcium or low-swelling bentonites continued to be produced in the other States.

All major western and southern bentonite producers either canceled or deferred ongoing expansions or modernizations. Most plants were shut down intermittently during the year or were on reduced production schedules. However, the industry remained in a position to meet reasonable increases in demand. The industry malaise was caused by low levels of oil- and gas-well drilling activities during the year compounded by continued depression in the steel and foundry industries. These three industries traditionally had consumed about 90% of domestic output. Some increase in drilling and foundry activities occurred near yearend.

Two notable exceptions to the bentonite industry's slowdown were the activities of the American Colloid Co. and Southern Clay Products Inc., a subsidiary of English China Clays America. American Colloid built a new facility in Belle Fouche, SD, the location of one of its sodium bentonite plants, for production of a white bentonite and a magnesium aluminum silicate for the pharmaceutical and cosmetic industries. Southern Clay began a $2 million expansion of an organoclay production operation in Gonzales, TX, which, when completed, will double the plant's capacity. Organoclay viscosifiers are used as rheological control additives in water-based systems, such as in paints, and oil-based drilling muds. In another bentonite event, Kaiser Aluminum and Gulf Oil Corp. set up a new specialty chemicals joint venture, Harshaw-Filtrol Partnership, that combined the assets of Gulf's Harshaw Chemicals and Kaiser's Filtrol subsidiary. Filtrol was a major producer of clay-based absorbents and catalysts for the oil refinery industry.

Table 15.—Bentonite sold or used by producers in the United States, by State

State	Nonswelling		Swelling		Total	
	Short tons	Value	Short tons	Value	Short tons	Value
1982						
Arizona	27,518	$529,189	--	--	27,518	$529,189
California	54,742	3,725,351	20,907	$995,104	75,649	4,720,455
Colorado	4,000	56,000	60	660	4,060	56,660
Kansas	--	--	15,000	300,000	15,000	300,000
Mississippi	231,596	6,063,403	--	--	231,596	6,063,403
Montana	--	--	207,879	8,042,594	207,879	8,042,594
Nevada	--	--	14,500	752,206	14,500	752,206
Texas	49,580	3,496,738	50,890	1,664,709	100,470	5,161,447
Utah	--	--	6,874	96,543	6,874	96,543
Wyoming	--	--	2,407,776	72,992,324	2,407,776	72,992,324
Other	[1]132,799	[1]3,198,914	[2]20,679	[2]852,102	153,478	4,051,016
Total	500,235	17,069,595	2,744,565	85,696,242	3,244,800	102,765,837
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	287,514	10,090,788
Total	503,410	16,472,638	2,383,460	65,233,488	2,886,870	81,706,126

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes Alabama, Idaho (1982), and Louisiana.
[2]Includes Idaho, South Dakota, and Tennessee.

Table 16.—Bentonite sold or used by producers in the United States, by use

(Short tons)

Use	1982 Non-swelling	1982 Swelling	1982 Total	1983 Non-swelling	1983 Swelling	1983 Total
Domestic:						
Adhesives	--	179	179	--	6,688	6,688
Animal feed	66,334	74,148	140,482	38,737	98,220	136,957
Catalysts (oil-refining)	4,311	4	4,315	10,329	178	10,507
Cement, portland	--	W	W	--	W	W
Drilling mud	15,275	1,409,072	1,424,347	580	1,155,189	1,155,769
Fertilizers	--	2,749	2,749	--	--	--
Filtering, clarifying, decolorizing:						
Animal oils and mineral oils and greases	120,120	1,936	122,056	81,781	4,260	86,041
Vegetable oils	27,135	--	27,135	21,250	4,203	25,453
Foundry sand	186,243	328,028	514,271	207,224	372,726	579,950
Glazes, glass, enamels	--	W	W	--	W	W
Medical, pharmaceutical, cosmetic	--	8,050	8,050	--	4,437	4,437
Paint	--	12,998	12,998	--	9,223	9,223
Pelletizing (iron ore)	--	396,506	396,506	--	301,357	301,357
Pesticides and related products	366	4,731	5,097	506	7,282	7,788
Pet waste absorbent	W	--	W	W	--	W
Waterproofing and sealing	17,939	87,527	105,466	20,079	73,534	93,613
Miscellaneous[1]	60,155	65,817	125,972	120,488	74,116	194,604
Total	497,878	2,391,745	2,889,623	500,974	2,111,413	2,612,387
Exports:						
Drilling mud	--	227,409	227,409	--	178,037	178,037
Foundry sand	109	53,441	53,550	126	34,943	35,069
Other[2]	2,248	71,970	74,218	2,310	59,067	61,377
Total	2,357	352,820	355,177	2,436	272,047	274,483
Grand total	500,235	2,744,565	3,244,800	503,410	2,383,460	2,886,870

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, oil and grease absorbents, paper coating, paper filling, 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.

On December 26, 1983, Chemical Marketing Reporter quoted domestic bentonite, 200 mesh, bags, carload lots, f.o.b. mines, as $43.50 per ton. The average unit value reported by domestic producers decreased 11% to $28.30 per ton. Per-ton values reported in the various producing States ranged from $12.10 to $82.23, but the average value reported by the larger producers was near the Montana average figure of $34.46.

Bentonite exports decreased 17% to 554,000 tons valued at $42.6 million. The unit value of exported bentonite decreased 6% to $76.86 per ton; this was attributed to a smaller percentage of the higher cost drilling muds and foundry sand grades shipped. Domestic bentonite producers were facing increased competition in foreign markets caused in part by the strength of the U.S. dollar.

Bentonite was exported to 70 countries. The major recipients were Canada, 35%; Japan, 13%; Singapore, 9%; Venezuela, 5%; and the Federal Republic of Germany and the Netherlands, 4% each. Domestic bentonite producers reported that the end uses of their exports were drilling mud, 65%; foundry sand, 13%; and other, 22%.

Bentonite imports, consisting largely of chemically activated material, increased 6% to 7,696 tons valued at $2.1 million, primarily because of increased shipments from Mexico. The chemically activated bentonite was imported from six countries, with Canada supplying 48%; Mexico, 44%; the Federal Republic of Germany, 5%; and the United Kingdom, Japan, and Italy, the remaining 3%.

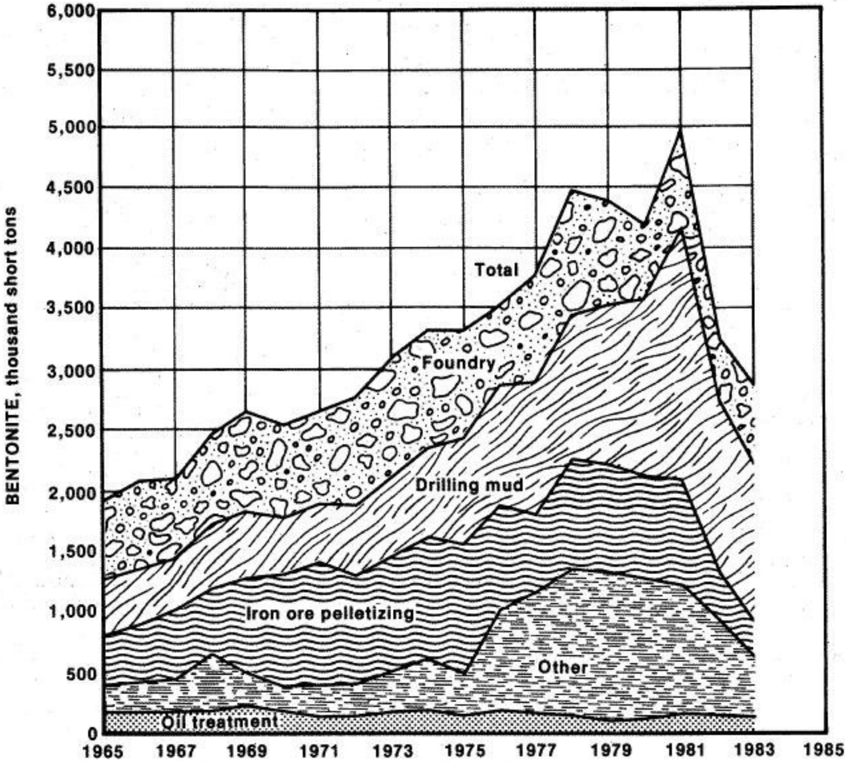

Figure 2.—Bentonite sold or used by domestic producers for specified uses.

FULLER'S EARTH

Production of fuller's earth increased 14% to 1.91 million tons valued at $107 million. Most of the increase was caused by a 69% increase in attapulgite production in Georgia. The average unit value decreased 3% to $55.81 per ton largely because of improved canvassing of lower valued absorbent clay producers. Production was reported from operations in 12 States. The two top producing States, Georgia and Florida, accounted for 58% of domestic production. All of the States except Florida and Nevada showed gains in production, while Utah was unchanged.

Significant increases 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 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 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 were either canceled or deferred until economic conditions improve. One notable exception was an expansion by Excel Minerals Inc. into eastern markets by setting up a packaging plant in Quincy, FL. The west coast-based company was planning to distribute pet waste absorbent clays supplied by the Floridin Co. from its nearby fuller's earth operation in Quincy.

Attapulgite, a fuller's earth-type clay, finds wide application in both the absorbent and thickening areas. The thixotropic properties of attapulgite clays provide the important thickening and viscosity controls necessary for suspending solids. Mineral thickeners are used in such diverse markets as paints, joint compound cement, polishes, and plastics.

Prices for attapulgite reported by producers ranged from $47.41 to $67.75 per ton; montmorillonite prices ranged from $10 to $79.

Fuller's earth exports to 32 countries increased 10% to 102,000 tons. The unit value of exported fuller's earth decreased 8% to $85.24 per ton. The major recipients were Canada, 70%; the Netherlands, 19%; and Japan and the United Kingdom, 3% each. No imports of fuller's earth were reported.

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
1982						
Florida	442,253	$30,907,739	--	--	442,253	$30,907,739
Georgia	294,861	15,763,497	239,323	$11,794,188	534,184	27,557,685
Other	[1]119,059	[1]6,645,625	[2]587,159	[2]31,533,356	706,218	38,178,981
Total	856,173	53,316,861	826,482	43,327,544	1,682,655	96,644,405
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	755,217	43,137,755
Total	1,029,236	58,190,704	882,398	48,499,791	1,911,634	106,690,495

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes Illinois (1983), Nevada, and Texas.
[2]Includes Arizona (1983), Illinois, Mississippi, Missouri, South Carolina, Tennessee, Utah, and Virginia (1982).

Table 18.—Fuller's earth sold or used by producers in the United States, by use

(Short tons)

Use	1982			1983		
	Attapulgite	Montmorillonite	Total	Attapulgite	Montmorillonite	Total
Domestic:						
Adhesives	661	--	661	1,865	--	1,865
Animal feed	10	--	10	--	--	--
Drilling mud	109,226	--	109,226	81,406	--	81,406
Fertilizers	54,268	19,285	73,553	47,257	13,331	60,588
Filtering, clarifying, decolorizing mineral oils and greases	19,102	--	19,102	21,185	1,576	22,761
Medical, pharmaceutical, cosmetic	112	--	112	111	2	113
Oil and grease absorbents	170,031	232,833	402,864	269,688	193,946	463,634
Paint	5,396	--	5,396	8,238	--	8,238
Pesticides and related products	92,327	75,210	167,537	69,731	83,858	153,589
Pet waste absorbent	320,179	359,958	680,137	320,587	485,844	806,431
Other	--	--	--	22,971	10,126	33,097
Miscellaneous[1]	34,032	81,557	115,589	66,945	40,879	107,824
Total	805,344	768,843	1,574,187	909,984	829,562	1,739,546
Exports:						
Drilling mud	653	--	653	865	--	865
Oil and grease absorbents	41,539	29,783	71,322	91,911	36,469	128,380
Pesticides and related products	--	--	--	7,437	458	7,895
Pet waste absorbent	3,297	27,513	30,810	12,805	12,898	25,703
Miscellaneous[2]	5,340	343	5,683	6,234	3,011	9,245
Total	50,829	57,639	108,468	119,252	52,836	172,088
Grand total	856,173	826,482	1,682,655	1,029,236	882,398	1,911,634

[1]Includes common brick; catalyst oil refining; chemical manufacturing; glazes, glasses, and enamel; gypsum products; mortar and cement refractories; plastics; pottery; and sanitary ware.
[2]Includes paint and uses not specified.

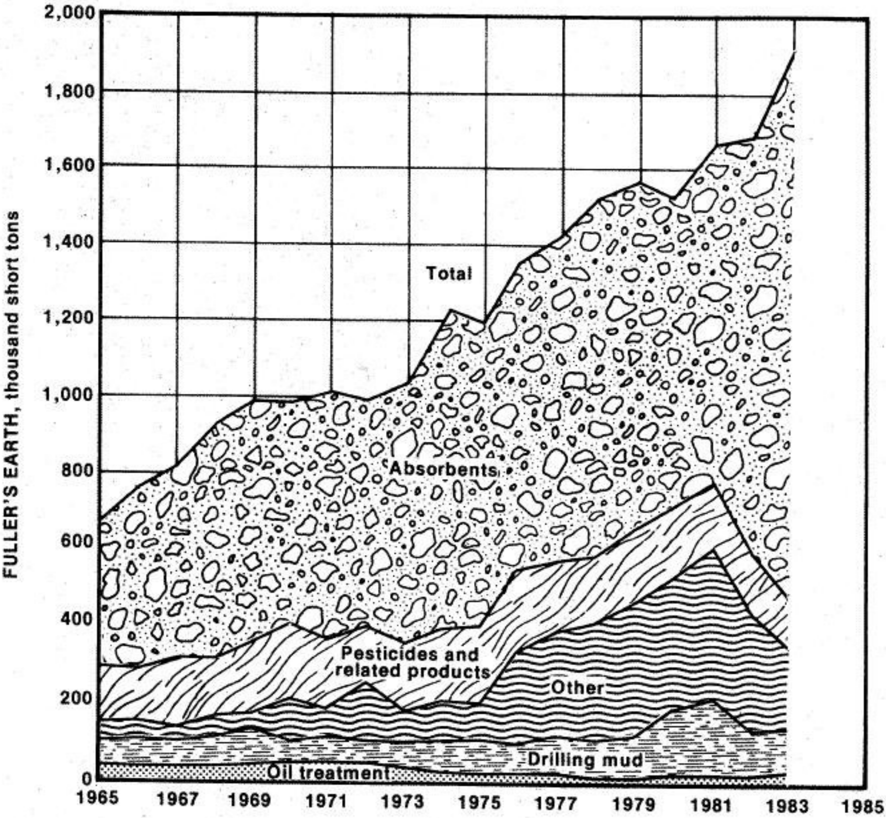

Figure 3.—Fuller's earth sold or used by domestic producers for specified uses.

COMMON CLAY

Domestic sales or use of common clay and shale increased 21% to 27.2 million tons valued at $116 million. Output increased significantly in Alabama, Georgia, and North Carolina and decreased in Texas, the major producing State. Common clay and shale represented 66% of the quantity and 12% of the value of total domestic clay production. Domestic clays and shales had been used mainly by producers to fabricate or manufacture products. Less than 10% of the total output was sold. The average unit value for all common clay and shale produced in the United States and Puerto Rico increased 3% to $4.25 per short ton. The range in unit value was from $2 to $20.93.

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 sedimentary rock composed chiefly of clay minerals that has been both laminated and indurated while buried under other sediments. Clay and shale are used in the manufacture of structural clay products such as brick and drain tile, portland cement clinker, and bloated lightweight aggregates.

Increased production capacities, new plants, and acquisitions and/or mergers slowed 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 emerging from its depressed state. Large inventories, which resulted in either plant shutdowns or lower production schedules during the first part of the year, were worked off by midyear and at yearend the industry was experiencing heavy production.

The Lingl Corp. installed a coal-firing kiln system for Glen-Gery Corp. at its York, PA, brickworks. Kiln capacity was 125,000 bricks per day. Another coal conversion contract was awarded to Harrop Industries Inc. by Richtex Corp. to convert one of its Columbia, SC, kilns to coal-firing by yearend.

Henderson Clay Products Co., Henderson,

TX, announced the acquisition of the Gleason Clay Products Div., Nashville, TN, from Herbert Materials Inc. that was divesting itself of its building materials holdings. Henderson operated six brick manufacturing plants in the Tennessee, Midsouth, and Southwestern areas.

Work was proceeding on a new $6 million clay lightweight aggregate complex in Clay County on Georgia's southwest border. The new plant, reportedly containing the world's largest lightweight aggregate kiln, was ideally located near the Chattahoochee River and accessible to barge transport.

Output of heavy clay products continued to be hindered by fluctuating fuel costs and labor shortages. Industry attention in the Northwest and Southeast focused on coal, sawdust, and woodchip firing as a possible escape from the high cost of oil and gas and intermittent availability of the latter.

Table 19.—Common clay and shale sold or used by producers in the United States, by State[1]

State	1982		1983	
	Short tons	Value	Short tons	Value
Alabama	1,153,099	$6,201,113	1,624,734	$8,487,924
Arizona	115,460	468,485	118,815	490,290
Arkansas	543,701	998,676	769,217	1,562,063
California	1,642,558	9,653,436	1,683,153	11,196,177
Colorado	194,301	1,039,188	442,807	2,473,005
Connecticut	55,874	329,459	86,034	514,910
Florida	203,031	431,466	231,416	674,043
Georgia	970,441	2,820,589	1,280,809	3,773,157
Illinois	444,055	2,174,132	716,580	3,359,537
Indiana	500,923	1,220,519	557,698	1,421,142
Iowa	436,763	2,391,983	576,251	3,257,649
Kansas	648,862	3,356,235	703,234	3,620,604
Kentucky	569,596	1,931,784	669,300	2,142,337
Louisiana	308,664	6,215,920	505,054	10,573,640
Maine	37,488	75,782	43,488	92,522
Maryland	404,737	1,346,287	483,741	1,746,874
Massachusetts	210,364	1,114,663	236,993	1,298,295
Michigan	1,022,436	4,369,853	1,198,900	5,693,416
Mississippi	329,857	1,212,289	943,089	2,694,071
Missouri	851,284	2,604,805	1,003,755	3,716,105
Montana	9,675	21,718	15,226	33,854
Nebraska	133,687	391,617	163,651	500,951
New Jersey	50,560	353,920	50,000	385,000
New Mexico	59,944	112,459	47,609	94,224
New York	352,319	896,647	371,060	868,551
North Carolina	1,573,368	5,243,016	2,067,947	6,680,959
Ohio	1,299,077	3,885,544	1,468,285	4,639,527
Oklahoma	751,858	1,907,322	861,531	2,287,746
Oregon	149,399	212,385	188,222	275,397
Pennsylvania	795,043	3,014,343	854,687	3,457,825
Puerto Rico	162,038	297,911	125,259	251,204
South Carolina	901,583	2,793,023	1,052,666	3,118,251
South Dakota	128,137	345,705	122,576	353,105
Tennessee	223,842	511,199	433,221	955,685
Texas	3,939,835	16,066,641	3,714,421	14,426,690
Utah	175,201	891,352	220,222	1,376,665
Virginia	419,340	2,094,051	744,291	3,466,950
Washington	244,104	1,724,303	275,285	1,714,671
West Virginia	209,653	583,478	248,571	531,990
Wyoming	153,269	703,528	201,263	1,011,916
Other[2]	111,995	662,105	90,934	367,358
Total	22,488,021	92,668,931	27,191,995	115,586,280

[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 24%, 18%, and 11%, respectively, of total domestic consumption. In summary, 66% 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 26% to $1.16 billion. Thousand-unit counts for building or common face brick increased 31%. Vitrified clay sewer pipe and fittings shipped increased 15% and shipments of clay floor and wall tile increased 12%. Notable increases in common clay and shale used in building brick production occurred in Alabama, Arkansas, Colorado, Illinois, Indiana, Iowa, Kentucky, Maryland, West Virginia, North Carolina, Ohio, and Virginia.

Lightweight Aggregates.—Consumption of clay and shale in the manufacture of lightweight aggregate increased 9% to 4.4 million tons. This was attributed to the upturn in construction. Demand in the newer markets, such as running tracks, golf courses, and horticulture, continued to grow.

Refractories.—All types of clay were used in manufacturing refractories. Fire clay, bentonite, and kaolin accounted for 36%, 23%, and 19%, respectively, of total clays used for this purpose. The remainder, ball clay, fuller's earth, and common clay and shale, was used primarily as bonding agents. Bentonite was used primarily 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 of the depressed refractory consuming industries, including steel, cement, foundry, and glass, were responsible for the increased consumption. These increases caused continued expansion in refractory aggregate production and a slight upsurge in the manufacture of more conventional brick-type 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 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. Kaolin, fuller's earth, and bentonite have been the principal filler clays. Kaolin was used in the manufacture of paper, rubber, paint, and adhesives. Fuller's earth was used primarily in pesticides and fertilizers. Clays were used 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 88%; fuller's earth, 5%; bentonite, 4%; and ball clay, common clay and shale, and fire clay, the remaining 3%. Kaolin consumed as fillers increased 45% to 3.9 million tons. Increases occurred in the use of kaolin as filler in adhesives, 28%; paint, 16%; and paper filler and coater, 15% each. The total quantity of fuller's earth used in insecticides and fungicides decreased 8%.

Absorbent Uses.—Absorbent uses for clays accounted for over 1.45 million tons, or 4% of total clay consumption. Demand for absorbents increased 19%. Fuller's earth was the principal clay used for absorbent purposes, and this application accounted for 88% of its entire output. Bentonite was also used. Demand for clays in pet waste absorbent, representing 66% of absorbent use, increased 18%. Use in floor absorbents, chiefly to absorb hazardous oily substances, representing the remaining 34% of absorbent demand, increased 16%.

Drilling Mud.—Demand for clays in rotary-drilling muds decreased 20% to 1.24 million tons and accounted for 3% of total clay production. The domestic bentonite industry had continued its rapid expansion, begun in the latter half of the 1970's, until mid-1982. Then an oil glut and economic downturn, compounded by uncertainty as to the future of unregulated deep gas, resulted in lower oil- and gas-well drilling activity that continued into 1983. Swelling-type bentonite remained the principal clay used in drilling mud mixes, although fuller's earth and nonswelling bentonite were 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.

Floor and Wall Tile.—Common clay and shale, ball clay, fire clay, and kaolin, 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 406,000 tons.

Table 20.—Clays sold or used by producers in the United States in 1983, including Puerto Rico, by use

(Short tons)

Use	Ball clay	Bentonite	Common clay and shale	Fire clay (refractory only)	Fuller's earth	Kaolin	Undistributed[1]	Total[2]
Adhesives	W	6,688	W	W	1,865	91,771	2,644	102,968
Alum (aluminum sulfate) and other chemicals	--	W	--	--	1,355	358,861	W	360,216
Animal feed	9,550	136,957	300	--	--	6,120	--	152,927
Building brick:								
Common	W	W	2,089,187	--	W	17,982	40,747	2,147,916
Face	--	--	11,513,047	50,277	--	287,997	--	11,851,321
Catalysts (oil-refining)	W	10,507	--	--	W	238,136	7,436	256,079
Cement, portland	--	W	7,489,945	W	--	46,507	3,618	7,540,070
China and dinnerware	34,779	--	--	--	--	22,358	--	57,137
Crockery and other earthenware	W	--	W	--	--	W	19,151	19,151
Drilling mud	W	1,155,769	--	--	81,406	1,502	W	1,238,677
Electrical porcelain	19,453	--	W	--	--	27,712	W	47,165
Fertilizers	--	--	--	--	60,588	15,844	--	76,432
Fiberglass, mineral wool, other insulation	--	W	--	--	--	256,224	W	256,224
Filtering, clarifying, decolorizing:								
Animal oil	--	74,215	--	--	--	W	W	74,215
Mineral oils and greases	--	11,826	--	--	22,761	--	--	34,587
Vegetable oils	--	25,453	--	--	--	--	--	25,453
Firebrick, blocks, shapes	W	W	11,650	485,002	--	12,851	11,668	521,171
Flower pots	--	--	33,849	W	--	--	W	33,849
Flue linings and high-alumina (minimum 50% Al_2O_3) refractories	8,766	--	36,281	104,531	--	110,818	--	260,396
Foundry sand	--	579,950	--	66,504	--	685	--	647,139
Grogs and crudes, refractory	W	--	W	110,388	--	329,483	W	439,871
Gypsum products	--	W	--	--	W	17,178	2,401	19,579
Ink	--	W	--	--	--	1,073	W	1,073
Kiln furniture	1,786	--	--	--	--	1,280	--	3,066
Lightweight aggregate:								
Concrete block	--	--	2,480,786	--	--	--	--	2,480,786
Structural concrete	--	--	1,322,067	--	--	--	--	1,322,067
Highway surfacing	--	--	288,276	--	--	--	--	288,276
Other	--	--	304,616	--	--	--	--	304,616
Linoleum and asphalt tile	--	--	--	--	--	3,635	--	3,635
Medical, pharmaceutical, cosmetic	--	4,437	--	--	113	2,674	--	7,224

See footnotes at end of table.

Table 20.—Clays sold or used by producers in the United States in 1983, including Puerto Rico, by use —Continued

(Short tons)

Use	Ball clay	Bentonite	Common clay and shale	Fire clay (refractory only)	Fuller's earth	Kaolin	Undistributed[1]	Total[2]
Mortar and cement, refractory	W	--	383,769	160,007	W	33,809	124,303	701,888
Oil and grease absorbents	--	W	--	--	463,634	--	31,735	495,369
Paint	--	9,223	W	--	8,238	138,601	W	156,062
Paper coating	W	W	--	--	--	2,321,663	W	2,321,663
Paper filling	W	W	--	--	--	1,000,513	W	1,000,513
Pelletizing (iron ore)	--	301,357	--	--	--	--	--	301,357
Pesticides and related products	W	7,788	W	--	153,589	17,678	W	179,055
Pet waste absorbent	--	W	W	--	806,431	--	W	806,431
Plastics	--	W	W	--	W	54,460	90,437	144,897
Pottery	196,172	--	19,322	W	W	13,989	W	229,483
Roofing granules	W	--	W	--	--	16,241	W	16,241
Rubber	W	W	--	--	--	279,089	W	279,089
Sanitary ware	137,211	--	--	--	W	74,557	W	211,768
Sewer pipe, vitrified	--	--	329,715	--	--	W	W	329,715
Tamping dummies	--	--	4,800	--	--	--	--	4,800
Tile:								
Drain	--	--	77,376	--	--	--	--	77,376
Floor and wall, vinyl, glazes, glass, enamels	103,301	--	78,903	W	--	39,053	W	221,257
Quarry	--	--	166,572	--	--	--	--	166,572
Roofing	--	--	22,248	--	--	W	W	22,248
Structural	--	--	24,052	--	--	--	--	24,052
Terra cotta	--	--	18,495	--	--	--	--	18,495
Waterproofing and sealing	--	93,613	--	--	--	W	W	93,613
Miscellaneous[3]	10,158	128,973	154,445	17,112	33,250	135,554	--	479,492
Exports	84,383	274,483	17,573	13,811	172,088	1,210,199	--	1,772,537
Total	605,559	2,821,239	26,867,274	1,007,632	1,805,318	7,186,097	334,140	40,627,259
Total undistributed	141,252	65,631	324,721	35,442	106,316	16,607	354,475	355,829
Grand total	746,811	2,886,870	27,191,995	1,043,074	1,911,634	7,202,704	XX	40,983,088

W Withheld to avoid disclosing company proprietary data; included with "Undistributed." XX Not applicable.
[1]Total of clays indicated by symbol W; unpublishable data included in "Total undistributed."
[2]Data may show incomplete total; difference included in "Total undistributed."
[3]Includes asphalt emulsion, graphite anodes, and unknown uses.

Table 21.—Shipments of principal structural clay products in the United States

Product	1979	1980	1981	1982	1983
Unglazed common and face brick:					
Quantity ---------- million standard brick--	8,020	6,513	5,202	4,407	5,792
Value ---------- million--	$749	$625	$540	$504	$704
Unglazed structural tile:					
Quantity ---------- thousand short tons--	69	102	92	49	30
Value ---------- million--	$4	$7	$8	$6	$5
Vitrified clay and sewer pipe fittings:					
Quantity ---------- thousand short tons--	847	654	463	325	375
Value ---------- million--	$120	$109	$73	$52	$64
Unglazed, salt-glazed, ceramic-glazed structural facing tile including glazed brick:					
Quantity ---------- million equivalent--	56	46	35	11	W
Value ---------- million--	$11	$11	$10	$8	W
Clay floor and wall tile including quarry tile:					
Quantity ---------- million square feet--	314	323	288	296	333
Value ---------- million--	$295	$310	$341	$354	$388
Total value ---------- do----	$1,179	$1,062	$972	[1]$923	$1,161

W Withheld to avoid disclosing company proprietary data.
[1]Data do not add to total shown because of independent rounding.

Source: Bureau of Census Report Form M32-D (82), Current Industrial Reports—Clay Construction Products.

Table 22.—Common clay and shale used in building brick production in the United States, by State

State	1982		1983	
	Short tons	Value	Short tons	Value
Alabama	579,011	$2,478,325	888,072	$3,627,864
Arizona and New Mexico	137,890	353,255	125,413	331,746
Arkansas	250,467	528,911	364,840	840,369
California	412,455	1,534,116	233,035	837,755
Colorado	193,101	1,036,854	441,007	2,470,391
Connecticut, Florida (1982), New Jersey	116,059	703,801	136,034	899,910
Georgia	829,824	2,407,097	1,026,196	2,949,605
Idaho (1982) and Utah	84,966	525,959	83,512	594,781
Illinois	358,294	1,742,151	566,145	2,739,175
Indiana and Iowa	252,095	884,170	337,512	1,133,137
Kansas	130,412	319,979	147,083	430,877
Kentucky	163,105	697,307	268,496	1,058,766
Louisiana	66,064	150,920	90,398	207,162
Maine, Massachusetts, New Hampshire	131,789	712,681	158,015	884,239
Maryland and West Virginia	205,829	706,038	306,914	1,187,226
Michigan and Minnesota	83,011	759,726	83,282	658,875
Mississippi	257,244	1,012,925	790,471	2,235,428
Missouri	60,544	222,586	82,183	323,846
Nebraska and North Dakota	134,453	366,774	145,812	410,601
New York	95,462	137,281	128,994	177,828
North Carolina	1,298,270	4,360,734	1,889,706	6,230,024
Ohio	563,360	1,769,679	838,689	2,670,674
Oklahoma	298,495	865,781	313,092	961,143
Oregon	48,385	61,490	18,898	26,914
Pennsylvania	663,871	2,330,421	750,578	2,875,034
South Carolina	559,536	1,899,236	642,380	2,027,300
Tennessee	169,082	329,710	278,790	538,740
Texas	1,408,155	5,521,876	1,635,777	6,889,517
Virginia	335,260	803,823	646,719	1,807,945
Washington	99,799	433,081	153,453	575,502
Wyoming	14,314	125,104	30,738	295,392
Total	10,000,602	35,781,791	13,602,234	48,897,766

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	
1982						
Alabama and Arkansas	456,296	116,001	990	13,483	586,770	$2,511,906
California	127,936	225,809	--	28,300	382,045	3,214,765
Florida, Indiana, Iowa	179,513	45,639	--	8,416	233,568	893,275
Kansas, Kentucky, Louisiana	419,417	163,287	52,076	8,844	643,624	9,153,840
Massachusetts, Minnesota, Missouri	208,434	73,647	18,345	--	300,426	1,638,081
Montana and New York	86,899	27,323	--	--	114,222	432,169
North Carolina and North Dakota	116,308	79,426	487	13	196,234	563,761
Ohio, Oklahoma, Pennsylvania	205,939	32,948	50	51,176	290,113	597,480
South Dakota, Utah, Virginia	110,415	42,027	--	14,100	166,542	1,600,724
Texas	244,771	449,201	166,740	260,071	1,120,783	4,075,042
Total	2,155,928	1,255,308	238,688	384,403	4,034,327	24,681,043
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

Pelletizing Iron Ore.—Bentonite continued to be used as a binder in forming hard iron ore pellets. Demand decreased 24% to 301,357 tons, reflecting a downturn in taconite pellet production because of decreasing steel demand, excerbated by inroads made by cheaper foreign bentonites into a traditional U.S. clay market. Of the total bentonite produced, about 44%, all of the swelling variety, was consumed for this purpose. U.S. deposits continued to be the major world source for swelling bentonites.

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 4%, to 1.25 million tons.

Table 24.—Shipments of refractories in the United States, by product

Product	Unit of quantity	1982 Quantity	1982 Value (thousands)	1983 Quantity	1983 Value (thousands)
CLAY REFRACTORIES					
Superduty fire clay brick and shapes	1,000 9-inch equivalent.	31,399	$37,061	29,716	$36,023
Other fire clay including semisilica brick and shapes, glasshouse pots, tank blocks, feeder parts, upper structure parts used only for glass tanks.	do	70,311	51,610	60,522	40,830
High-alumina (50% to 60% Al_2O_3) brick and shapes made of calcined diaspore or bauxite.[1]	do	58,711	116,492	70,402	130,773
Insulating firebrick and shapes	do	31,852	30,031	25,328	25,419
Ladle brick	do	78,473	25,110	77,134	24,615
Sleeves, nozzles, runner brick, tuyeres	do	23,373	22,357	20,768	26,998
Hot-top refractories	Short tons	1,198	W	W	W
Kiln furniture, radiant heater elements, potter's supplies, other miscellaneous-shaped refractory items.	do	20,862	20,327	26,524	24,495
Refractory bonding mortars	do	64,799	25,791	56,286	24,103
Plastic refractories and ramming mixes, containing up to 87.5% Al_2O_3.[2]	do	190,984	70,099	182,584	99,409
Castable refractories	do	210,495	77,543	204,154	77,937
Gunning mixes	do	91,014	27,447	77,825	31,868
Other clay refractory materials sold in lump or ground form.[3] [4]	do	318,365	55,787	474,563	52,829
Total clay refractories		XX	559,655	XX	595,299
NONCLAY REFRACTORIES					
Silica brick and shapes	1,000 9-inch equivalent.	W	W	6,718	14,513
Magnesite and magnesite-chrome brick and shapes	do	17,824	67,949	21,864	88,526
Chrome and chrome-magnesite brick and shapes	do	28,620	108,214	29,286	109,455
Shaped refractories containing natural graphite	Short tons	19,067	31,903	16,386	31,973
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.	3,321	30,534	1,289	22,922
Other mullite, kyanite, sillimanite, or andalusite brick and shapes.	do	1,884	9,267	2,366	11,628
Other extra-high (over 60%) alumina brick and fused bauxite, fused alumina, dense-sintered alumina shapes.[6]	do	13,000	35,541	4,036	36,230
Silicon carbide brick, shapes, kiln furniture	do	3,296	42,916	3,241	9,939
Refractory bonding mortar	Short tons	19,769	10,324	12,731	9,194
Hydraulic-setting nonclay refractory castables	do	16,840	16,524	18,402	19,503
Plastic refractories and ramming mixes	do	108,978	67,562	123,824	71,217
Gunning mixes	do	254,821	84,691	235,916	73,997
Dead-burned magnesia or magnesite[3] [7]	do	61,446	68,294	300,907	71,523
Dead-burned dolomite	do	156,518	9,528	120,661	7,675
Other nonclay refractory material sold in lump or ground form.[3]	do	318,258	39,995	237,948	44,104
Total nonclay refractories		XX	623,242	XX	622,399
Grand total refractories		XX	1,182,897	XX	1,217,698

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 Census Report Form MQ 32C (82), Current Industrial Reports—Refractory.

Table 25.—U.S. exports of clays in 1983, 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)	64	--	--	(2)	36	8	1,027	(2)	344	8	1,471
Australia	--	--	19	899	9	591	(2)	32	11	2,102	2	553	41	4,177
Belgium-Luxembourg	(2)	7	(2)	29	51	3,930	1	86	10	1,062	1	175	63	5,289
Brazil	--	--	7	1,606	--	--	--	--	3	1,022	(2)	39	10	2,667
Canada	54	1,519	195	11,739	19	1,135	71	5,832	239	21,940	42	3,815	620	45,980
Chile	(2)	12	8	1,184	--	--	(2)	1	2	348	(2)	60	10	1,605
Colombia	--	--	5	609	1	164	(2)	15	6	944	1	707	13	2,440
Ecuador	1	104	1	217	--	--	--	--	1	196	5	890	8	1,407
Finland	--	--	--	--	--	--	(2)	11	14	1,801	(2)	9	14	1,821
France	(2)	3	14	546	1	180	1	123	28	4,561	2	526	46	5,940
Germany, Federal Republic of	(2)	17	22	1,832	1	364	(2)	29	23	3,948	19	2,411	65	8,601
Hong Kong	--	--	3	340	--	--	--	--	1	167	(2)	51	4	558
Italy	(2)	2	(2)	35	(2)	17	1	121	86	9,300	1	101	88	9,576
Japan	1	122	74	7,583	49	4,400	3	189	416	53,107	62	9,192	605	74,593
Korea, Republic of	(2)	3	2	840	(2)	34	(2)	10	39	8,028	1	121	42	9,036
Mexico	85	2,705	2	180	18	1,062	(2)	11	61	5,690	15	1,398	181	11,046
Netherlands	--	--	21	1,275	3	443	19	1,399	215	18,215	3	439	261	21,771
Peru	(2)	3	1	169	--	--	--	--	4	332	1	31	6	535
Philippines	(2)	32	5	984	(2)	9	(2)	96	9	1,028	1	154	15	2,303
Saudi Arabia	--	--	13	961	--	--	(2)	35	(2)	78	(2)	56	13	1,130
Singapore	--	--	51	2,899	--	--	(2)	23	3	480	(2)	109	54	3,511
South Africa, Republic of	1	66	2	246	--	--	1	45	17	2,694	1	467	22	3,518
Spain	--	--	1	160	1	77	--	--	9	1,170	(2)	191	11	1,598
Sweden	--	--	(2)	5	3	372	(2)	8	27	2,885	7	988	37	4,258
Switzerland	--	--	(2)	17	3	215	(2)	2	29	3,481	(2)	21	32	3,736
Taiwan	(2)	7	12	1,410	2	180	--	--	38	4,582	(2)	28	52	6,207
Thailand	--	--	3	451	--	--	--	--	1	233	(2)	79	4	763
United Arab Emirates	--	--	3	780	--	--	(2)	50	--	--	(2)	23	3	853
United Kingdom	(2)	9	14	1,128	3	186	3	284	11	1,976	6	1,479	37	5,062
Venezuela	1	35	27	1,536	(2)	9	(2)	39	8	1,159	1	324	37	3,102
Other	3	182	49	2,856	1	109	2	215	19	4,326	8	1,995	82	9,683
Total[1]	146	4,828	554	42,580	165	13,477	102	8,694	1,338	157,882	179	26,776	2,484	254,237

[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 1983, by kind

Kind	Quantity (short tons)	Value (thousands)
China clay or kaolin, whether or not beneficiated:		
Canada	74	$11
China	24	1
France	38	21
Germany, Federal Republic of	25	5
Italy	4	1
Mexico	74	3
New Zealand	41	10
Sweden	1	1
United Kingdom	7,146	699
Other[1]	21	1
Total	7,448	[2]754
Bentonite:		
Canada	158	57
Germany, Federal Republic of	6	2
Japan	123	4
Mexico	467	13
Other[1]	10	2
Total	764	78
Common blue and other ball clay, not beneficiated:		
Canada	25	4
Korea, Republic of	--	2
United Kingdom	2,724	150
Total	2,749	156
Common blue and other ball clay, wholly or partly beneficiated:		
United Kingdom	1,136	117
Other[1]	77	7
Total	1,213	124
Other clay, not beneficiated:		
Canada	25	5
Other[1]	45	11
Total	70	16
Clay, n.e.c., wholly or partly beneficiated:		
Belgium	10	7
Canada	379	97
Germany, Federal Republic of	38	9
Japan	1	1
Mexico	26	2
Netherlands	9	4
United Kingdom	1,223	249
Other[1]	2	2
Total	1,688	371
Artificially activated clay:		
Canada	3,355	833
Germany, Federal Republic of	374	223
Italy	2	1
Japan	94	74
Mexico	3,034	742
United Kingdom	73	116
Total	6,932	1,989
Grand total	20,864	3,488

[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 and fuller's earth increased 5% and 11%, respectively, while production of bentonite decreased 24%. Kaolin production during the year was 22 million tons, and U.S. output was 32% of the world total. World fuller's earth production was 2.5 million tons, with the United States accounting for 78% of the total. Bentonite production was 5.2 million tons, and U.S. output accounted for 56% of the total.

Australia.—An extensive kaolin deposit at Weipa, only 10 to 15 feet below the bottom of its bauxite mine floor, was discovered by Comalco Pty. Ltd.[3] Construction of a 100,000-ton-per-year plant to produce paper-coating-quality clays was scheduled to begin by mid-1984.

Austria.—Aspanger Kaolinwerke, a major Austrian kaolin producer, installed a new and reportedly more efficient quartz-and/or grit-removal step in its processing plant.[4] The new circuit was reported to have upgraded the quality and value of the kaolin.

Benin.—The Government planned to develop a kaolin deposit recently discovered in Zou Province.[5]

Bolivia.—Reserves of bentonite deposits on the Altiplano, near Rio Mulatos, currently worked by NL Baroid/NL Industries Inc. and Mosamar (Bolivar) were reported to be about 350,000 tons.[6] The joint venture was producing less than 10,000 tons per year of drilling-mud-grade bentonite at its barite-bentonite beneficiation plant in Oruro.

Bulgaria.—Geological studies were being carried out on kaolin deposits near the village of Gruncharvo in the Silistra district.[7]

Cameroon.—The Government planned to develop clay and kaolin deposits located near Kribi on the Gulf of Guinea.[8] Total production was to be an estimated 100,000 tons per year.

China.—The major bentonite producing area was reported to be in Heishan County, Liaoning, where an open pit processing complex was capable of producing in excess of 100,000 tons per year of finished product. Total resources in the area were declared to be over 0.5 million tons. Plans were being made for the complex to produce over 50,000 tons per year of activated sodium bentonite using imported technology and equipment. A 10-square-mile bentonite deposit, found in Guangxi, was estimated to contain over 100 million tons of recoverable ore.[9]

Cyprus.—The Government was seeking a joint venture partner to help develop the island's extensive bentonite deposits.[10] Attention was focused on an estimated 20-million-ton calcium bentonite deposit located 10 miles from the southeast port city of Limassol. Plans were to use a Cypriot-developed activation process for producing drilling mud- and civil engineering-grade bentonite targeted for the Persian Gulf region and local construction projects, respectively.

India.—A newly formed subsidiary of Ashapura Minechem Industries, Ashapura Mineral Co., began production from its 15,000-ton-per-year attapulgite operation at Bhavnagar in Gujurat.[11] All of the product was being exported for saltwater drilling applications in the United Arab Emirates, Saudi Arabia, and elsewhere for use in fertilizers. The subsidiary was also contemplating producing a pet waste absorbent-grade attapulgite for export.

F. L. Smidth and Co. A/S announced receiving an order to build a 200-ton-per-day lightweight expanded clay aggregate (LECA) plant at an undisclosed site.[12] The raw materials to be used in LECA production were bentonite and a lateritic clay and the firing was to be in a lignite-fueled rotary kiln. The manufactured low-density aggregate was to be used captively to make hollow building blocks. Low-density LECA has been used as a building material in Europe for many years.

Morocco.—The Bureau de Recherches et de Participations Minières reported a sizable bentonite deposit located near the port city of Nador on the Mediterranean Sea.[13]

Netherlands.—Redland PLC, of the United Kingdom, announced that its subsidiary, Redland-Brass-Bredero Europa BV, had agreed to purchase the Dutch brick company of Ibstock Johnson PLC for over $2 million.[14] The business consisted of six face brick manufacturing plants with a total annual capacity of 160 million bricks.

Nigeria.—Kaolin deposits at South Rapp and Werram in Plateau State and at Agharansu and Ukpor in Imo and Anambra States, respectively, were being readied to be mined for use by the local insecticide, pottery, and ceramic industries.[15]

Oman.—A specially commissioned geological investigation for pinpointing economic industrial mineral deposits located a number of quality ceramic clay or kaolin deposits.[16]

Spain.—Production from Caolines de Vimianzo's new 100,000-ton-per-year plant in northwest Spain was nearing capacity, and the firm announced plans to begin pilot plant production of coating-quality kaolin clay.[17]

Sweden.—In another kaolin action, English China Clay PLC (ECC) acquired the assets of SPH Chemicals AB, a major Scandinavian paper-grade clay distributor, and Cedpro Chemical Development and Production AB (CDM), its Swedish sales agent, and formed a new company, ECC International, Sweden, to handle its regional marketing.[18]

Togo.—A Government partnership with three unnamed Swiss firms were planning on establishing a company to recover attapulgite and bentonite clays.[19] The company's first task was to find export markets for the 20-million-ton attapulgite deposit situated at Aveta, about 20 miles from the capital, Lomé, on the Gulf of Guinea.

U.S.S.R.—The Yermakovskiy brickworks under construction in Pavlodar Oblast' was designed to produce 60 million bricks per year using a mixture of clay and thermal-power-station ash.[20]

United Kingdom.—Renovation of Laporte Industries Ltd.'s fuller's earth plant near Redhill was nearing completion and would increase production capacity by about 200,000 tons per year.[21] In another fuller's earth event, Steetly Minerals Ltd. started work on its new deposit at Woburn, Bedfordshire. English China Clays Ltd. (ECC) opened its Vale storage and distribution center designed to serve the pottery industry.[22] The new center was capable of handling rail and truck shipments of ball clay and china clay.

The Monopolies and Mergers Commission (MMC), after a 6-month investigation into the takeover bid by London Brick PLC for Ibstock Johnson, announced that the merger would not be against the public interest.[23] The decision by the MMC was influenced by the fact that the two companies were involved in two different markets. London Brick manufactured a mass produced brick for interiors and modest homes while Ibstock Johnson produced a higher priced brick usually specified by architects for prestigious residential and commercial buildings.

Vietnam.—The Vientiane brick factory, capable of producing 7 million bricks per year, was commissioned at midyear.[24]

Yugoslavia.—A bentonite deposit was found near Sipovo in Bosnia-Hercegovina, and plans were being advanced for processing up to 70,000 tons per year at a nearby clay mine.[25] Demand for bentonite clay had been met largely by imports.

Table 27.—Kaolin: World production, by country[1]

(Thousand short tons)

Country[2]	1979	1980	1981	1982[p]	1983[e]
Algeria	10	[r]9	[r] [e]21	[r] [e]17	19
Argentina	146	101	74	80	[3]80
Australia	160	241	188	[r] [e]254	275
Austria (marketable)	87	92	87	85	[3]92
Bangladesh[4]	8	[r]12	11	7	[3]2
Belgium	[r]72	[r]67	60	58	55
Brazil (beneficiated)	385	452	518	544	540
Bulgaria	223	229	244	261	265
Burundi[e]	2	2	2	2	22
Chile	65	66	63	23	45
Colombia	903	867	893	[e]893	893
Costa Rica	1	1	1	1	1
Czechoslovakia	565	571	560	581	575
Denmark[e]	22	22	22	22	22
Ecuador	[r]6	4	3	5	[3]1
Egypt	51	45	35	55	50
Ethiopia (including Eritrea)	33	61	10	[r] [e]10	10
France[5]	347	373	365	382	385
German Democratic Republic (marketable)[e]	210	220	220	[r]230	220
Germany, Federal Republic of (marketable)	613	553	523	500	550
Greece	36	47	47	[e]47	47
Hong Kong	3	1	9	([6])	1
Hungary	70	57	58	50	50
India:					
Salable, crude	418	391	432	585	550
Processed	128	116	126	[r] [e]110	110
Indonesia	65	83	89	85	90
Iran	176	165	110	[e]121	110
Israel	25	10	41	[r] [e]40	40
Italy:					
Crude	74	98	82	59	60
Kaolinitic earth	28	30	34	32	33
Japan	240	252	232	218	[3]254
Kenya[e]	2	[3]2	2	2	2
Korea, Republic of	413	302	248	193	256
Madagascar	2	3	2	[e]2	2
Malaysia	36	51	49	49	60
Mexico	85	299	229	190	200
Mozambique	([6])	([6])	([6])	([6])	([6])
New Zealand	28	51	54	26	50
Nigeria	1	1	1	[e]1	1
Pakistan	17	30	42	46	46
Paraguay	44	55	77	[e]61	55
Peru	7	6	[e]7	[e]7	7
Poland	54	56	47	50	50
Portugal	[e]60	54	58	56	55
Romania	400	444	[e]452	[e]452	452
South Africa, Republic of	164	119	165	141	[3]143
Spain (marketable)[7]	776	709	870	768	770
Sri Lanka	6	7	8	9	[3]9
Suriname[8]	3	3	[e]3	[e]3	3
Taiwan	94	88	100	96	114
Tanzania[e]	1	1	1	1	1
Thailand	47	22	16	20	[3]40
Turkey[e]	65	55	[3]49	50	60
U.S.S.R.[e]	2,800	2,800	2,800	2,900	2,900
United Kingdom	4,899	4,370	4,189	3,922	3,970
United States[9]	7,761	7,879	7,660	6,362	[3]7,203
Venezuela	24	[e]24	72	[e]72	72
Vietnam[e]	1	1	1	[r]1	1
Yugoslavia	196	217	248	258	265
Zimbabwe	3	5	5	3	3
Total	[r]23,161	[r]22,892	22,615	21,098	22,237

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through July 3, 1984.
[2]In addition to the countries listed, China and Lebanon also produced kaolin, but information is inadequate to make reliable estimates of output levels. Guatemala and Morocco each produced less than 500 tons in each of the years covered by this table.
[3]Reported figure.
[4]Data for year ending June 30 of that stated.
[5]Includes kaolinitic clay.
[6]Less than 1/2 unit.
[7]Includes crude and washed kaolin and refractory clays not further described.
[8]Data represent exports.
[9]Kaolin sold or used by producers.

Table 28.—Bentonite: World production, by country[1]

(Short tons)

Country[2]	1979	1980	1981	1982[p]	1983[e]
Algeria[3]	38,462	38,162	[r][e]38,600	[r][e]38,600	38,600
Argentina	173,484	144,826	135,274	135,864	[4]137,568
Australia[3]	[r]7,304	12,112	14,299	[e]12,700	16,500
Brazil	234,244	273,322	183,356	180,845	187,400
Burma	1,594	1,485	2,554	69	780
Cyprus[5]	5,842	25,353	49,600	[e]49,600	[4]33,069
Egypt[e]	3,900	5,700	5,700	5,700	6,600
France	17,711	[r][e]8,820	[r][e]1,430	1,179	1,100
Greece	545,837	553,225	343,862	[e]343,900	330,700
Guatemala[e]	3,000	2,900	2,750	2,750	8,800
Hungary	79,904	85,633	88,770	93,624	93,700
Iran[e]	22,000	22,000	11,000	12,100	14,300
Israel (metabentonite)	6,930	20,195	13,868	[r][e]13,200	13,200
Italy	310,851	356,046	305,340	261,611	253,600
Japan	[e]440,000	604,427	564,141	533,993	[4]486,034
Mexico	187,225	194,037	243,009	203,837	220,500
Morocco	[r]1,119	3,620	3,203	4,913	[4]4,514
Mozambique[e]	[4]1,825	1,650	1,650	1,650	1,650
New Zealand (processed)	5,461	3,307	2,078	[r][e]6,800	6,600
Pakistan	1,588	1,658	1,246	1,022	1,100
Peru	19,677	20,062	33,620	[e]34,200	34,200
Philippines	3,443	5,570	6,092	5,149	5,500
Poland[e]	55,000	55,000	55,000	55,000	55,000
Romania	[r]197,865	194,558	[e]194,000	[e]193,000	195,100
South Africa, Republic of	51,141	54,912	48,912	33,981	[4]43,573
Spain	133,025	107,701	129,772	123,818	121,300
Tanzania	88	44	[e]55	[e]55	83
Turkey[e]	15,400	22,000	[4]33,827	34,200	34,200
United States	4,422,075	4,184,619	4,947,000	3,244,800	[4]2,886,870
Total[6]	[r]6,985,995	[r]7,002,945	7,460,008	5,628,161	5,232,141

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through July 3, 1984.
[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]Data may not add to totals shown because of independent rounding.

Table 29.—Fuller's earth: World production, by country[1]

(Short tons)

Country[2]	1979	1980	1981	1982[p]	1983[e]
Algeria	(3)	(3)	(3)	(3)	--
Argentina	6,002	5,205	5,783	13,002	[4]15,322
Australia	55	55	(3)	55	55
Italy	[e]1,190	4,740	6,057	[e]6,000	6,000
Mexico	53,815	62,675	72,067	46,536	50,000
Morocco (smectite)	14,976	19,213	21,771	27,121	[4]30,187
Pakistan	44,457	26,966	22,661	15,557	15,500
Senegal (attapulgite)	14,330	4,385	55,116	109,128	[4]110,644
South Africa, Republic of	1,013	794	478	343	[4]344
Spain (attapulgite)	68,809	52,933	52,059	47,318	47,400
United Kingdom	242,508	231,485	225,974	267,861	265,000
United States	1,568,247	1,533,802	1,655,854	1,682,655	[4]1,911,634
Total	[r]2,015,402	[r]1,942,253	2,117,820	2,215,576	2,452,086

[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 3, 1984.
[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]Revised to zero.
[4]Reported figure.

TECHNOLOGY

The Bureau of Mines published the results of research on the acid extraction of alumina from calcined Georgia kaolin at its miniplant facilities in Boulder City, NV, and its research laboratory in Albany, OR. Studies of the continuous leaching of kaolin with boiling 25% hydrochloric acid (HCl) indicated that 93% to 99% of the acid soluble alumina could be extracted from the kaolin. Obtained were compositional and physical properties information for calcined kaolin, process liquors, and acid-leached residue solids. It was shown that, although alumina could be easily leached from the calcined clay with boiling mineral acids, the presence of fines and slimes in the leached residue hindered leaching efficiency.[26] A "misted" feed preparation method was developed that overcame the fines problem by yielding a dense, smooth-surfaced, fine-grained clay that could be readily leached.[27] The important factors affecting misted feed quality were determined to be (1) crushing the raw clay to the size desired for the leaching process, (2) moistening the crushed clay with a fine mist of water while tumbling on a rotating disk (misting), (3) drying the misted clay, and (4) calcining the dried clay at 750° C in a fluidized bed.

Another study determined the leaching rates for calcined kaolin prepared by the misted technique. Leaching was so rapid that diffusional resistances became rate controlling and a zero-order kinetic relationship was applicable. The work further showed that clays calcined in a fluidized bed reacted 50% faster than clays calcined in other ways.[28] Other reports by the Bureau of Mines pertaining to alumina recovery from clays by both acid and nonacid processes were also released during the year.[29]

The U.S. Geological Survey reported the clay mineralogy of Devonian black shales in the Appalachian Basin.[30] The study, undertaken to predict areas of potential gas resources in the basin, was based on X-ray diffraction analyses of more than 2,100 clay and nonclay samples from 84 drill holes representing 11 shale units. The comprehensive geologic study, which included stratigraphic relationships, maps, and drill hole information, stressed the kaolinite areas in the western part of the Appalachian Basin.

A paper detailed the use of clays used for gelling saltwater drilling fluids. The work included information on the mineralogy, properties, and mining and processing of the clay minerals, attapulgite and sepiolite. The paper included a technical rationale of how these clays were employed as gelling agents, their rheological characteristics, the effects of other additives, and the properties of the resulting drilling fluids.[31]

A report highlighting the use of bentonite in freshwater-based drilling fluids indicated that the amount of bentonite used per foot of hole drilled more than doubled in the period 1960 to 1980. The drilling industry found that faster and more economical drilling could be accomplished not only by lowering the solids in the drilling muds, by desanders and desilters and other mechanical devices, but also by frequently renovating the mud by adding fresh bentonite. The fresh bentonite additions controlled the means of solids reduction in the mud systems and lowered drilling costs.[32]

A paper on the thermal efficiency of clay adobe brick cited the effect of wall mass and thermal conductivity on heating and cooling loads of residential buildings and concluded that adobe brick had a unique ability to store and release heat and thereby automatically moderating temperature changes within buildings. The paper also featured techniques used in the Southwestern United States to manufacture the six typical fired and unfired types of adobe brick.[33]

A report resolved a longstanding problem associated with beneficiated kaolin clays.[34] Previously, it had been unclear whether the carbonaceous matter present in processed clays, known to adversely affect the whiteness of the final beneficiated product, was caused by the flotation oil residues or natural contaminants. This new instrumental technique should permit processers to modify their production flowsheets to minimize the carbonaceous content of their finished kaolin products.

A comprehensive two-part work on refractory clays was published.[35] One part contained a raw material assessment that addressed the geology, stratigraphy, and classification of the domestic refractory clay regions. Maps depicting the major fire clay, ball clay, and kaolin areas in the Southeast and Midwest were included. Foreign refractory clays were afforded a less sophisticated treatment. The second part was devoted to the product demand for each class of fire clay bricks. The novel approach discussed the future for each of the classes—low-, medium-, high-, and super-duty—including fire clay specialties.

Detailed works on the industrial minerals of India,[36] Romania,[37] and Sri Lanka,[38] with special clay sections, were published. The Indian article reviewed the geology, mining, production flowsheets, and companies currently recovering ball clay, bentonite, fire clay, fuller's earth, and kaolin in the subcontinent. The country's small but growing acid-activated and heat-treated bentonite industry, based on calcium bentonites from Bhavnagar and Hyderabad, was singled out for special mention. A similar treatment, but more heavily oriented towards a geological and mineralogical approach, was afforded kaolin, refractory clays, and bentonites in Romania. A highlight of the Romanian paper was maps depicting the locality of its clay deposits. The Sri Lanka paper emphasized the integrated cottage industry nature of the clay industry by region. The island's commercial clay deposits were ball clays, bentonite, and kaolin.

The effect of the reducing atmosphere during the firing of clay bodies on the clay's minerals and iron oxides, and the role of calcium content, were studied by X-ray diffraction, scanning electron microscopy, Mossbauer, and magnetization techniques.[39] The study showed that gehlenite, calcium aluminosilicate, formed at temperatures about 900° C in calcareous clays, while wollastonite, calcium metasilicate, formed at temperatures nearing 1,100° C. In noncalcareous clays, extensive vitrification was noted that was attributed to the dissociation of the iron oxide into the vitreous matrix or partly incorporated into the spinel mineral, hercynite. This work was considered to be helpful to brick and pottery manufacturers in controlling coloring systems in their finished products.

An investigation of the interior fissures and microstructure of fired bricks was made by optical and scanning electron microscopy.[40] The results showed that different types of interior brick delaminations were directly related to extrusion and firing and cooling process parameters. It was determined that long-term failures of shale bricks and mortars, an industrywide problem, were caused by interaction of the walls of the interstitial pore system with absorbed water that migrates through the interconnecting pore system.

The transformation of refractory-grade kaolins into mullite was studied extensively by lattice energy techniques.[41] Kaolinite was shown to decompose into a spinel phase with expulsion of excess silica into a high-temperature crystalline form upon cooling. These mullites, commonly known as calcines, are used widely in refractory bricks and specialty products. The results of this basic research should allow a refractories manufacturer to better control the physical properties of the mullite component to optimize the density of these high-performance refractories.

The superior performance of fire clay bricks (42% to 45% Al_2O_3) over high-alumina bricks (60% to 85% Al_2O_3) in torpedo ladles was investigated.[42] Experiments revealed that cracks in the fire clay refractory bricks were light, thin, and perpendicular to the hot face, while, in the high-alumina bricks, they were heavy, wide, and parallel to the hot face. The crack patterns demonstrated that the wear of the better performing fire clay brick was caused primarily by slag attack and that of the high-alumina was by two mechanisms—slagging and spalling. Torpedo ladles, conventionally used to transport hot metal from blast furnaces to steelmaking converters, are also used to contain hot metal as it undergoes refining to decrease its sulfur content.

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[1]Physical scientist, Division of Industrial Minerals.

[2]Albany slip clay is included with ball clay solely for statistical convenience.

[3]Iannicelli, J. Kaolin. Eng. and Min. J., v. 185, No. 3, Mar. 1984, p. 95.

[4]Polegeg, S., and K. Punzengruber. Mining Annual Review. Western Europe: Austria. Min. J. (London), June 1983, pp. 497-498.

[5]World Mining Yearbook. Worldwide Mining: Africa-Benin. V. 36, No. 8, Aug. 1983, p. 113.

[6]U.S. Embassy, La Paz, Bolivia. State Dep. Airgram A-19, p. 58.

[7]Industrial Minerals (London). Company News and Minerals Notes. No. 186, Mar. 1983, p. 64.

[8]Work cited in footnote 7.

[9]Chin, E. Mining Annual Review. Far East: China. Min. J. (London), June 1983, pp. 349-357.

[10]Engineering and Mining Journal. This Month in Mining: Cypriot Hopes of a Mining Revival Focus on Bentonite Project. V. 184, No. 9, Sept. 1983, p. 175.

[11]Clark, G. M. The Industrial Minerals of India. Ind. Miner. (London), No. 191, Aug. 1983, p. 50.

[12]Industrial Minerals (London). Company News and Minerals Notes. No. 187, Apr. 1983, p. 67.

[13]World Mining Yearbook. Worldwide Survey: Africa-Morocco. V. 36, No. 8, Aug. 1983, p. 120.

[14]Industrial Minerals (London). World of Minerals: Netherlands-Redland Expands Brick Operations. No. 187, Apr. 1983, p. 11.

[15]World Mining Yearbook. Worldwide Survey: Africa-Nigeria. V. 36, No. 8, Aug. 1983, p. 122.

[16]———. Worldwide Survey: Asia-Oman. V. 36, No. 8, Aug. 1983, p. 146.

[17]Work cited in footnote 3.

[18]Mining Journal (London). Company News/Comment: English China Clays—Better Outlook. V. 302, No. 7749, Feb. 24, 1983, p. 130.

[19]World Mining Yearbook. Worldwide Survey: Africa-Togo. V. 36, No. 8, Aug. 1983, p. 130.

[20]Industrial Minerals (London). Company News and Minerals Notes. No. 195, Dec. 1983, p. 76.

[21]Shrimpton, G. J. Mining Annual Review. Western Europe: United Kingdom. Min. J. (London), June 1983, pp. 487-488.

[22]Industrial Minerals (London). World of Minerals: ECC Ready for Market Improvement. No. 186, Mar. 1983, p. 14.

[23]———. World of Minerals: United Kingdom-MMC Open Way for London Brick. No. 192, Sept. 1983, pp. 17-18.

[24]———. Company News and Minerals Notes. No. 192, Sept. 1983, p. 77.

[25]———. Company News and Minerals Notes. No. 189, June 1983, p. 89.

[26]Sawyer, D. L. Jr., T. L. Turner, and D. B. Hauter. Alumina Miniplant Operations—Overall Mass Balance for Clay-HCl Acid Leaching. BuMines RI 8759, 1983, 29 pp.

[27]Olsen, R. S., W. G. Gruzensky, S. J. Bullard, and J. L. Henry. Factors Affecting the Preparation of Misted Clay Feed and Solids-Liquid Separation After HCl Leaching. BuMines RI 8772, 1983, 25 pp.

[28]Olsen, R. S., S. J. Bullard, W. G. Gruzensky, R. V. Mrazek, and J. L. Henry. Leaching Rates for the HCl Extraction of Alumina From Calcined Kaolinitic Clay. BuMines RI 8744, 1983, 11 pp.

[29]Doerr, R. M. Laboratory Studies on the Treatment of Ferric Chloride Stripping Liquor From a Clay-Hydrochloric Acid Leaching Process. BuMines RI 8725, 1982, 7 pp.

Gokcen, N. A. Rates of Chlorination of Aluminous Resources. BuMines IC 8952, 1983, 14 pp.

Kramer, D. A. Economic and Technical Evaluation of the Sulfurous Acid-Caustic Purification Process for Producing Alumina From Kaolinitic Clay. BuMines IC 8959, 1983, 26 pp.

Landsberg, A. Aluminum From Domestic Clay Via a Chloride Process. The State of the Art. BuMines IC 8923, 1983, 15 pp.

White, J. C., J. L. Henry, and D. E. Traut. Calcination of Aluminum Nitrate Nonahydrate in a Fluidized Bed. BuMines RI 8705, 1982, 23 pp.

[30]Hosterman, J. W., and S. I. Whitlow. Clay Mineralogy of Devonian Shales in the Appalachian Basin. U.S Geol. Surv. Prof. Paper 1298, 1983, 31 pp.

[31]Sawyer, E. W. Jr., The Characterization and Use of Clays for Gelling Saltwater Drilling Systems. Pres. at Soc. Min. Eng. AIME Ann. Meeting, Atlanta, GA, Mar. 6-10, 1983. Soc. Min. Eng. AIME preprint 83-56, 11 pp.

[32]Hughes, J. The Use of Bentonite in Oil and Gas Well Drilling Fluids. Pres. at Soc. Min. Eng. AIME Ann. Meeting, Atlanta, GA, Mar. 6-10, 1983, Soc. Min. Eng. AIME preprint 83-129, 55 pp.

[33]Austin, G. S. Adobe as an Insulating Building Material. Pres. at Soc. Min. Eng. AIME Fall Meeting, Salt Lake City, UT, Oct. 19-21, 1983. Soc. Min. Eng. AIME preprint 83-337, 3 pp.

[34]Lass, B. D., P. Oldham, J. Kennedy, and I. M. Warner. A Qualitative Determination of Residual Flotation Oils on Beneficiated Kaolin Clays. Pres. at Soc. Min. Eng. AIME Ann. Meeting, Atlanta, GA, Mar. 6-10, 1983. Soc. Min. Eng. AIME preprint 83-72, 11 pp.

[35]Stack, C. E., and M. A. Schnake. Refractory Clays. Ind. Miner. (London), Refractory Supplement, No. 187, Sept. 1983, pp. 69-77.

[36]Clarke, G. M. The Industrial Minerals of India. Ind. Miner. (London), No. 191, Aug. 1983, pp. 21-52.

[37]Avramescu, C., I. Calugaru, and M. Angelesco. The Industrial Minerals of Romania. Ind. Miner. (London), No. 186, Mar. 1983, pp. 35-45.

[38]Clarke, G. Sri. Lanka's Industrial Minerals—Much Potential To Be Realized. Ind. Miner. (London), No. 193, Oct. 1983, pp. 61-71.

[39]Maniatis, Y., A. Simopoulos, and A. Kostikas. Effect of Reducing Atmosphere on Minerals and Iron Oxides Developed in Fired Clays: The Role of Ca. J. Am. Ceram. Soc., v. 66, No. 11, Nov. 1983, pp. 773-781.

[40]Marusin, S. L. Interior Fissures and Microstructure of Shale Brick. Bull. Am. Ceram. Soc., v. 62, No. 11, Nov. 1983, pp. 1264-1268.

[41]Mazumdar, S., and B. Mukherjee. Structural Characterization of the Spinel Phase in the Kaolin-Mullite Reaction Series Through Lattice Energy. J. Am. Ceram. Soc., v. 66, No. 9, Sept. 1983, pp. 610-612.

[42]Ko, Y.-H., and Y.-C. Ho. Simulated Service of Torpedo Ladle Brick. Bull. Am. Ceram. Soc., v. 62, No. 9, Sept. 1983, pp. 1010-1012.

Cobalt

By William S. Kirk[1]

Domestic consumption of cobalt increased in 1983 for the first time in 4 years. Reported consumption rose to 11.3 million pounds, while calculated apparent consumption rose to 15.7 million pounds. The producer price remained at $12.50 per pound throughout 1983. Spot prices ranged from $4.75 to $6.40 per pound. Zaire regained its share of the U.S. cobalt market, accounting for 45% of imports. There was no domestic mine production of cobalt in 1983. There was, however, one domestic refiner that produced cobalt from imported nickel-copper-cobalt matte.

Table 1.—Salient cobalt statistics

(Thousand pounds of contained cobalt unless otherwise specified)

	1979	1980	1981	1982	1983
United States:					
Consumption	17,402	15,321	11,680	9,468	11,319
Imports for consumption	19,998	16,302	15,594	12,870	17,221
Stocks, Dec. 31: Consumer	3,390	2,540	1,411	1,327	1,441
Price: Metal, per pound	$20.00-$25.00	$25.00	$17.26-$25.00	[r] [1]8.56	[1]$5.76
World: Production[2]	[r]65,856	[r]68,356	66,180	[p]53,692	[e]53,192

[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.—The President proclaimed an Exclusive Economic Zone in which the United States would exercise sovereign rights over all mineral resources within 200 nautical miles of its coast. The proclamation affected the waters adjacent to the United States, Puerto Rico, and all U.S. overseas territories, including the Pacific Islands Trust Territories. Deposits of cobalt-bearing manganese crusts have been discovered in some of these areas.

The Federal Emergency Management Agency (FEMA) recommended at a Senate hearing that the cobalt inventory in the National Defense Stockpile be raised to 80 million pounds. The stockpile inventory at yearend was 45.9 million pounds, and the stockpile goal remained at 85.4 million pounds. In September, the General Services Administration (GSA) awarded contracts to the metals marketing arms of Zaire and Zambia for the purchase of 6.5 million pounds of cobalt for the stockpile. Zaire was to supply 4 million pounds and Zambia the balance, all at $5.50 per pound. Provisions of the contract called for the cobalt to meet GSA grade B specifications (99.65% cobalt) and to be delivered between December 23, 1983, and December 23, 1984.

The American Society for Metals, under contract to FEMA, issued a report on the quality of the cobalt in the stockpile. The report found that the cobalt that was purchased after 1980 met the quality requirements of current technology for critical defense and industrial applications. The pre-1980 cobalt, however, was found to be unsuitable for immediate use in applications with the most stringent quality requirements, such as superalloys. The report recommended and outlined pilot tests using existing chemical and metallurgical technology to determine the most efficient procedures for upgrading the pre-1980 cobalt.

The U.S. Air Force, under title III of the Defense Production Act, issued a draft Request for Proposals in an effort to establish domestic cobalt production. The initial project plans included the possibility of construction of one or more pilot plant operations to mine and process domestic ore. The plans also specified that any cobalt produced under this program would have to be suitable for use in superalloys used in jet turbine engines.

The Defense Production Act lapsed on September 30, 1983, and in mid-November was extended to March 31, 1984. The U.S. Trade and Development Program awarded a grant to a Peruvian mining company to study the feasibility of producing a cobalt concentrate from an existing mine. (See World Review section.)

DOMESTIC PRODUCTION

Anschutz Mining Corp. further curtailed maintenance operations at its Madison Mine near Fredericktown, MO. The facility was placed on a care and maintenance status in 1982 but continued to pump water from the mine. Pumping was discontinued in August 1983, and the work force at the mine was reduced from four to one.

AMAX Inc. closed its Port Nickel nickel-cobalt refinery at Braithwaite, LA, for 2 months. In an unrelated move, AMAX began having its cobalt refined by Sherritt Gordon Mines Ltd. of Canada in April. At Port Nickel, AMAX produced cobalt hydroxide, an intermediate cobalt product, that was shipped to the Sherritt Gordon refinery at Fort Saskatchewan, Alberta, for refining into powder or electrodes. California Nickel Corp., Palos Verdes, CA, announced plans to build a pilot plant to produce cobalt and nickel from deposits located in northern California.

Table 2.—Cobalt products[1] produced and shipped by refiners and processors in the United States

(Thousand pounds)

	1982				1983			
	Production		Shipments		Production		Shipments	
	Gross weight	Cobalt content	Gross weight	Cobalt content	Gross weight	Cobalt content	Gross weight	Cobalt content
Metal	1,016	1,016	NA	NA	206	206	NA	NA
Hydrate (hydroxide)	NA	336	NA	341	NA	1,000	NA	1,100
Salts[2] (inorganic compounds)	NA	609	NA	600	NA	667	NA	643
Driers (organic compounds)	NA	902	NA	931	NA	1,359	NA	1,428
Total	1,016	2,863	NA	1,872	206	3,232	NA	3,171

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, ending 4 consecutive years of decline. The increased demand was largely the result of improved economic conditions.

Apparent industrial demand, calculated from net imports, secondary production, and changes in industry and Government stocks, increased to 15.7 million pounds, about 40% more than that of 1982. Consumer stocks of cobalt were held at a relatively high level throughout the year owing to low prices.

Table 3.—U.S. consumption of cobalt, by end use

(Thousand pounds of contained cobalt)

End use	1982	1983
Steel:		
Stainless and heat-resisting	51	54
Full-alloy	114	W
High-strength, low-alloy	W	W
Tool	161	248
Superalloys	3,319	4,034
Alloys (excludes alloy steels and superalloys):		
Cutting and wear-resistant materials[1]	638	666
Welding materials (structural and hard-facing)	446	472
Magnetic alloys	1,544	1,711
Nonferrous alloys	145	169
Other alloys	56	72
Mill products made from metal powder	W	W
Chemical and ceramic uses:		
Pigments	382	366
Catalysts	789	1,064
Ground coat frit	477	651
Glass decolorizer	32	41
Drier in paints or related usage	1,114	1,503
Feed or nutritive additive	52	51
Miscellaneous and unspecified	148	217
Total	9,468	11,319

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	1979	1980	1981	1982	1983
Metal	12,006	10,825	7,450	6,055	7,165
Oxide	704	441	557	732	938
Purchased scrap	1,170	1,183	972	871	723
Chemical compounds (organic and inorganic) other than oxide	3,254	2,475	2,421	1,643	2,297
Other	268	397	280	167	196
Total	17,402	15,321	11,680	9,468	11,319

PRICES

The listed producer price of cobalt cathodes remained at $12.50 per pound throughout 1983 but was irrelevant because spot prices, which were much lower, prevailed in the market. The spot price began the year at a low of $4.75 per pound, rose to a high of $6.40 per pound in April and ended the year at $6.00 per pound of cobalt cathodes.

Table 5.—Yearend published prices of cobalt materials for 1983[1]

Material	Price per pound
Cobalt:	
Powder	$6.91
Fine powder	10.11
Cobalt oxide:	
Ceramic-grade (70% cobalt)	4.90
Ceramic-grade (72% cobalt)	5.04
Metallurgical-grade (76% cobalt)	5.21

[1]Metals Week. V. 54, No. 52, Dec. 27, 1983, p. 5.

FOREIGN TRADE

Exports of unwrought cobalt metal and waste and scrap totaled 1,089,000 pounds, gross weight, with an estimated 824,000 pounds cobalt content valued at $5.7 million. These exports were shipped to 42 countries with the following, in descending order, receiving the largest quantities: Belgium-Luxembourg, the Netherlands, Japan, Taiwan, the United Kingdom, and Canada. Exports of wrought metal totaled 615,000 pounds, gross weight, valued at $5.6 million. Of the 33 countries to which wrought cobalt was shipped, the major recipients, in descending order, were China, Ireland, France, Canada, and the United Kingdom.

Total imports were 17.2 million pounds (contained weight). The major sources of cobalt imports, in descending order, were: Belgium-Luxembourg, Canada, Finland, Norway, Zaire, and Zambia. Material originating in south-central Africa, that is, imports from Belgium-Luxembourg (Zairian origin), Botswana, the Republic of South Africa, Zaire, and Zambia, represented 68% of total cobalt imports during the year, compared with 55% from that area in 1982.

Table 6.—U.S. imports for consumption of cobalt, by class

(Thousand pounds and thousand dollars)

Class	1981	1982	1983
Metal:[1]			
Gross weight	13,906	11,610	15,853
Cobalt content[e]	13,906	11,610	15,853
Value	$238,820	$137,652	$110,076
Oxide:			
Gross weight	444	362	403
Cobalt content[e]	329	268	298
Value	$5,375	$2,560	$1,813
Salts and compounds:			
Gross weight	1,249	1,340	1,671
Cobalt content[e]	375	404	502
Value	$4,969	$2,650	$2,244
Other forms:[2]	984	588	568
Value	$11,650	$4,552	$1,969
Total content	15,594	12,870	17,221

[e]Estimated.
[1]Includes unwrought metal and waste and scrap.
[2]Contained cobalt in nickel-copper and nickel matte.

Table 7.—U.S. import duties for cobalt

Item	TSUS No.	Most favored nation (MFN) Jan. 1, 1983	Most favored nation (MFN) Jan. 1, 1987	Non-MFN Jan. 1, 1983
Ore and concentrate	601.18	Free	Free	Free.
Unwrought metal, waste and scrap	632.20	do	do	Do.
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	5.1% ad valorem	4.2% ad valorem	30% ad valorem.

Table 8.—U.S. imports for consumption of cobalt, by country

(Thousand pounds and thousand dollars)

Country	Metal[1]				Oxide				Other forms[2]				Total content[3 4]	
	1982		1983		1982		1983		1982		1983			
	Gross weight	Value	Gross weight	Value	Gross weight	Value	Gross weight	Value	Cobalt content	Value	Cobalt content	Value	1982	1983
Australia	6	23	---	---	2	19	---	---	162	[5]1,263	168	[5]578	169	168
Belgium-Luxembourg	369	4,345	816	5,469	225	1,397	187	789	77	660	168	1,043	613	1,123
Botswana	---	---	---	---	---	---	---	---	364	[5]2,817	400	[5]1,391	364	400
Canada	1,391	13,382	1,886	11,776	107	881	19	91	12	141	50	247	1,483	1,950
Finland	798	10,423	1,017	6,712	---	---	---	---	---	---	---	---	798	1,017
France	324	3,131	79	246	---	---	---	---	12	71	12	64	336	91
Germany, Federal Republic of	194	2,154	39	357	4	43	2	15	58	885	39	266	255	79
Japan	1,020	8,734	442	2,138	---	---	11	50	4	37	12	49	1,024	462
Netherlands	27	653	499	2,541	([6])	6	---	---	---	---	8	37	28	507
Norway	852	9,053	707	3,592	---	---	---	---	---	---	([6])	2	852	707
South Africa, Republic of	---	---	---	---	---	---	---	---	266	[5]1,127	185	281	266	185
United Kingdom	238	1,947	237	606	---	---	144	677	33	162	23	213	271	367
Zaire	4,971	68,704	7,721	63,082	---	---	---	---	---	---	2	6	4,971	7,723
Zambia	1,164	11,323	2,347	13,226	---	---	---	---	([6])	([6])	---	---	1,164	2,347
Zimbabwe	---	---	32	143	---	---	---	---	---	---	---	---	---	32
Other	254	3,780	31	188	24	214	40	191	4	39	4	36	276	64
Total[4]	11,610	137,652	15,853	110,076	362	2,560	403	1,813	992	7,202	1,070	4,212	12,870	17,221

[1]Includes unwrought metal and waste and scrap.
[2]Contained cobalt in nickel-copper and nickel matte from Australia, Botswana, and the Republic of South Africa. Salts and compounds were imported from the remaining countries.
[3]Estimated contained cobalt.
[4]Data may not add to totals shown because of independent rounding.
[5]Based on weighted average cobalt metal price of \$8.56 (revised) per pound for 1982 and \$5.76 per pound for 1983, multiplied by 0.6 (estimated factor for matte) for imports from Australia, Botswana, and the Republic of South Africa.
[6]Less than 1/2 unit.

WORLD REVIEW

Australia.—Production at the Greenvale nickel-cobalt mine in Queensland was cut by one-half. Prior to the cutbacks, the mine had been operating at full capacity. According to reports, many of Greenvale's customers had been contractually obligated to buy its products and those contracts expired.

Botswana.—Botswana RST Ltd., a nickel-copper-cobalt producer, was forced to reschedule outstanding loans and obtain additional financing. A subsidiary company, Bamangwato Concessions Ltd. (BCL), operated the Selebi-Pikwe Mine. AMAX Nickel Inc. exercised its option, under an existing contract, to purchase all of the nickel-copper-cobalt matte produced by BCL. Since the end of 1981 AMAX Nickel had only been buying 75% of the matte production. Beginning April 1, 1983, the matte was shipped in the form of pellets.

Canada.—Inco Ltd.'s electrolytic cobalt refinery at Port Colborne, Ontario, became operational during the year. This refinery was closed on December 26 for 5 weeks as part of Inco's nickel inventory adjustment. Plans called for a similar, 4-week shutdown beginning July 2, 1984. The plant's production capacity was 2 million pounds per year. Inco resumed development of its open pit mine at Thompson, Manitoba. The project, which had been deferred in 1982 because of Inco's capital expenditure cutbacks, was to replace an existing open pit mine that was expected to be depleted in 1985. Plans called for the transfer of a 70-person work force to the Thompson pit. Inco also planned to use its new milling process to reject more of the sulfur-bearing pyrrhotite into the tailings before the concentrate reached the smelter at Sudbury, Ontario.

Falconbridge Ltd. transferred its 50% share of the Windy Craggy copper-cobalt project to its joint venture partner, Geddes Resources Ltd., in return for a royalty equal to 22.5% of net proceeds should the project develop into a mine. The royalty was to be payable only after Geddes recouped its exploration and development costs. The Windy Craggy deposit, in northwestern British Columbia, was reported to have an inferred tonnage of more than 330 million short tons with grades of 1.52% copper and 0.08% cobalt.

China.—A rich cobalt deposit was reported to have been found in northeast Hainan Island. It was described as not only the single largest known cobalt deposit in the country, but the first primary cobalt deposit as well. The deposit was said to be shallow and easy to develop. Tests indicated that beneficiation and smelting efficiencies were excellent and that nickel could also be extracted.

Cuba.—Reports indicated that Cuba planned to greatly increase its nickel production capacity, which would normally affect cobalt production; however, it was uncertain how these plans would affect cobalt production. Existing facilities at Moa Bay and Nicaro were to be expanded. Plans had called for two more facilities to be built, but the Las Camariocas project was reported to be postponed indefinitely in order to bring the Punta Gorda complex into full production at the end of the decade.

Finland.—Outokumpu Oy, the Government-owned mining company, began selling a full range of cobalt salts. The salts were produced at a new plant at Kokkola. Outokumpu was investigating a deposit of black schist near Solamo in eastern Finland. The deposit contained an estimated 275 to 330 million tons of low-grade ore, about one-half of which could be extracted by open pit mining. The ore averaged 0.26% nickel, 0.52% zinc, 0.14% copper, and 0.02% cobalt. Pilot plant operations were conducted to test the technical and economic feasibility of a new process to extract the metal values.

Elsewhere in Finland, the Luikonlahti Mine, owned by Myllikoski Oy, ceased mining operations. The mine had been operating since 1971.

India.—Deposits containing cobalt, nickel, and other metals were found in the northeastern State of Arunachal Pradesh. There were also reports of cobalt-containing manganese nodules found during a survey of the waters off the west coast. Plans called for a similar survey of the east coast.

Japan.—Japanese cobalt production declined considerably owing to problems in obtaining feedstocks. Sumitomo Metal Mining Co. Ltd. ceased production in December 1982, when its supply of concentrate was cut off by the temporary shutdown of its supplier, Marinduque Mining and Industrial Corp. (MMIC), of the Philippines. Sumitomo cobalt production resumed in August 1983. Nippon Mining Co. Ltd., the other Japanese producer, was forced to curtail production owing to reduced concentrate supplies from Greenvale, Australia.

Kobe Steel Ltd. began operating a superalloy powder pilot plant with a capacity of 110 tons per month. The new facility was located at the company's Kobe works and consisted of a vacuum melting furnace, an argon gas atomizing unit, a powder handling unit and a clean room.

Papua New Guinea.—Nord Resources was reported to have been looking for a joint venture partner to participate in the development of the Ramu River cobalt-nickel-chromium deposit. The deposit was reported to contain about 300 million pounds of cobalt.

Peru.—A Government mining company received a grant from the U.S. Trade and Development Program to study the feasibility of producing a cobalt concentrate from pyrite rejects from the Marcona Mine in southern Peru. The $400,000 grant, made to Empresa Minera del Hierro del Perú, stipulated that, if cobalt was produced from the mine, U.S. technology and equipment were to be used and the product was to be made available to the United States.

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

(Short tons)

Country	Mine output, metal content[2]					Metal[3]				
	1979	1980	1981	1982[p]	1983[e]	1979	1980	1981	1982[p]	1983[e]
Australia[4]	1,745	2,177	[r,e]1,836	[r,e]1,995	2,000	--	--	--	--	--
Botswana	324	249	280	280	280	--	--	--	--	--
Brazil	NA	NA	NA	NA	[5]130	--	--	--	--	--
Canada[6]	1,808	1,767	2,293	1,548	[5]1,746	667	763	1,003	1,148	[5]1,168
Cuba	1,356	1,778	1,890	[e]1,650	1,820	--	--	--	--	--
Finland	1,174	1,141	1,140	1,025	1,000	1,281	1,269	1,355	1,604	[5]1,709
France	--	--	--	--	--	850	745	493	[e]550	--
Germany, Federal Republic of	--	--	--	--	--	424	[r,e]330	[r,e]160	[r,e]160	160
Japan	--	--	--	--	--	2,924	3,160	2,669	2,141	[5]1,511
Morocco	1,059	924	870	[e]770	--	--	--	--	--	--
New Caledonia[7]	[r]274	[r]395	[r]407	299	300	--	--	--	--	--
Norway	--	--	--	--	--	1,051	1,405	1,592	1,092	1,100
Philippines	1,510	1,467	1,099	629	660	--	--	--	--	--
U.S.S.R.[e]	2,200	[r]2,300	[r]2,400	[r]2,500	2,600	[r]4,200	[r]4,600	4,700	[r]4,700	5,000
United Kingdom[e 8]	--	--	--	--	--	375	800	800	800	800
United States	--	--	--	--	--	464	500	447	508	[5]103
Zaire	[e]16,530	[r,e]17,000	[r,e]17,000	[e]12,460	12,460	15,464	15,964	12,262	6,143	6,060
Zambia	4,718	4,850	3,765	[e]3,580	3,530	3,501	3,649	2,833	2,696	2,650
Zimbabwe	[e]230	[e]130	[e]110	[r,e]110	70	225	127	103	107	55
Total	[r]32,928	[r]34,178	33,090	26,846	26,596	[r]31,426	33,312	28,417	21,649	20,316

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

[1]Table includes data available through May 9, 1984.

[2]Figures presented 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. Data series represent content of intermediate metallurgical products (cobalt oxide and nickel-cobalt sulfide) produced and reported by Australia.

[5]Reported figure.

[6]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.

[7]Series reflects recovery from ores and intermediate metallurgical products exported from New Calendonia to France, Japan, and the United States. The estimated content of total ores mined is as follows, in short tons: 1979—3,314 (revised); 1980—3,527 (revised); 1981—3,074 (revised); 1982—2,351; and 1983—2,320 (estimated).

[8]Estimated recovery of elemental cobalt in refined cobalt oxides and salts from intermediate metallurgical products originating in Canada.

NOTE: Footnote 4 on Australia is taken from Australia Mineral Industry Annual Review—1979 (p. 95, table 1). Footnote 7 on New Calendonia is taken from New Calendonia table "Content by analysis."

Philippines.—Owing to severe financial difficulties, a major cobalt, nickel, and copper producer, MMIC was granted a further 5-year exemption from taxes, fees, and other charges payable to both state and national governments. MMIC facilities were closed from December 1982 to May 1983 for conversion from oil-fired boilers to coal-fired boilers.

Saudi Arabia.—The Arabian Shield Development Co. reported the completion of prefeasibility studies on developing a nickel and iron deposit at Wadi Qatan. The possibility of producing 800,000 pounds of cobalt per year was being considered.

Uganda.—An official of the Lands, Water and Mineral Resources Ministry reportedly announced that the renovation of the Kilembe copper mines was to go ahead. The renovation was expected to cost about $100 million and was to be accomplished in two phases. The first phase was to consist of upgrading and modernizing the copper mine and mill, while the second phase was to involve the construction of a cobalt recovery facility. Feedstock for the facility was to consist of pyrite concentrate tailings that have accumulated since the mine opened in 1971. It was estimated that several million tons of concentrates, containing 1.4% cobalt and 38% iron, were present at the site in 1983.

U.S.S.R.—Cobalt, nickel, copper, platinum-group metals, and other byproduct production capacity were being expanded at the Noril'sk complex in east Siberia.

Zaire.—The International Bank for Reconstruction and Development (World Bank) approved a loan to Zaire; the $32 million loan was to be used to rehabilitate facilities at two major ports and to strengthen the management of La Générale des Carrières et des Mines du Zaire, the state-owned mining company.

Zambia.—As part of its efforts to upgrade its mining facilities, Zambia Consolidated Copper Mines Ltd. ordered a crusher for a mine near Chambishi and was spending $34 million on two new pumping stations for its Konkola division. An electrolytic cobalt plant at Rokana was officially opened.

Zimbabwe.—Rio Tinto (Zimbabwe) Ltd. closed its Eiffel Flats nickel-copper-cobalt refinery. The company failed to negotiate a new contract to provide nickel-copper-cobalt matte from Botswana.

The Government agreed to the closure of the Empress Nickel Mine owing to escalating costs, depressed nickel prices, and technical mining problems.

TECHNOLOGY

The Bureau of Mines published a report composed of a compilation of the state of the science in Pacific Ocean manganese nodule mineralogy and elemental chemistry.[2] The report was divided into three sections: morphology, mineralogy, and elemental composition. The nodule morphology section defined what was considered a nodule for the study, and detailed the external characteristics and internal structure. Nodule mineralogy was discussed in three sections: manganese minerals, iron oxide minerals, and accessory minerals. The elemental composition section presented data on 74 elements occurring as cations or anions. Further Bureau research on manganese nodules included a report on the methods of characterizing the nodules and their processing wastes.[3]

A Bureau report on nodule processing updated a previous National Oceanic and Atmospheric Administration study.[4] The updated report contained detailed flowsheets and descriptions of the five potential first-generation nodule recovery schemes most likely to be used by industry. These were: high-temperature gas reduction and ammoniacal leach, cuprion ammoniacal leach, high-temperature and high-pressure sulfuric acid leach, reduction and hydrochloric acid leach, and smelting and sulfuric acid leach.

Another Bureau report on nodules concerned estimating the tonnage and grade of deposits with significant potential and describing and estimating the profitability of operations designed to mine and process deposits with the greatest apparent potential.[5] Analysis of over 800 sample locations identified three areas for detailed study. The Bureau published a study of the characterizations of lateritic nickel-cobalt ores by electron-optical and X-ray techniques.[6] For comparison, the study included the transition-type, low-grade laterite found in northern California and southern Oregon as well as the limonitic-type laterites from New Caledonia and the Philippines. Results showed that for both laterite types studied, most of the nickel and minor amounts of cobalt were associated with the mineral geothite. Most of the cobalt and minor amounts of nickel were associated with a mixed manganese oxide mineral.

The other Bureau publication on laterites in 1983 focused on the effluents generated from their processing.[7] The results indicated a method of washing residues that prevented significant amounts of nickel and cobalt from being absorbed in those residues and thus improved the overall metal recovery.

The Bureau also conducted research on solvent extraction to evaluate the usefulness of neodecanoic acid for extracting cobalt from ammoniacal leach liquors high in ammonium sulfate.[8] The resulting report discussed the fundamental problems involved in the electrolytic recovery of cobalt from extractants of the cobaltic amines.

The copper-nickel ore of the Duluth Gabbro Complex in northeastern Minnesota is a large potential domestic resource of cobalt and platinum-group metals. However, because of the low grade of the primary metal values, 0.5% copper and 0.15% nickel, the private sector assigned a relatively low priority to the development of technology for processing this ore. As part of an effort to help provide the basis for technology to recover critical and strategic minerals from domestic resources, the Bureau investigated methods to recover all of the mineral values in the Duluth Gabbro material with particular attention to the byproduct critical minerals. A report resulting from this effort described a direct smelting method that removed most of the iron to produce a copper-nickel-cobalt matte from which the metal values were recovered.[9]

The Bureau investigated a method for increasing the leaching rate of bulk superalloy scrap to facilitate recycling and recovery of critical metals such as cobalt, nickel, and chromium.[10] Three superalloys were melted with varying percentages of aluminum metal to form intermetallic compounds. These compounds were easily crushed to a convenient particle size and reacted rapidly with acid solutions that dissolved the metals. Superalloys were found to dissolve in acid solutions much more quickly when part of an intermetallic compound and when the surface area was larger. The separation of cobalt and nickel from sulfate solutions by solvent extraction was investigated.[11] Recently developed solvent-extraction reagents showed much improved selectivity for cobalt compared with established extractants. The new reagents had the added advantage of operating efficiently at ambient temperatures.

The process technology used at AMAX Nickel's Port Nickel hydrometallurgical complex was described.[12] Some of the more innovative practices were presented, which included the pressure leaching of nickel-copper mattes, separation of cobalt from nickel in sulfate solution by ammonium persulfate, improved practices for producing nickel powder by hydrogen reduction from nickel sulfate solution, modified pentammine processing with ion exchange for cobalt purification, and sulfide scavenging of nickel and cobalt from ammonium sulfate liquor.

A hydrometallurgical process, developed for the production of cathode cobalt from Blackbird cobaltite-pyrite concentrate, was described.[13] The process was based on the selective dissolution of cobaltite and has been demonstrated on a miniplant scale.

An acid leach process, developed by AMAX for the treatment of nickel oxide ores, such as laterite, was described.[14] An important feature of the process which was demonstrated in an integrated pilot plant, was the recycling of reagents resulting in the reduction of waste effluent streams.

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[1]Physical scientist, Division of Ferrous Metals.

[2]Haynes, B. W., S. L. Law, and D. C. Barron. Mineralogical and Elemental Description of Pacific Manganese Nodules. BuMines IC 8906, 1982, 60 pp.

[3]Haynes, B. W., D. C. Barron, G. W. Kramer, and S. L. Law. Methods for Characterizing Manganese Nodules and Processing Wastes. BuMines IC 8953, 1983, 10 pp.

[4]Haynes, B. W., S. L. Law, and R. Maeda. Updated Process Flowsheets for Manganese Nodule Processing. BuMines IC 8924, 1983, 100 pp.

[5]Hillman, C. T. Manganese Nodule Resources of Three Areas in the Northeast Pacific Ocean: With Proposed Mining-Beneficiation Systems and Costs. A Minerals Availability System Appraisal. BuMines IC 8933, 1983, 60 pp.

[6]Chandra, D., C. O. Rudd, and R. E. Siemens. Characterization of Lateritic Nickel Ores by Electron-Optical and X-Ray Techniques. BuMines RI 8835, 1983, 12 pp.

[7]Powers, L. A., and R. E. Siemens. Examination of Effluents Generated From Processing Domestic Laterites. BuMines RI 8797, 1983, 13 pp.

[8]Penner, L. R., D. E. Traut, and J. L. Henry. Neodecanoic Acid as a Co^{3+} Solvent Extractant. BuMines RI 8826, 1983, 10 pp.

[9]Shah, I. D., P. L. Ruzzi, and R. B. Schluter. Low-Iron Cu-Ni-Co Matte From Duluth Complex Sulfide Concentrate by Direct Smelting. BuMines RI 8752, 1983, 10 pp.

[10]Atkinson, G. B. Increasing the Leaching Rate of Bulk Superalloy Scrap by Melting With Aluminum. BuMines RI 8833, 1983, 11 pp.

[11]Preston, J. S. Recent Developments in the Separation of Nickel and Cobalt From Sulfate Solutions by Solvent Extraction. J. S. Afr. Inst. Min. Metall., v. 83, No. 6, June 1983, pp. 126-132.

[12]Crnojevich, R., D. H. Wilkinson, and J. L. Blanco. Contributions to the Hydrometallurgy of Nickel, Copper and Cobalt in the AMAX Inc. Port Nickel Plant. Paper in Hydrometallurgy Research, Development, and Plant Practice, Metall. Soc. AIME, 1983, pp. 941-953.

[13]Harris, G. B., S. Moette, and R. W. Stanley. Hydrometallurgical Treatment of Blackbird Cobalt Concentrate. Paper in Hydrometallurgy Research, Development, and Plant Practice, Metall. Soc. AIME, 1983, pp. 139-150.

[14]Mahesh, C. J., and G. A. Meyer. AMAX Chloride Refining Process for Recovery of Nickel and Cobalt From Mixed Sulfide Precipitates. Paper in Hydrometallurgy Research, Development and Plant Practice, Metall. Soc. AIME, 1983, pp. 903-924.

Columbium and Tantalum

By Larry D. Cunningham[1]

The United States continued to be dependent on imports as there was no domestic mine production of either columbium or tantalum minerals. Imports for consumption of columbium mineral concentrates increased substantially with Canada continuing as the major source of supply. However, imports for consumption of tantalum mineral concentrates fell to the lowest level in three decades as processors continued to draw from in-house inventories. There were no imports of tantalum materials from Canada, because tantalum production there was suspended for the entire year. To ensure future availability to the United States, contracts for purchase of tantalum materials for the National Defense Stockpile were awarded by the General Services Administration (GSA).

Reported consumption of columbium in the form of ferrocolumbium and nickel columbium increased modestly from that of 1982. This increase corresponds with the gains made in the carbon and the stainless and heat-resisting segments of the steelmaking industry. Columbium consumption in superalloys experienced substantial improvement. Increases in reported shipments of tantalum products and sales of tantalum capacitors indicated some recovery in the depressed tantalum market.

Prices for columbium and tantalum raw materials and products remained stable. Net trade for columbium and tantalum continued at a deficit with overall trade volume down for both imports and exports.

Thailand was granted a loan from the International Bank for Reconstruction and Development (World Bank) to construct a tantalum-processing facility in that country. This development has the potential for altering the future pattern of movement for a significant proportion of tantalum supply.

Table 1.—Salient columbium statistics

(Thousand pounds of columbium content unless otherwise specified)

	1979	1980	1981	1982	1983
United States:					
Mine production of columbium-tantalum concentrates	--	(1)	(1)	(1)	--
Releases from Government excesses	--	--	--	--	--
Consumption of raw materials	2,402	3,122	1,983	e1,900	e1,900
Production of ferrocolumbium	969	2,028	1,145	W	W
Consumption of primary products: Ferrocolumbium and nickel columbium	6,337	6,503	6,244	3,679	4,318
Exports: Columbium metal, compounds, alloys (gross weight)e	100	120	150	100	100
Imports for consumption:					
Mineral concentrate	1,690	2,320	1,050	580	730
Columbium metal and columbium-bearing alloys	e4	73	(2)	e9	e2
Ferrocolumbiume	5,515	5,918	6,068	3,128	2,539
Tin slags3	1,133	1,417	r842	e636	W
World: Production of columbium-tantalum concentrates	r31,709	33,359	32,664	p23,388	e18,680

eEstimated. pPreliminary. rRevised. W Withheld to avoid disclosing company proprietary data.
1A small unreported quantity was produced.
2Less than 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)

	1979	1980	1981	1982	1983
United States:					
Mine production of columbium-tantalum concentrates	--	(1)	(1)	(1)	--
Releases from Government excesses	--	--	--	--	--
Consumption of raw materials	1,740	1,863	1,269	e800	e900
Exports:					
Tantalum ore and concentrate (gross weight)[2]	329	468	99	235	121
Tantalum metal, compounds, alloys (gross weight)	426	524	205	382	211
Tantalum and tantalum alloy powder (gross weight)	296	251	97	115	123
Imports for consumption:					
Mineral concentrate	630	860	650	440	180
Tantalum metal and tantalum-bearing alloys	144	r 3 93	r 3 34	r 3 71	3 27
Tin slags[4]	1,140	1,327	r896	e576	W
World: Production of columbium-tantalum concentrates	1,049	r1,168	822	p690	e678

eEstimated. pPreliminary. rRevised. W Withheld to avoid disclosing company proprietary data.
[1]A small unreported quantity was produced.
[2]Includes reexports.
[3]Exclusive of waste and scrap.
[4]Receipts reported by consumers; includes synthetic concentrates and other miscellaneous materials, after deduction of reshipments.

Table 3.—Columbium and tantalum materials in Government inventories as of December 31, 1983

(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 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 tantalum minerals shortfall. Total offset was 271,000 pounds.
[4]100 pounds.

Domestic Data Coverage.—Domestic production data for ferrocolumbium are developed by the Bureau of Mines from the annual voluntary survey for ferroalloys. Of the four domestic operations to which a survey was sent, 100% responded, representing 100% of total production. Ferrocolumbium production data are withheld for 1983 to avoid disclosing company proprietary data.

Legislation and Government Programs.—The National Defense Stockpile goals and inventories for columbium and tantalum materials did not change, and there were no sales of stockpile excess materials.

In October, GSA agreed to purchase tantalum materials containing 244,200 pounds of tantalum pentoxide (Ta_2O_5), equivalent to approximately 200,000 pounds of tantalum, for the National Defense Stockpile. The purchase followed a solicitation in June for tantalum natural mineral and concentrates containing up to 305,250 pounds of Ta_2O_5 to be provided in five lots containing not less than 61,050 pounds of Ta_2O_5 per lot. 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%. Under the contracts, Greenbushes Tin Ltd., Australia, will supply two 61,050-pound lots of Ta_2O_5 and Norore Corp. and Bomar Resources Inc., both of New York, NY, will each supply a 61,050-pound lot of Ta_2O_5 with the average purchase price being about $31.62 per pound of contained Ta_2O_5, f.o.b. the Hammond, IN, storage depot. Material deliveries are to be completed within 365 days after the effective date of the contracts.

In the February 17, 1983, Federal Register, the Environmental Protection Agency proposed effluent limitation guidelines and standards under the Clean Water Act for nonferrous metals including columbium and tantalum. The proposed effluent limits are based on best practicable technology, best available technology, and best conventional technology to handle water wastes.

DOMESTIC PRODUCTION

Domestic production of ferrocolumbium, expressed as contained columbium, was up 10% from that of 1982. Value of ferrocolumbium production increased to an estimated $9.6 million. The regular grade continued to be favored over the high-purity grade of ferrocolumbium in the production mix.

All columbium- and tantalum-bearing concentrates were imported, but a major tantalum processor was considering future domestic mining of low-grade tantalum ores.[2]

Tantalum content of raw materials consumed by processors in the production of tantalum compounds and metals was estimated to be about 900,000 pounds. In addition, consumption of purchased metal scrap was estimated at about 40,000 pounds.

The H. K. Porter Co. Inc. distributed all of the common stock it held in Fansteel Inc. to the company's shareholders on May 31, 1983. This amounted to nearly 96% of Fansteel's outstanding shares.[3]

The Pesses Co., Solon, OH, producer of a wide range of ferroalloys including ferrocolumbium, was declared bankrupt by a Federal judge in Cleveland, OH. Three creditors of the company filed a petition in Federal Bankruptcy Court seeking liquidation of the firm under Chapter 7 of the Federal Bankruptcy Code.

Ashland Chemical Co., Columbus, OH, expanded its line of foundry products to include specialty metals and alloys. A Cleveland, OH, plant was retrofitted with a new furnace that now provides a capability for producing high-purity ferrocolumbium and nickel columbium.

Table 4.—Major domestic columbium and tantalum processing and producing companies in 1983

Company	Plant location	Products[1] Metal[2] Cb	Metal[2] Ta	Carbide Cb	Carbide Ta	Oxide and/or salts Cb	Oxide and/or salts Ta	FeCb and/or NiCb
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	--	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

[1]Cb, columbium; Ta, tantalum; FeCb, ferrocolumbium; NiCb, nickel columbium.
[2]Includes miscellaneous alloys.
[3]Jointly owned by South American Consolidated Enterprises S.A. and H. C. Starck Berlin.

CONSUMPTION, USES, AND STOCKS

Overall reported consumption of columbium as ferrocolumbium and nickel columbium rose by 17%, a reversal of the downward trend that existed in 1981 and 1982. Consumption of columbium by the steelmaking industry increased 11%, in line with a 12% increase in raw steel production, with virtually no change in the percent of columbium usage per short ton of steel produced. Consumption in the carbon and the stainless and heat-resisting steels increased by 16% and 47%, respectively, again following the pattern of production increases for these grades of steels. Increased demand in the automotive and other consumer product industries contributed to the advances. However, columbium demand in high-strength, low-alloy (HSLA) steels continued to fall, a decline of more than 40% from the 1981 peak year total.

Demand for columbium in superalloys was up by more than 40%. However, that portion used in the form of nickel columbium continued to decline by 6% to less than 260,000 pounds, indicating a shift to ferrocolumbium.

The Tantalum Producers Association reported a 15% rise in overall tantalum shipments, indicating some recovery in the market. This was the first increase in shipments since 1979. Major segments of the tantalum market showing increases were powder and anodes and mill products. Changes in the reporting method for some of the materials contributed to the substantial increase in the alloy additives segment. Tantalum for cemented carbide advanced by almost 40% as a result of improvements made in the automotive industry and in the production of consumer goods. However, manufacturers in this market continued to conserve tantalum with scrap recycling programs, substitutions, and product redesigns to reduce or eliminate tantalum.

Factory sales of tantalum capacitors rose by 12% as reported by the Electronic Industries Association. This was the highest level since 1980. Stable tantalum prices and improvements in the electronics and automotive industries helped to strengthen the tantalum capacitor market. However, continued improvement in tantalum capacitor powder coupled with substitution of aluminum and ceramic capacitors in the consumer electronic industries contributed to a lesser demand for tantalum powder. By yearend, Sprague Electric Co. had started production of solid tantalum capacitors at its new capacitor-manufacturing facility in San Antonio, TX. The new facility supplements Sprague's capacitor plants in Sanford, ME, and Concord, NH. Western Electric Corp., a major producer of tantalum capacitors for in-house use, reportedly was considering a move into capacitor sales to outside consumers.[4]

Aggregated stocks of columbium and tantalum raw materials reported by processors for 1983 were incomplete at the time this chapter was prepared. Aggregate stocks of columbium and tantalum raw materials reported by processors for yearend 1982 contained an estimated 3.5 million pounds of columbium and 3.2 million pounds of tantalum, both down from yearend 1981 totals of 4.3 million pounds and 3.5 million pounds, respectively.

Table 5.—Reported shipments of columbium and tantalum materials

(Pounds of metal content)

Material	1982	1983
Columbium products:		
Compounds including alloys	562,680	1,049,500
Metal including worked products	355,400	424,400
Other	29,700	20,000
Total	947,780	1,493,900
Tantalum products:		
Oxides and salts	36,500	14,160
Alloy additive	31,700	104,020
Carbide	82,170	114,190
Powder and anodes	451,100	503,800
Ingot (unworked consolidated metal)	16,700	5,700
Mill products	168,020	214,100
Scrap	94,500	59,700
Other	--	--
Total	880,690	1,015,670

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]

	1982	1983
END USE		
Steel:		
Carbon	1,138,323	1,315,624
Stainless and heat-resisting	450,305	662,320
Full alloy	(2)	(2)
High-strength, low-alloy	1,411,992	1,348,814
Electric	--	(3)
Tool	(3)	(3)
Unspecified	7,453	24,641
Total	3,008,073	3,351,399
Superalloys	648,522	937,463
Alloys (excluding alloy steels and superalloys)	17,315	24,333
Miscellaneous and unspecified	5,077	4,877
Total consumption	3,678,987	4,318,072
STOCKS		
Dec. 31:		
Consumer	W	W
Producer[4]	W	W
Total stocks[e]	711,000	760,000

[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. A price for Brazilian pyrochlore concentrates remained unavailable; exports of the concentrates were stopped in 1981. The price of pyrochlore concentrates produced in Canada by Niobec Inc. was quoted throughout 1983 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. This price has remained unchanged since April 1980. The spot price of regular-grade ferrocolumbium containing 63% to 68% columbium was unchanged at $6 per pound of contained columbium, f.o.b. shipping point.

High-purity ferrocolumbium and nickel columbium experienced modest price changes. The quoted price for high-purity ferrocolumbium eased from $21 to $19.75 per pound of contained columbium in mid-March, and the price for nickel columbium was $21 per pound of contained columbium by yearend. Columbium metal price quotes remained unchanged. The spot price for columbite concentrates was quoted the entire year at $5 to $7 per pound of combined columbium and tantalum pentoxides. In October, the price for columbium oxide, both foreign and domestic, increased from about $6 to about $6.60 per pound of oxide, reportedly boosted by an upturn in demand.

Most tantalum prices remained virtually unchanged, with tantalum demand and trade volume for tantalite ore continuing at depressed levels. The spot market price for tantalite, on the basis of 60% combined tantalum and columbium pentoxides, c.i.f. U.S. ports, started the year at $20 to $25 and increased to $28 to $31 in the fourth quarter. The Canadian tantalum producer, Tantalum Mining Corp. of Canada Ltd., contract price for tantalite was 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 at about $150 per pound.

FOREIGN TRADE

Net trade remained at a deficit for both columbium and tantalum, but was at the lowest level since 1978. Overall trade volume and value was down for both exports and imports. Exports and reexports of tantalum ores and concentrates declined almost 50% to 121,000 pounds valued at $1.1 million. Belgium replaced the Federal Republic of Germany as the principal recipient with 95% 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 30%. Imports for consumption from Brazil included 3.9 million pounds of ferrocolumbium, down by nearly 20% and the lowest level reported in recent years. Imports for consumption of columbium oxide from Brazil increased significantly to 372,000 pounds valued at $1.8 million compared with 84,000 pounds valued at $468,000 in 1982. Estimated data for both ferrocolumbium and columbium oxide were based on entries in nonspecific classes.

Imports for consumption of columbium mineral concentrates increased by more than 60%; receipts from Canada almost doubled those of 1982. However, average unit value for overall imports decreased by 26% largely owing to the lower unit value for Canadian pyrochlore, which was more than 80% of the total quantity. Imports were estimated to contain 603,000 pounds of columbium and 33,000 pounds of tantalum at an average grade of approximately 58% Cb_2O_5 and 3% Ta_2O_5.

Table 7.—U.S. foreign trade in columbium and tantalum metal and alloys, by class

(Thousand pounds, gross weight, and thousand dollars)

Class	1982		1983		Principal destinations and sources, 1983
	Quantity	Value	Quantity	Value	
EXPORTS[1]					
Tantalum:					
Powder	115	16,231	123	14,397	Japan 37, $4,451; West Germany 26, $3,286; France 25, $2,885; United Kingdom 19, $2,408.
Unwrought and waste and scrap	330	11,231	154	5,892	West Germany 113, $3,207; Belgium-Luxembourg 17, $1,118; Japan 10, $845.
Wrought	52	7,267	57	7,032	United Kingdom 19, $2,187; Japan 13, $1,953; West Germany 11, $1,341; France 8, $771.
Total	XX	34,729	XX	27,321	West Germany $7,800; Japan $7,200; United Kingdom $4,900; France $3,900.[2]
IMPORTS FOR CONSUMPTION					
Columbium:					
Ferrocolumbium[e]	4,812	17,174	3,906	12,992	All from Brazil.
Unwrought metal and waste and scrap	1	15	3	39	West Germany 2, $30; France 1, $9.
Unwrought alloys	13	140	2	4	All from Brazil.
Wrought	--	--	(3)	2	Austria (3), [2]$2; United Kingdom (3), $(3).
Tantalum:					
Waste and scrap	97	3,614	122	2,803	West Germany 50, $1,500; United Kingdom 20, $372; Mexico 14, $222; France 20, $213.
Unwrought metal	67	6,858	23	2,022	West Germany 21, $1,979; Belgium-Luxembourg 1, $33.
Unwrought alloys	1	62	5	231	Belgium-Luxembourg 4, $196; Canada [2]1, $34.
Wrought	2	87	(3)	24	Austria (3), $18; United Kingdom (3), $4.
Total	XX	27,950	XX	18,117	Brazil $13,000; West Germany $3,500; United Kingdom $385; Belgium-Luxembourg $232.[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	1982		1983	
	Gross weight	Value	Gross weight	Value
Brazil	31	148	52	438
Canada	642	1,601	1,198	2,119
Malaysia	--	--	67	162
Nigeria	231	950	164	597
Zaire	7	66	--	--
Total[1]	910	2,765	1,482	3,316

[1]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	1982		1983	
	Gross weight	Value	Gross weight	Value
Australia	161	2,243	182	1,543
Brazil	260	3,111	240	1,749
Canada	373	7,215	--	--
China	14	174	--	--
Germany, Federal Republic of[1]	--	--	(2)	2
Malaysia	12	146	--	--
Mozambique	32	580	18	239
Nigeria	12	146	--	--
Portugal	11	131	--	--
South Africa, Republic of	19	199	9	112
Spain	7	80	--	--
Taiwan[1]	--	--	(2)	1
Thailand	328	1,276	55	159
Zaire	63	861	31	212
Zimbabwe	6	124	--	--
Total[3]	1,297	16,286	536	4,017

[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.

Imports for consumption of tantalum mineral concentrates were down nearly 60% to the lowest level in three decades, with the average unit value decreasing by 40%. Imports were estimated to contain 147,000 pounds of tantalum and 127,000 pounds of columbium. Average contents of Ta_2O_5 and Cb_2O_5 were 38% and 34%, respectively. Brazil accounted for over 40% of both the total quantity and total value, replacing Canada as the leading source, since Canada's production was suspended for the entire year.

Data on receipts of raw materials other than mineral concentrates were incomplete.

Imports for consumption of columbium-tantalum synthetic concentrates were down significantly: 2.1 million pounds valued at $14.9 million, compared with 2.7 million pounds valued at $24.9 million in 1982. These figures are not included in the salient statistics data.

WORLD REVIEW

The supply and consumption of tantalum on a worldwide and country-by-country basis was reported in a German language publication entitled "Tantal."[5] Major tantalum producers, in order of magnitude, were stated to be Thailand, Brazil, and Malaysia, with principal consuming countries being the United States, Japan, the Federal Republic of Germany, and the U.S.S.R. Approximately 55% of the total tantalum consumed was used for electrolytic capacitors and an additional 30% was used for hard metals.

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, and 1983 was, in thousand pounds, 1,133, 1,006, 991, and 1,049, respectively, according to data from the Tantalum Producers International Study Center.

Regarding the shipments of old tin slags, data were only available from Thailand. In 1983, Thailand reported no shipments of old tin slags compared with 36 short tons in 1982.

Developments having potential effects on tantalum supply included formation of the Association of Tin Producing Countries (ATPC) whose membership is comprised of six of the major tin-producing countries. The ATPC, headquartered in Kuala Lumpur, Malaysia, is reportedly aimed at pursuing cooperative research, development, and marketing activities. The Governments of Malaysia and Thailand both adopted measures in an effort to combat tin smuggling. In Malaysia, new regulations took effect that require permission from the Malaysian Primary Industries Ministry before tin concentrate can be imported. In Thailand, a proposal to reduce tin royalties was approved. Also, Thailand announced that producers would be allowed to maintain, in storage facilities as approved by the Ministry of Commerce, tin stockpiles in excess of their Government-allocated quota levels.

Australia.—For the fiscal year ending June 30, 1983, Greenbushes reported that its tin-tantalite mine operated at approximately 35% of installed capacity for the year. The tantalum market continued to be depressed, and tin export quotas remained in force. Ore treated was 730,000 cubic meters in fiscal year 1983, down from 826,000 cubic meters in fiscal year 1982. The tailings retreatment and alluvial treatment plants were out of operation for the entire year. The solvent extraction plant was also closed down and rebuilt for a continuous production capacity of 80,000 pounds of Ta_2O_5.

Greenbushes was no longer seeking joint venture partners to develop its underground mine and ore deposits. Terms satisfactory to the company were not available. However, funding was being arranged for new mine development and installation of a crushing and grinding plant to allow for initial production in early 1985. Development plans are to bring on-stream additional production of about 250,000 pounds of contained Ta_2O_5 from the new mine, with a projected capacity to double this production within 1 year. To meet anticipated increased demand for tantalum, Greenbushes' plan calls for an overall increase in production from 130,000 pounds of contained Ta_2O_5 in 1983 to 220,000 pounds in 1984, 450,000 pounds in 1985, and 650,000 pounds in 1986.

Brazil.—Late in 1983, the Cia. Brasileira de Metalurgia e Mineração restarted production of high-purity columbium oxide at its plant in Araxa. Production of the oxide had been suspended for about 2 years.

The Goiás Niobio S.A., a joint venture of Produtos Metalúrgicas S.A. and Metais de Goiás S.A., was studying the viability of bringing into production a mining and ferrocolumbium operation in the Catalao-Ouvidor region of Goiás in late 1984. Initial annual ferrocolumbium production is envisioned at about 1,200 tons.

Brazil's production and exports of ferrocolumbium continued to decline in 1983. Production and exports were 10,700 tons and 10,200 tons, respectively, compared with the 1982 totals of 12,700 tons and 12,200 tons, respectively.

Canada.—As reported by Teck Corp. for the fiscal year ending September 30, production of columbium oxide at the Niobec Inc. mine at St. Honoré, Quebec, was down about 40% to 4,000,600 pounds, compared with 6,889,189 pounds in 1982. The mine, which operated at capacity during its 7-year history, was closed from April 1 to August 22 to reduce accumulating columbium concentrate inventories at the mine and in the hands of customers. Ore milled was down almost 40% to 502,400 tons from 809,242 tons in 1982. Closed for 5 months, the mill operated on the average of 2,310 tons per day compared with the 2,325 tons per day in 1982. Estimated recovery was down to about 62% compared with the reported 68% in 1982, even though Cb_2O_5 grade of ore increased to 0.64% from 0.63% in 1982. Ore reserves declined at the end of the fiscal year to 12.6 million tons, content basis, at 0.66% Cb_2O_5 compared with about 13.0 million tons at 0.66% Cb_2O_5 in 1982.

The Hudson Bay Mining and Smelting Co. Ltd. (HBMS) reported that mining and milling activity at the Bernic Lake, Manitoba, operation of the Tantalum Mining Corp. of Canada Ltd. (Tanco) remained suspended throughout the year with no sales of Ta_2O_5. In midyear, HBMS became a wholly owned subsidiary of Inspiration Resources Corp. of New York, NY. HBMS has a 37.5% interest in Tanco and is responsible for the company's overall operation.

Shell Canada Resources Ltd. decided to

terminate mineral exploration activities at its Martison Lake property, a major columbium-phosphate deposit, north of Hearst, Ontario. Limited drilling indicated the deposit contains 154 million tons of ore potential grading 0.35% Cb_2O_5 and 20% phosphorous pentoxide. A joint venture of Camchib Resources Inc. and New Venture Equities Ltd. purchased the property from Shell Canada and indicated plans for a 2-year drilling program to allow accurate assessment of ore reserves, leading to a feasibility study.

Exploration and test work at other Canadian properties with potential for columbium and tantalum include that by Highwood Resources Ltd. at its Thor Lake columbium-tantalum-rare-earths deposit in the Northwest Territories. Completed gravity surveying suggests that the deposit is substantially larger than the drill-indicated ore body previously outlined at 77 million tons of ore grading 0.40% columbium, 0.03% tantalum, 3.5% zirconium, and 1.7% combined rare earths. Metallurgical studies were carried out on methods to recover the fine-grained tantalo-columbite crystals in the deposit. The Iron Ore Co. of Canada continued exploration and metallurgical studies at its Strange Lake deposit near Schefferville, Quebec. Minerals associated with the deposit include columbium, tantalum, and rare-earth elements.

China.—A joint research project was undertaken by China and Japan to extract columbium from Chinese iron ore. The research goal for the first year was to produce slag containing 10% columbium. Pig iron produced from iron ore mined in Baotou, Inner Mongolia, containing 0.1% to 0.2% columbium was being used in experiments conducted in Japan. The extraction process under development hopefully will provide a means for extracting columbium from the pig iron during the steelmaking process. Japanese sources have estimated Chinese deposits of columbium-bearing iron ore to contain 441 million tons.

Egypt.—The Egyptian Government continued to seek financial support for joint development of its Abu Dabbab and Nuweibi tantalum deposits, located in the Eastern Desert near the Red Sea coast. Factors thus far preventing such a venture include the high cost of mining hard-rock, low-grade material, and the lack of an infrastructure in the area. Geological evaluation suggests total combined ore reserves to be about 77 million tons. Capital costs for a mining project to develop reserves at the Nuweibi deposit have been estimated at $70 to $150 million.

France.—The state-owned Bureau de Recherches Géologiques et Minières (BRGM) reportedly identified a major tantalum deposit, second only to Greenbushes (Australia), 25 miles west of Vichy in southern France.[6] Preliminary drilling and evaluation of the Echassieres deposit suggests about 55 million tons of ore in a dome-like granite structure grading 0.023% Ta_2O_5, 0.022% columbium, 0.13% tin, and 0.71% lithium. Compagnie Française de Mines (Coframines), the industrial mining subsidiary of BRGM, undertook a feasibility study to exploit the richest portion of the main ore body having an estimated grade of 0.034% Ta_2O_5 and 0.14% tin. Financial partners were being sought to bring a mining operation on-stream having an initial annual capacity of about 39 tons of Ta_2O_5 and 165 to 176 tons of tin. Coframines' initial intention is to concentrate on tantalum.

Japan.—Production of ferrocolumbium was 584 tons, down substantially from the 1,145 tons produced in 1982. Columbium ore imported from Canada for ferrocolumbium production was 816 tons. Ferrocolumbium imports were 1,960 tons compared with 2,560 tons in 1982, the bulk of imports came from Brazil. Tantalum ore imports totaled 133 tons with 90% of the imports coming from Malaysia.

Namibia.—Natresco (Pty.) Ltd. of the Republic of South Africa continued to examine a tantalite deposit grading up to 50% Ta_2O_5 in the Tantalite Valley area of southern Namibia. Joint venture partners are being sought to establish a mine at the pegmatite deposit, which is under claim to Natresco.

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., continued to fall with a combined output of 121 tons compared with 182 tons in 1982. ATMN accounted for over 85% of production with the rest coming from Bisichi-Jantar.

The Government was considering a plan to bring the country's five major tin-producing firms under a new holding company in hopes of reviving its tin-mining industry. The Nigerian Mining Corp. would own 60% of the new company, the Nigerian Tin Mining Co. (NTMC). However, there was opposition to forming NTMC based on the high cost of investing in deep mine development and Nigeria's low tin export quota.

Table 10.—Columbium and tantalum: World production of mineral concentrates, by country[1]

(Thousand pounds)

Country[2]	Gross weight[3]					Columbium content[4]					Tantalum content[4]				
	1979	1980	1981	1982[p]	1983[e]	1979	1980	1981	1982[p]	1983[e]	1979	1980	1981	1982[p]	1983[e]
Argentina: Columbite	4	--	--	--	--	[r]2	--	--	--	--	([5])	--	--	--	--
Australia: Columbite-tantalite	379	351	657	595	440	76	70	118	100	80	125	116	230	200	150
Brazil:															
Columbite-tantalite	825	1,186	659	443	308	153	213	138	97	70	260	380	178	130	90
Pyrochlore	63,733	67,682	65,887	43,195	36,200	26,729	28,426	27,673	18,142	15,200	--	--	--	--	--
Canada:															
Pyrochlore	[e]9,229	[e]8,256	[e]9,040	[e]10,400	6,830	[6]3,872	[6]3,796	[6]4,224	4,728	2,870	--	--	--	--	--
Tantalite	[e]625	[e]620	[e]640	[e]590	--	17	17	19	18	--	[6]287	[6]208	[6]188	170	--
Malaysia: Columbite-tantalite	88	73	51	[e]22	134	22	18	8	3	51	7	8	4	2	17
Mozambique:															
Columbite[e]	5	NA	NA	NA	NA	1	NA	NA	NA	NA	2	NA	NA	NA	NA
Microlite	[e]70	NA	NA	NA	NA	3	NA	NA	NA	NA	40	NA	NA	NA	NA
Tantalite[e]	70	NA	NA	NA	NA	10	NA	NA	NA	NA	25	NA	NA	NA	NA
Nigeria:															
Columbite	1,250	1,221	831	400	245	550	537	363	180	110	75	73	48	24	15
Tantalite	2	2	2	2	2	([5])	([5])	([5])	([5])	([5])	1	1	1	1	1
Portugal: Tantalite	8	9	20	18	13	2	2	5	5	4	2	2	5	4	3
Rwanda: Columbite-tantalite	104	132	126	137	111	35	42	38	40	33	20	24	28	30	24
Spain: Tantalite	76	112	129	118	120	NA	NA	NA	NA	NA	[6]19	[r] [6]31	[6]36	[6]31	30
Thailand: Columbite-tantalite	897	785	106	86	1,210	209	171	18	15	205	152	259	23	20	278
Uganda: Columbite-tantalite[e]	5	--	--	--	--	1	--	--	--	--	1	--	--	--	--
United States: Columbite-tantalite	--	([7])	([7])	([7])	--	--	([7])	([7])	([7])	--	--	([7])	([7])	([7])	--
Zaire: Columbite-tantalite	71	203	165	176	176	20	57	45	48	48	15	43	46	50	50
Zimbabwe: Columbite-tantalite	65	90	99	79	57	7	10	15	12	9	18	23	35	28	20
Total	77,506	80,722	78,412	56,261	45,846	[r]31,709	33,359	32,664	23,388	18,680	1,049	[r]1,168	822	690	678

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available.
[1]Excludes columbium- and tantalum-bearing tin ores and slags. Table includes data available through May 16, 1984.
[2]In addition to the countries listed, China, 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, pyrochlore, and microlite 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.
[5]Less than 1/2 unit.
[6]Reported in official country sources.
[7]A small unreported quantity was produced.

Thailand.—Columbite-tantalite production increased more than tenfold, and struverite production was up to 303 tons from 11 tons in 1982. Thailand's Department of Mineral Resources was reported to be undertaking a series of projects involving the development of the country's mineral resources including both onshore and offshore surveys to determine tantalite and tin deposits.

The Thailand Tantalum Industry Corp. Ltd. (TTIC) was granted a loan of $53.5 million from the International Finance Corp., an affiliate of the World Bank, to construct a tantalum processing facility at Phuket. TTIC plans include a smelter for upgrading low- and medium-grade tin slags and a chemical plant for processing tantalum-bearing ores, high-grade tin slags, and upgraded materials from the smelter. The plant's eventual annual capacity was projected at levels up to 700,000 pounds of Ta_2O_5. Once operational, the plant is to have first access to all tin slags produced in Thailand. Early in the year, the Thailand Smelting and Refining Co. Ltd. (Thaisarco) abandoned its policy of paying miners for the tantalum content in tin concentrates. The payments started in 1980 when tantalum prices were at peak levels. Later in the year, Thaisarco's smelter was reported to be operating at less than one-half capacity owing to a shortfall in tin concentrates.

Zaire.—The French Coframines indicated plans to bring its mining project, Société Minière de Kania (Somika), into operation by yearend. Somika, a joint venture of Coframines (80%) and the Government of Zaire (20%), was located at Kania, in Zaire's Shaba Province. Tin was the dominant metal with tantalum as the byproduct.

TECHNOLOGY

The status of columbium (niobium) technology was reviewed in a comprehensive treatise entitled "Niobium, Proceedings of the International Symposium."[7] The review covered geology and mineralogy, mining, extraction and purification, properties of the metal and alloys, use in HSLA steels, applications, and future prospects.

The use of 0.04% columbium to strengthen 0.04% carbon steels was effective in achieving strengths in the range of 310 to 1,000 megapascals with adequate ductility to form moderately drawn shapes. The combination of strength and ductility is aided by low-residual elements in a vacuum degassed aluminum-killed, low-carbon steel.[8] In another review, the role that columbium and other alloying elements have played in the development of stronger and tougher steels was discussed.[9]

A superconducting generator was successfully tested by the General Electric Co., which the company termed a milestone accomplishment in ultralow-temperature research. Coils carrying an electric current to produce a magnetic field are made of a columbium-titanium alloy. At temperatures near absolute zero, the coils have almost no electrical resistance. The technology, if successfully applied commercially, would improve the efficiency of electrical generators and reduce fuel and construction costs for utilities.[10]

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[1]Physical scientist, Division of Ferrous Metals.

[2]American Metal Market. V. 91, No. 169, Aug. 31, 1983, pp. 1, 8.

[3]Fansteel Inc. 1983 Annual Report, 20 pp.

[4]American Metal Market. V. 91, No. 178, Sept. 13, 1983, pp. 1, 10.

[5]Krausz, U., H. Schmidt, C. Kippenberger, P. Eggert, D. Kamphausen, J. Priem, and E. Wettig. Untersuchungen über Angebot und Nachfrage mineralischer Rohstoffe. 17. Tantal. (Investigation of Supply and Demand of Mineral Raw Materials. 17. Tantalum.) Bundesanstalt Für Geowissenschaften und Rohstoffe and Deutsches Institut Für Wirtschaftsforschung, Hannover and Berlin, 1982, 279 pp.

[6]American Metal Market. Tantalum and Columbium Supplement. V. 91, No. 176, Sept. 9, 1983, pp. 4A, 12A.

[7]Stuart, H. (ed.) Niobium. Proc. Metall. Soc. AIME Int. Symp. on Niobium 81, San Francisco, CA, Nov. 8-11, 1981. Metall. Soc. AIME, Warrendale, PA, 1984, 1260 pp.

[8]Newby, J. R. Control of Strength and Ductility in HSLA Cb Treated Steels. Iron and Steelmaker, v. 10, No. 2, Feb. 1983, pp. 24-30.

[9]Irving, R. R. Micro Alloying the Route to Stronger Tougher Steels. Iron Age, v. 226, No. 5, Feb. 16, 1983, pp. 41-47.

[10]The Wall Street Journal. General Electric Co. Tests New Method To Produce Power. V. 201, No. 99, May 20, 1983, p. 58.

Copper

By J. L. W. Jolly[1] and D. L. Edelstein[1]

The depressed state of the U.S. copper mining industry continued in 1983. Increased imports of low-priced copper and the consequent increased domestic inventories and depressed prices resulted in the closure of several domestic mines. At yearend, 12 of the top 25 mines in operation in 1981 were closed in addition to 5 smaller mines. The industry reported domestic operating losses of $318 million—an improvement compared with the 1982 net loss of $515 million.[2] The domestic economy and copper demand improved toward yearend, and the excess copper stocks were beginning to decline. However, the economies of several of the more important copper consuming countries remained depressed, or were recovering at a much slower pace than that of the United

Table 1.—Salient copper statistics

	1979	1980	1981	1982	1983
United States:					
Ore produced ---- thousand metric tons--	277,532	221,597	277,674	[r]181,944	177,993
Average yield of copper -----percent--	0.47	[r]0.48	0.51	0.55	0.51
Primary (new) copper produced:					
From domestic ores, as reported by:					
Mines ---------- metric tons--	[r]1,446,586	1,181,116	1,538,160	[r]1,146,975	1,038,098
Value ---------- thousands--	[r]$2,966,891	$2,666,931	$2,886,440	[r]$1,840,856	$1,751,476
Smelters ---------- metric tons--	1,313,224	994,479	1,294,962	940,547	888,130
Percent of world total -------	16	13	16	[r]11	11
Refineries ---------- metric tons--	[r]1,412,797	[r]1,126,231	1,430,210	[r]1,064,533	1,003,668
From foreign ores, matte, etc., as reported by refineries ------------do----	103,858	88,957	113,807	162,245	178,422
Total new refined, domestic and foreign ----------do----	[r]1,516,655	[r]1,215,188	1,544,017	[r]1,226,778	1,182,090
Secondary copper recovered from old scrap only ----------------do----	604,301	613,458	598,122	517,726	455,153
Exports: Refined -------------do----	73,677	14,489	24,397	30,558	81,397
Imports for consumption:					
Unmanufactured ----------do----	281,584	547,006	429,601	505,986	643,511
Refined ---------------do----	203,855	426,948	330,625	258,439	459,568
Stocks, Dec. 31: Producers:					
Refined (primary producers) ---do----	64,000	49,000	151,000	268,000	154,000
Blister and materials in solution -do----	275,000	272,000	277,000	233,000	174,000
Total ---------------do----	339,000	321,000	428,000	501,000	328,000
Consumption:					
Refined copper ------------do----	2,158,442	1,862,096	2,025,169	1,658,142	1,767,469
Apparent consumption, primary and old copper (old scrap only) ------do----	[r]2,432,000	[r]2,175,000	[r]2,278,000	[r]1,760,000	2,020,000
Price: Weighted average, cathode, cents per pound -----------------------	92.19	101.31	84.21	72.80	76.53
World:					
Production:					
Mine ------- thousand metric tons--	[r]7,691	[r]7,739	8,191	[p]8,072	[e]8,027
Smelter ---------------do----	[r]8,014	[r]7,946	8,346	[p]8,281	[e]8,304
Price: London, high-grade, average cents per pound -----------------------	90.07	99.25	[1]79.35	[r]67.14	72.13

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Based on Jan.-Nov. monthly averages.

States, with the result that world demand for refined copper continued to decline. Western World consumption was down to 6.7 million metric tons in 1983 compared with 7.5 million tons in 1979.[3] As a consequence, the excess supply of copper in the world was sold in U.S. markets, which in 1983 accounted for about 27% of Western World consumption.

Refined copper production in the Western World continued more or less unabated, reaching a near-record-high level of 7.3 million tons. Countries reporting significant increases in refined copper production were Australia, Canada, Finland, the Federal Republic of Germany, Japan, the Republic of Korea, the Republic of South Africa, and the United Kingdom. Oman and the Philippines were new producers with a first-time refined copper production during the year. Among the producers of refined copper experiencing cutbacks in production were Chile, Peru, Spain, the United States, and Zambia. World copper mine production also continued at high rates, decreasing only marginally, largely the result of cutbacks at mines in the United States and Canada.

Issues of concern and debate for the U.S. copper industry during the year included the influences of foreign production subsidization, development bank and International Monetary Fund (IMF) loans, devaluation of foreign currencies, continued expansion of foreign copper producing facilities, and the high rates of production in the major producing countries. In addition, domestic factors such as the influence of a strong dollar on exports and imports, high interest rates, low prices for byproduct metals, the renegotiation of labor contracts, and continued expenses required by environmental constraints at smelters were also of considerable concern. Foreign producers were charging that the U.S. industry was simply noncompetitive because of low ore grades, high wages, and inefficient plant and equipment. The U.S. producers maintained that ore grade was not an issue since the U.S. ore grades had not changed measureably over the past 10 years or so. The United States still had a large share of world reserves of recoverable copper at similar grades. The average ore grades of several of the larger foreign competitors, on the other hand, were expected to decrease measureably in the near future for geological reasons.

An analysis of 72 domestic copper deposits, 32 of which were producing mines, indicated the United States had recoverable resources totaling 66 million tons of copper, or 20.1% of the Western World resources of potentially recoverable copper using current extraction technology. Only Chile, with 26% of the total, had recoverable copper resources larger than that of the United States. The average ore grade for the 72 U.S. deposits was 0.66% copper, compared with a world average of 0.83% copper.[4]

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 105 operations to which a survey request was sent, 54% responded, representing an estimated 99.98% of the total mine production. Production for the remaining 48 companies was estimated using data reported in other surveys.

Legislation and Government Programs.—Signed into law at yearend, Public Law 98-181, entitled "Supplemental Appropriations—Fiscal Year 1984," increased the U.S. contribution to the IMF, in addition to requiring that detailed economic feasibility evaluations be made for development bank loans for foreign mining and mineral processing operations that cost more than $20 million. The evaluation must take into account a project's impact on world markets and its effect on the overall long-term development of the country in which it is located. The new law also required withholding of funds intended for projects that would enable a country to produce commodities, such as copper or steel, that are in surplus on world markets when such production would cause "material injury" to U.S. producers of those materials. Federal agencies with bank supervisory responsibilities (i.e., Federal Reserve Board, Comptroller of the Currency, and the Federal Deposit Insurance Corp.) were instructed to carry out the law's requirements by prescribing regulations or issuing orders. The U.S. Department of the Treasury was required to make an annual report to the U.S. Congress on all requests for project loans that would cause material injury to U.S. producers. Also included in the legislation was an extension of an authorization for the Export-Import Bank (EXIM Bank) for 3 years to September 30, 1986.

The Administration was placing a greater emphasis on economic and financial factors when evaluating multilateral development bank (MDB) loan proposals, including those in the mining sector.[5] Within the Working

Group on Multilateral Aid, the Department of the Treasury worked during the year with other agencies, including the U.S. Department of State, U.S. Department of Commerce, U.S. Department of the Interior, EXIM Bank, the Federal Reserve, and others in reviewing all MDB loan proposals when they were brought to the boards of banks in which the United States was an important shareholder. The United States was a voting and capital shareholder in the International Bank for Reconstruction and Development (World Bank) (capital share 22.4% and voting share 21%); International Development Association (capital share 33.7% and voting share 19%); the International Finance Corp. (IFC) (capital share 31.7% and voting share 31.7%); the Inter-American Development Bank (IDB) (capital share 35% and voting share 35%); and the IMF (capital share 20.65% and voting share 19.6%).[6] Since 1981, there were five loans considered solely for copper mining by the MDB's, one of which was canceled (the IFC loan for the Cananea, Mexico, project for \$50 million). In 1983, the United States opposed two of four remaining loans, but both were passed. The first was the \$268 million IDB loan to Chile in November 1983, and the second was the \$75 million World Bank loan to Zambia that was to be granted in early 1984.

On June 11, 1983, acting under a deadline imposed by a New York district court in January, the Environmental Protection Agency (EPA) proposed regulations governing arsenic emissions from industrial sources. Included in the source categories for which regulations were proposed were copper smelters processing high-arsenic feed materials, containing 0.7% or greater arsenic, and smelters processing low-arsenic feed materials, containing less than 0.7% arsenic. The proposed regulations would require additional emissions controls at six copper smelters processing low-arsenic feed materials and ASARCO Incorporated's Tacoma, WA, smelter, the only smelter that processes high-arsenic feed materials.

The proposed regulations, which stress the use of best available technology, would require the installation of horizontal air-curtain hoods at the Tacoma smelter to capture fugitive emissions from converter operations. According to EPA estimates, the regulations would reduce fugitive ground-level emissions, which were thought by EPA to pose the greater risk to public health, by 82%. EPA estimated the capital cost of controls to be \$35 million and the annualized cost to be \$1.5 million. At low-arsenic smelters, the proposed regulations would require emissions control for converters that process 6.5 kilograms or more of arsenic per hour and control of matte and slag topping operations from smelting furnaces processing 40 kilograms or more of arsenic per hour. The regulations were expected to reduce fugitive emissions for all low-arsenic smelters by 54%, at an estimated capital cost of \$35.3 million and an annualized cost of \$9.5 million.[7]

The EPA held hearings in Tacoma, WA, and Washington, DC, to take testimony on the proposed regulations. Public debate focused on EPA exposure models, emissions estimates, and health risk assessment, particularly in regard to the Tacoma smelter.

DOMESTIC PRODUCTION

Mine Production.—Although some mines reopened in early 1983 in response to the brief price recovery, it became apparent by yearend that production would not reach even the recessionary levels of 1982. Twenty-eight mines, where copper was the principal metal recovered, accounted for 97% of the total production. Seventy-seven mines, where copper was produced as a coproduct or byproduct of silver, tungsten, molybdenum, lead, zinc, or sulfur mining, accounted for the other 3% of production. There were 18 mines producing either precipitate or electrowon copper from dump leaching, in situ leaching, or vat-leaching operations. Precipitate capacity at 13 mines was 136,000 tons; electrowon capacity at 10 plants was 189,200 tons. Of the electrowon capacity, 65,000 tons at two plants was shut down all year. Precipitate production also ceased at Anaconda Minerals Co.'s Montana operation during the year.

Of the total available copper mine capacity operational in 1981, including byproduct mines, 23 mines with 750,000 tons of contained copper capacity per year were shut in 1983. In addition, about 150,000 tons of capacity at 21 smaller mines had been shut since the middle 1970's, making a total of 900,000 tons of capacity shut permanently or idled within the past 10 years.

Table 2.—Electrowinning capacity at U.S. mines

(Metric tons unless otherwise specified)

Operator and mine	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Capacity:										
Anaconda Minerals Co.:										
Twin Buttes, AZ	--	6,350	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000
Arbiter, MT	14,500	14,500	14,500	14,500	(1)	--	--	--	--	--
Amoco Minerals Co.:										
Cyprus Bagdad, AZ	6,800	6,800	6,800	6,800	6,800	6,800	6,800	6,800	6,800	6,800
Cyprus Johnson, AZ	--	3,600	5,400	5,400	5,400	5,400	5,400	5,400	5,400	5,400
Duval Corp.:										
Sierrita, AZ	--	--	--	--	29,000	29,000	36,000	36,000	36,000	36,000
Battle Mountain, NV	--	--	--	--	2,000	5,000	5,000	5,000	5,000	5,000
Noranda Mines Ltd. (Hecla Mining Co.):										
Lakeshore, AZ	--	--	18,000	18,000	18,000	18,000	18,000	18,000	18,000	18,000
Inspiration Consolidated Copper Co.:										
Inspiration, AZ	4,500	4,500	4,500	4,500	4,500	4,500	18,000	42,000	42,000	42,000
Kennecott:										
Ray Mine, AZ	18,000	18,000	18,000	18,000	23,600	23,600	23,600	23,600	29,000	29,000
Newmont Mining Corp.:										
Pinto Valley, AZ	--	--	--	--	--	--	8,000	8,000	8,000	8,000
Miami Leach, AZ	--	--	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000
Ranchers Exploration and Development Corp.:										
Bluebird, AZ	7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300	(1)
Total	51,100	61,050	113,500	113,500	135,600	138,600	167,100	191,100	196,500	189,200
Production	40,265	42,874	71,887	81,110	98,416	100,134	117,572	161,083	131,858	101,935
Percent of capacity	79	70	63	71	73	72	70	84	67	54

[1]Closed.

Table 3.—Average number of copper industry workers in the United States, including office workers, by State

State	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Mines and mills:										
Alaska	--	--	--	--	4	5	--	--	--	--
Arizona	21,042	17,290	17,579	16,914	14,662	17,209	15,998	18,157	11,779	8,315
Arkansas	--	--	--	--	--	--	2	2	--	--
California	--	2	20	--	--	2	2	1	--	--
Colorado	10	9	23	10	2	--	--	2	--	--
Idaho	83	48	47	46	49	31	66	42	28	52
Maine	--	151	119	108	--	--	--	--	--	--
Michigan	2,776	2,563	1,595	1,312	996	1,049	1,026	1,173	883	179
Montana	2,029	2,635	1,496	1,305	1,279	1,278	1,062	1,620	855	612
Nevada	2,338	1,636	1,510	1,631	867	411	506	514	460	25
New Mexico	1,950	1,570	1,872	1,912	2,224	2,433	2,561	2,682	1,369	1,053
Oklahoma	--	20	--	--	--	--	--	--	--	--
Oregon	--	--	--	--	--	--	28	49	--	--
Tennessee	562	913	782	949	962	491	752	668	675	921
Utah	5,392	4,284	4,620	5,161	5,627	5,888	5,523	5,700	4,587	3,533
Washington	--	4	--	15	19	8	--	--	--	--
Wisconsin	--	4	--	--	4	5	--	--	--	--
Total	36,182	31,129	29,663	29,363	26,695	28,810	27,526	30,610	20,636	14,690
Smelters and refineries	18,100	16,500	14,600	13,100	15,000	15,000	13,000	14,000	11,200	9,700
Grand total	54,282	47,629	44,263	42,463	41,695	43,810	40,526	44,610	31,836	24,390

Sources: Bureau of Labor Statistics and Mine Safety and Health Administration.

In the 1983 round of wage negotiations, most labor contracts settled included a freeze in basic wages but retained a cost-of-living allowance (COLA). Kennecott was the first to settle early in April, but Phelps Dodge Corp. sought wage reductions in addition to the elimination of the COLA; some other companies followed suit later in the year. As a result, some contracts were left unsettled at yearend, even though many of the workers had returned to the job. At yearend, labor unions and companies were returning to the negotiating table to work out agreements, as it became apparent that market conditions were not improving rapidly.

The impact of mine and plant closures, in addition to a reduction of the number of employees used per plant and mine in the past 10 years, was severe. At the mine and mill level, a 60% drop in employment occurred in the 1974-83 period, with the most significant impact in the last 2 years. The number of employees per ton of copper produced decreased from 0.025 in 1974 to 0.014 in 1983, a 44% reduction in the number of employees required to produce a ton of copper.

The high wages paid to U.S. copper workers were an issue of debate during the year. Both producers and industry analysts were examining the issue as it related to the production and competitiveness of U.S. copper mines. According to the Phelps Dodge 1983 Annual Report,[8] in the years 1972-82, wage rates increased an average of 12% per year while copper prices increased an average of only 3.5% per year. Another source[9] indicated that wages in the domestic copper industry rose from 8% above the national average in 1950 to 14% above the national average in 1969, and then to 50% above the national average in 1983. In large part, these wage increases had been offset by increased productivity in terms of physical product.

On June 30, Anaconda, citing weekly losses of $1 million, laid off the last 700 workers of a onetime work force of thousands at the 1.5-mile-wide, 1,300-foot-deep Berkeley Pit in Butte, MT. The company emphasized that this was a suspension of mining and not a permanent shutdown. Some 50 to 70 employees were retained to ensure a state of readiness for future reopening of the mine, should the copper market improve. The company contemplated that local mining could again become profitable with a new labor contract and with improved processing methods, such as a new crushing system at the concentrator. To continue mining in the East Berkeley Pit, much overburden would have had to be stripped, contributing to higher costs. The company also cited high freight charges, a 43% increase in electricity rates by the State Public Service Commission, and an increase in State property taxes as reasons for the increased noncompetitiveness of its copper mining operations at Butte. The company claimed Montana's mining tax was the highest among six Western States. Mining costs were reported by Anaconda to be about $1.25 per pound of copper when the mine closed.

Flooding of the Butte underground mines was complete by November, and water had started to rise in the Berkeley Pit. At the expected rate of rise, an estimated 40 years would be required to fill the pit with water. The potential for ground water contamination was the subject of debate in 1983, and Anaconda proposed to pump excess water from the pit and treat it with lime to neutralize acidity. The Montana Bureau of Mines and Geology cooperated with the U.S. Geological Survey, the Montana Department of State Lands, and Anaconda to monitor water around the Berkeley Pit and seven mine shafts. The State legislature granted the Montana Bureau of Mines $60,000, to be added to $30,000 already appropriated, to drill more monitor wells close to Silver Bow Creek to determine changes in ground water condition.

In March, Anaconda bought out Martin Marietta Corp.'s 33.8% share in the Greens Creek polymetallic deposit on Admiralty Island in southeast Alaska. Estimated reserves at Greens Creek totaled 3.6 million tons of ore having an average grade of 13 troy ounces of silver per ton, 2.5% lead, 7.5% zinc, 0.1 ounce of gold per ton, and 0.4% copper. The deposit was to be mined primarily for silver. Noranda Mines Ltd., with 33.8% of the mine, became operator of the project in January 1981. Production was expected to begin as early as 1985.

Anaconda, in 1983, attempted to divest itself of its one-half interest in the Anamax Mining Co. to comply with a 1977 order from the Federal Trade Commission. Anaconda was ordered to effect the divestiture when it merged with Atlantic Richfield Co. Anamax is a joint venture with AMAX Copper Inc., which operated the Twin Buttes Mine, and with Asarco, the nearby Palo Verde (Eisenhower) Mine, in Arizona. The Twin Buttes Mine was closed at the end of January, except for the electrowinning plant, which continued to operate until October from stockpiled oxide ore. Anamax also continued to mill its portion of the ore from the Palo Verde open pit until a labor strike occurred in August that continued through yearend. Following the announcement of the Anamax strike, a force majeure was declared on receiving ore shipments from Palo Verde. Asarco laid off 45 production workers at Palo Verde, but mining continued there at a reduced rate. Both AMAX and Anaconda had to suspend shipments of concentrates to their overseas buyers.

AMAX reported a net loss from both foreign and domestic operations of $489 million in 1983, up nearly $100 million from the $390 million loss reported for 1982. These losses included write-downs of $65 million of its investments in Anamax and of $30 million in its secondary copper refinery at Carteret, NJ.

According to Asarco's annual report for 1983, net earnings were $58.3 million, compared with a loss in 1982 of $38.7 million. Higher prices during the first part of the year were in part responsible for the improvement. The cost-cutting measures taken in 1982, including the shutdown or selling of money-losing operations, reducing employment, and increasing productivity, contributed an estimated $40 million to the improved 1983 results. Average employment was 21% lower than in 1981. The improved conditions prompted the reopening of Asarco's Silver Bell Mine in Arizona in September; it had been closed since December 1981. Output from the Silver Bell was intended to offset loss of production from the Sacaton open pit, scheduled to shut down in early 1984. Planned development of an underground mine at Sacaton was postponed indefinitely. Asarco signed a new labor contract effective July 1, 1983, providing for COLA retention but no increase in wages, and for reductions in the costs of certain benefit programs. Asarco suspended stripping at its Mission Mine, in Arizona, and laid off 120 workers in October as copper prices continued to deteriorate.

Duval Corp., a subsidiary of Pennzoil Co. Inc., succeeded in cutting its losses from copper mining in half during the first 9 months of 1983, compared with that of the same period in 1982. At the Sierrita pit, operational cost savings of 29 cents for each ton of ore processed were being realized through the portable crushing system and an average truck fleet reduction of 37%. More efficient mining and smelting processes instituted over the next few years were expected to lower Duval's cost to mine even lower, by several cents per pound. Higher prices for its byproducts, such as molybdenum, gold, and silver, were also expected to help.

Duval's contract with labor unions expired on September 30. The union workers went out on strike, but operations at Sierrita continued, utilizing supervisory personnel. After a few days, most of the striking employees returned to work even though the unions were technically on strike. By October 4, two unions had agreed to the company's proposal for elimination of the COLA and for a 3-year wage freeze. A separate contract was being negotiated for the Mineral Park Mine, which had remained closed since December 15, 1981. The company recognized that if Mineral Park reopened, it would be operated primarily as a molybdenum mine. The Esperanza Mine also remained closed in 1983, except for some production of precipitate copper.

Kennecott reported losses of $91 million, with $25 million of that lost in the fourth quarter; even so, it was an improvement over the $189 million loss in 1982. Kennecott sought two tax relief measures from the State of Utah, one of which was approved. It granted mining companies a 5-year exemption from sales and use taxes on equipment, materials, and supplies used for modernization and expansion. Kennecott estimated that this tax relief would save about $13 million of its proposed $400 million expenditures for modernization of the transportation system at the Bingham Canyon Mine. The company proposed to eliminate in-pit rail haulage, establish an in-pit crushing system, and remove ore and waste with conveyors. Phase one of Kennecott's plans to convert in-pit ore haulage from rail to truck started in May, with the transfer of four 170-ton trucks from the Ray Mine, in Arizona, to Bingham Canyon. Cost savings were expected to arise from elimination of the need to maintain and move the 95 miles of train track within the mine, and from greater flexibility in mining operation and design. Kennecott employed 4,700 workers in 1983, compared with 7,300 3 years previously.

The Kennecott North Ore Shoot Extension ore body was under development, with production scheduled for 1988. The skarntype deposit was located near the Bingham Canyon pit and had estimated reserves of 95 million tons of 2% copper ore. The deposit lies beneath the eastern flank of the Oquirrh Mountains within two altered limestone units, northeastward on the flank of the Bingham quartz monzonite, within which the Bingham Canyon ore deposit is located. It was being developed as an underground mine independent of the pit, and the ore was to be processed in a different mill, to be located at the site of the Bonneville mill at Magna, UT. Production at Kennecott's Ray Mines Div. in Arizona, which had been closed since May 1982, was resumed in August 1983. This was made feasible by arranging to have Asarco smelt Ray's concentrates, instead of firing up Ray's own Hayden smelter. The electrowinning plant at the Ray Mine remained closed all year.

Chino Mines Co., a partnership between Kennecott and Mitsubishi Corp. of Japan, was stockpiling excess copper concentrate in a new $5 million blending shed and in covered piles outside of the new concentrator in readiness for completion of the new flash furnace smelter. The new $280 million concentrator and a conveyor system from the pit, which replaced a more costly truck and rail haulage system, were completed in 1982. The new plant resulted in a reduction of operating costs by about 31 cents per pound, according to the Standard Oil Co. of Ohio 1983 Annual Report. At the New Mexico open pit, Chino added 11 new 170-ton trucks, increasing the fleet to 34, and was gradually replacing 17 of its smaller 150-ton trucks. Plans called for computerizing control of trucks and shovels in order to increase productivity by a minimum of 8%; a computerized truck system was to be in use by yearend 1984. Chino recalled 20 workers in July 1983 to speed up stripping at the mine to expose additional ore for milling. The increase brought the total number of employees to about 1,205. At yearend, Chino was shipping some concentrates to Kennecott's Utah Div. for processing. Beginning September 1, Chino also shipped about 14,500 tons to California ports for routing to Mitsubishi's Naoshima smelter in Japan. The average grade being mined at the Chino pit was 0.84% copper, with a cutoff grade of 0.60% copper.

Newmont Mining Corp. completed its acquisition, for $75 million, of Cities Service Co.'s Arizona copper operations in March. These included the Pinto Valley surface mine, which remained closed throughout the year, and the Miami East underground mine. In late 1983, Newmont arranged for cancellation of Pinto Valley's toll smelting contract with Inspiration Consolidated Copper Co. and anticipated possible opening of the Pinto Valley Mine in 1984, with delivery of concentrates to Newmont's San Manuel, AZ, smelter. At yearend 1983, Pinto Valley's reserves were 349 million tons of 0.50% copper. At Miami East, development of a new ore body of 5.4 million tons, averaging 3.14% copper, was virtually complete. Miami East remained closed but had a planned annual capacity of 12,000 tons of contained copper in ore. The two solvent-extraction-electrowinning plants at Miami, AZ, one processing copper leached from old Pinto Valley dumps and the other from an in situ underground leach operation at Miami, operated throughout the year.

Magma Copper Co.'s underground mine near Superior, AZ, remained closed, but its San Manuel, AZ, open pit operated through the year on a curtailed basis. According to the company's 1983 annual report, the San Manuel Mine operated at 83% of capacity, producing 16.6 million tons of ore at an average grade of 0.64% copper. A major research project was initiated to recover copper from oxide ores that overlie the sulfides at San Manuel. At yearend, estimated reserves at the San Manuel and Kalamazoo ore bodies were 620 million tons, averaging 0.70% copper. At Superior, estimated reserves were reported as 4 million tons averaging 5.69% copper.[10]

At midyear, the Newmont subsidiaries, Magma and Pinto Valley Copper Corp., signed labor contracts for 3 years, reducing some fringe benefits and limiting wage increases solely to COLA. Magma sustained a loss of $28.6 million and Pinto Valley Copper a loss of $1.1 million in 1983. Newmont also had losses at some of its overseas copper investments, such as at O'okiep and Tsumeb, but continued to make some profit from its 28.6% share of the Palabora copper mine and from its 10.7% investment in the Southern Peru Copper Corp. (SPCC).

Noranda Lakeshore Mines Inc., a division of Noranda Mines Ltd. of Toronto, Canada, operated its underground Lakeshore Mine at Casa Grande, AZ, through most of 1983, with a reported production of 17,000 tons of copper.[11] At yearend, the company announced its intention to close the underground mine and the vat-leaching operation, and to concentrate on in situ leaching of the low-grade copper oxide ore body at the mine. Closing the mine and the vat-leaching operation resulted in the layoff of 250 of the 400 workers at the mine. The in situ operation at the 1,100-foot level of the mine was phased in and operated concurrently with conventional mining on the 900-foot level near yearend, when problems encountered with the Lakeshore fault in the mine caused mining costs to escalate. The underground mine was to be maintained, however, and reopened if prices recovered sufficiently.

At the beginning of 1983, Phelps Dodge's copper mining was curtailed, with only the Morenci-Metcalf open pits of Arizona in operation, but the New Cornelia Mine at Ajo, AZ, was reopened on February 28, and the Tyrone Mine in New Mexico on May 2, prompted by the price improvements of early 1983. All had been shut since April 1982. A small amount of precipitates continued to be produced at the Copper Queen Mine from the Lavender pit dumps. As a consequence, the Primary Metals Div. of Phelps Dodge reported profits of $7.6 million in the first half of 1983, but lost $27.3 million in the third quarter because of lower copper prices and a strike that began on July 1, following expiration of labor agreements at the Arizona operations and the El Paso, TX, refinery. Although Morenci was shut for 10 days during August because of the strike, Phelps Dodge continued to operate throughout the year using nonunion workers. The economic impact of the strike, which remained unsettled at yearend, on the company's operations was minimal. According to the company's 1983 annual report, copper production was 238,600 tons, or about 80% of capacity, compared with 136,078 tons in 1982.

Phelps Dodge continued to work on priority goals that included improvement of production costs, reduction of debt, and development of a broader product mix of metals and minerals. Production was managed for cash flow, with cash losses reported at yearend less than the cash drain incurred during shutdown. Phelps Dodge had a net loss of $63.5 million, a small improvement over the 1982 net loss of $74.3 million. As the company's debt was reduced, available capital spending was directed toward lowering costs. One notable project was the construction of a new 15,000-ton-per-year, solvent-extraction-electrowinning plant at the Tyrone Mine. Moves were also made to further control mine design and efficiency and work force and equipment costs. Other cost-cutting examples given were the suspension and redesign of mining in the Metcalf pit when the adjacent Morenci Mine was sufficiently developed to feed both concentrators; expansion of dump leaching at Morenci; addition of a molybdenum recovery unit at Ajo and reactivation of the recovery unit at Morenci; installation of computerized truck dispatching at Tyrone; use of larger flotation cells at the Ajo and Morenci concentrators; use of precious metals-bearing fluxes instead of barren ores at smelters; and the use of coal instead of fuel oil at the Hildalgo flash smelter. The company trimmed the work force to about 70% of the personnel in place before the April shutdowns. At yearend, the Morenci and Metcalf pits were being operated as an integrated mining unit.

According to the company's annual report, copper ore reserves at Phelps Dodge's U.S. mines totaled 1.5 billion tons, with an average weighted ore grade of 0.75% copper. This did not include the Phelps Dodge Copper Basin property southwest of Prescott, AZ, which contains 159 million tons averaging 0.55% copper and 0.021% molybdenum. In addition, the Western Copper property purchased in 1981 adjoining the Morenci-Metcalf Mines was estimated to contain 167 million tons of copper-bearing material, with an estimated grade of about 0.64% copper.

Ranchers Exploration and Development Corp. closed the solvent-extraction-electrowinning plant at the Bluebird Mine, Gila County, AZ, in October 1982, but in 1983 was considering converting the site to an in situ leach operation. After fracturing the underground ore and treatment with sulfuric acid, the copper-bearing liquid would be collected through bore holes and pumped to the existing electrowinning plant for cathode production. The plant had a capacity of 7,200 annual tons of copper cathode when it was operating. A pilot operation for the in situ recovery would be required first, and full-scale production was scheduled to begin in 1985.

Smelter Production.—U.S. smelter production decreased again in 1983, to a level that was about 32% lower than the peak reached in 1979. At yearend, 5 of the 15 primary smelters were closed. In addition, operation of the AMAX smelter complex at Carteret, NJ, was severely curtailed and limited to processing copper scrap. The Inspiration smelter was shut temporarily for repairs. Expenditures required for compliance with environmental regulations and a general shortage of concentrates caused by mine closures and realinement of contracts continued to be notable problems for most of the plants.

Competition for the shrinking U.S. fire-refined market was also an issue as U.S. producers of primary copper worried that the increased production of blister and fire-refined copper from planned smelter expansions in both Chile and Mexico would find its way into U.S. markets. The U.S. consumption of fire-refined copper (slab, cake, billet, and ingot sector) was about 15% of total refined consumption, or about 270,300 tons, in 1983; this compared with 23%, or about 505,000 tons, in 1970. Chile was a major supplier for the fire-refined market, with an installed capacity of about 150,000 tons. Kennecott's Chino smelter in New Mexico was a producer of fire-refined ingot, and although the White Pine plant in Michigan and the AMAX plant in Carteret, NJ, also had been major producers of primary fire-refined ingot, neither plant had produced fire-refined ingot in significant quantities in recent years. In addition, the secondary plants of the Essex Group, Reading Metals Refining Co., Nassau Recycle Corp., Cerro Copper Products Co., Thermal Reduction Corp., the Metal Bank of America Inc., General Cable Co. (H. R. Metals), and others also produced fire-refined copper, mostly for internal use. Fire-refined copper comprised between 4% and 8% of primary domestic refined production in recent years.

Cleveland Wrecking Co. purchased all the property, fixtures, improvements, and other property excluding real property, at the Anaconda smelter in October 1982. Included in that sale were concentrate and residual materials in various furnace and roaster bottoms. A contract was given to U.S. Industrial Metals Corp. to construct a processing plant to treat the estimated 236,000 tons of flue dust containing high levels of arsenic and other contaminants left at the Anaconda smelter site. By yearend 1983, however, labor and environmental problems were such that progress on the U.S. Industrial flue dust project was stalled. In October, two on-site monitors went to work at the Anaconda smelter site with funding obtained from the EPA for pollution cleanup.

Construction of the new Inco oxygen furnace at Hayden was completed by Asarco on schedule under the $132.6 million budget slated for the project. One of the two reverberatory furnaces had been shut down and dismantled in late 1982 to make way for the new furnace. The new furnace, monitored by a complex computerized system, was started up in November and was expected to be fully operational by April 1984. In addition, new water treatment, oxygen, and sulfuric acid plants were constructed in 1983. The new acid plant had more than twice the 590-ton-per-day capacity of the old plant, which was to be shut and reactivated in emergencies only. A further modernization was the addition of a closed conveyor belt system to carry the gas-dried charge to the furnace. With converters and two anode furnaces, the capacity of the plant was reported to be 14,000 tons of anode copper per month. The anodes were shipped to Asarco's Amarillo, TX, refinery. In addition to concentrates from Asarco's own mines, the smelter was scheduled to toll concentrates from Arizona, California, Montana, and Washington. Approximately 550 persons were employed at the Hayden plant.

Under the timetable ordered by the Puget Sound Air Pollution Control Agency, Asarco will be required to capture 95% of the sulfur dioxide emissions at its Tacoma, WA, smelter beginning in 1987. The plant captured only about 45% of the sulfur dioxide emitted in 1983.

On August 8, Inspiration, owned by a consortium of Hudson Bay Mining and Smelter Co., Plateau Holdings Ltd., and Mineral and Resources Corp., shut down the Globe-Miami smelter because of a shortage of concentrates. In October, fire damaged the smelter extensively, delaying a plan to put it back on-stream soon. At yearend, as the shortages of concentrates continued because of the shutdown of several mines, Inspiration decided to cut back from the operation of three converters to two. In June, a team from the Occupational Safety and Health Administration checked Inspiration smelter workers and the work environment following labor union complaints that 21 workers suffered heart attacks within a 5-month period. Air and dust samples were analyzed for arsenic, lead, sulfur dioxide, and other potentially dangerous substances.

Inspiration signed a 5-year contract with Duval to toll about 23,000 tons per month of concentrates. The first shipments to the Inspiration smelter were expected in January 1984. Duval had previously shipped its concentrates to Asarco's Hayden, AZ, smelter. Inspiration lost its toll contract with Pinto Valley Copper in late 1983;

Newmont had decided to send the Pinto Valley Copper concentrates to the Magma smelter.

Modernization plans for Kennecott's Utah smelter were delayed until final approval by the EPA of the State plan for sulfur emissions, under which the Utah Copper Div. had been operating for more than 2-1/2 years. State standards limit average emissions per hour to 18,200 pounds of sulfur dioxide, based on an annual limit. Under the plan's "multi-point roll back" method of control, the smelter was allowed an emission of up to three times the permitted hourly average level at any one time, as long as the annual limit was not exceeded. Similar standards were in place in Arizona and New Mexico. Kennecott spent nearly $400 million through 1978 to upgrade smelter facilities, through the use of licensed Noranda continuous process technology, a 1,215-foot stack, and a new acid plant. The improvements increased sulfur capture to about 90%. Kennecott shut its McGill, NV, smelter in June 1983.

By yearend, construction work on Chino's new Inco smelter at Hurley, NM, was nearly complete. The rated capacity was expected to increase from 272,000 to 454,000 tons of blister copper per year in November 1984 when the new flash furnace was expected to be complete. In 1983, Chino planned to buy oxygen from the Linde Div. of Union Carbide Corp., which was building a new plant nearby to supply 408 tons of oxygen per day to the smelter. The total project cost was estimated to be $130 million. About 50% of the cost was for improvement to pollution control equipment and facilities, which would bring the company into compliance with air quality standards established by the New Mexico State Environmental Improvement Division.

Magma was granted permission to defer compliance with EPA's ultimate sulfur dioxide emission limits at its San Manuel, AZ, smelter, but must be in full compliance with EPA regulations as of January 1, 1988. Magma was to start modifications to its smelter by 1985. Preliminary estimates indicated that the compliance program could cost in excess of $200 million, in addition to an approximate $50 million already spent to date for environmentally related capital additions to the San Manuel smelter.

Air quality control requirements continued to impact Phelps Dodge's three smelters at Ajo, Morenci, and Douglas, AZ, in 1983. The company and EPA reached agreement to modify the 1981 consent decree affecting the Morenci and Ajo smelters. The Ajo smelter remained closed the entire year while the company spent over $1 million to repair and modernize it. The smelter still did not meet EPA standards; however, Phelps Dodge expected to reopen it in 1984. Concentrates were smelted at the Phelps Dodge plants in 1983 on a toll basis for others, including Amoco Minerals Co.'s Cyprus Bagdad Mine before it closed in early 1984, and Mexico's La Caridad Mine in Sonora, Mexico.

Refinery Production.—Two of the thirteen electrolytic refineries were closed in 1983, one of these permanently. Six of the electrolytic plants produced refined copper largely from secondary material. Production at one plant, which produced from secondary material, was severely curtailed during the year. In addition, refined copper cathode was produced by 9 of 12 electrowinning plants. An additional plant was under construction; Phelps Dodge planned to have its new electrowinning plant at the Tyrone Mine operational in early 1984. Electrowinning plants closed were Ranchers Exploration and Development's plant at the Bluebird Mine, Arizona; the Duval plant at Sahuarita, AZ; and the Kennecott plant at Hayden, AZ. Near yearend, the plant at Anamax's Twin Buttes Mine also closed. The AMAX plant at Braithwaite, LA, produced electrowon copper cathode from imported copper-nickel matte.

Both the Cyprus Bagdad and Anamax electrowon cathodes were registered on the London Metal Exchange (LME) as high-grade cathode, and were the first electrowon cathodes to receive this distinction. Nearly all U.S. producers of electrowon cathode had taken steps to upgrade plants to produce a higher quality product in recent years. The Kennecott Hayden plant started selling its upgraded electrowon cathode direct to market in 1981. Duval closed its plant in 1982 in the midst of making adjustments to further upgrade the system.

Production of refined copper from secondary sources was about 8% lower than in 1982, even though the demand for copper scrap remained relatively strong during the year. Approximately 77% of secondary refined copper was derived from old scrap. Less scrap was available largely because of depressed copper prices. No. 2 and precious metals-bearing copper scrap were particularly scarce. U.S. smelters and refiners had increasingly turned to scrap as feed over the past 5 years as domestic concentrates and blister became progressively more scarce, a trend that was expected to continue with improvement in copper scrap prices.

At yearend 1983, AMAX announced that its subsidiary, U.S. Metals Refining Co., would reduce refined copper production at its Carteret, NJ, electrolytic refinery, operating only 4 out of 32 sections of the refinery. Emphasis was to be placed on the production of precious metals from scrap. Fire-refining, once done on a moderate scale about 10 years ago, had been discontinued, as had the production of wirebar in more recent years, except for the production of some specialty OFHC (AMAX brand) wirebar. This was an old plant that was readjusting its production scheme to stay competitive under depressed copper market conditions. Processing of primary blister copper had been deemphasized over the past 10 years; the operations utilized mostly scrap during 1983.

Kennecott shut down its refining operations in Baltimore, MD, in mid-July. The 165,000-ton-per-year, continuous-cast rod operation continued to operate, however, using cathodes from inventory at Kennecott's Utah operations. The refining operation had been processing primarily toll material and had been on a reduced work schedule since January. Phelps Dodge also closed its Laurel Hill, Long Island, NY, refinery permanently.

The Louisiana Land and Exploration Co. was seeking to sell its White Pine copper properties, but by yearend had not found a suitable buyer. Crippled by a strike in July and by the continued low copper prices, the company was unable to reopen its White Pine mine and smelter. The new electrolytic refinery was operating with existing stock and copper scrap, using salaried workers. The strike remained unsettled at yearend. The company had laid off all but 10% of its remaining work force of about 300 by April, and the concentrator was placed on a caretaker basis. One of the two reverberatory furnaces was restarted temporarily at midyear to process stockpiled concentrates.

Magma's marketing of refined copper continued to be directed toward the wire and cable industry. Magma's 1983 sales of continuous-cast copper rod to this market accounted for 87% of its sales, up 8% from those of 1982. Byproduct recovery from the refinery at San Manuel, AZ, was lower than in 1982 because of the closure of the Superior Mine, where ores have a higher precious metals content than at the San Manuel Mine. According to the company's 1983 annual report, Magma produced 99,100 tons of copper in 1983.

Copper Sulfate.—Copper sulfate was produced from copper scrap, electrolytic refinery solutions, and blister copper by at least six companies. It was usually sold as pentahydrate crystal containing about 25% copper by weight, available in several mesh sizes, or as basic copper sulfate powder, containing about 53% copper. Imports, primarily from Italy, Peru, and Canada, accounted for about 6% of domestic consumption. It was estimated that 46% of domestic production was consumed in agricultural chemicals, such as fungicides and fertilizers, and that 54% was consumed in industrial uses, such as metal finishing, mineral flotation, and wood preservatives. Production of copper sulfate by Phelps Dodge declined markedly during the fourth quarter, following permanent closure of its Laurel Hill, NY, refinery.

Table 4.—Copper sulfate producers in the United States in 1983

Company	Plant location
Chevron Chemical Co	Richmond, CA.
CP Chemicals Inc	Sewaren, NJ.
International Metals Recycling Corp	Casa Grande, AZ.
Madison Industries Inc	Old Bridge, NJ.
Phelps Dodge Corp	Laurel Hill, NY, and El Paso, TX.
Tennessee Chemical Co	Copperhill, TN.

Byproduct Sulfuric Acid.—Sulfuric acid was produced as a byproduct from sulfur dioxide recovered at 11 primary domestic copper smelters. In response to stricter environmental standards for sulfur dioxide emission and corresponding improvements in smelter design, production of sulfuric acid increased slightly despite the decline in primary smelter production. A new 2,500-ton-per-day acid plant was constructed to accommodate the new Inco oxygen furnace, which started up at the Asarco Hayden, AZ, smelter in November. Sulfuric acid production from Phelps Dodge's smelters reportedly was 613,000 tons, up from the 525,000 tons reported for 1982. Approximately 597,000 tons was sold in 1983 at prices that averaged substantially less than production costs.[12]

CONSUMPTION AND USES

U.S. apparent consumption of refined copper reflected a 15% recovery in copper demand compared with that of 1982, but as depressed prices continued, the increase in demand was not matched by an increase in domestic production. U.S. copper mine production was down by 27% compared with that of 1979. As a percentage of apparent U.S. refined copper consumption, refined and blister imports comprised 27% in 1983, up from about 8% in 1979. Apparent consumption was revised in this report to reflect a calculation from net imports, primary and secondary (old scrap) production, and changes in industry and Government stocks. Past methods did not include stocks, other than producers' stocks, or old scrap in the calculations.

Largely as the result of increased use of the continuous casting process for production of copper rod, and of increased demand for high-quality copper alloys for electronic purposes, the consumption and quality of wirebar and brass-grade refined forms had changed in recent years. In 1983, only 2% of the refined copper forms consumed in the United States was wirebar, while cathode comprised 82%. This compared with 63% wirebar in 1970. This change in quality and form requirement by refined copper consumers had been fairly rapid since the middle 1970's.

Use of copper and copper-alloy mill products in 1983 was estimated to be 35% in the building construction sector, 25% in electrical and electronic products, 17% in industrial machinery and equipment, 12% in transportation equipment, and 11% in consumer and general products, according to the Copper Development Association annual data report. Compared with 1982 data, the building construction sector and transportation sector showed increases, while the electrical products sector used about 3% less copper in 1983. The demand for beryllium-copper alloys remained buoyant throughout the year, spurred in large part by the alloy's growing usage in electronics. The U.S. electronics industry was expected to expand by about 17% per year over the next few years, and the industry was reportedly consuming about 250,000 tons per year of copper-based alloys, according to one of the major producers.[13] Growth in the industry was not proportionately tied to copper alloys consumption since the industry was using thinner gauge strip, rod, and wire wherever possible, but analysts expected that the use of beryllium-copper alloys would easily grow by about 12% per year over the next 5 years.

STOCKS

Total refined stocks, including those held by the Commodity Exchange Inc. (COMEX) of New York and the U.S. Government stockpile, were 696,000 tons in January 1983 and continued to increase to a peak of 744,000 tons in August. By yearend, stocks had receded to 692,000 tons, with the drop occurring mostly at producers; inventories on the COMEX continued to rise throughout most of the year. Both LME and COMEX reported large stocks of lower grade material including wirebar, brass-grade cathode, and fire-refined ingot. This was largely the result of the change in refined copper demand over the past decade to mostly high-grade cathode and high-purity or oxygen-free forms.

At yearend, COMEX announced amendments to the specifications of its copper futures contract, which will upgrade the quality of the metal deliverable on the exchange. Effective December 1985, delivery of certain grades and shapes of copper that no longer have commercial applications such as cake, slab, billets, some ingot forms, and all forms of lake copper will be eliminated. Grade 2 (basis grade) cathodes, wirebars, ingot bars, fire-refined ingot bars, and fire-refined high-conductivity ingot bars will continue to be deliverable. Grade 1 electrolytic cathode will be recognized as the highest grade of metal deliverable and will be valued at a premium over the basis grade. Wirebars currently carry a 0.625 cent per pound premium to basis grade, but the new contract will eliminate that.

PRICES

U.S. producer prices for refined copper cathode increased from an average of 77.5 cents in January to 82.9 cents per pound in May and then began to decline. By December, the price had retreated to an average of 68.1 cents per pound. The price decline was associated with an extraordinary increase in refined copper imports. After a brief rally in the first 2 weeks in December, the price retreated again and continued at 66.9 cents per pound through the remainder of the year.

In testimony before the U.S. International Trade Commission, Asarco reported[14] that underselling by foreign competitors in the United States during 1983 caused the company not only to lose sales, but forced them to lower prices and adjust terms no fewer than 103 times, compared with 26 times in 1978, resorting to spot sales throughout the year. In the past, Asarco primarily had sold directly to U.S. customers on long-term contract, rather than through merchants.

In an attempt to meet competitors' prices and maintain sales, to compete against large quantities of physical copper available on a prompt basis from COMEX warehouses, and foreign supplies from merchants, Asarco testified[15] that the company had to set its price increasingly closer to that of COMEX. At yearend, Asarco had set its price at a 2.5-cent differential over the COMEX price, compared with a 5- and 6-cent difference just 2 years earlier. The company also was unable to secure many annual contracts in 1982 and 1983, selling a greater proportion of copper on a spot basis, at times on COMEX to prevent inventory accumulations. This provided additional downward pressure on COMEX prices. The shift of domestic producers to spot sales also made production of copper and investment planning more difficult for them.

By November, scrap metal dealers had also trimmed their prices an average of 2 cents per pound for copper scrap, with quotations at 51 to 52 cents per pound for No. 1 copper, 42 to 43 cents per pound for No. 2 copper, 43 to 44 cents for red brass solids, and 25 to 26 cents per pound for heavy yellow brass. The price cuts reflected a conviction that primary copper prices would slide further. With few exceptions, scrap dealers reported their volume was adversely affected by the declining scrap metal prices and reported volume declines of up to 10% in October. Most believed that copper was underpriced and that there was more copper available than the market could absorb.

In August, nine northeastern States filed civil antitrust suits in their respective State courts against six copper water tubing manufacturers, charging them with price fixing between 1975 and June 1981. The suits were the latest steps in litigation developing out of Federal antitrust and price-fixing charges filed in March 1983 by copper tubing customers in Philadelphia against the producers. Three companies named in the States' suits were also named in the latter indictment: Cambridge-Lee Industries Inc., Alston, MA; Cerro Copper Products Co., Sauget, IL; and Phelps Dodge Industries Inc., New York. Two companies cited in the States' litigation were Anaconda, which produced water tube in Waterbury, CT, and which was currently the American Brass Co., a division of Arco Metals Co., Illinois, and the Wolverine Div. of Universal Oil Products, Decatur, AL. The sixth company named in the States' action was Howell Metal Co. of New Market, VA. The action also charged three companies in bankruptcy with alleged price fixing, but did not sue them because of their legal standing. Those firms were Revere Copper and Brass Inc. and its subsidiary, Revere Copper Products Inc., of Rome, NY, and Reading Industries Inc., of Reading, PA. In addition to New York, the States filing suit were Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, and Rhode Island.[16]

TRADE

In early 1983, some market analysts were showing guarded optimism as copper buying by China on Western markets, in addition to general market speculation, contributed to a temporary price recovery. However, a sharp increase in U.S. imports of copper resulted in copper prices dropping below the cost to produce for most U.S. mines by midyear. The highest level of copper imports occurred from March through August and coincided with buildup of stocks and leveling off and weakening of domestic prices. Nearly every market form of copper was affected by increased import competition. In comparing 1983 data with that of 1975, imports of refined copper increased by 253%, concentrates by 241%, unalloyed scrap by 50%, and semimanufactures by 170%. Exports between 1975 and 1983 decreased for refined copper by 53% and for semimanufactures only marginally from 95,250 tons in 1975 to 85,700 tons in 1983.

Of general concern to domestic producers was the increased supplies of copper from Chile, which currently was the world's lowest cost producer. The United States became Chile's largest export destination for refined copper in 1981, displacing Brazil, which had been the largest Chilean market for refined copper in recent years.[17] As a percentage of U.S. imports for consumption, the Chilean share of refined and blister imports was 16% in 1971, but by 1983, had increased to 56%. As a consequence, the normally more significant share of U.S. refined copper imports by other traditional U.S. suppliers formed a much smaller proportion of the 1983 total.

WORLD REVIEW

Although copper consumption in the United States and Canada increased, copper consumption in most of the rest of the world continued to decline from the depressed 1982 level. Western World consumption, according to the World Bureau of Metal Statistics, dropped by almost 1% in 1983 compared with 1982 levels, and was down by 11% compared with that of 1979. Consumption was particularly low in the European countries and in Argentina, Brazil, and Mexico, which in recent years had become growing and significant consumers of copper. Exponential copper consumption growth rates for the less developed countries had been forecast only a few years ago by many observers, predictions that were in part responsible for the multitude of planned expansion projects and the resulting overcapacity. Many of these countries have had to adopt austerity measures because of heavy debt burdens, a factor seen likely to curb economic growth rates and copper consumption for some time to come.

Despite the decline in Western World consumption of refined copper, production of refined copper increased by about 3% during 1983. The resulting supply-demand imbalance of as much as 400,000 tons of copper gave rise to large increases in visible stocks, COMEX and LME yearend stocks increasing by 123,000 and 182,000 tons, respectively. The imbalance would have been greater had China not taken delivery of an estimated 300,000 tons of copper purchased on the LME. By yearend, the supply-demand balance had improved.

During the year, a shortage of copper concentrates developed on world markets mainly owing to such events as the opening of the Philippine Associated Smelting and Refining Corp. (PASAR) smelter; cutbacks in Canadian and U.S. mine production; the shutdown of Anaconda's Berkeley Pit, which had contracted to ship 40,000 tons per year of concentrate to Japan; and increasing smelter capacities in countries such as Brazil, Chile, and the Republic of Korea. The shortage of concentrates was first reflected in the spot price of concentrates and later in long-term contract renewals. Japanese smelters, which receive about two-thirds of the world's trade in copper concentrates, had to reduce treatment and refining charges.

Currency devaluations, particularly among member countries of the Intergovernmental Council of Copper Exporting Countries (CIPEC), had, to varying degrees, the effect of reducing copper production costs in those countries, especially fixed costs such as labor. Since 1978, the Chilean peso had been devalued by 60%, the Zambian kwacha by 48%, the Zairian zaire by 97%, the Peruvian sol by 90%, and the Philippine peso by 47%. Conversely, the strength of the U.S. dollar increased the relative fixed costs for U.S. producers. In addition to the benefits derived from devaluation, governments sought to directly support copper production through guaranteed price-support systems, as in Brazil, Chile, and the Philippines; protective tariffs, as in Japan and the Republic of Korea; import restrictions, as in Brazil; and direct financial aid through loan guarantees and assumptions of company debt.

Brazil.—Brazilian refined copper consumption grew at an annual rate of 5.6% in the 1973-82 period, compared with average annual growth in Western World consumption of only 0.1% over the same period. In

1983, however, this trend was sharply reversed, estimated consumption falling by 42%, to about 145,000 tons per year. In recent years, Brazil has sought to develop its copper industry to reduce its dependence on imported refined copper. Modernization and expansion of mining operations at the Uruquai and São Luís ore bodies, owned by Cia. Brasileira de Cobre S.A., was completed in 1980. Production was from the underground mine at São Luís, which had proven reserves of 5.5 million tons of 1.1% copper. At Uruquai, both open pit and underground mines were planned for the time when production at São Luís stops. Uruquai had proven reserves of 10 million tons of 0.83% copper.

In the late 1970's, the Government initiated the Caraíba Metais S.A. mine, smelter, and refinery project. The Jagrarari open pit capacity was reported to be 40,000 tons per year of contained copper. Caraíba Metais' Outokumpu flash smelter came on-stream at Camacari at yearend 1982. Production, which reached 63,000 tons in 1983, was from domestic and foreign concentrates. The refinery at Caraíba also was started up in 1982 and was expected to produce 115,000 tons of copper per year, assuming production problems encountered at the smelter can be resolved. The Caraíba Project also included a 150,000-ton-per-year mill for continuous-cast wire rod. The project enjoyed the protection of the Government through import restrictions and price controls, and was reported to be unprofitable owing to its high operating costs and large debts. With six wire rod mills currently operating, Brazil's wire rod capacity of nearly 300,000 tons per year was far in excess of copper wire consumption.[18]

Canada.—Canadian copper mines in the western Provinces, principally in British Columbia, accounted for 46% of Canadian copper mine production. Most of their copper concentrates were exported, mainly to Japan and Western Europe, while central and eastern mines shipped concentrates to six Canadian smelters, which had a combined capacity of about 650,000 tons per year of copper. Byproduct metals played an important role in Canadian copper production, with much of Canada's copper being mined in conjunction with nickel, gold, silver, molybdenum, and zinc. The relative cost competitiveness of Canadian copper production, on a world basis, continued to deteriorate as a result of weaker byproduct metal prices, rising energy and labor rates, and a strong Canadian dollar relative to the major copper producing countries, exclusive of the United States. As a result, cost-cutting measures were implemented and competitive pricing strategies adopted.[19] By yearend, Noranda had reduced its producer premium for North American sales to 2.5 cents per pound over that of COMEX, down from the 5-cent premium instituted 1 year earlier. Although some mines reopened, most of the mine closures and cutbacks instituted during 1982 were continued in 1983, capacity from operating mines having dropped by over 100,000 tons of copper per year since 1981.

Selected openings and closures that occurred during 1983 include the closure of Noranda's Gaspé, Quebec, smelter for 3 months, owing to a shortage of concentrates; permanent closure of Teck Corp.'s 25,000-ton-per-year smelter near Kamloops, British Columbia, in July, with the Afton Mine, which had reopened in May along with the smelter, continuing to operate; reopening of Corporation Falconbridge Copper's Lake Dufault copper-zinc-silver-gold property in April in anticipation of higher copper prices; closure of Brenda Mines Ltd.'s mine near Peachland, British Columbia, in September; resumption of stripping in October at Noranda's Bell Mine, which was closed during July 1982 along with the Granisle Mine; and the startup of Arrowhead Metals Ltd.'s $4 million copper and copper alloy rolling mill in July.

Chile.—The Government-owned Corporación Nacional del Cobre de Chile (CODELCO-Chile) produced 1,012,000 tons of copper, accounting for 84% of Chilean copper production; it operated four mining divisions, Chuquicamata, El Teniente, El Salvador, and Andina. Chuquicamata and El Teniente were the world's largest open pit and underground copper mines, respectively, and accounted for over 80% of CODELCO-Chile's production. CODELCO-Chile, with a reported production cost, including byproduct credits, of 36.1 cents per pound of copper,[20] had an aftertax net income of $220 million, up 37% from that of 1982, and contributed $678.5 million to the national treasury.

As part of its plans to maintain CODELCO-Chile's copper production at levels of at least 1 million tons per year, the Ministry of Finance budgeted $215 million in 1983 for capital projects, in large part aimed at offsetting declining ore grades. In December, CODELCO-Chile made a public announcement detailing its short- and long-term investment projects, expected to total \$2 billion over the next 5 years. The projects, which are centered on the Chuquicamata Mine, were aimed at maintaining and then increasing production levels despite decreasing ore grades. Included in the planned investments was development of the Sur-Sur deposit adjacent to the Andina Mine.

In support of its development projects, CODELCO-Chile sought financial backing through MDB. In December, the IDB approved a \$268 million loan to CODELCO-Chile, in support of expansion and modernization projects at Chuquicamata and El Teniente, totaling \$670 million. The loan, which carried a 15-year amortization period and a 5-year grace period, was broken into two installments, \$100 million for 1983 and the balance to be disbursed in 1984. The IDB was also arranging complementary financing of an additional \$268 million from commercial banks. It was estimated that the proposed project at the Chuquicamata and El Teniente Div. would increase CODELCO-Chile's copper capacity by 142,000 tons per year. In December, Fluor Corp. and Bechtel Corp., both U.S. corporations, made application to the EXIM Bank to finance \$134 million of U.S. goods and services for expansion of the Chuquicamata concentrator. The proposed expansion was expected to increase copper production by an estimated 174,000 annual tons.

A 4-day strike in June began at CODELCO-Chile's El Salvador Mine and spread to the Andina and El Teniente Mines following the arrest of the Copperworkers Confederation president. The Government response, firing over 2,000 strikers for contract violation, led to a national general strike, which lasted for 3-1/2 days. Following the strike, CODELCO-Chile announced that operations were back to normal; however, slowdowns were reported at the El Teniente Mine, where replacement workers had been hired; the Government reportedly permanently dismissing over 500 of its original workers.

The state-owned custom smelting and refining company, Empresa Nacional de Minería (ENAMI), established a price-support system effective in December 1983, and reduced smelter toll charges as of January 1984 for copper and silver produced at small- and medium-size private sector mines. The copper support price was 70 cents per pound, with the mines required to reimburse ENAMI for the difference between the price support and market price when the market price recovers. ENAMI had no mines of its own, having sold its small mines in recent years, but operated two smelters with a combined capacity of 470,000 tons per year of concentrate. Planned expansion and modernization was geared toward absorbing the 800,000 tons per year of concentrate available from small- and medium-size mines, and toward tolling contracts with CODELCO-Chile.

At yearend, Rio Algom Ltd., of Canada, developer of the Cerro Colorado Project, was seeking support for the project from Japanese smelting and trading companies. Projections called for production of 60,000 tons per year of copper contained in concentrates, beginning in 1988.

Exxon Corp.'s Cía Minera Disputada de las Condes S.A., which operates the El Soldado and Los Bronces copper mines, increased copper production from the two mines by 14%, to almost 60,000 tons. Plans for expansion of the El Soldado Mine were shelved, while plans for expansion of the Los Bronces Mine were cut to 180,000 tons per year of copper within 4 years, from the original plans, which called for 280,000 tons per year.

China.—China made news in early 1983 when it was reported to be buying significant amounts of refined copper from Western markets. Domestic copper production capacity was reported to be about 300,000 tons per year of refined copper. Construction of a 90,000-ton-per-year Japanese-built smelter in Jiangxi was completed. However, startup was reportedly postponed for 2 years, owing to a delay in completion of railways and other infrastructure as well as lack of feed material.

Iran.—In December 1981, following delays due to the 1979 revolution, the concentrator at the Sar Chesmeh copper mine was commissioned; in May 1982, the smelter began producing blister copper. The mine reportedly reached its originally planned capacity of 145,000 tons per year of contained copper by mid-1983, and the 158,000-ton-per-year refinery was expected to begin production early in 1984. The Sar Chesmeh deposit included a 20-million-ton oxide ore body grading 8% copper and proven reserves of 450 million tons of ore grading 1.13% copper.

Japan.—Japan was a net importer of refined copper in 1983, with domestic production supplying over 85% of Japanese consumer demand. Demand was estimated at 1.2 million tons, down 3% from that of 1982. Although Japan was the second largest producer of refined copper, with a refinery capacity exceeding 1.2 million tons per year and a smelter capacity of over 1.3 million tons per year of copper, it had a mine production capacity of only 53,000 tons per year of copper. There were 10 primary copper smelters and 11 refineries in Japan, with 6 companies owning over 95% of Japan's smelting capacity.[21]

In recent years, Japan was the terminus for between 60% and 70% of Western World trade in copper concentrates. A 7.5% tariff on refined copper, in theory aimed at protecting the small domestic mining sector, allowed the integrated smelting-refining companies to charge a premium over world prices for refined copper and to compete favorably for foreign concentrates. However, because of the short supply of copper concentrates in 1983 and the resulting less favorable contract terms, most Japanese smelters announced plans to cut smelter production in 1984 by at least 10%.

Mexico.—Although smelter and refinery expansion projects were underway in 1983, recent expansions of copper mines had resulted in Mexico becoming a major exporter of copper concentrates. Mexico had a mine capacity of about 250,000 tons, more than twice its 120,000-ton-per-year smelting and refining capacity.

The $450 million loan to Cía. Minera de Cananea for expansion of its Cananea Mine and smelter complex in Sonora State, originally approved in July 1982 and later deferred, remained on hold, with approval deemed unlikely. Although funding for the project had not been definitely secured, Cananea was proceeding with expansion plans that called for about a threefold increase in mine production and a smelter expansion from 70,000 to 125,000 tons per year of copper. Cananea reportedly planned to spend about $350 million of the project funding for engineering and equipment, and an additional $75 million EXIM Bank credit for trucks and mining equipment in the United States. Potential air pollution problems from the smelter, located 20 miles from the U.S. border, became a controversial issue in the U.S. Congress and in Arizona. A 42-day strike that affected over 2,400 employees of Cananea ended on October 17.

According to the Mexican Mining Chamber, over $1 billion had already been committed to the La Caridad Project, operated by Mexicana de Cobre S.A., with $250 million allocated to the smelter alone. Startup of the smelter was expected in 1985, although the refinery contract had been suspended indefinitely.

Peru.—Despite the low value of copper exports and an almost 10% decline in copper production, copper accounted for 14.5% of Peru's total export earnings in 1983. The decline in production was primarily due to lengthy strikes at SPCC's Toquepala Mine (62 days), Cuajone Mine (47 days), and Ilo smelter (65 days), which resulted in a 13% decline in production by Peru's largest copper producer. SPCC, along with state-owned Empresa Minera del Perú and Empresa Minera del Centro del Perú (Centromín Perú), comprised the large-scale mining sector, and accounted for about 90% of copper output.

Centromín Perú's $250 million mine and concentrator expansion project at the Cobrizza copper mine was not expected to be profitable. Although work on expansion of the concentrator was completed in May 1982, mine capacity was not reached until late 1983, owing to difficult geologic conditions. Lower than anticipated ore grade, 1.4% versus an expected 1.8%, was expected to reduce annual production by an estimated 39,700 tons of copper, about 20% below the original estimate.

A Centromín Perú subsidiary, Cía Minera Los Montes S.A., opened the Monterrosas copper mine near Ica in 1982. At a mining rate of 1,000 tons per day, the estimated 1.3 million tons of ore grading 1.4% copper presented a serious reserve depletion problem. This was alleviated somewhat in 1983 with the discovery of an estimated 800,000 tons of ore grading 3% copper, at the Sol Radiant vein in the neighboring Raquel concession. Los Montes was considering purchasing these concessions if preliminary ore reserve estimates are confirmed by further exploration.

Philippines.—The financial situation of Philippine copper producers improved slightly from that of 1982, primarily owing to the improved price for copper and to devaluations of the Philippine peso; however, mine production dropped and many of the small producers that closed during 1982 remained closed because of high production costs and insufficient operating funds. The price-support system instituted by the state-owned National Development Co. during 1982 expired at the end of April 1983, corresponding with a second-quarter rise in copper prices. By yearend, Government plans were being formulated to renew financial aid for the country's mining sector.

Although its production dropped from the 1982 level, primarily because of temporary mine flooding, Atlas Consolidated Mining Development Corp., the Philippines' largest copper producer, reported a modest profit in 1983. Atlas, which operated one of the world's largest copper mining projects, the Toledo operations, processed ore from two open pit mines and one underground mine at its three concentrators. Expansion of its Lutopon underground mine was reportedly 90% complete, with production from the lower levels expected to begin in April 1984.

In April 1983, Philex Mining Corp., the most profitable Philippine copper producer, approved a $33 million expansion program to increase its copper milling capacity at Bagnio, Benguet, from 27,000 to 37,000 tons per day by 1987. In October, Marinduque Mining and Industrial Corp. closed its Sipalay Mine after it was unable to arrange financing to obtain spare parts. The company lost over $300 million in 1983, having lost a total of $660 million since 1980.

PASAR completed its 138,000-ton-per-year smelting and refining complex at Isabel, in southern Leyte, and began production of copper cathode in July. Because of an unstable power supply, mechanical adjustments to the plant, and shortages of concentrate, production of refined copper was below the planned output of 60,000 tons for the second half of 1983. Despite the higher treatment and refining charges, most copper producers, except Benguet, under Government pressure to do so, shipped about 30% of their copper concentrate to PASAR.

In May, ASEAN Copper Products Inc. was established as a joint venture by the Association of South East Asian Nations (ASEAN) to build a 100,000-ton-per-year copper fabrication plant adjacent to the PASAR smelter. The plant, which was scheduled to be completed by 1987, was to be 60% Philippine owned, with Indonesia, Malaysia, Singapore, and Thailand each taking a 10% share.

Zaire.—Copper was produced in Zaire by the state-owned company, La Générale des Carrières et des Mines du Zaire (Gécamines) and by Société de Dévelopment Industriel et Minière du Zaire (Sodimiza). Gécamines, the larger of the two, accounted for all of Zaire's smelter and refinery production. Eight Japanese companies, which held an 80% interest in Sodimiza, withdrew from the copper mining consortium in midyear, selling their interest to the Zairian Government for $30 million. The Japanese companies, which will continue to buy Sodimiza concentrates, lent the $30 million purchase price as well as an additional $20 million to the Zairian Government, repayment to take place over 15 years. The Japanese consortium reportedly lost more than $200 million from the withdrawal; poor copper prices and rising transportation costs were cited as reasons for Sodimiza's unprofitability.

The long-standing refining arrangement between Gécamines and Belgium's Métallurgie Hoboken-Overpelt SA (MHO) came under stress at midyear with Gécamines claiming that the Belgian refiner was charging as much as 30% more than other refiners. Approximately 100,000 tons per year of electrowon cathode and 150,000 tons per year of blister were shipped to Belgium for refining. A new 3-year contract, reached in October, included a reduction in MHO refining charges, bringing them in line with charges by other European refiners.

Zambia.—Copper mine, smelter, and refinery production in Zambia was controlled by Zambia Consolidated Copper Mines Ltd. (ZCCM), which was founded in March 1982 through the merger of Nchanga Consolidated Copper Mines Ltd. and Roan Consolidated Mines Ltd. ZCCM, which was 60.3% Government owned, produced copper from 10 underground mines and 7 open pit mines located primarily in north-central Zambia, in an extensive copperbelt that extends into Zaire. ZCCM also operated three smelters, three electrowinning plants, and three refineries. Zambia exported more than 99% of its refined copper production, copper accounting for more than 85% of its export earnings. Between 1974 and 1983, Zambia experienced an 18% decline in refined copper production, in part owing to lack of capital expenditures and poor equipment maintenance owing to a shortage of spare parts. Although ZCCM was able to show a pretax profit for the last three quarters of 1983, in part owing to a 20% devaluation of the kwacha in January, an 8% mineral export tax resulted in net losses for the last two quarters.

In August, China agreed to allow Tanzania and Zambia an additional 10 years to repay a $494 million loan that had been used to finance the railway linking the two countries, freeing money for repair work on the line. The railway, which provided a vital link to market for landlocked Zambia, suffered damage in February that halted shipments for 3 weeks. Zambia was seeking additional funding for modernization of the 10-year-old railway.

The African Development Bank approved a $28 million loan to Zambia to aid in improving mine efficiency. In September, a new contract agreement was reached with the Mineworker's Union of Zambia that averted a major strike.

TECHNOLOGY[22]

Research and development over the broad spectrum of copper technology continued. New technologies were becoming necessary and evolving to improve productivity and reduce costs, while at the same time minimizing environmental damage. Much attention was given to materials handling and the application of computers to process control. The former included advanced systems such as in-pit mobile crushing and conveying systems. For example, Kennecott was planning a major modernizing program for the Bingham Canyon Mine. This was to include in-pit crushing, with a conveying system for both ore and waste, and a new mill, to be constructed near the pit. Other areas of interest included advanced mining technologies, such as the use of continuous mining machines in underground operations. Significant articles and publications dealing with a variety of these subjects are listed as references.[23]

In a study funded by the Bureau of Mines,[24] a 62-member panel of copper experts from government, industry, and academia evaluated the possible use of innovative technologies over the next two decades. Twenty-two technologies, covering the six phases of the copper production cycle, i.e., exploration, mining, beneficiation, smelting, refining, and recycling, were considered. According to the panel, the possibility for major change appeared most apparent in exploration; the change could occur through the development of better computer software and more sophisticated analytical techniques with which to interpret data. In the mining phase, the consensus was that any radical change is unlikely; rather, change will be incremental and evolve from current mining methods. The direction probably will be toward continuous mining systems, including mobile crushers and conveyor belts together with greater use of computers to control the process. Other improvements in open pit mining, such as the use of double benching and twin blasting to obtain steeper slopes and competent walls, were discussed. A moderate increase in in situ leaching was considered possible. Changes in beneficiation also were expected to be gradual, with autogenous and semiautogenous grinding being likely to get universal acceptance. Concentrators were expected to become increasingly automated.

In smelting, energy and environmental concerns were expected to lead the domestic industry to adopt flash smelting. More advanced and efficient technology, such as continuous smelting, also may be adopted. Other than acid leaching, hydrometallurgical techniques for processing sulfide ores have not been widely adopted. It appeared that in the case of acid leaching, improved methods such as thin-layer leaching and coproduct recovery, such as cobalt recovery from copper leach solutions, could make this process significantly more attractive in the future.

Innovative changes in copper refining processes were expected to be minimal. However, the processes were expected to gradually become highly automated and use stainless steel blanks for cathodes rather than the traditional copper starting sheets. With respect to electrowinning of copper, reduction of cell voltage and power consumption by introducing sulfur dioxide into the system was believed possible.

In the recycling phase, four technologies were the subject of research: cryogenic, eddy current, shredding, and granulation. A Bureau of Mines study indicated that scrap processing plants were capital intensive and that recycling was significantly more sensitive to price than to technology. Improvements can be effected through the use of improved methods for rapid identification and sorting.

[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. Int. Trade Comm. Invest. No. TA-201-52, May 8, 1984, p. 9.

[3]World Bureau of Metal Statistics. World Metal Statistics. Apr. 1984, p. 36.

[4]Rosenkranz, R. D., E. H. Boyle, Jr., and K. E. Porter. Copper Availability—Market Economy Countries. A Minerals Availability Program Appraisal. BuMines IC 8930, 1983, pp. 2-7.

[5]U.S. House of Representatives. Statement by George Hoguet, Principal Deputy Assistant Secretary of Treasury for International Affairs Before the Subcommittee on Mining, Forest Management, and Bonneville Power Administration. Apr. 10, 1984. 6 pp.; copy available from the Committee on Interior and Insular Affairs, U.S. Senate, Washington, DC.

[6]Everest Consulting Associates Inc. IMF and Development Bank Lending to CIPEC Majors: Data for Analysis. Apr. 2, 1984, 18 pp.

[7]Federal Register. National Emission Standards for Hazardous Air Pollutants, Proposed Standards for Inorganic Arsenic. V. 48, No. 140, July 20, 1983, pp. 33112-33180.

[8]Phelps Dodge Corp. 1983 Annual Report. 36 pp.

[9]Arnold & Porter. Post-hearing Brief of Corporacion Nacional del Cobre de Chile (CODELCO-Chile). U.S. Int. Trade Comm. Invest. No. TA-201-52, May 23, 1984, pp. 45-49.

[10]Newmont Mining Corp. 1983 Annual Report. 52 pp.

[11]Noranda Mines Ltd. 1983 Annual Report. 48 pp.

[12]Work cited in footnote 8.

[13]Metal Bulletin (London). Beryllium Copper Demand Remains Buoyant. No. 6872, Feb. 17, 1984, p. 11.

[14]ASARCO Incorporated. Testimony of Alan S. Kafka, Manager of Copper Sales, Asarco in Support of the Petition for Relief; Before the U.S. International Trade Commission. Unalloyed Copper TA-201-52, May 15, 1984, 7 pp.

[15]Work cited in footnote 14.

[16]American Metal Market. Nine States Filed Price Fixing Suits Vs. Copper Tube Cos. V. 91, No. 155, Aug. 10, 1983, pp. 1, 16, 17.

[17]Page 47 of work cited in footnote 2.

[18]Commodities Research Unit Ltd. (London). Brazil. Copper Studies. V. 11, No. 9, Mar. 1984, 20 pp.

[19]Department of Energy, Mines and Resources (Canada). Canada's Nonferrous Metals Industry: Nickel and Copper. A Special Report. 1984, pp. 28-31.

[20]Statement by Patrick Cussen Before the U.S. International Trade Commission. U.S. Int. Trade Comm. Invest. No. TA-201-52, May 15, 1984, p. 31.

[21]Roskill Information Services (London). The Economics of Copper. 3d. ed., 1984, pp. 206-207.

[22]Prepared by N. L. Jensen, physical scientist, Division of Nonferrous Metals.

[23]Peterson, A. N. Using Conveyors To Cut Costs. Min. Eng., v. 35, No. 6, June 1983, pp. 589-591.

Fauquier, G. P. Trim Blasting and Double Benching. Eng. and Min. J., v. 184, No. 4, Apr. 1983, pp. 46-52.

Verney, L. R. Economic and Technological Aspects of Sulfide Smelting Processes. J. Met., v. 36, No. 1, Jan. 1984, pp. 35-42.

Domic, E. M. Thin Layer Leaching Practice: Cost of Operation and Process Requirements. J. Met., v. 36, No. 1, Jan. 1984, pp. 48-53.

Jeffers, T. H. Separation and Recovery of Cobalt From Copper Leach Solutions. Pres. at Metall. Soc. AIME Conf., Los Angeles, CA. Metall. Soc. AIME-TMS Selection A-84-21, Feb. 1984, 9 pp.

Hopper J. R. The ISA Process. Min. Mag., July 1983, pp. 29-35.

Robinson, D. SO_2 Electrowinning in Copper Hydrometallurgy for Energy Conservation. J. Met., v. 36, No. 1, Jan. 1984, pp. 43-47.

Riley, W. D., R. E. Brown, and D. M. Soboroff. Rapid Identification and Sorting of Scrap Metals. BuMines Conser. Recycling, v. 6, No. 4, 1983, pp. 181-192.

Ahlness, J. K., and M. G. Pojar. In Situ Copper Leaching in the United States. BuMines IC 8961, 1983, 37 pp.

Borovsky, J. P., D. F. Grigal, and R. L. Strassman. Reclamation of Tailing Basins Resulting From Copper-Nickel Milling. BuMines OFR 214-83, Aug. 1983, 149 pp.

Butterman, W. C. Copper. BuMines Mineral Commodity Profile, 1983, 18 pp.

Conway, E. J., and M. S. Sanders. Recommendations for Human Factors Research and Development Projects in Surface Mining. BuMines OFR 211-83, May 1982, 86 pp.

Dareing, D. W., E. T. Wood, and D. H. Davidson. Evaluation of Branch and Horizontal Boreholes for In Situ Leach Mining. BuMines OFR 34-84, July 1980, 151 pp.

Haynes, B. W., C. Carron, W. Kramer, and S. Law. Methods for Characterizing Manganese Nodules and Processing Wastes. BuMines IC 8953, 1983, 10 pp.

Helander, M. G., and G. S. Krohn. Human Factors Analysis of Underground Metal and Nonmetal Mines. BuMines OFR 16-84, Feb. 1983, 99 pp.

Kafritsas, J., H. H. Einstein, and B. Baecher. Combined Stability-Deformation Analysis for Rock Slopes in Open Pit and Strip Mines. BuMines OFR 183-83, Sept. 1983, 115 pp.

Pugliese, J. M., and J. P. Ludwig. Derivation and Use of the Critical-Path-Method Diagram To Streamline Metallic Premine Stage Requirements. BuMines OFR 208-83, 28 pp.

Richardson, P. E., J. V. Stout III, C. L. Proctor, and G. W. Walker. Electrochemical Flotation of Sulfides: Chalcocite-Ethylxanthate. Int. J. Miner., v. 12, 1984, pp. 73-93.

Termes, S. C., R. L. Wilfong, and P. E. Richardson. Flocculation of Sulfide Mineral Fines by Insoluble Cross-Linked Starch Xanthate. BuMines RI 8819, 1983, 23 pp.

Torbin, R., and E. Thimons. Applications for Turbomachinery in the Deep Mining Industry. Turbomachinery Int., v. 24, No. 9, Nov.-Dec. 1983, pp. 23-26.

Walkiewicz, J. W., M. M. Wong, and E. Morrice. Magnetic Properties of Synthetic Mischmetal Alloyed With Cobalt, Copper, Iron, and Magnesium. BuMines RI 8808, 1983, 14 pp.

[24]Mineral System Inc. Technological Innovation in the Copper Industry. BuMines OFR 125(1)—(3)-83, Mar. 1983, 58 pp., 137 pp., and 91 pp.

Table 5.—Copper produced from domestic ores in the United States

(Thousand metric tons)

Year	Mine	Smelter	Refinery
1979	[r]1,447	1,313	[r]1,413
1980	1,181	994	[r]1,126
1981	1,538	1,295	1,430
1982	[r]1,147	941	1,065
1983	1,038	888	1,004

[r]Revised.

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]
1979	89	84	11	16
1980	91	86	9	14
1981	89	84	11	16
1982	88	82	12	18
1983	89	85	11	15

[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	1982[r]	1983
January	113,150	90,025
February	108,134	77,664
March	120,578	89,274
April	112,662	84,646
May	97,628	92,170
June	90,614	89,717
July	85,179	76,323
August	81,574	79,211
September	78,585	86,704
October	87,071	89,608
November	90,285	93,706
December	81,515	89,050
Total	1,146,975	1,038,098

[r]Revised.

Table 8.—Mine production of recoverable copper in the United States, by State

(Metric tons)

State	1979	1980	1981	1982	1983
Alaska	--	--	--	W	W
Arizona	[r]949,031	770,118	1,040,813	[r]769,521	678,216
California	W	W	W	W	W
Colorado	362	461	W	575	W
Idaho	3,618	3,103	4,245	3,074	3,556
Michigan	W	W	W	W	--
Missouri	13,021	13,576	8,411	7,941	7,725
Montana	69,854	37,749	62,485	[r]64,951	33,337
Nevada	W	W	W	W	W
New Mexico	164,281	149,394	154,114	W	W
Oregon	2	--	W	--	W
South Carolina	--	--	W	--	--
Tennessee	W	W	W	W	W
Utah	193,082	157,775	211,276	189,090	169,751
Washington	W	--	W	W	--
Total	[r]1,446,586	1,181,116	1,538,160	[r]1,146,975	1,038,098

[r]Revised. W Withheld to avoid disclosing company proprietary data; included in "Total."

Table 9.—Twenty-five leading copper-producing mines in the United States in 1983, in order of output

Rank	Mine	County and State	Operator	Source of copper
1	Bingham Canyon	Salt Lake, UT	Kennecott	Copper ore and copper precipitates.
2	Morenci	Greenlee, AZ	Phelps Dodge Corp	Do.
3	San Manuel	Pinal, AZ	Magma Copper Co	Copper ore and copper tailings (slag).
4	Chino	Grant, NM	Chino Mines Co	Copper ore and copper precipitates.
5	Bagdad	Yavapai, AZ	Cyprus Bagdad Copper Co	Copper ore.
6	Inspiration	Gila, AZ	Inspiration Consolidated Copper Co.	Do.
7	Sierrita	Pima, AZ	Duval Corp	Do.
8	Tyrone	Grant, NM	Phelps Dodge Corp	Do.
9	New Cornelia	Pima, AZ	do	Copper ore and copper precipitates.
10	Ray	Pinal, AZ	Kennecott	Do.
11	Eisenhower	Pima, AZ	Eisenhower Mining Co	Copper ore.
12	Twin Buttes	do	Anamax Mining Co	Do.
13	Mission	do	ASARCO Incorporated	Do.
14	Berkeley	Silver Bow, MT	Anaconda Copper Co	Copper ore and copper precipitates.
15	Lakeshore	Pinal, AZ	Noranda Lakeshore Mines Inc	Copper ore.
16	Sacaton	do	ASARCO Incorporated	Do.
17	Troy	Lincoln, MT	do	Silver ore.
18	San Xavier	Pima, AZ	do	Copper ore.
19	Silver Bell	do	do	Copper ore and copper precipitates.
20	Copperhill (1 mine)	Polk, TN	Tennessee Chemical Co	Copper-zinc ore.
21	Pinto Valley	Gila, AZ	Pinto Valley Copper Corp	Copper ore.
22	Battle Mountain	Lander, NV	Duval Corp	Do.
23	Johnson	Cochise, AZ	Cyprus Johnson Copper Co	Do.
24	Miami	Gila, AZ	Pinto Valley Copper Corp	Do.
25	Esperanza	Pima, AZ	Duval Corp	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
1982				
Mined copper ore:				
By concentration or leaching	r [1]181,826	r1,007,001	0.55	
By direct smelting	118	167	.14	
Total or average	r181,944	r1,007,168	.55	
Tailings, dump, in-place material by leaching	--	104,791	--	
Miscellaneous:				
Silver ore	3,652	20,616	--	
Lead ore	8,531	7,941	--	
Gold ore, gold-silver ore, lead-zinc ore, molybdenum ore, tungsten ore, cleanup, tailings	6,417	6,459	--	
Grand total	XX	r1,146,975	XX	
1983				
Mined copper ore:				
By concentration or leaching	[2]177,930	915,081	.51	See table 12.
By direct smelting	63	24	.04	See table 13.
Total or average	177,993	915,105	.51	
Tailings, dump, in-place material by leaching	--	89,274	--	See table 14.
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	

rRevised. XX Not applicable.
[1]Includes 7,288,615 tons (revised) of ore leached for electrowinning.
[2]Includes 6,153,969 tons of ore leached for electrowinning.

Table 11.—Copper ore shipped directly to smelters or concentrated in the United States in 1983, by State, with copper, gold, and silver content in terms of recoverable metal

State	Ore shipped or concentrated (thousand metric tons)	Recoverable metal content				Value of gold and silver per metric ton of ore
		Copper		Gold (troy ounces)	Silver (troy ounces)	
		Metric tons	Percent			
Arizona	115,990	524,295	0.45	54,534	4,131,928	$0.61
Montana	6,283	16,454	.26	1,383	313,093	.66
New Mexico	W	W	W	W	W	W
Tennessee[1]	W	W	W	---	W	W
Utah	30,219	151,881	.50	W	W	W
Total or average	171,839	810,114	.47	258,222	7,344,180	1.13

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 1983, by State, with content in terms of recoverable copper

State	Ore concentrated (thousand metric tons)	Recoverable copper content	
		Metric tons	Percent
Arizona	115,983	524,291	0.45
Montana	6,283	16,454	.26
New Mexico	W	W	W
Tennessee[2]	W	W	W
Utah	30,219	151,881	.50
Total or average	171,776	810,090	.47

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 1983, by State, with content in terms of recoverable copper

State	Ore shipped to smelters		
	Metric tons	Recoverable copper content	
		Metric tons	Percent
Arizona	6,941	4	0.06
New Mexico	56,548	20	.04
Total or average	63,489	24	.04

[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 1983, by State

(Metric tons)

State	Precipitates shipped	Recoverable copper content
Arizona	75,807	51,201
California	W	W
Montana	W	W
New Mexico	W	W
Utah	25,828	17,809
Total	130,857	89,274

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		Concentrated and leached ore		Total				
	Thousand metric tons	Yield in copper (percent)	Thousand metric tons[1]	Yield in copper (percent)	Thousand metric tons[1]	Yield in copper (percent)	Yield per metric ton in gold (troy ounces)	Yield per metric ton in silver (troy ounces)	Value per metric ton in gold and silver
1979	199	0.30	264,591	0.49	264,790	0.49	0.0016	0.057	$1.12
1980	111	.38	221,486	.48	221,597	.48	.0013	.053	1.90
1981	158	.14	277,516	.51	277,674	.51	.0013	.053	1.18
1982	118	.14	r181,826	.55	r181,944	.55	.0013	r.052	r.90
1983	63	.04	177,930	.51	177,993	.51	.0015	.041	1.09

rRevised.
[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
1979	1,313,224	22,383	60,231	1,395,838
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

Table 17.—Primary and secondary copper produced by primary refineries and electrowinning plants in the United States

(Metric tons)

	1979	1980	1981	1982	1983
PRIMARY					
From domestic ores, etc.:[1]					
Electrolytic	r1,207,572	924,190	r1,194,566	891,615	820,778
Electrowon	r100,134	r 2117,572	r161,083	r131,858	101,935
Fire-refined	105,091	84,469	74,561	41,060	80,955
Total	r1,412,797	r1,126,231	1,430,210	r1,064,533	1,003,668
From foreign ores, etc.:[1]					
Electrolytic[3]	103,858	88,957	113,807	162,245	178,422
Electrowon	W	W	W	W	W
Fire-refined	W	W	--	--	--
Total primary	r1,516,655	r1,215,188	1,544,017	r1,226,778	1,182,090
SECONDARY					
Electrolytic[3]	298,344	315,062	303,338	268,952	224,721
Electrowon	W	W	W	W	W
Fire-refined	W	W	W	W	W
Total secondary	298,344	315,062	303,338	268,952	224,721
Grand total	r1,814,999	r1,530,250	1,847,355	r1,495,730	1,406,811

rRevised. 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 electrowon and fire-refined quantities indicated by symbol W.

Table 18.—Copper cast in forms at primary refineries in the United States

	1982		1983	
	Thousand metric tons	Percent	Thousand metric tons	Percent
Billets	98	7	97	7
Cakes	37	2	22	2
Cathodes	1,170	78	1,184	84
Ingots and ingot bars	31	2	81	6
Wirebars	149	10	22	1
Other forms	11	1	1	--
Total	1,496	100	1,407	100

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		
1979	35,005	9,286	33,802	8,861
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	37,160	5,029

[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	Zinc plants[3]	Total
1979	2,513,035	282,704	773,836	3,569,575
1980	2,097,692	[4]410,266	560,784	3,068,742
1981	2,593,762	[4]405,974	545,890	3,545,626
1982	1,879,983	[4]310,606	341,728	2,532,317
1983	1,837,827	[4]319,137	384,529	2,541,493

[1]Includes acid from foreign materials.
[2]Excludes acid made from pyrite concentrates.
[3]Excludes acid made from native sulfur.
[4]Includes acid processed at molybdenum plants to avoid disclosing company proprietary data.

Table 21.—Copper recovered from scrap processed in the United States, by kind of scrap and form of recovery

(Metric tons)

	1982	1983
KIND OF SCRAP		
New scrap:		
Copper-base	649,406	611,038
Aluminum-base	20,192	21,926
Nickel-base	122	254
Zinc-base	20	31
Total	669,740	633,249
Old scrap:		
Copper-base	501,576	436,860
Aluminum-base	16,047	18,015
Nickel-base	76	158
Tin-base	NA	NA
Zinc-base	27	120
Total	517,726	455,153
Grand total	1,187,466	1,088,402
FORM OF RECOVERY		
As unalloyed copper:		
At primary plants	268,952	224,721
At other plants	212,613	194,067
Total	481,565	418,788
In brass and bronze	660,152	629,950
In alloy iron and steel	1,492	1,444
In aluminum alloys	41,930	36,971
In other alloys	77	173
In chemical compounds	2,250	1,076
Total	705,901	669,614
Grand total	1,187,466	1,088,402

NA Not available.

Table 22.—Secondary copper produced in the United States

(Metric tons unless otherwise specified)

	1979	1980	1981	1982	1983
Copper recovered as unalloyed copper	516,271	534,556	514,518	481,565	418,788
Copper recovered in alloys[1]	1,036,254	902,871	903,594	705,901	669,614
Total secondary copper[1]	1,552,525	1,437,427	1,418,112	1,187,466	1,088,402
Source:					
New scrap	948,224	823,969	819,990	669,740	633,249
Old scrap	604,301	613,458	598,122	517,726	455,153
Percentage equivalent of domestic mine output	108	122	92	104	105

[1]Includes copper in chemicals as follows in metric tons: 1979—3,004; 1980—2,869; 1981—3,227; 1982—2,250 (revised); and 1983—1,076.

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	
	1982	1983	1982	1983	1982	1983
Secondary smelters	186,827	91,014	237,366	184,021	424,193	275,035
Primary copper producers	74,055	40,925	194,897	183,796	268,952	224,721
Brass mills	375,289	464,032	31,271	26,640	406,560	490,672
Foundries and manufacturers	12,118	14,706	37,357	41,660	49,475	56,366
Chemical plants	1,117	361	685	743	1,802	1,104
Total	649,406	611,038	501,576	436,860	1,150,982	1,047,898

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	1982	1983
UNALLOYED COPPER PRODUCTS		
Refined copper by primary producers	268,952	224,721
Refined copper by secondary smelters	198,597	176,911
Copper powder	9,686	11,425
Copper castings	4,330	5,731
Total	481,565	418,788
ALLOYED COPPER PRODUCTS		
Brass and bronze ingots:		
Tin bronzes	18,220	15,824
Leaded red brass and semired brass	102,654	98,111
High-leaded tin bronze	11,210	10,375
Yellow brass	6,528	7,628
Manganese bronze	6,959	7,520
Aluminum bronze	5,593	6,331
Nickel silver	2,646	3,265
Silicon bronze and brass	3,330	3,596
Copper-base hardeners and master alloys	12,620	14,977
Total	169,760	167,627
Brass-mill products	500,573	612,820
Brass and bronze castings	34,646	39,259
Brass powder	933	644
Copper in chemical products	2,259	1,076
Grand total	1,189,727	1,240,214

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]							
1982	144,808	3,969	7,659	12,920	349	55	169,760
1983	133,766	4,895	8,901	19,646	318	101	167,627
Secondary metal content of brass-mill products:							
1982	406,560	387	2,148	89,703	1,769	6	500,573
1983	490,181	429	3,187	116,129	2,880	14	612,820
Secondary metal content of brass and bronze castings:							
1982	28,885	1,002	1,739	2,944	--	76	34,646
1983	32,503	1,185	2,032	3,461	6	72	39,259

[1]About 95% from scrap and 5% from other than scrap in 1982 and 1983.

Table 26.—Stocks and consumption of purchased copper scrap in the United States in 1983, by class of consumer and type of scrap

(Metric tons, gross weight)

Class of consumer and type of scrap	Stocks, Jan. 1	Receipts	Consumption: New scrap	Consumption: Old scrap	Consumption: Total	Stocks, Dec. 31
SECONDARY SMELTERS						
No. 1 wire and heavy copper	1,107	21,679	3,819	17,373	21,192	1,594
No. 2 wire, mixed heavy and light copper	8,026	104,744	38,643	68,467	107,110	5,660
Composition or red brass	2,970	37,381	8,449	29,259	37,708	2,643
Railroad-car boxes	68	714	--	674	674	108
Yellow brass	4,081	44,508	12,178	32,730	44,908	3,681
Cartridge cases and brass	28	208	--	228	228	8
Automobile radiators (unsweated)	2,505	60,935	59	59,837	59,896	3,544
Bronze	2,092	15,879	2,373	14,063	16,436	1,535
Nickel silver and cupronickel	650	2,816	198	2,636	2,834	632
Low brass	163	1,545	594	764	1,358	350
Aluminum bronze	59	338	244	58	302	95
Low-grade scrap and residues	9,133	82,990	69,152	18,592	87,744	4,379
Total	30,882	373,737	135,709	244,681	380,390	24,229
PRIMARY PRODUCERS						
No. 1 wire and heavy copper	1,882	33,562	13,923	20,737	34,660	784
No. 2 wire, mixed heavy and light copper	14,986	161,344	19,033	141,639	160,672	15,658
Refinery brass } Low-grade scrap and residues	19,307					29,972
Refinery brass		4,006	34	3,572	3,606	
Low-grade scrap and residues		124,615	26,954	87,396	114,350	
Total	36,175	323,527	59,944	253,344	313,288	46,414
BRASS MILLS[1]						
No. 1 wire and heavy copper	13,849	188,357	163,307	25,050	188,357	9,660
No. 2 wire, mixed heavy and light copper	1,237	52,535	50,973	1,562	52,535	3,519
Yellow brass	18,416	279,226	279,226	--	279,226	16,196
Cartridge cases and brass	11,292	66,306	66,306	--	66,306	9,150
Bronze	882	3,955	3,955	--	3,955	1,178
Nickel silver and cupronickel	4,182	19,963	19,963	--	19,963	4,428
Low brass	3,120	14,095	14,095	--	14,095	3,044
Aluminum bronze	--	29	29	--	29	--
Total[1]	52,978	624,466	597,854	26,612	624,466	47,175
FOUNDRIES, CHEMICAL PLANTS, AND OTHER MANUFACTURERS						
No. 1 wire and heavy copper	2,204	28,215	7,387	20,394	27,781	2,638
No. 2 wire, mixed heavy and light copper	390	4,422	1,731	2,617	4,348	464
Composition or red brass	559	15,166	2,060	13,044	15,104	621
Railroad-car boxes	691	3,845	--	3,791	3,791	745
Yellow brass	200	5,161	1,418	3,393	4,811	550
Automobile radiators (unsweated)	1,213	4,790	--	4,918	4,918	1,085
Bronze	826	586	277	281	558	854
Nickel silver and cupronickel	22	116	--	115	115	23
Low brass	69	1,227	848	392	1,240	56
Aluminum bronze	130	781	12	794	806	105
Low-grade scrap and residues	--	--	--	--	--	--
Total	6,304	64,309	[2]13,733	[2]49,739	63,472	7,141
GRAND TOTAL						
No. 1 wire and heavy copper	19,043	271,813	188,436	83,554	271,990	14,676
No. 2 wire, mixed heavy and light copper	24,640	323,045	110,380	214,285	324,665	25,301
Composition or red brass	3,528	52,547	10,509	42,303	52,812	3,263
Railroad-car boxes	759	4,559	--	4,465	4,465	854
Yellow brass	22,697	328,895	292,822	36,123	328,945	20,428
Cartridge cases and brass	11,320	66,514	66,306	228	66,534	9,158
Automobile radiators (unsweated)	3,718	65,725	59	64,755	64,814	4,629
Bronze	3,800	20,420	6,605	14,344	20,949	3,568
Nickel silver and cupronickel	4,854	22,895	20,161	2,751	22,912	5,084
Low brass	3,353	16,867	15,537	1,156	16,693	3,450
Aluminum bronze	188	1,148	284	852	1,136	199
Low-grade scrap and residues[3]	28,440	211,611	96,140	109,560	205,700	34,352
Total	126,340	1,386,039	807,240	574,376	1,381,616	124,962

[1]Brass-mill stocks include home scrap; purchased scrap consumption is assumed equal to receipts, so lines in "BRASS MILLS" and "GRAND TOTAL" sections do not balance.
[2]Of the totals shown, chemical plants reported 355 tons of new unalloyed copper scrap and 720 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
1982:						
Copper scrap	381,701	508,478	--	59,889	564,779	1,514,847
Refined copper[1]	--	393,205	1,232,841	27,732	4,364	1,658,142
Brass ingot	--	12,727	--	[2]161,230	--	173,957
Slab zinc	--	74,483	--	2,623	4,032	81,138
Miscellaneous	--	--	--	--	4,105	4,105
1983:						
Copper scrap	313,288	624,466	--	63,472	380,390	1,381,616
Refined copper[1]	--	500,263	1,233,882	30,173	3,151	1,767,469
Brass ingot	--	14,759	--	[2]132,596	--	147,355
Slab zinc	--	99,664	--	4,327	3,944	107,935
Miscellaneous	--	--	--	--	4,980	4,980

[1]Detailed information on consumption of refined copper can be found in table 29.
[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	1979	1980	1981	1982	1983
Tin bronzes	35,242	30,327	28,885	24,577	23,664
Leaded red brass and semired brass	107,596	95,138	94,142	75,402	86,421
Yellow brass	21,138	17,780	19,659	12,584	5,471
Manganese bronze	7,724	6,287	6,270	5,220	5,423
Hardeners and master alloys	5,913	5,446	4,411	2,499	2,493
Nickel silver	2,315	2,579	2,030	1,619	1,611
Aluminum bronze	7,267	6,727	6,853	5,038	5,675
Total	187,195	164,284	162,250	126,939	130,758

Table 29.—Foundries and miscellaneous manufacturers consumption of brass ingot and refined copper and copper scrap in the United States in 1983, by geographic division and State

(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[1] ingot	Refined copper consumed	Copper scrap consumed
New England:										
Connecticut	801	1,358	640	76			325	3,390	128	678
Maine, New Hampshire, Rhode Island, Vermont	206	1,657	76	262	22	400		2,427		
Massachusetts	403	1,914	18	167			109	2,621	651	196
Total[1]	1,410	4,929	734	505	22	400	434	8,434	779	874
Middle Atlantic:										
New Jersey	355	840	58	50			123	1,441	2,596	6,329
New York	485	5,724	250	515	406	445	81	7,120		
Pennsylvania	6,233	6,064	417	422			1,183	15,090	3,905	5,889
Total	7,073	12,628	725	987	406	445	1,387	23,651	6,501	12,218
East North Central:										
Illinois		8,885	14	496			715	11,409	94	8,345
	5,272				1,351	130				
Indiana		6,189	634	190			39	12,208	440	
Michigan		3,085	329	958			257	4,927	8,208	3,716
Ohio		6,813	135	355			424	10,732		5,976
	3,900				472	45			2,673	
Wisconsin		5,649	1,132	179			92	8,463		2,213
Total[1]	9,172	30,621	2,244	2,178	1,823	175	1,527	47,740	11,415	20,250
West North Central:										
Iowa, Kansas, Minnesota	102	3,846	58	577	78	52	118	4,807	2,378	10,647
Missouri, Nebraska, South Dakota	88	1,561	76	202			273	2,224		
Total	190	5,407	134	779	78	52	391	7,031	2,378	10,647

South Atlantic:										
Delaware, District of Columbia, Florida, Georgia, Maryland	225	374	404	45	1	396	67	1,086	1,404	4,613
North Carolina, South Carolina, Virginia, West Virginia	135	7,572		54			260	8,445		
Total[1]	360	7,946	404	99	1	396	327	9,533	1,404	4,613
East South Central:										
Alabama, Kentucky, Mississippi, Tennessee	1,010	9,322	1	399			633	10,987		4,220
West South Central:										
Arkansas, Louisiana, Oklahoma, Texas	2,735	7,727	251	18	116	100		11,319	6,355	897
Mountain:										
Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah	281	614	70	11			12	994		329
Pacific:										
California	1,323	7,161	908	447	47	43	964	9,951	732	9,823
Oregon and Washington	110	66						1,118		517
Total	1,433	7,227	908	447	47	43	964	11,069	732	10,340
Grand total	23,664	86,421	5,471	5,423	2,493	1,611	5,675	130,758	29,564	64,388

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

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
1982:							
Wire rod mills	1,028,024	183,876	W	W	--	20,941	1,232,841
Brass mills	172,088	11,231	35,203	92,430	82,152	101	393,205
Chemical plants	--	--	--	--	--	361	361
Secondary smelters	897	--	3,335	--	--	132	4,364
Foundries	1,440	W	3,865	--	W	2,340	7,645
Miscellaneous[1]	8,527	W	2,686	W	W	8,513	19,726
Total	1,210,976	195,107	45,089	92,430	82,152	32,388	1,658,142
1983:							
Wire rod mills	1,205,290	27,215	W	W	--	1,377	1,233,882
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	929	11,253
Miscellaneous[1]	8,753	W	3,636	1,149	W	4,774	18,312
Total	1,448,072	41,395	53,222	115,251	101,837	7,692	1,767,469

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
1979	275,000	64,000	44,000	25,000	9,000	90,000	232,000
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

[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 1982,[1] by grade

(Cents per pound)

Grade	Jan.	Feb.	Mar.	Apr.	May	June
No. 2 heavy copper scrap	57.43	57.20	53.76	53.99	53.38	43.24
No. 1 composition scrap (red brass)	52.50	52.50	51.80	50.50	50.30	45.18
No. 115 brass ingot (85-5-5-5)	92.50	92.50	89.11	88.50	88.50	86.91

Grade	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average
No. 2 heavy copper scrap	47.12	46.49	47.83	48.79	48.61	50.75	50.73
No. 1 composition scrap (red brass)	41.50	41.50	41.50	41.50	41.50	41.50	45.98
No. 115 brass ingot (85-5-5-5)	84.07	84.41	85.50	85.50	83.55	79.50	86.71

[1]Data not available for 1983.

Source: Metal Statistics, 1983.

Table 33.—Average monthly prices for electrolytic copper in the United States and on the London Metal Exchange

(Cents per pound)

Month	1982				1983			
	Domestic delivered		London spot[1]		Domestic delivered		London spot[1]	
	Cathode	Wirebar	Cathode	High	Cathode	Wirebar	Cathode	High
January	77.62	78.63	72.84	73.03	77.54	80.22	68.86	71.28
February	77.62	78.78	72.20	72.36	81.05	84.02	73.09	74.70
March	74.83	75.86	68.27	68.48	79.24	82.07	71.13	72.44
April	75.46	76.27	68.60	69.00	80.85	83.49	74.58	75.95
May	76.83	77.95	68.62	69.27	82.93	85.63	77.50	80.07
June	70.03	71.49	58.32	58.98	79.16	81.84	74.87	77.14
July	70.13	71.05	63.86	65.33	80.19	82.95	74.61	77.29
August	69.93	71.00	63.41	65.81	77.94	80.54	72.14	74.36
September	69.49	71.06	62.39	64.66	74.38	77.59	68.77	70.77
October	70.10	72.41	62.47	66.27	69.70	72.39	63.58	65.08
November	70.01	72.97	62.15	65.47	71.57	74.23	61.88	62.99
December	71.57	74.23	63.74	66.81	68.14	70.81	63.06	64.18
Average	72.80	74.31	65.57	67.14	76.53	79.26	70.29	72.13

[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[1]	Foreign copper
1979	93.3	[r]90.1
1980	102.4	[r]99.3
1981	85.1	[r 2 3]79.4
1982	74.3	[r]67.1
1983	79.3	72.1

[r]Revised.
[1]Producers cathode, delivered.
[2]Based on Jan.-Nov. monthly averages.
[3]Wirebar contract replaced by high-grade contract.

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)
1982	195,275	$211,196	2,874	$10,385	30,558	$45,797	54,419	$63,484	2,008	$3,680
1983:										
Belgium-Luxembourg	--	--	521	2,792	719	1,982	2,429	8,587	23	31
Canada	83	29	4,462	3,178	1,736	2,796	13,373	15,563	360	640
China	--	--	--	--	2,155	3,730	--	--	--	--
France	--	--	--	--	636	1,391	18	12	--	--
Germany, Federal Republic of	6,981	7,952	211	2,245	2,176	4,019	686	744	128	567
Greece	--	--	--	--	644	931	--	--	--	--
Hong Kong	--	--	--	--	28	45	72	113	62	131
India	113	160	850	1,116	59	136	2,326	2,377	139	272
Israel	--	--	--	--	11	24	--	--	4	29
Japan	29,330	32,597	102	463	5,704	9,650	3,467	3,924	8	44
Korea, Republic of	--	--	--	--	2	6	14,831	21,389	6,528	5,640
Mexico	--	--	71	109	5,313	6,295	8,502	11,546	16	25
Netherlands	--	--	7	6	60,561	98,619	155	174	(2)	2
Oceania	--	--	1	6	4	9	5	5	3	7
Spain	--	--	--	--	62	118	362	338	--	--
Sweden	--	--	--	--	121	236	56	91	--	--
Taiwan	6,231	7,321	21	20	962	1,700	1,216	1,032	61	150
Turkey	--	--	--	--	--	--	--	--	--	--
United Kingdom	--	--	598	1,505	440	842	440	961	10	16
Other	(2)	1	90	176	64	124	48	73	112	529
Total	42,738	48,060	6,934	11,616	81,397	132,653	47,986	66,929	7,454	8,083

	Pipes and tubing		Plates and sheets		Wire and cable, bare		Wire and cable, insulated		Other copper manufactures[3]	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
1982	4,576	$14,684	11,829	$20,036	7,550	$29,377	60,634	$328,325	17,591	$32,787
1983:										
Africa	55	189	3	8	62	285	5,488	36,578	468	546
Belgium-Luxembourg	5	12	9	96	33	99	149	5,633	79	158
Brazil	--	--	--	--	4	371	487	1,793	(2)	4
Canada	1,307	3,961	1,033	2,146	631	3,070	14,861	59,848	3,331	7,546
China	(2)	2	1	10	1	65	326	3,092	--	--
El Salvador	1	2	36	71	35	126	139	566	125	248
France	2	5	3	34	5	65	621	15,556	55	181
Germany, Federal Republic of	2	23	1	7	18	195	615	13,521	3	16
Greece	1	6	(2)	1	(2)	3	13	149	--	--
Haiti	2	6	(2)	2	168	632	894	3,300	2	13
Hong Kong	9	44	(2)	1	74	435	253	1,901	1	13
India	--	--	--	--	10	57	141	2,123	--	--
Israel	16	74	20	50	18	187	234	3,500	7	59
Italy	4	51	(2)	2	10	63	252	3,177	4	12
Japan	7	35	82	77	49	303	515	9,252	26	208
Korea, Republic of	25	143	7	51	3	57	1,137	11,241	2	10
Kuwait	265	737	2	1	1	8	55	371	--	--
Mexico	36	133	90	461	5,218	13,581	17,608	56,972	1,946	3,270
Netherlands	69	288	(2)	1	149	1,088	273	4,742	22	124
Oceania	41	185	1	4	60	259	720	6,696	1	16
Saudi Arabia	1,037	3,291	11	46	602	4,369	8,548	40,070	28	82
Singapore	38	138	6	32	21	192	724	7,793	11	29
Spain	37	95	--	--	7	36	57	977	(2)	6
Sweden	2	11	(2)	8	8	57	124	2,858	1	6
Taiwan	12	40	24	35	47	766	327	3,361	8	62
Turkey	--	--	--	--	--	--	35	455	--	--
U.S.S.R.	--	--	--	--	--	--	140	1,103	--	--
United Kingdom	153	605	19	109	87	727	2,121	27,264	129	284
Venezuela	71	247	9	33	47	133	223	1,621	2,938	4,847
Other	424	1,504	13	127	945	3,166	5,883	28,794	252	620
Total	3,621	11,827	1,370	3,413	8,313	30,395	62,963	354,307	9,439	18,360

[1]Includes matte.
[2]Less than 1/2 unit.
[3]Excludes copper wire cloth.

Table 36.—U.S. exports of copper scrap, by country

Country	Unalloyed copper scrap				Copper-alloy scrap			
	1982		1983		1982		1983	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Belgium-Luxembourg	2,767	$4,785	2,429	$8,587	4,413	$11,428	4,742	$8,656
Brazil	504	620	--	--	536	507	--	--
Canada	10,067	10,143	13,373	15,563	11,429	12,713	17,343	20,620
Finland	--	--	--	--	729	1,201	--	--
France	56	47	18	12	427	519	272	1,183
Germany, Federal Republic of	1,395	1,583	686	744	7,297	6,217	2,639	2,868
Hong Kong	--	--	72	113	18	23	354	351
India	5,605	6,010	2,326	2,377	11,105	11,820	3,890	4,178
Italy	--	--	--	--	52	59	3	4
Japan	6,721	8,459	3,467	3,924	18,601	20,121	16,117	19,357
Korea, Republic of	15,530	19,532	14,831	21,389	16,087	18,462	8,548	10,417
Mexico	2,821	3,329	8,502	11,546	1,318	1,530	5,458	5,994
Netherlands	565	632	155	174	1,602	2,105	1,953	1,162
Spain	3,947	4,329	362	338	5,496	7,296	444	543
Sweden	731	1,119	56	91	2,068	3,041	5,350	6,713
Switzerland	--	--	--	--	405	575	448	620
Taiwan	1,338	1,011	1,216	1,032	7,021	5,448	12,057	7,843
Turkey	408	478	--	--	1,685	3,004	--	--
United Kingdom	1,917	1,324	440	961	1,164	1,671	439	1,491
Other	47	83	53	78	139	275	205	189
Total	54,419	63,484	47,986	66,929	91,592	108,015	80,262	92,189

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)
1982	118,055	$141,478	4,042	$3,609	97,374	$142,249	258,439	$394,654	28,076	$35,281	505,986	$717,271
1983:												
Belgium-Luxembourg	--	--	--	--	--	--	5,773	8,636	14	20	5,787	8,656
Canada	37,317	35,481	268	481	14	59	91,215	146,651	24,995	36,330	153,809	219,002
Chile	3,941	4,571	2,949	3,724	35,968	52,223	245,961	383,229	3,608	4,975	292,427	448,722
Ghana	--	--	--	--	--	--	3,461	5,641	--	--	3,461	5,641
Honduras	2,006	584	--	--	--	--	--	--	36	39	2,042	623
Japan	10	10	--	--	--	--	9,181	14,714	--	--	9,191	14,724
Korea, Republic of	--	--	--	--	--	--	3,000	4,756	224	315	3,224	5,071
Kuwait	--	--	--	--	--	--	--	--	1,859	2,772	1,859	2,772
Mexico	31,134	22,113	--	--	6,271	7,608	--	--	7,301	9,858	44,706	39,579
Peru	3,859	2,016	15	45	3,239	4,581	31,761	39,568	48	131	38,922	46,341
Philippines	11,349	16,266	--	--	--	--	--	--	11	24	11,360	16,290
South Africa, Republic of	--	--	19	35	--	--	13,711	11,658	230	336	13,960	12,029
Zaire	--	--	--	--	--	--	29,103	45,301	--	--	29,103	45,301
Zambia	--	--	--	--	--	--	24,693	37,671	--	--	24,693	37,671
Other	981	654	1	1	879	1,556	1,709	2,739	5,397	8,147	8,967	13,097
Total	90,597	81,695	3,252	4,286	46,371	66,027	459,568	700,564	43,723	62,947	643,511	915,519

Table 38.—Copper: World mine production,[1] by country

(Thousand metric tons)

Country	1979	1980	1981	1982[p]	1983[e]
Albania[e]	14.0	15.3	15.5	16.2	16.5
Algeria	.2	.2	.2	.1	.1
Argentina	.1	.2	.1	.1	[2].2
Australia	237.6	243.5	231.3	245.3	256.0
Bolivia	1.8	1.9	2.6	2.3	2.0
Botswana[3]	14.6	15.6	17.8	18.4	[2]20.3
Brazil	5.3	1.4	13.9	19.2	19.0
Bulgaria	[r]60.0	[r]62.0	62.0	70.0	70.0
Burma[3]	[r].7	[r].6	.8	1.0	4.2
Canada[4]	636.4	716.4	691.3	612.4	625.0
Chile[5]	1,062.7	1,067.9	1,081.1	1,240.7	1,190.0
China[e]	200.0	200.0	200.0	200.0	200.0
Colombia	.1	.1	.1	[e].1	.1
Congo (Brazzaville)	1.0	1.3	.2	.1	.1
Cuba	2.8	3.3	2.9	2.6	3.0
Cyprus[6]	1.2	--	--	.8	[2]1.2
Czechoslovakia[e]	6.2	6.6	5.2	5.2	5.2
Ecuador	[r].7	.9	.8	.1	.2
Finland	41.1	36.9	38.5	34.8	35.0
France	.1	.1	.1	.2	.1
German Democratic Republic[e]	[r]14.0	[r]11.8	[r]12.0	[r]13.0	12.0
Germany, Federal Republic of[4]	.9	1.3	1.4	1.3	1.2
Greece	--	.1	.1	--	--
Guatemala	1.8	.8	.7	[e].7	.7
Honduras	1.4	.3	.5	[e].5	.7
Hungary[7]	.1	--	--	--	--
India	27.7	27.6	25.2	[e]24.0	24.5
Indonesia	60.2	59.0	62.5	77.9	79.0
Iran[8]	3.0	1.0	2.0	43.0	[2]48.5
Ireland	[r]4.8	[r]4.2	3.5	1.6	1.6
Israel	--	[r].4	4.4	4.1	4.8
Italy	.5	.6	.8	.8	.1
Japan	59.1	[r]52.6	51.5	50.7	[2]46.0
Korea, North[e]	15.0	15.0	15.0	15.0	15.0
Korea, Republic of	.5	.4	.5	[r e].3	.3
Malaysia	24.5	27.0	28.6	31.5	30.0
Mexico[5]	107.1	175.4	230.5	239.1	250.0
Mongolia[e]	21.7	[r]44.0	[r]71.8	[r]90.0	104.0
Morocco	7.0	7.2	6.9	21.0	23.0
Mozambique[e]	.2	.2	.2	.2	.2
Namibia	41.9	39.2	46.1	49.8	[2]45.3
Nepal	--	--	(9)	(9)	(9)
Norway[6]	28.0	28.9	28.2	27.4	28.0
Papua New Guinea	170.8	146.8	165.4	170.0	[2]183.0
Peru[5]	390.7	366.8	342.1	369.4	[2]335.6
Philippines	298.3	304.5	302.3	292.1	309.0
Poland	325.0	346.1	294.0	[r e]376.0	380.0
Portugal[5]	3.6	3.0	2.9	2.5	2.4
Romania[e 4]	29.0	28.0	27.0	26.0	27.0
South Africa, Republic of[5]	190.6	200.7	208.7	188.7	[2]210.8
Spain	[r]31.3	42.5	50.9	47.6	[2]63.9
Sweden	45.8	42.8	50.7	54.9	55.0
Taiwan	[r]6.7	[r]1.9	[r e].5	(10)	--
Turkey[7]	31.4	26.4	31.9	34.4	[2]25.0
U.S.S.R.[e 4]	[r]855.0	900.0	[r]940.0	[r]970.0	1,000.0
United Kingdom	--	.2	.7	.6	.7
United States:[4]					
By concentration or leaching	1,346.5	1,063.5	1,377.1	1,015.1	[2]936.2
Leaching (electrowon)	100.1	117.6	161.1	131.9	101.9
Yugoslavia[7]	111.4	114.8	110.9	119.3	[2]134.8
Zaire	[r]430.4	[r]539.5	555.1	519.0	535.0
Zambia:					
By concentration or leaching	456.3	471.0	465.8	436.9	423.8
Leaching (electrowon)	132.0	124.8	122.2	130.9	119.0
Zimbabwe	[r]29.6	[r]26.9	24.6	24.7	20.9
Total	[r]7,690.5	[r]7,739.0	8,190.7	8,071.5	8,027.1

[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 20, 1984.
[2]Reported figure.
[3]Copper content of matte produced.
[4]Recoverable content.
[5]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.
[6]Includes copper content of cupriferous pyrite.
[7]Copper content by analysis of ore mined.
[8]Data are for years beginning Mar. 21 of that stated.
[9]Less than 1/2 unit.
[10]Revised to zero.

Table 39.—Copper: World smelter production,[1] by country

(Thousand metric tons)

Country	1979	1980	1981	1982[p]	1983[e]
Albania, primary[e]	9.7	9.9	10.0	[r]11.2	11.5
Argentina, primary	([2])	([2])	([2])	([2])	([2])
Australia:					
Primary	[r]166.3	174.9	173.5	175.6	175.0
Secondary	6.2	7.1	5.0	4.8	5.0
Total	[r]172.5	182.0	178.5	180.4	180.0
Austria, secondary	21.8	26.1	27.1	30.0	28.0
Belgium:[e]					
Primary	1.5	.7	[r]3.1	[r]2.5	2.2
Secondary	47.8	49.3	47.5	47.5	47.0
Total	49.3	50.0	[r]50.6	[r]50.0	49.2
Brazil, primary	--	--	--	9.6	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]	374.5	473.7	450.1	394.3	375.0
Secondary[e]	10.0	19.0	15.0	10.0	10.0
Total	384.5	492.7	465.1	404.3	385.0
Chile, primary[3]	[r]948.9	953.1	953.8	1,046.8	1,039.0
China, primary[e]	210.0	210.0	210.0	210.0	210.0
Czechoslovakia:[e]					
Primary	8.2	7.6	7.4	7.4	7.4
Secondary	1.8	2.4	2.4	2.4	2.4
Total	10.0	10.0	9.8	9.8	9.8
Finland:					
Primary	55.3	[e]49.2	[e]54.7	66.3	74.5
Secondary	9.9	[e]10.0	[e]13.0	19.1	12.6
Total	65.2	59.2	67.7	85.4	87.1
France, secondary	5.0	7.3	6.5	7.0	--
German Democratic Republic, primary[e]	[r]18.0	[r]16.0	16.0	17.0	16.0
Germany, Federal Republic of:					
Primary	158.2	153.9	163.1	161.8	160.0
Secondary	92.5	103.9	88.3	78.2	78.0
Total	250.7	257.8	251.4	240.0	238.0
Hungary, secondary[e]	.1	.1	.1	.1	.1
India, primary	[r]21.5	28.5	25.7	32.6	34.0
Iran, primary[e]	.7	.8	.8	13.5	[4]23.5
Japan:					
Primary	853.7	889.5	930.0	948.2	944.6
Secondary	67.7	[r]39.8	50.1	96.6	117.3
Total	921.4	[r]929.3	980.1	1,044.8	1,061.9
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	48.2	64.1	101.2	119.4	103.0
Mexico, primary	83.9	85.6	69.2	77.4	75.0
Namibia, primary	42.7	40.0	39.7	49.8	[4]54.2
Norway, primary (including electrowon)	27.3	33.7	32.0	24.4	25.0
Oman, primary	--	--	--	--	12.0
Peru, primary	[r]339.7	[r]323.1	279.3	294.4	[4]258.3
Philippines, primary	--	--	--	--	52.2
Poland:					
Primary[e]	325.0	346.0	315.0	338.0	346.0
Secondary[e]	16.0	17.0	15.8	6.0	17.0
Total	341.0	363.0	330.8	344.0	363.0

See footnotes at end of table.

Table 39.—Copper: World smelter production,[1] by country —Continued

(Thousand metric tons)

Country	1979	1980	1981	1982[p]	1983[e]
Portugal:					
Primary	5.1	[r]2.7	3.1	1.1	1.0
Secondary	.4	.5	.4	.4	.2
Total	5.5	[r]3.2	3.5	1.5	1.2
Romania:					
Primary	41.1	40.7	39.4	[e]35.0	34.0
Secondary[e]	4.0	4.0	4.0	4.0	5.0
Total[e]	45.1	44.7	[r]43.4	39.0	39.0
South Africa, Republic of, primary	182.3	185.8	185.4	184.7	[4]205.0
Spain:					
Primary	90.3	85.1	87.9	[r e]110.0	110.0
Secondary	18.0	18.0	20.0	[r e]25.0	30.0
Total	108.3	103.1	107.9	135.0	140.0
Sweden:					
Primary	51.7	45.7	60.6	72.5	70.0
Secondary	12.9	10.7	13.2	17.4	15.0
Total	64.6	56.4	73.8	89.9	85.0
Taiwan, primary	14.3	17.0	53.1	47.5	43.0
Turkey:					
Primary	21.6	15.3	26.7	24.9	18.2
Secondary	.6	.6	.6	.4	.3
Total	22.2	15.9	27.3	25.3	[4]18.5
U.S.S.R.:[e]					
Primary	[r]930.0	[r]970.0	[r]1,030.0	[r]1,070.0	1,100.0
Secondary	[r]90.0	95.0	[r]100.0	[r]110.0	115.0
Total	[r]1,020.0	[r]1,065.0	[r]1,130.0	[r]1,180.0	1,215.0
United States:					
Primary[5]	1,335.6	1,008.4	1,316.8	975.7	[4]927.7
Secondary	60.2	44.9	60.9	45.1	[4]59.3
Total	1,395.8	1,053.3	1,377.6	1,020.8	[4]987.0
Yugoslavia, primary	108.7	93.8	92.5	[e]92.0	95.0
Zaire, primary:					
Electrowon	231.4	285.7	301.9	302.4	[4]291.6
Other	151.0	162.1	178.5	171.1	[4]175.0
Total	382.4	447.8	480.4	473.5	[4]466.6
Zambia, primary	582.1	609.9	560.6	584.7	581.2
Zimbabwe, primary[e]	28.5	26.1	23.0	[r]23.2	19.6
Grand total	[r]8,013.9	[r]7,946.3	[6]8,345.9	8,281.0	8,303.9
Of which:					
Primary	[r]7,263.4	[r]7,134.8	7,467.0	7,349.2	7,361.1
Electrowon	231.4	285.7	301.9	302.4	291.6
Secondary	[r]470.9	[r]461.7	475.9	510.0	548.2
Undifferentiated	[r]48.2	[r]64.1	101.2	119.4	103.0

[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 20, 1984.

[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: 1979—126,514; 1980—107,980; 1981—113,991; 1982—104,791; and 1983—89,274.

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

Table 40.—Copper: World refinery production,[1] by country

(Thousand metric tons)

Country	1979	1980	1981	1982[p]	1983[e]
Albania, primary[e]	7.5	7.7	9.0	9.0	10.0
Australia:					
Primary	[r]137.7	144.8	164.2	160.2	[2]165.5
Secondary	[r]36.2	37.6	26.8	17.9	34.0
Total	[r]173.9	182.4	191.0	178.1	199.5
Austria:					
Primary	8.8	[r]9.3	9.1	8.6	11.4
Secondary	24.0	[r]34.0	30.0	33.0	34.0
Total	32.8	43.3	39.1	41.6	45.4
Belgium:					
Primary[e]	318.8	321.7	[r]368.4	[r]397.8	395.0
Secondary[e]	50.0	52.0	60.0	60.0	60.0
Total	368.8	373.7	428.4	457.8	455.0
Brazil:					
Primary	--	--	--	9.6	10.0
Secondary	53.1	63.0	45.0	47.4	47.0
Total	53.1	63.0	45.0	57.0	57.0
Bulgaria, primary and secondary[e]	62.0	[r]63.0	62.0	[r]65.0	65.0
Canada:					
Primary[e]	[r]396.3	[r]511.7	[r]492.5	[r]311.6	510.8
Secondary[e]	[r]40.7	[r]44.0	[r]31.9	[r]16.5	33.0
Total	[r]437.0	[r]555.7	524.4	328.1	[2]543.8
Chile, primary	779.5	810.7	775.6	851.6	[2]813.0
China:[e]					
Primary	255.0	255.0	255.0	255.0	255.0
Secondary	25.0	25.0	25.0	25.0	25.0
Total	280.0	280.0	280.0	280.0	280.0
Czechoslovakia, primary and secondary	24.6	25.6	25.6	25.6	25.6
Egypt, secondary	2.0	2.0	2.0	2.4	[2]2.4
Finland:					
Primary	33.0	30.5	23.8	38.0	35.0
Secondary[e]	10.0	10.0	10.0	10.0	10.0
Total[e]	43.0	40.5	33.8	[2]48.0	45.0
France:					
Primary[e]	22.0	23.0	23.0	[r]24.0	22.0
Secondary[e]	23.4	23.5	[r]23.0	[r]23.1	21.9
Total	45.4	46.5	46.0	47.1	[2]43.9
German Democratic Republic, primary and secondary[e]	51.0	51.0	51.0	51.0	51.0
Germany, Federal Republic of:					
Primary	303.1	302.5	304.1	313.7	[2]332.8
Secondary	79.4	[r]71.5	83.4	80.4	[2]87.9
Total[3]	382.5	[r]374.0	387.4	394.1	[2]420.8
Hungary, primary and secondary[e]	12.0	12.0	12.0	[r]12.2	12.0
India:					
Primary (electric wirebar)	14.7	17.0	14.9	15.1	17.0
Secondary	4.6	6.2	8.2	12.0	10.0
Total	19.3	23.2	23.1	27.1	27.0
Iran, primary[4]	3.0	.8	.8	1.0	[2]10.0
Italy:					
Primary[e]	6.6	2.0	1.0	--	--
Secondary[e]	9.0	10.2	22.7	19.6	20.0
Total	15.6	12.2	23.7	19.6	20.0

See footnotes at end of table.

Table 40.—Copper: World refinery production,[1] by country —Continued

(Thousand metric tons)

Country	1979	1980	1981	1982[p]	1983[e]
Japan:					
Primary	853.7	889.5	930.0	948.2	[2]944.6
Secondary	130.0	124.8	120.2	126.8	[2]147.4
Total[3]	983.7	1,014.3	1,050.1	1,075.0	[2]1,091.9
Korea, North, primary and secondary[e]	22.0	22.0	22.0	22.0	22.0
Korea, Republic of:					
Primary (electrowon)	63.1	72.9	108.0	110.8	123.3
Secondary[e]	[r]12.9	[r]6.1	5.0	5.0	2.7
Total	[r]76.0	[r]79.0	113.0	115.8	126.0
Mexico:					
Primary	71.8	74.6	61.3	61.4	60.0
Secondary[e]	10.0	11.0	10.0	14.0	15.0
Total[e]	81.8	85.6	71.3	75.4	75.0
Norway:					
Primary (electrowon)[5]	[r]21.0	25.8	26.1	18.0	21.0
Secondary[e]	[r]6.0	[r]6.0	[r]6.0	[r]6.0	6.0
Total	[r]27.0	31.8	32.1	24.0	27.0
Oman, primary	--	--	--	--	12.0
Peru, primary:					
Other	196.7	195.7	175.6	194.4	[2]158.1
Electrowon	33.1	33.3	33.4	33.5	[2]32.6
Total	[r]229.8	[r]229.0	209.0	227.9	[2]190.7
Philippines, primary	--	--	--	--	38.8
Poland, primary[6]	335.8	357.3	327.2	348.0	357.0
Portugal, primary	3.4	[r]4.5	4.9	4.6	4.6
Romania:					
Primary	42.0	42.0	42.0	40.0	40.0
Secondary[e]	24.3	23.0	18.0	20.0	20.0
Total[e]	66.3	65.0	60.0	60.0	60.0
South Africa, Republic of, primary[7]	150.8	140.9	144.1	142.8	[2]152.0
Spain:					
Primary[e]	126.0	138.7	137.1	151.3	138.6
Secondary[e]	[r]18.7	[r]15.6	15.0	[r]20.6	20.0
Total	[r]144.7	[r]154.3	152.1	171.9	158.6
Sweden:					
Primary	[r]43.7	[r]43.2	50.1	50.3	50.0
Secondary	[r]15.2	[r]12.5	11.8	12.0	12.0
Total[3]	[r]59.0	[r]55.7	61.9	62.3	62.0
Taiwan:					
Primary[e]	8.3	11.5	45.2	39.4	30.0
Secondary[e]	7.0	8.0	8.0	8.0	8.0
Total	15.3	19.5	53.2	47.4	38.0
Turkey, primary	22.2	18.8	24.2	32.2	[2]30.0
U.S.S.R.:[e]					
Primary	[r]870.0	[r]910.0	[r]960.0	[r]1,010.0	1,030.0
Secondary	170.0	170.0	170.0	170.0	170.0
Total	[r]1,040.0	[r]1,080.0	[r]1,130.0	[r]1,180.0	1,200.0
United Kingdom:					
Primary	48.5	68.3	59.8	63.2	67.5
Secondary	73.2	93.0	76.3	71.0	76.8
Total	121.7	161.3	136.1	134.2	144.3

See footnotes at end of table.

Table 40.—Copper: World refinery production,[1] by country —Continued

(Thousand metric tons)

Country	1979	1980	1981	1982[p]	1983[e]
United States:					
Primary:					
Electrowon	100.1	117.6	161.1	131.9	[2]101.9
Other	[r]1,416.5	[r]1,097.6	1,382.9	1,094.9	[2]1,080.2
Secondary	[r]498.5	515.1	493.6	467.5	[2]401.6
Total	[r]2,015.1	[r]1,730.3	2,037.6	1,694.3	[2]1,583.7
Yugoslavia:					
Primary	99.2	91.8	90.7	90.0	91.0
Secondary	38.3	39.5	41.9	36.9	32.7
Total	137.5	131.3	132.6	126.9	123.7
Zaire, primary	[r]130.1	[r]144.0	151.3	175.0	226.7
Zambia, primary:					
Electrowon	132.0	124.8	122.2	130.9	[2]119.0
Other	429.9	482.8	438.2	453.7	456.4
Total	561.9	607.6	560.4	584.6	[2]575.4
Zimbabwe, primary	3.0	3.1	8.0	23.0	19.0
Grand total	[r]9,020.1	[r]9,102.6	9,441.0	9,223.6	9,444.8
Of which:					
Primary	[r]7,486.9	[r]7,525.4	7,924.8	7,742.7	7,971.8
Secondary[3]	[r]1,361.5	[r]1,403.6	1,343.8	1,305.1	1,297.4
Undifferentiated	171.6	[r]173.6	172.6	175.8	175.6

[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 20, 1984.

[2]Reported figure.

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

[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 Arthur C. Meisinger[1]

The quantity of processed diatomite produced in 1983, all in four Western States, was 619,000 short tons, a slight increase over that in 1982. California continued to be the leading producing State.

Exports of diatomite also increased slightly and comprised 24% of domestic production.

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.

Table 1.—Diatomite sold or used by producers in the United States

(Thousand short tons and thousand dollars)

	1979	1980	1981	1982	1983
Domestic production (sales)	717	689	687	613	619
Total value of sales	$90,323	$100,610	$113,010	$107,619	$114,279

DOMESTIC PRODUCTION

U.S. production of diatomite increased slightly to 619,000 tons valued at $114 million. Domestic output was processed at nine plants by seven companies in four Western States. California was again the principal producing State followed by Nevada, Washington, and Oregon.

The major diatomite producers continued to be Manville Products Corp., with operations at Lompoc, CA; Grefco Inc., Dicalite Div., at Lompoc, CA, and Mina, NV; Eagle-Picher Industries Inc. at Sparks and Lovelock, NV; and Witco Chemical Corp., Inorganic Specialties Div., at Quincy, WA. Diatomite was also mined and processed during the year by Lassenite Industries Inc., Herlong, CA; Cyprus Diatomite Co., a division of Amoco Minerals Co., Fernley, NV; and Oil-Dri Production Co., Christmas Valley, OR. American Resources Equity Corp., Denver, CO, mined diatomite in Shasta County, CA, and shipped the unprocessed material in-State for use as a silica source in making cement.

CONSUMPTION AND USES

Apparent domestic consumption of diatomite remained essentially unchanged at 473,000 tons. Diatomite use as fillers and insulation increased while its use in filtration and other areas decreased. Filtration continued to be the primary domestic market for diatomite.

Table 2.—Diatomite sold or used,[1] by principal use

(Percent of U.S. production)

Use	1979	1980	1981	1982	1983
Filtration	65	66	64	68	66
Fillers	21	21	23	19	21
Insulation	3	3	2	1	3
Other	11	10	11	12	10

[1]Includes exports.

PRICES

The average unit value of sales for processed diatomite increased by $9 per ton to $185.

Table 3.—Average annual value per ton[1] of diatomite, by use

Use	1981	1982	1983
Abrasives	W	W	--
Fillers	$153.14	$160.72	$176.77
Filtration	179.01	191.85	200.16
Insulation	125.02	121.61	119.26
Miscellaneous[2]	110.19	111.55	116.05
Weighted average	164.50	175.63	184.58

W Withheld to avoid disclosing company proprietary data; included with "Miscellaneous."
[1]Based on unrounded data.
[2]Includes abrasives (1981-82), absorbents, catalysts (1982), fertilizer coatings (1981), lightweight aggregates (1981-82), and silicate admixtures (1983).

FOREIGN TRADE

Exports of processed diatomite by U.S. producers increased slightly to 146,000 tons. The average unit value also increased slightly to $216 per ton. The quantity of diatomite exported during the year represented 24% of U.S. production. Diatomite was exported to 79 countries, and the following 5 countries received 62% of the total: Canada, 33,700 tons; Japan, 23,000 tons; Australia, 12,400 tons; the Federal Republic of Germany, 11,000 tons; and the United Kingdom, 9,900 tons.

Imports of diatomite increased 37% to 346 tons valued at $56,000, with Mexico supplying 205 tons of the total.

Table 4.—U.S. exports of diatomite

(Thousand short tons and thousand dollars)

Year	Quantity	Value[1]
1980	173	32,238
1981	162	32,933
1982	141	29,863
1983	146	31,569

[1]U.S. Customs.

WORLD REVIEW

World production of diatomite remained at near an estimated 1.7 million tons. The United States produced 37% of the world output, followed by France and the U.S.S.R. with 16% each.

[1]Industry economist, Division of Industrial Minerals.

Table 5.—Diatomite: World production, by country[1]

(Thousand short tons)

Country	1979	1980	1981	1982[p]	1983[e]
Algeria	5	5	5	5	5
Argentina	8	7	5	7	9
Australia	4	3	1	[e]2	2
Brazil (marketable)	[r]18	[r]16	10	18	18
Canada	2	[r]4	4	[e]2	2
Chile	1	1	(2)	(2)	(2)
Colombia[e]	1	1	1	1	1
Costa Rica	1	1	1	1	1
Denmark:					
Diatomite	[e]28	[e]28	3	---	---
Moler[e]	138	138	138	138	138
Egypt	(2)	---	---	---	(2)
France	[e]220	[e]240	230	269	265
Germany, Federal Republic of	[r]48	58	47	47	47
Iceland	23	20	22	28	28
Italy[e]	33	33	28	22	28
Kenya	[r e]1	[r](2)	(2)	2	2
Korea, Republic of	26	28	46	61	60
Mexico	[r]48	62	62	62	62
Peru	[r]8	8	[e]8	[e]8	8
Portugal	[r]4	3	3	[e]3	3
Romania[e]	45	45	45	45	45
South Africa, Republic of	1	1	1	1	1
Spain	30	26	42	70	72
Thailand	4	2	(2)	(2)	(2)
U.S.S.R.[e]	250	250	250	260	260
United Kingdom[e]	[r]1	[r]1	[r]1	1	1
United States	717	689	687	613	619
Total	[r]1,665	[r]1,670	1,640	1,666	1,677

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through Apr. 11, 1984.
[2]Less than 1/2 unit.

Feldspar, Nepheline Syenite, and Aplite

By Michael J. Potter[1]

Total U.S. feldspar output in 1983, including soda, potash, mixed, and feldspar-silica mixtures, was 710,000 short tons with a value of $22.5 million. The increased level of housing construction resulted in improved markets for feldspar in ceramic uses and in glass fiber for insulation. Imports of crude and ground nepheline syenite decreased 11% to 407,000 tons although total value increased 2% to $14 million.

Domestic Data Coverage.—Domestic production data for feldspar are developed by the Bureau of Mines by means of a voluntary domestic 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 1983, the depletion rate allowed on domestic and foreign feldspar production was 14%.

Table 1.—Salient feldspar and nepheline syenite statistics

	1979	1980	1981	1982	1983
United States:					
Feldspar:					
Produced[1] short tons	740,000	710,000	665,000	615,000	710,000
Value thousands	$21,500	$23,200	$21,000	$20,300	$22,500
Exports short tons	12,300	13,000	14,025	10,800	9,360
Value thousands	$1,025	$896	$1,110	$989	$856
Imports for consumption short tons	266	404	206	48	64
Value thousands	$31	$133	$61	$24	$31
Nepheline syenite:					
Imports for consumption short tons	536,000	504,340	506,100	455,596	407,351
Value thousands	$10,846	$11,264	$11,529	$13,751	$13,997
Consumption, apparent[2] (feldspar plus nepheline syenite) thousand short tons	1,264	1,202	1,157	1,060	1,108
World: Production (feldspar) do	[r]3,432	[r]3,481	3,556	[p]3,745	[e]3,842

[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]Measured by quantity produced plus imports, minus exports (rounded figures).

FELDSPAR

DOMESTIC PRODUCTION

Soda feldspar is defined commercially as containing 7% Na_2O or higher; potash feldspar contains 10% K_2O or higher. However, 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 with Na_2O. Hand cobbing decreased and was 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 a naturally occurring material, such as sand deposits, or a flotation product. Total feldspar content of this mixture was 25% 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 five plants, California had three, and Connecticut, Georgia, South Carolina, and South Dakota each had one.

The data for potash feldspar were collected from the three U.S. producers of this material; some of this feldspar contained less than 10% K_2O (8% to 10% K_2O). Therefore, to publish information on potash feldspar without revealing proprietary company data, the potash feldspar has a K_2O content of 8% or higher.

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
1979	20	238	580	16,460	140	4,770	740	21,500
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

[1]Includes potash feldspar (8% K_2O or higher).
[2]Feldspar content.
[3]Data may not add to totals shown because of independent rounding.

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.

Significant increases in feldspar shipments were made to Georgia, Illinois, and Indiana.

Fifty-eight percent of the total feldspar consumed in the United States was used in glassmaking, including container glass and glass fiber; 38% was used in pottery; and the remaining 4% was used in enamels, electrical insulators, etc.

An increase in housing construction resulted in improved markets for plumbing fixtures, tile, and glass fiber for insulation. However, competition from plastic bottles kept the output of glass containers flat.

Because of the cyclical nature of the construction industry, the major outlet for glass fiber, producers of this material were seeking to build up other markets. Possible outlets for the material are in road repair, radial tires, roofing and shingles, and reinforced plastic in cars and marine and defense markets.[2]

Porcelain enamel, another outlet for feldspar, is used on household equipment such as ranges, laundry equipment, dishwashers, water heaters, etc. Future outlook for the enamel industry was described as very good if the economy stays on track.[3]

Table 3.—Destination of shipments of feldspar[1] sold or used by producers in the United States, by State

(Short tons)

State	1979	1980	1981	1982	1983
Alabama	13,900	21,100	19,600	16,500	14,600
California	(2)	(3)	(4)	(5)	(6)
Connecticut	21,600	18,400	17,800	18,800	W
Florida	23,600	32,800	25,700	21,000	22,700
Georgia	69,000	64,700	68,300	74,600	96,900
Illinois	43,700	36,600	31,100	26,900	46,600
Indiana	25,300	26,700	22,700	20,200	37,200
Kentucky	13,100	12,800	11,700	13,400	11,400
Louisiana	16,900	14,600	13,900	12,200	17,400
Maryland	7,600	5,100	4,300	4,600	4,500
Massachusetts	W	11,100	8,800	9,300	1,200
Michigan	4,000	2,700	W	2,000	W
Mississippi	17,600	15,600	13,000	15,800	15,900
Missouri	7,600	4,900	4,300	4,100	5,000
New Jersey	59,600	64,600	63,400	51,700	56,600
New York	22,000	23,100	19,400	17,800	18,300
North Carolina	W	W	17,000	16,500	20,100
Ohio	64,400	56,400	52,800	51,600	53,600
Oklahoma	31,700	31,000	34,700	31,900	W
Pennsylvania	52,900	46,200	42,900	28,800	33,200
South Carolina	17,700	15,600	16,400	14,900	18,400
Tennessee	19,400	18,300	16,100	15,300	W
Texas	40,400	35,000	39,400	36,700	41,900
West Virginia	59,800	55,400	36,100	31,600	38,100
Wisconsin	W	W	W	W	9,400
Other destinations[7]	112,200	97,300	75,600	73,800	147,000
Total	744,000	710,000	655,000	610,000	710,000

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; included with "Other destinations."
[3]Data are incomplete; Bureau of Mines estimate is 40,000 tons or more; included with "Other destinations."
[4]Data are incomplete; Bureau of Mines estimate is 35,000 tons or more; included with "Other destinations."
[5]Data are incomplete; Bureau of Mines estimate is 30,000 tons or more; included with "Other destinations."
[6]Data are incomplete; Bureau of Mines estimate is 45,000 tons or more; included with "Other destinations."
[7]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 4.—Destination of shipments of potash feldspar[1] sold or used by producers in the United States

(Short tons)

Destination	1979	1980	1981	1982	1983
Illinois, Indiana, Wisconsin	15,500	13,400	11,300	8,000	6,000
Maryland, New York, West Virginia	29,500	28,200	24,800	21,600	25,300
Massachusetts	1,400	W	W	W	W
Ohio	12,000	10,700	9,800	8,100	8,100
Pennsylvania	9,000	8,200	9,100	6,400	7,100
Texas	W	400	200	200	300
Canada	5,200	4,300	4,900	3,200	4,300
Mexico	2,900	1,600	2,800	2,400	W
Other[2]	18,600	18,200	17,500	16,300	14,100
Total	94,100	85,000	80,400	66,200	65,200

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, Minnesota, Missouri, New Jersey, North Carolina, South Carolina, Tennessee, States indicated by symbol W, and other unspecified States. May also include foreign countries.

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

(Thousand short tons and thousand dollars)

Use	1982 Quantity	1982 Value	1983 Quantity	1983 Value
Hand-cobbed:				
Pottery	W	W	(2)	26
Other	W	W	7	427
Total	10	735	7	453
Flotation concentrate:				
Glass	212	6,662	254	7,393
Pottery	227	10,637	249	10,875
Other	18	1,082	W	W
Total[3]	458	18,381	W	W
Feldspar-silica mixtures:[4]				
Glass	125	5,699	157	7,570
Pottery	W	W	19	1,399
Other	W	W	W	W
Total	142	6,884	W	W
Total:[3]				
Glass[5]	337	12,360	410	14,963
Pottery	251	12,205	268	12,300
Other[6]	22	1,434	32	1,683
Grand total	610	26,000	710	28,946

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]Data may not add to totals shown because of independent rounding.
[4]Feldspar content.
[5]Includes container glass and glass fiber.
[6]Includes enamel, filler, etc., and unknown.

Table 6.—Potash feldspar[1] sold or used by producers in the United States, by use

Use	1982 Quantity (short tons)	1982 Value (thousands)	1983 Quantity (short tons)	1983 Value (thousands)
Pottery	54,600	$3,879	42,100	$2,935
Other[2]	11,600	596	23,100	1,260
Total	66,200	4,475	65,200	4,195

[1]K_2O content of 8% or higher.
[2]Includes glass, enamel, etc.

PRICES

Engineering and Mining Journal, December 1983, listed the following prices for feldspar, per short ton, f.o.b. mine or mill, carload lots, bulk, depending on grade:

	1982	1983
North Carolina:		
20 mesh, flotation	$27.50	$29.25
40 mesh, flotation	51.00	51.00
200 mesh, flotation	70.25	$44.00- 70.25
Georgia:		
40 mesh, granular	51.00	51.00
200 mesh	69.25	69.25
Connecticut:		
20 mesh, granular	37.25	39.00
200 mesh	50.50	53.25

FOREIGN TRADE

U.S. exports in 1983 classified as feldspar, leucite, and nepheline syenite, but presumably mostly feldspar, decreased 13% to about 9,400 tons valued at $856,000. Chief recipients were Canada, 57%; Mexico, 13%; Taiwan, 7%; and the Philippines, 7%. The remaining 16% was shared among 11 other countries.

In addition to feldspar and nepheline syenite, the United States imported 400 tons of "Other mineral fluxes, crushed" with a value of $88,900 and 31,100 tons of "Other crude natural mineral fluxes" with a value of $900,400.

The tariff schedule in force throughout the year for most favored nations provided for a 3.2% ad valorem duty on ground feldspar; imports of unground feldspar were admitted duty free.

Table 7.—U.S. exports of feldspar, by country

Country	1982		1983	
	Short tons	Value	Short tons	Value
Canada	2,290	$251,400	5,370	$338,900
Dominican Republic	820	57,700	330	113,600
Leeward and Windward Islands	300	29,300	--	--
Mexico	4,480	338,400	1,240	78,600
Philippines	270	35,400	640	38,400
Taiwan	580	120,000	670	177,900
Venezuela	820	81,600	300	30,800
Other	1,240	75,200	810	77,600
Total	10,800	989,000	9,360	855,800

Table 8.—U.S. imports for consumption of feldspar, by type and country

Type and country	1982		1983	
	Short tons	Value	Short tons	Value
Crude:				
Canada	48	$23,804	--	--
Japan	--	--	3	$578
Mexico	--	--	15	5,650
Ground, crushed, or pulverized:				
Canada	--	--	3	1,320
Japan	--	--	34	13,406
Mexico	--	--	9	9,839
Total	48	23,804	64	30,793

WORLD REVIEW

India.—Production of feldspar in 1981 was approximately 65,000 tons, with two-thirds of the output coming from Rajasthan State and lesser quantities coming from eight other States. In Rajasthan, 12 companies produced feldspar from surface pegmatite vein occurrences, with significant producers including Jain Minerals, Bharat Mineral Supply Corp., and Golecha Palawat & Co. Major end uses were ceramics, 57%, and glass, 40%.[4]

Italy.—Preliminary figures for feldspar output in 1982 and 1983 showed a significant increase over those of previous years. However, much of the increase was attributed to the inclusion of aplite and feldspathic sand.

An increase in demand had taken place in recent years in the use of aplitic flux materials, especially in the manufacture of white-bodied Monocottura tiles. A new company, Tekmin Srl, had been formed in late 1980 from the two original producers of aplite and eurite. The aplite had lower alkali and higher silica content than conventional feldspathic fluxes, and the eurite is essentially like the aplite. Consumption of these fluxes had grown to about 330,000 tons per year in 1982.

The two major feldspar producers were C. Maffei & Co., with output of about 150,000 tons per year of soda feldspar going into mostly sanitaryware and tile bodies, and Italmineraria S.p.A., with an output of about 50,000 tons per year of soda feldspar going largely into sanitaryware.[5]

A model-16 Photometric Ore Sorter was installed at the feldspar plant at the Giustino Mine, owned by C. Maffei. Cost for the equipment was about $1 million, and material being handled was in the 3/8-inch to 1-inch size range. Prior to installation of the new equipment, hand sorters had been used to remove waste material; however, this was effective only for pieces larger than 1-1/2 inches, representing 30% of the plant feed. A recovery of up to 92% could be achieved by photometrically sorting the ore in the 1/2-inch to 2-inch size range.[6]

A recent development was the use of feldspathic sands in light-bodied, single-fired Monocottura tiles. The leading producer of these sands was Esercizio della Cave Colombara S.p.A., with output of about 120,000 tons per year.

Norway.—A new laboratory-scale pilot flotation machine was designed by Aker Trondelag AS. The cell, with a volume of 1 cubic foot, was the successful scale-down of the range of Aker flotation machines, with volumes of 27 cubic feet to 1,416 cubic feet. Four of the laboratory-scale machines were installed in a pilot plant at the technical university in Trondheim and reportedly gave very good metallurgical results in the flotation of feldspar and other minerals from quartz.[7]

Romania.—Soda and potash feldspars were extracted from pegmatites at three locations. Material was processed by dry-grinding in ball mills followed by pneumatic classification. A flotation plant had recently been put into operation at Muntele Rece. Recent research work, with washing or flotation, on high-potash feldspar pegmatite ore in the northern part of the country had yielded a product with a maximum iron oxide, Fe_2O_3, content of 0.2%.[8]

Turkey.—The country's first quartz, feldspar, and kaolin plant was scheduled to begin operation in August 1983. The Hisar-San plant, located at Hissarlik, was estimated to cost about $4.5 million,[9] and annual capacity for feldspar was to be about 13,000 tons per year.[10]

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

(Thousand short tons)

Country[2]	1979	1980	1981	1982[p]	1983[e]
Argentina	37	36	29	17	18
Australia	[r]4	4	4	3	3
Austria	8	12	11	3	6
Brazil[3]	159	173	167	105	110
Burma	[r]2	[r]2	5	3	3
Chile	([4])	2	3	1	1
Colombia	32	[r]30	30	30	33
Egypt	4	4	4	9	10
Finland	75	82	70	77	77
France	215	231	211	191	190
Germany, Federal Republic of	411	420	377	365	370
Guatemala	12	24	11	[e]13	11
Hong Kong	1	[r]18	4	36	29
India	55	[r]65	65	49	47
Iran[e]	3	3	2	3	3
Italy	325	[r]380	472	864	880
Japan[5]	42	33	29	33	34
Kenya	1	([4])	([4])	--	--
Korea, Republic of	40	79	114	94	94
Madagascar	([4])	[e]([4])	[e]([4])	[e]([4])	([4])
Mexico	122	129	144	127	120
Nigeria[e]	6	6	6	--	--
Norway[6]	97	[r]74	[e]80	80	80
Pakistan	[r]16	12	12	10	10
Peru	2	[r]17	24	[e]28	28
Philippines	[r]21	18	17	[e]17	17
Poland[e]	44	44	90	[r]88	88
Portugal	37	[r]54	49	[e]47	44
Romania[e]	[r]65	[r]65	[r]65	65	65
South Africa, Republic of	52	[r]58	63	53	50
Spain[7]	128	114	143	144	135
Sri Lanka	4	4	4	3	3
Sweden	65	64	44	[e]44	44
Thailand	29	[r]27	27	21	22
Turkey[e]	80	80	80	80	80
U.S.S.R.[e]	340	340	350	360	360

See footnotes at end of table.

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

(Thousand short tons)

Country[2]	1979	1980	1981	1982[p]	1983[e]
United Kingdom (china stone)[e]	55	55	55	55	55
United States	740	710	665	615	[8]710
Uruguay	3	3	3	3	3
Venezuela	98	7	24	8	8
Zambia	[r]1	[r]1	(4)	(4)	(4)
Zimbabwe	1	1	3	1	1
Total	[r]3,432	[r]3,481	3,556	3,745	3,842

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through Mar. 19, 1984.
[2]In addition to the countries listed, Czechoslovakia, and Namibia produce feldspar, but output is not officially reported and available general information is inadequate for the formulation of reliable estimates of output levels.
[3]Series excludes production of leucite and sodalite; data consist only of that material reported by Brazil under the heading of "Feldspar." Data represent the sum of (1) run-of-mine production for direct sale and (2) salable beneficiated product; total run-of-mine feldspar production was as follows, in thousand short tons: 1979—172 (revised); 1980—150 (revised); 1981—133 (revised); 1982—87; and 1983—90 (estimated).
[4]Less than 1/2 unit.
[5]In addition, the following quantities of aplite were produced, in thousand short tons: 1979—435 ; 1980—334; 1981—386; 1982—385; and 1983—430 (estimated).
[6]Described in source as lump feldspar; does not include nepheline syenite.
[7]Includes pegmatite.
[8]Reported figure.

TECHNOLOGY

The Bureau of Mines continued its investigation of the recovery of alumina from domestic nonbauxitic resources, including anorthosite, a lime-soda feldspar rock. The United States has large reserves of anorthosite, but its aluminum content is less than 50% soluble in acid, unless a source of fluoride is added to the acid. A flowsheet was developed, including leaching with hydrochloric acid (HCl) and fluoride followed by crystallization of aluminum chloride, $AlCl_3 \cdot 6H_2O$, from the pregnant liquor by HCl gas injection. The source of the fluoride was hydrofluosilicic acid, H_2SiF_6. Approximately 90% of the aluminum values were recovered from the anorthosite when a ratio of 0.14 mole of fluorine per mole of aluminum was used.[11]

A variety of chemicals was evaluated as dewatering aids for aqueous slurries of feldspar, feldspar-silica mixtures, and silica sand. The purpose of the dewatering aid was to reduce the amount of fuel consumed in drying the solid material. One chemical, a polyalkoxylated amine, showed very good laboratory results as a dewatering aid.[12]

A joint technology agreement between Owens-Illinois Inc. (O-I) and Heye Glass Co. of Obernkirchen, Federal Republic of Germany, was expected to result in substantial increases in the production of high-quality, lighter weight, narrow-neck glass bottles, such as those used by the brewery and soft drink industries. Although some development work remained, O-I planned to install the forming process at company plants in the United States.[13]

O-I began operation of its third California processing center for reclaimed bottles and jars, in Tracy, CA. The company had recycled about 930 million glass containers in 1981. O-I's glass bottles and jars have been comprised of 20% to 25% recycled glass, and the company's goal was to increase this to 50% recycled glass.[14]

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, are consumed in making glass and ceramics. There is no domestic production of nepheline syenite in grades suitable for these purposes, and U.S. needs are 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. Canadian production in 1982 had decreased 15% to approximately 570,000 tons valued at $17 million. In 1983, output of nepheline syenite was 550,000 tons with a value of $15.6 million.[15]

Other than Canada, only two countries, Norway and the U.S.S.R., were known to have produced significant quantities of nepheline syenite. Production in the U.S.S.R. was from large deposits in south-central Siberia and consisted mostly of nepheline concentrates containing 25% to 30% Al_2O_3 as feed for domestic alumina production. Estimated output in 1982 was 2.75 million tons.[16]

In Pakistan, a resource of 6 billion tons of nepheline syenite was established in Koga, Mardan. In addition to possible use in ceramics, the material was being considered as raw material for the production of alumina and soda ash. A contract for a feasibility study was to be awarded to a Canadian group. Process technology was reportedly also available from Mexico, Sweden, and the U.S.S.R.[17]

In the U.S.S.R., a process for production of alumina from nepheline was reportedly developed by scientists at the Research Institute of Leningrad. Operating costs for the process were estimated to be 15% less than for production of alumina from bauxite.[18]

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 1983.

Table 10.—U.S. imports for consumption of nepheline syenite

Year	Crude		Ground	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1981	2,780	\$25	503,320	\$11,504
1982	316	16	455,280	13,735
1983	212	13	407,139	13,984

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 in 1983 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 in 1983 was approximately 7% lower in tonnage than in 1982 and marked the fifth consecutive year that a decrease took place. The data were company proprietary and could not be released for publication. Aplite traditionally has a somewhat lower price than feldspar. Industrial Minerals (London), December 1983, gave a value of about \$24 per ton for glass grade, bulk, 100% plus 200 mesh, f.o.b. Montpelier, VA.

[1]Physical scientist, Division of Industrial Minerals.
[2]Chemical Week. Glass Fiber's Struggle To Build New Markets. V. 132, No. 24, June 15, 1983, pp. 82, 84.
[3]Oliver, J. C. Porcelain Enamel—Review and Outlook. Am. Ceram. Soc. Bull., v. 62, No. 5, May 1983, pp. 562-563.
[4]Clarke, G. M. The Industrial Minerals of India. Ind. Miner. (London), No. 191, Aug. 1983, pp. 47, 49.
[5]Watson, I. Troubled Times in Italy's Glass and Ceramics Industries. Ind. Miner. (London), No. 186, Mar. 1983, pp. 28-29.
[6]Industrial Minerals (London). Processing/Equipment. No. 194, Nov. 1983, p. 67.
[7]Mining Journal. Pilot Scale Cell From Norwegian Manufacturer. V. 300, No. 7703, Apr. 8, 1983, pp. 229, 231.
[8]Avramescu, C., I. Calugaru, and M. Angelescu. The Industrial Minerals of Romania. Ind. Miner. (London), No. 186, Mar. 1983, p. 37.
[9]Value converted from pounds sterling (£) to U.S. dollars at the rate of £1.00 = US\$1.50.
[10]Industrial Minerals (London). Company News & Mineral Notes. No. 192, Sept. 1983, p. 81.
[11]Eisele, J. A., and D. J. Bauer. Recovery of Alumina From Anorthosite by an HCl-F-Gas Sparging Crystallization Process. BuMines RI 8806, 1983, 11 pp.
[12]Mehaffey, J. L. Dewatering Feldspathic Minerals From North Carolina. Paper in Process Mineralogy III. Applications in Metallurgy, Coal, Concrete, Smelting and Exploration, ed. by W. Petruk (SME-AIME Annu. Meeting, Atlanta, GA, Mar. 6-10, 1983). Soc. Min. Eng. AIME, Littleton, CO, July 1984, pp. 275-288.
[13]Glass Industry. Newsletter. V. 64, No. 8, Aug. 1983, p. 6.
[14]———. O-I Opens Processing Center for Recycled Glass. V. 64, No. 1, Jan. 1983, p. 8.
[15]The Northern Miner (Toronto). Mineral Output Up by \$2.2 Billion; Crude Oil Is Biggest Contributor. V. 69, No. 46, Jan. 19, 1984, p. A2.
[16]Ash, D. R. Nepheline Syenite. Min. Eng., v. 35, No. 5, May 1983, p. 502.
[17]U.S. Embassy, Karachi, Pakistan. State Dep. Airgram A-012, May 5, 1983, pp. 14-15.
[18]Engineering and Mining Journal. In Europe—U.S.S.R. V. 184, No. 11, Nov. 1983, p. 144.

Ferroalloys

By Gerald F. Murphy[1] and Raymond E. Brown[1]

World demand for ferroalloys in 1983 was only slightly more than the low level of 1982, because of continued weak demand by the iron and steel industry, the major consumer of ferroalloys. Demand for ferroalloys in the United States was greater than that of most other countries. Overcapacity and oversupply were the main problems confronting world ferroalloy producers in 1983. Despite this situation, a number of countries installed or planned to install additional ferroalloy capacity. Protectionist pressures were aggravated by the high value of the U.S. dollar, by prolonged unemployment in Europe, and the need to earn trade surpluses in developing countries to pay off very large debts.

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. Data presented in table 2 represent over 95% of all ferroalloys and ferroalloy metals produced and/or shipped.

Legislation and Government Programs.—In December, the General Services Administration (GSA) awarded two contracts for the upgrading of chromium and manganese ores to high-grade ferroalloys. GSA initiated the solicitation of bids the previous June. Macalloy Corp., Charleston, SC, was awarded an approximate $23 million contract to convert 121,753 short tons of chromite into about 51,000 tons of high-carbon ferrochromium, and Elkem Metals Co., Pittsburgh, PA, received an approximate $10 million contract to upgrade 48,476 tons of manganese ore into about 25,000 tons of high-carbon ferromanganese. These were the first contracts let under the President's upgrading program ordered in late 1982 to maintain domestic ferroalloy furnace and processing capacity and improve stockpile readiness.

In March, following a request by The Ferroalloys Association, the President, by Executive Order 12413, removed imported high-carbon ferromanganese from special duty-free treatment allowed under the Generalized System of Preferences (GSP) for developing countries. In addition, the order removed two grades of Brazilian 75% ferrosilicon and Brazil's silicomanganese from GSP status.

In November, the U.S. Trade Representative, after consultation with the President and the National Security Council, requested the International Trade Commission to conduct an investigation under Section 406 of the Trade Act of 1974 to determine if recent imports of Soviet 50%-grade ferrosilicon had caused market disruptions. Section 406 deals with products from centrally planned economy countries that compete unfairly with domestic industry or cause market disruptions.

Following an administrative review, the U.S. Department of Commerce directed the U.S. Customs Service to collect cash deposits of 1.53% in countervailing duties on shipments of ferrochromium (over 3% carbon), ferromanganese (over 4% carbon), ferrosilicon manganese, and ferrosilicon (60% to 80% silicon) from Spain. Also, Commerce instructed Customs to collect duties retroactively, ranging from 2.14% to 3.09% on shipments of affected ferroalloys during 1980 and 1981. Commerce made a final decision in May that shipments of ferrochromium from the Republic of South Africa, between April and December 1981, received a subsidy of 0.40% ad valorem but directed Customs not to assess countervailing duties, since the total subsidy was less than 0.50% and considered minimal.

The Congressional Budget Office released a study dealing with strategic and critical nonfuel minerals. The study shows that U.S. import dependence is almost total for minerals such as chromium and manganese, and others. Moreover, U.S. dependence on imported minerals is increasing. Several policy options to reduce this dependence are examined.[2] The Library of Congress also released a report on the status of the domestic ferroalloy industry. The report briefly explains the nature and development of the ferroalloy industry, examines its relationship to the steel industry and output and demand, reviews economic aspects of various national security considerations, and then examines a number of policy options.[3]

The U.S. International Development Cooperation Agency's Trade and Development Program was assessing alternate foreign sources for critical and strategic materials, such as chromium and manganese, among others, in an attempt to attract investment by U.S. companies in the more promising foreign minerals development prospects. Alternate sources and more effective recycling would help reduce U.S. dependence on the Republic of South Africa for these critical and strategic materials.

Table 1.—Government inventory of ferroalloys, December 31, 1983

(Thousand short tons)

Alloy	Stock-pile grade	Non-stock-pile grade	Total
Ferrochromium:			
High-carbon	402	1	403
Low-carbon	300	19	319
Ferrochromium-silicon	57	1	58
Ferrocolumbium (contained columbium)	.3	.2	.5
Ferromanganese:			
High-carbon	600	--	600
Medium-carbon	29	--	29
Ferrotungsten (contained tungsten)	.4	.6	1
Silicomanganese	24	--	24

DOMESTIC PRODUCTION

Total domestic production of ferroalloys and ferroalloy metals was about 776,000 tons, 7% less than the low levels of 1982. Weak demand and competition from low-priced imports were the main reasons for the decline in production. Production of the bulk ferroalloys (chromium, manganese, and silicon) and their respective metals in 1983 was down by 9% but shipments were up slightly by 3% compared with that of 1982. Demand for bulk ferroalloys and their respective metals increased by about 10% compared with that of 1982, and imports captured a larger share of the domestic market, 56% compared with 53% in 1982. Capacity utilization averaged 31%, compared with 34% in 1982. Specialty ferroalloy producers like bulk ferroalloy producers also operated at low production levels owing to continued weak demand by consuming industries, primarily iron and steel.

Although the domestic ferroalloy industry continued to operate at very low production rates, two companies began initial production of specialty ferroalloys. Ashland Chemical Co., Columbus, OH, began production of specialty ferroalloys at its new aluminothermic and silicothermic reduction plant in Cleveland, OH, on September 15. Some of the company's production equipment was acquired from the The Pesses Co., a former specialty ferroalloys producer, scrap processor, and trading firm, which was declared bankrupt at midyear. Affiliated Metals and Minerals Inc., headquartered in Pittsburgh, PA, began initial production of specialty ferroalloys in February at its Zelienople plant. Initial output included ferromolybdenum and ferrovanadium.

Foote Mineral Co.'s plants at Graham, WV, and Cambridge, OH, were shut down for about 1 month owing to a strike that began October 2. The Graham plant produced ferrosilicon, while the Cambridge facility produced ferrovanadium and ferroboron. A new 3-year labor agreement was ratified by the workers and included wage and benefits concessions.

The Hanna Mining Co. reopened its ferronickel operation located in Riddle, OR, on November 7. The facility, which was closed in April 1982, is the only integrated nickel mine and smelter in the United States. Although the nickel market remained unfavorable, the reopening was made possible by a new power contract negotiated with the Bonneville Power Administration and a new 2-year labor agreement. The power contract calls for Hanna Nickel Smelting Co. to operate with a reduced power rate during offpeak hours. The new power rate amounted to seven mills per kilowatt hour compared with a previous rate of 20 mills per kilowatt hour. Labor concessions included wage and benefits modifications, and a fundamental shift in work rules permitting the plant to operate mainly at night and during other offpeak hours.

Macalloy, Charleston, SC, reported that it will use its $23 million Government contract to convert stockpiled chromium ore to ferrochromium as the basis of the company's reorganization plan required under Chapter 11 of the Federal Bankruptcy Code. Macalloy filed for protection under Chapter 11 in February 1982. Macalloy was the last U.S. company to independently produce 50% to 55% charge chrome, the major grade used in steelmaking. Low chrome prices were claimed responsible for idling the two furnaces at its 150,000-ton-per-year plant.

Ratification of a new labor agreement in July 1983 enabled Ohio Ferro-Alloys Corp., Canton, OH, to resume ferrosilicon production at its Philo, OH, facility, the company's only ferrosilicon plant. The plant had been idle since late 1982. The contract, which includes all three of the company's plants, called for an immediate wage reduction of $1.75 per hour and also provides for revisions in pensions, premium pay, vacation pay, and other worker benefits. The lengthy shutdown depleted Ohio Ferro-Alloy's inventories of some grades of magnesium ferrosilicon and had left stocks of other grades of regular-grade ferrosilicon and magnesium ferrosilicon at very low levels. The company resumed silicon metal production at its Powhatan Point, OH, plant after being out of production since November 1981. However, no concessions in wages or benefits were involved.

SKW Alloys Inc., Niagara Falls, NY, established early in the year an independent trading subsidiary, SKW Alloys and Metals Inc., to market the metallurgical products of SKW Canada (Montreal), Murex Ltd. (United Kingdom), and SKW Trostberg (Federal Republic of Germany). These companies produced ferrochromium, ferrosilicon, and ferrovanadium. SKW Alloys and Metals took over the marketing of SKW Alloys' ferroalloys and other products late in the year. SKW Alloys' plant in Calvert City, KY, was idled by a strike on September 1, and remained down for the rest of the year. The plant produces both 50% and 75% ferrosilicon and other alloys. However, the company indicated that it would reopen the plant utilizing management personnel in January 1984 whether or not the strike was settled. This action was cited as necessary since the company stocks were reaching a low level.

The Ferroalloys Association reported that its member companies consumed 4.1 billion kilowatt hours of electricity, up from 4.0 billion in 1982. In addition, in 1983, its member companies employed 3,800 workers and reported losses amounting to $65 million before taxes, compared with 8,500 workers and a $32 million profit in 1979.

Table 2.—Ferroalloys[1] produced and shipped from furnaces in the United States

	1982				1983			
	Production		Shipments		Production		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]	119,200	82	98,400	$64,961	85,930	81	108,889	$53,757
Silicomanganese	68,867	66	82,900	40,787	W	66	63,087	21,211
Manganese metal	18,589	100	18,085	25,319	W	100	W	W
Ferrosilicon[3]	298,947	53	317,345	161,715	314,955	54	359,115	179,346
Silicon metal	76,603	98	80,805	102,787	121,890	99	123,076	113,479
Chromium alloys:								
Ferrochromium	91,905	r61	82,353	53,087	19,928	65	39,510	34,802
Other alloys[4]	27,380	r50	36,961	30,602	16,471	39	13,696	18,645
Total	119,285	r58	119,314	83,689	36,399	53	53,206	53,447
Ferrocolumbium	W	65	W	W	W	64	W	W
Ferrophosphorus	61,547	25	W	W	74,992	25	62,077	7,010
Other[5]	74,723	XX	109,177	172,962	142,037	XX	97,671	122,139
Grand total	837,761	XX	826,026	652,220	776,203	XX	867,121	550,389

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 miscellaneous silicon alloys.
[4]Includes ferrochromium-silicon, chromium briquets, exothermic chromium additives, other miscellaneous chromium alloys, and chromium metal.
[5]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 1983

Producer	Plant location	Products[1]	Type of furnace
FERROALLOYS (EXCEPT FERROPHOSPHORUS)			
A. Johnson & Co. Inc	Lionville, PA	FeAl, FeTi, FeZr	Electric.
Affiliated Metals and Minerals Inc	Newcastle, PA	FeMo, FeV	Metallothermic.
Alabama Alloy Co. Inc	Bessemer, AL	FeSi	Do.
Aluminum Co. of America, Northwest Alloys Inc.	Addy, WA	FeSi, Si	Do.
Ashland Chemical Co	Columbus, OH	FeB, FeCb, FeMo, FeTi, FeW, NiCb.	Electric and metallothermic.
Autlan Manganese Corp	Mobile, AL	FeMn, SiMn	Do.
AMAX Inc., Climax Molybdenum Co. Div	Langeloth, PA	FeMo	Metallothermic.
Cabot Corp., KBI Div., Penn Rare Metal Div	Revere, PA	FeCb	Do.
Chromasco Ltd., Chromium Mining & Smelting Corp. Div.	Woodstock, TN	FeCr, FeCrSi	Electric.
Dow Corning Corp	Springfield, OR	Si	Do.
Elkem AS, 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.
Engelhard Corp., Chemstone Corp	Strasburg, VA	FeV	Metallothermic.
Foote Mineral Co., Ferroalloys Div	Cambridge, OH; Graham, WV; Keokuk, IA; New Johnsonville, TN.	FeSi, FeV, Mn, silvery pig iron, other.[2]	Electric and electrolytic.
Hanna Mining Co., The:			
Hanna Nickel Smelting Co	Riddle, OR	FeNi, FeSi	Electric.
Silicon Div	Wenatchee, WA	FeSi, Si	Do.
Interlake Inc., Globe Metallurgical Div	Beverly, OH; Selma, AL	FeCr, FeSi, Si, SiMn	Do.
International Minerals & Chemical Corp., Industry Group, TAC Alloys Div.	Bridgeport, AL	FeSi	Do.
	Kimball, TN	FeSi, other[2]	Do.
Kerr-McGee Chemical Corp	Hamilton (Aberdeen), MS.	Mn	Electrolytic.
Macalloy Inc	Charleston, SC	FeCr, FeCrSi	Electric.
Metallurg Inc., Shieldalloy Corp	Newfield, NJ	Cr, FeAl, FeB, FeCb, FeTi, FeV, other.[2]	Metallothermic.
Ohio Ferro-Alloys Corp	Montgomery, AL; Philo, OH; Powhatan Point, OH	FeSi, Si	Electric.
Pennzoil Co., Duval Corp	Sahuarita, AZ	FeMo	Metallothermic.
Pesses Co., The	Fort Worth, TX; Newton Falls, OH; Pulaski, PA; Solon, OH	FeAl, FeB, FeCb, FeMo, FeNi, FeTi, FeW, other.[2]	Electric and metallothermic.
Reactive Metals and Alloys Corp	West Pittsburg, PA	FeAl, FeB, FeTi, other.[2]	Electric.
Reading Alloys Inc	Robesonia, PA	FeCb, FeV	Metallothermic.
Reynolds Metals Co	Sheffield, AL	Si	Electric.
Satra Corp., Satralloy Inc. Div.	Steubenville, OH	FeCr	Do.
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.
South African Manganese Amcor Ltd., Roane Ltd.	Rockwood, TN	FeMn, FeSi, SiMn	Do.
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	Mt. 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

Reported consumption increased over that of 1982 for all ferroalloy categories except silicomanganese, ferroboron, ferromolybdenum, and ferrovanadium. Total consumption of ferroalloys and ferroalloy metals, on a gross weight basis, increased moderately to 1.46 million tons, about 10% higher than in 1982. The increase was attributed to the modest recovery of the steel and ferrous foundry industries and a surge in demand for silicon metal by the secondary aluminum industry. The main consumers of ferroalloys were the steel and ferrous foundry industries, amounting to 90% of total ferroalloy consumption. Raw steel production and ferrous castings shipments rose by 13% to 85 million tons and 8% to 10 million tons, respectively, compared with 1982 figures. According to usage patterns of the respective ferroalloys, consumption trends generally paralleled modestly increased raw steel production and a similarly modest recovery in iron foundry activity, and a 42% greater production of stainless steel.

Combined consumption for bulk ferroalloys and their respective metals, accounting for about 95% of all ferroalloys and metals consumed, increased by about one-tenth compared with that of 1982. Consumption of chromium ferroalloys in stainless steel, its major end use, increased by a larger percentage than that for other bulk ferroalloys, mainly owing to the increase in stainless steel production. Demand for ferronickel, which is also mainly consumed in the production of stainless steel, increased by slightly more than one-fifth compared with that of 1982. Although silicomanganese reported consumption was down in 1983, raw steel production was up. This decline, in part, may be the result of changing steelmaking technology.

Table 4.—U.S. consumption of ferroalloys as additives in 1983, by end use[1]

(Short tons of alloys unless otherwise specified)

End use	FeMn	SiMn	FeSi	FeTi	FeP	FeB
Steel:						
Carbon	341,075	50,199	[2]61,938	737	9,672	234
Stainless and heat-resisting	16,327	4,418	[2]51,128	1,709	([3])	18
Other alloy	77,360	19,063	[2]31,781	734	1,543	160
Tool	336	74	[2]835	--	([3])	--
Unspecified	335	201	35,282	--	7	--
Total	435,433	73,955	180,964	3,180	11,222	412
Cast irons	15,056	7,993	171,204	38	2,030	W
Superalloys	[4]482	W	265	W	--	W
Alloys (excluding alloy steels and superalloys)	9,256	1,245	38,236	197	72	42
Miscellaneous and unspecified	4,386	200	63,898	71	2,234	43
Total consumption	464,613	83,393	454,567	3,486	15,558	497
Percent of 1982	103	79	106	141	122	48

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 1983, by end use[1]

(Short tons of contained elements unless otherwise specified)

End use	FeCr	FeMo	FeW	FeV	FeCb	FeNi
Steel:						
Carbon	4,468	41	--	577	658	--
Stainless and heat-resisting	183,239	236	27	14	331	13,987
Other alloy	24,341	603	W	1,682	675	589
Tool	2,317	228	57	426	(2)	(3)
Unspecified	(4)	(4)	--	--	12	--
Total[5]	214,365	1,108	84	2,699	1,676	14,576
Cast irons	3,701	417	--	10	--	98
Superalloys	7,254	62	W	10	469	330
Alloys (excluding alloy steels and superalloys)	3,111	86	5	21	12	590
Miscellaneous and unspecified	902	29	28	1	2	1
Total consumption	229,333	1,702	117	2,741	2,159	15,595
Percent of 1982	146	91	124	92	117	101

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]Included with "Steel: Unspecified."
[3]Included with "Steel: Other alloy."
[4]Included with "Miscellaneous and unspecified."
[5]Part 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	
	1982 (gross weight)	1983 (gross weight)	1982 (gross weight)	1983 (gross weight)	1982 (gross weight)	1983 (gross weight)
Manganese ferroalloys[1]	98,185	[2]61,143	183,119	157,350	281,304	218,493
Silicon alloys[3]	177,726	79,934	28,728	28,053	206,454	107,987
Ferrochromium[4]	[r]63,631	33,293	29,082	26,670	[r]92,713	59,963
Ferroboron[5]	W	183	192	203	192	386
Ferrophosphorus	153,822	168,263	1,345	1,468	155,167	169,731
Ferrotitanium	W	W	481	431	481	431
Total	[r]493,364	342,816	242,947	214,175	[r]736,311	556,991
	1982 (contained element)	1983 (contained element)	1982 (contained element)	1983 (contained element)	1982 (contained element)	1983 (contained element)
Ferrocolumbium[6]	W	W	W	W	380	399
Ferromolybdenum[7]	2,195	2,150	308	285	2,503	2,435
Ferronickel	W	W	1,122	756	1,122	756
Ferrotungsten	W	W	45	35	45	35
Ferrovanadium[8]	[r]1,185	1,345	280	313	[r]1,465	1,658
Total	[r]3,380	3,495	1,755	1,389	[r]5,515	5,283

[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

Depressed markets and competition among producers either prevented price increases or pushed prices down for ferroalloys, despite rising production costs. Although prices began to firm toward yearend, they were still lower than those in 1982. In certain instances, ferroalloys were reportedly being offered at a substantial discount from published prices. Posted prices of individual imported ferroalloys were lower than those of domestically produced ferroalloys. The average posted price for both domestic and imported high-carbon ferrochromium declined about 20% compared with that of 1982, and imports were priced 5% lower than domestic material. The listed price quotation for domestic high-carbon ferromanganese was meaningless and unchanged. However, the average posted price of high-carbon ferromanganese imports was down 17% to $320 per long ton of alloy, and the average price of imports was 35% less than U.S.-produced alloys compared with a 21% differential in 1982. Yearend price differentials between domestic and imported silicomanganese narrowed from 33% in 1982 to 14% in 1983, but the average price differentials between domestic and imported material widened slightly from 20% in 1982 to 23% in 1983. The price differential between imported and domestic 50% ferrosilicon, 75% ferrosilicon, and silicon metal narrowed as the yearend price of imported material rose by 8%, 14%, and 28%, respectively, while that of domestic material declined by 4%, 9%, and 3%, respectively. However, the average price for these domestic and imported materials in 1983 declined by as little as 2% for imported 75% ferrosilicon to as much as 12% for 50% ferrosilicon.

Domestic producers of specialty ferroalloys also showed great willingness to discount aggressively and compete with imports. For example, posted prices of domestically produced ferronickel remained constant at $3.16 per pound of contained nickel, but actual sale prices were reportedly near $2.00 and listed prices of domestically produced ferrovanadium ranged from $5.80 to $8.50 per pound of contained vanadium, but offering prices were reportedly near $4.00. Prices for domestic ferroalloys are shown in the following tabulation:

Alloy	Yearend price[1]	
	1982	1983
Charge chromium (66% to 70%)	$0.43	$0.42
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	3.30	4.45
Ferronickel	3.16	3.16
Ferrosilicon, 50%	.4500	.4300
Ferrosilicon, 75%	.4700	.4300

[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 $323 million in 1982 to $361 million in 1983. However, a deficit of $1 million for ferroalloy metals in 1982 changed to a surplus of $14 million in 1983.

The quantity of exported ferroalloys and ferroalloy metals on a gross weight basis increased 57% to about 75,000 tons. The quantity and value of exported ferroalloys and ferroalloy metals were 7% and 22% of the quantity and value of imports, respectively, compared with 6% and 20%, respectively, in 1982.

Total imports of ferroalloys and ferroalloy metals increased 20% compared with those of 1982, to about 1 million tons. Of the manganese ferroalloy imports, only high-carbon ferromanganese showed a decrease, by about one-third compared with that of 1982. Imports of silicomanganese were a little more than double, while those of low-carbon ferromanganese were slightly less than double those of 1982. Both regular grade of 50% ferrosilicon (30% to 60% silicon) and 75% ferrosilicon (60% to 80% silicon) imports increased dramatically, about triple and double those of 1982, respectively. Of the chromium ferroalloy imports, only high-carbon ferrochromium showed an increase, slightly more than double those of 1982. Imports of chromium and silicon (99% to 99.7% silicon) metal also increased dramatically by about two-thirds, compared with 1982 totals. Manganese metal imports were little changed. Ferrotitanium and ferrosilicon-titanium imports were about six times those for 1982, while imports of ferromolybdenum decreased by about three-tenths. Ferroalloy and ferroalloy metal imports were equal to 69% of reported consumption, up from 64% in 1982.

Ferroalloy and ferroalloy metals imported into the United States in 1983 were supplied by the following sources: Africa, 35%; Europe, 33%; the Western Hemisphere, 25%; and Asia, 5%, compared with 43%, 26%, 23%, and 4%, respectively, in 1982. The Republic of South Africa and Zimbabwe collectively shipped to the United States 73% of its chromium ferroalloys, up from 64% in 1982. Brazil's share of chromium ferroalloy imports to the United States decreased from 12% in 1982 to 3% in 1983. Major sources for imported manganese ferroalloys were the Republic of South Africa with 29% and France with 24%, compared with 46% and 19%, respectively, in 1982. Europe's overall share increased from 29% in 1982 to 45% in 1983. The Western Hemisphere, Canada, Brazil, and Mexico furnished 22% of the manganese ferroalloy imports, compared with 19% in 1982. Brazil's and Mexico's shares were up significantly, while Canada's share showed a comparable decline. The leading suppliers of ferrosilicon were Norway (20%), Brazil (19%), Canada (19%), and Venezuela (16%), compared with 14%, 40%, 14%, and 11%, respectively, in 1982. The principal sources of ferronickel imports were the Dominican Republic (41%), New Caledonia (22%), Colombia (17%), and Japan (9%), compared with 0%, 59%, 1%, and 40%, respectively, in 1982. Major suppliers of ferroalloy metal imports were Canada with 42% and Brazil with 21% of the silicon metal compared with 45% and 8%, respectively, in 1982; the Republic of South Africa with 89% and Canada with 11% of the manganese metal compared with 97% and 2%, respectively, in 1982; and Japan and the United Kingdom combined with 77% and China with 11% of the chromium metal, compared with 81% and 8%, respectively, in 1982.

Table 7.—U.S. exports of ferroalloys and ferroalloy metals

Alloy	1981		1982		1983	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Ferroalloys:						
Ferrocerium and alloys	11	$117	27	$264	41	$372
Ferrochromium and ferrochromium-silicon	14,098	10,361	4,943	5,081	4,247	4,822
Ferromanganese	14,925	12,477	10,311	7,517	8,433	5,765
Silicomanganese	3,941	2,172	2,952	1,532	6,426	1,746
Ferromolybdenum	228	2,984	128	675	85	687
Ferrophosphorus	7,463	2,031	4,031	1,402	26,933	3,716
Ferrosilicon	15,768	12,136	14,932	11,996	13,338	10,712
Ferrovanadium	434	4,397	326	3,436	775	6,144
Ferroalloys, n.e.c	6,358	8,439	4,980	8,481	5,775	7,965
Total ferroalloys	63,226	55,114	42,630	[1]40,388	66,053	41,929
Metals:						
Manganese	2,523	3,980	2,948	3,861	6,391	8,531
Silicon	8,673	57,001	2,411	34,335	2,767	47,826
Chromium	395	5,209	213	2,685	238	2,555
Total ferroalloy metals	[1]11,592	66,190	5,572	40,881	9,396	58,912
Grand total	74,818	121,304	48,202	81,269	75,449	100,841

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

Table 8.—U.S. imports for consumption of ferroalloys and ferroalloy metals

Alloy	1982 Gross weight (short tons)	1982 Content (short tons)	1982 Value (thousands)	1983 Gross weight (short tons)	1983 Content (short tons)	1983 Value (thousands)
Manganese alloys:						
Ferromanganese containing less than 1% carbon	3,858	3,393	$3,807	6,967	5,957	$5,410
Ferromanganese containing over 1% and less than 4% carbon	25,907	21,124	15,159	29,442	23,735	13,952
Ferromanganese containing 4% or more carbon	462,944	359,185	135,524	305,199	236,668	73,721
Ferrosilicon-manganese	62,095	[1]41,121	21,471	139,657	[1]91,992	40,117
Spiegeleisen	43	([2])	25	157	([2])	91
Total manganese alloys[3]	554,846	424,824	175,986	481,421	358,352	133,290
Ferrosilicon:						
8% to 30% silicon	641	162	204	29	6	11
30% to 60% silicon, over 2% magnesium	5,805	2,653	4,657	13,575	6,372	8,308
30% to 60% silicon, n.e.c	11,940	5,984	6,733	34,108	16,449	9,267
60% to 80% silicon, over 3% calcium	5,526	3,771	5,155	5,671	3,658	5,094
60% to 80% silicon, n.e.c	50,642	37,816	22,850	106,041	79,512	44,752
80% to 90% silicon	698	601	208	20	15	13
Over 90% silicon	1,490	1,361	536	--	--	--
Total ferrosilicon[3]	76,742	52,348	40,343	159,443	106,012	67,445
Chromium alloys:						
Ferrochromium containing 3% or more carbon	118,491	69,357	55,796	263,546	151,285	93,738
Ferrochromium containing less than 3% carbon	22,819	15,417	21,699	16,757	11,713	15,274
Ferrosilicon-chromium	6,993	2,725	3,322	1,438	579	670
Total chromium alloys[3]	148,304	87,499	80,817	281,741	163,577	109,682
Ferronickel	21,351	5,344	28,215	45,134	16,696	65,264
Other ferroalloys:						
Ferrocerium and other cerium alloys	95	([2])	1,092	115	([2])	1,185
Ferromolybdenum	832	609	6,308	579	399	3,189
Ferrophosphorus	22	([2])	4	6	([2])	10
Ferrotitanium and ferrosilicon-titanium	152	([2])	263	893	([2])	1,288
Ferrotungsten and ferrosilicon-tungsten	95	77	1,222	66	53	604
Ferrovanadium	852	669	8,065	847	681	6,259
Ferrozirconium	683	([2])	881	551	([2])	696
Ferroalloys, n.e.c.[4]	6,273	([2])	19,764	2,318	([2])	14,400
Total other ferroalloys[3]	9,003	XX	37,599	5,375	XX	27,631
Total ferroalloys[3]	810,246	XX	362,960	973,114	XX	403,312
Metals:						
Manganese	5,226	([2])	5,213	5,950	([2])	5,323
Silicon (96% to 99% silicon)	13,366	([2])	13,494	7,535	([2])	6,665
Silicon (99% to 99.7% silicon)	12,322	12,214	13,246	19,953	19,418	19,699
Chromium	1,850	([2])	10,078	3,092	([2])	13,687
Total ferroalloy metals[3]	32,764	XX	42,032	36,530	XX	45,374
Grand total[3]	843,011	XX	404,992	1,009,644	XX	448,686

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

The world ferroalloy industry continued to be confronted with two main problems, overcapacity and oversupply, primarily owing to the continuation of a shrinking world steel market. Changes in steelmaking technology also resulted in less ferroalloy consumption, thereby contributing to reduced demand for these materials. Despite a shrinking world market for ferroalloys, new capacity was either planned, under construction, or placed on-line in a number of countries such as Brazil, Egypt, Greece, Iceland, India, the Philippines, and Yugoslavia. Silicon metal, which is also produced in submerged arc furnaces like most bulk ferroalloys, is primarily dependent on the aluminum industry, which rebounded strongly in 1983, resulting in increased demand for silicon metal. Because of the shrinking market for their products, intense competition arose among producers in their efforts to increase market share and recover losses. The three large ferroalloy consuming markets, Europe, Japan, and the United States, have not only stopped growing in the last few years, but have become smaller. As a result, many countries have applied trade restraints to protect their domestic markets. Protectionist pressures were aggravated by the high value of the U.S. dollar, by prolonged high unemployment in Europe, and the need by developing countries to earn trade surpluses to pay off very large debts.

Following a decision to raise prices for ferrosilicon exports to the European Economic Community (EEC) by producers in Iceland, Norway, Sweden, Venezuela, and Yugoslavia the EEC decided against taking protective action on imports of ferrosilicon from these countries. Investigation by the EEC had established earlier that dumping had occurred and that there had been injury to EEC producers. The EEC maintained, however, that the price increases would eliminate injury to EEC ferrosilicon producers and also eliminate the dumping margin, estimated at 26% for Venezuelan and Yugoslav ferrosilicon exports and at 12% for exports from Iceland, Norway, and Sweden. The EEC also set quotas for duty-free imports of ferrosilicon and other ferroalloys and set a minimum price for ferrosilicon imports to protect their members.

Australia.—Comalco Pty. Ltd. and Agnew Clough Ltd. planned to establish a joint venture to produce silicon metal. Agnew Clough already controls the silica deposit located near Moora, Western Australia. The companies have already negotiated power contracts with the State Energy Commission. The plant was expected to produce about 25,000 tons per year, including high-purity, chemical-grade metal for use in semiconductors and photovoltaic cells. The project was expected to be started by mid-1984 and will be Australia's first entry into silicon metal production.[4]

Brazil.—Brazil continued to expand its ferroalloy industry as part of its general plan to develop and exploit its abundant natural resources. However, some major projects have been delayed owing to lack of funding. Brazilian ferroalloy producers planned to increase total furnace capacity to 1,000 megavolt amperes (MV•A) by 1990 from 650 MV•A currently. This expansion, undertaken despite a large world overcapacity, elicited sharp criticism from other ferroalloy producers.

The Carajás metallurgical manganese project has been delayed for 1 year along with the iron ore project in that area because financial considerations forced the Government to trim back some of its plans. Cia. Vale do Rio Doce (CVRD), the State-owned minerals company responsible for the project, claimed a savings of nearly $500 million by shelving the metallurgical manganese project. CVRD officials said the battery-grade manganese ore project will continue. Production of this material began in 1983, and the first exports of ore took place in November.

Empresa de Desenvolvimento de Recursos Minerais S.A. (CODEMIN) put into operation in May the second furnace at its ferronickel plant in Goiás following a delay caused by technical problems. CODEMIN, a subsidiary of Morro do Niquel S.A. Mineração Indústria e Comércio, began exporting some of its ferronickel production because of weak domestic demand. Total plant capacity is rated at about 7,700 tons per year. Produtos Metalúrgicas S.A., a Brazilian ferromanganese producer, and Metals de Goiás S.A. have formed a $6 million venture, Goiasnibio, to begin producing ferrocolumbium in 1984. The company planed to program the total production for export. Construction of the project, in the Catalao region of Goiás, was scheduled to begin in October 1983.

Italmagnésio S.A. Indústria e Comércio a major ferrosilicon producer engaged mainly in export, planned to further expand its production of 75% ferrosilicon and silicon metal by installing a second 24-MV•A electric furnace at its Varzea da Palma plant in Minas Gerais to produce either about 20,000 tons of ferrosilicon or about 13,000 tons of silicon metal. The first furnace was installed in the first half of 1983. The new furnace was scheduled to begin operating in late 1984. The company earlier in 1983 installed a 0.85-MV•A smelting furnace capable of producing high-purity 90% ferrosilicon and semiconductor-grade silicon metal.[5] Cia. de Ferro-Ligas da Bahia S.A., which had switched two ferrochromium furnaces to ferrosilicon production early in the year because of poor demand, announced late in the year that one of the furnaces was to be reconverted to ferrochromium production. The reconversion to ferrochromium production was in response to a dramatic increase in demand, both in Brazil and worldwide. Ferroligas de Minas Gerais S.A. (Minasligas) announced plans that would triple its ferrosilicon production of about 13,000 tons per year by 1985. The expansion project was to include the installation of two new furnaces that will be capable of producing 45% to 95% ferrosilicon as well as silicon metal. Most of Minasligas' production was expected to be exported.

CVRD, the Brazilian State mining organization, planned to build a 25,000-ton-per-year ferrosilicon furnace, instead of two pig iron plants. The ferrosilicon plant was to be located at Nova Era. Mitsubishi Mining Co. was expected to contribute to the required investment of $25 million, with the entire production destined for the Japanese market. Electrometalur S.A. Indústria e Comércio, a ferroalloy producer, began silicon metal production in April 1983 in a new 5,500-ton-per-year furnace. Later in the year, the company began building a second 6,600-ton-per-year silicon metal furnace, which was scheduled to come on-line by the third quarter of 1984. The major market for the new production was to be Japan. Electrometalur also planned to increase calcium silicide production from the current 5,500 tons per year to about 13,000 tons per year. Overall, the largest market for Electrometalur's silicon materials is the United States. Camargo Correa S.A. was given authorization by the Brazilian Government for construction of a silicon metal plant in the Carajás region. The facility was to have four furnaces, each with a capacity of 8,800 tons per year. The first was scheduled to come on-stream by yearend 1985, with the other three to be completed and to begin production sequentially in 1986. In the course of its work on the Tucurui Dam, Camargo Correa located a large deposit of high-purity quartz gravel. Ample supplies of timber are available locally for charcoal, with relatively cheap hydroelectric power to be made available from the Tucurui hydroelectric project.[6]

China.—China and Albania signed bilateral trade agreements under which Albania was to supply China with a minimum of 88,000 tons of chrome ore in 1983 and was also to supply China with ferrochromium. In exchange, China will ship cotton, machinery, chemicals, and other products. This was the first link between the two countries since their ideological split in 1978 and was expected to have long-term effects on China's need for chromium-containing products. China also purchased chrome ore from Madagascar, New Caledonia, and Turkey.

Colombia.—Cerro Matoso S.A., a joint venture between the Colombian Government, Billiton International Metals BV, and Hanna Mining, shut down its 25,000-ton-per-year ferronickel furnaces for repairs in December 1983. The smelter, which came on-line in June 1982, was operating at about 80% of capacity. Production was expected to resume at the end of January 1984. The company announced that all shipments were to be made from existing stocks.[7]

Egypt.—The Egyptian Ferroalloy Co., a state-owned firm at Edfu on the Nile, expected to put on-line two of its planned four 21.5-MV•A furnaces by the end of 1984. The company expected to be operating at full capacity of about 55,000 tons per year of 75%-grade ferrosilicon during 1985. Most of the production was to be exported since only a small portion would be required to meet Egypt's domestic needs. Low-cost hydroelectric power was to be available from the Aswan Dam.[8]

Finland.—Outokumpu Oy and Etibank of Turkey have established a joint marketing company in Finland. This marketing agreement followed previous cooperative activities in Turkey, which included the modernization and expansion of the Kefdag chrome concentrator and the construction of a high-carbon ferrochromium plant at Elazig. Outokumpu Oy planned to double the capacity of its Tornio ferrochrome plant to 132,000 tons of charge chrome by 1986. Most of the production was to be used in the company's stainless steel plant, which is also at Tornio.[9]

Gabon.—Elkem Metals, United States, and Elkem AS, Norway, acquired 6% of Compagnie Minière de l'Ogooue S.A. (COMILOG), a Gabonese manganese ore producer. Other COMILOG owners include United States Steel Corp., the Gabonese Government, and various French companies. The purchase gives the companies a dependable supply of high-quality manganese ore for their ferromanganese operations, which require about 970,000 tons of ore per year.[10]

Greece.—Hellenic Ferroalloy S.A., a subsidiary of the state-controlled Hellenic Industrial Mining & Investment Co. (HIMIC), began production of ferrochromium at its new facility at Tsingeli near Volos early in 1983. Plant capacity was expected to reach about 50,000 tons per year of high-carbon ferrochromium. Chromite feed for the smelter was supplied from HIMIC's Skoumtsa mines, with reserves estimated to be 3 to 4 million tons. HIMIC was expanding production of ore from 660 to 1,100 tons per day to meet the new project's needs. The ore was concentrated to produce a product containing 50% to 52% chrome oxide and with a 3:1 chromium-to-iron ratio. A new concentration plant to be put in operation in 1983 was to convert 275,000 tons of ore per year into 66,000 tons of concentrate. HIMIC is also exploring and developing two chromite mining sites in the Volos area and another two in Macedonia.[11]

The Greek Bank for Industrial Development and Tsvetmetproexport, U.S.S.R., agreed to cooperate in the exploration for chromite and other ore deposits in Greece. Greece's Institute of Geological and Mining Research put forth a plan for exploration for chromite and several other minerals for inclusion in the Government's new 5-year economic development plan (1983-87).

Iceland.—Icelandic Metal PLC signed a contract with Mannesmann Demag, Federal Republic of Germany, for the engineering and supply of two 33-MV•A furnaces and auxiliary equipment for a silicon metal plant with a capacity of about 28,000 tons per year. Final approval of the project by the Icelandic Parliament was contingent on the company's success in getting a foreign partner to bear a substantial part of the cost burden. The plant will need to import all its raw materials, although the entire output will be for export.[12]

India.—India's bulk ferroalloy industry was forced to cut back production early in 1983 because of severe power cuts, especially in Orissa and Karnataka States, which are dependent on hydroelectric power. However, the massive power cuts were partially restored subsequent to the onset of the monsoon season.

Two ferrochromium plants started production in India. Ferro Alloys Corp. Ltd. (FACOR) and Indian Metals and Ferroalloys Ltd. (IMFA) commissioned their charge chrome furnace in March and February, respectively. However, there was little production until later in the year because of massive power cuts, when 50% of the power required was restored to both charge chrome furnaces. FACOR's plant, at Randia in Balasore District, Orissa State, has a 45-MV•A furnace, built by Tanabe Kakoki Co. Ltd., Japan. Production capacity is rated at 55,000 tons per year of 55%-chromium charge chrome. Plant output was to be marketed by Marc Rich and Co. and slated for the United States and Japan.[13] IMFA's plant at Therubali, Orissa State, has a 39-MV•A furnace with a capacity of 55,000 tons of charge chrome per year. The new furnace, installed in 1982, was originally intended for ferrosilicon production, but was converted to charge chrome to allow earlier production of this material. Production will be for export only and marketed through Elkem of Norway. Apparently unable to readily procure suitable chromite locally, the company was granted a Government permit to import Albanian chromite. IMFA also planned to construct a new charge chrome furnace with an annual capacity of 55,000 tons at Choudar despite the conversion of the other furnace.[14] Orissa Mining Corp., a State-owned company, planned to bring a charge chrome plant online early in 1985. The plant would have an annual capacity of 55,000 tons. Technical collaboration would be provided by Outokumpu Oy, Finland, and marketing assistance from Klöckner & Co., Federal Republic of Germany.[15]

Sandur Manganese and Iron Ores Ltd. began producing ferromanganese in its plant in Karnataka, with the total amount produced dependent on the availability of electricity. The company converted one of its 20-MV•A ferrosilicon furnaces to ferromanganese production. Production was expected to go to Indian consumers. Sandur can meet 60% to 70% of its ore requirements from captive mines; the ores of which are low in phosphorus.

Nava Bharat Ferro Alloys Ltd., Andhra Pradesh, installed a third 16.5-MV•A Soviet furnace, apparently to be used for calcium silicon production. Another plant, with a capacity of 11,000 tons per year, was scheduled to come on-line in Andhra Pradesh.[16]

Indonesia.—P.T. Aneka Tambang (Antam), a state-owned metal company, terminated its 10-year contract to supply Japan's four nickel smelters at the end of June. The Japanese agreed to ending the contract, under which the Japanese companies were to import all of the ferronickel produced by Antam at its 4,400-ton-per-year plant, beginning in 1976. The decline in ferronickel demand forced Japan to cut its imports by 50%. Sumitomo Metal Mining Co. Ltd., Nippon Yakin Kogyo Co., Nippon Mining Co. Ltd., and Pacific Metals Co. Ltd. comprise Japan's four ferronickel producers, with only Nippon Yakin also being a stainless steel producer.[17] P.T. International Nickel Indonesia, a subsidiary of Inco Ltd., cut back production by about one-half at the beginning of 1983, owing to weak demand. The plant, which produces 75% nickel matte and ferronickel, planned to operate only one furnace. The company is a major supplier of the Japanese market.

Italy.—Exploration directed by Società per Azioni Minero-Metallurgiche discovered manganese nodules that contain 40% to 41% manganese on the bed of the Tyrrhenian Sea between Rome and Sicily. More work was planned to determine whether or not the deposit is large enough for economic development. The advantages of these nodules is that they lie in relatively shallow water, about 230 feet, and within Italian territorial water. More nodules are expected to be found as exploration proceeds to as deep as 13,000 feet.

Montedison S.p.A., which had reported record losses for 1982, reported that its ferroalloy division operated at near capacity in 1983 for ferrochromium production, 44,000 tons.

Japan.—The Ministry of International Trade and Industry (MITI) began a stockpile program for chromium, manganese, molybdenum, nickel, vanadium, and others with the aim of achieving a 60-day consumption volume over a 5-year period. The system is comprised of a national stockpile financed by the Government, with a 25-day supply; a joint stockpile financed privately and by the Government, with a 25-day supply; and a privately financed stockpile, with a 10-day supply. MITI, who achieved a 5-day supply in the national and joint stockpiles in 1983, planned to add a 2-day supply to the national stockpile in 1984. MITI also planned to erect warehouses to store the materials.[18] MITI's duty-free import quotas in fiscal year 1983 for ferrochromium and ferrosilicon were about 24,800 tons and 13,726 tons, respectively. Brazil, China, the Philippines, Venezuela, and Zimbabwe are the countries likely to benefit from the quotas. The duty on imports of ferrochromium and ferrosilicon above the quotas is 8% and 3.8%, respectively. Total 1983 imports of ferrochrome and ferrosilicon were about 327,000 tons and 301,000 tons, respectively. The dominant supplier of ferrochrome was the Republic of South Africa, with Norway and Brazil the leading suppliers of ferrosilicon.

Production of ferrochromium continued to decline, while consumption showed an increase. As a consequence, Japanese stainless steel makers are seeking an increase in the duty-free import quotas for ferrochrome, beginning April 1, 1984. Awamura Metal Industry Co. Ltd., planned to shut down one of its two furnaces at its Uji plant. Japan Metals and Chemicals Co., which had decided to permanently close its 22,000-ton-per-year Sakata plant was apparently reconsidering this action because of rising demand and prices.[19] Showa Denko K.K. planned to close its Toyama plant, which was idled in August.

The Specific Industries Restructure Law became effective July 1, replacing the Depressed Industries Law. The new law provides for a reduction of production capacity in structurally depressed materials producing industries. The Japanese ferroalloy industry was designated as one that came under this law. Producers of energy-intensive products such as silicon metal, ferrosilicon, and ferrochromium have been unable to compete with imported materials, mainly owing to high electricity costs. Japan's electric power is produced mostly from oil-fired powerplants. MITI was expected to review a plan that would further reduce Japan's ferrosilicon capacity by about 14% to 330,000 tons per year by 1986. Nippon Keiso Kogyo K.K., Japan's only silicon metal producer, ended production at its Minamuta plant at the end of 1982. Japanese consumers of the metal subsequently called for tariff removal on imports. Japan imported an alltime high of about 88,000 tons of silicon metal in 1983, about a 30% increase over that of 1982. The main suppliers were China, Norway, the Republic of South Africa, France, and Brazil. In response to the high level of ferrosilicon imports, Japanese ferrosilicon producers prepared a report aimed at prompting an antidumping investigation against seven countries.[20] Kobe Steel Ltd. planned to close its ferroalloy plant at Kochi. The plant produces ferromanganese and ferrochrome and has a capacity of 11,000 tons per year.

Though Japan is the Western World's leading producer of ferromanganese, Japanese producers were deeply concerned that Nissan Motor Co. Ltd.'s barter arrangement, in which Mexican ferromanganese was exchanged for automobile parts, may set a precedent. Autlán, Mexico, was being replaced by Gabon as a major supplier of manganese ore to Japan. Ferromanganese producers in Japan have fewer problems since ferromanganese is the least energy intensive of the bulk ferroalloys.[21]

Japanese import duties on ferrosilicon, ferromolybdenum, ferrotungsten, ferrocolumbium, and silicochrome were to be reduced from 3.8% to 3.7% beginning April 1984, 2 years ahead of schedule. The import duty on ferronickel was to be reduced a more significant amount, from the current 9.3% to 6.5%, moving up the schedule by 3 years. Imports of ferronickel amounted to about 40,000 tons in 1983.

Mexico.—Cía. Minera Autlán S.A. de C.V. was reported to be seeking joint venture agreements with U.S. companies as part of its long-range expansion plans. The proposal most likely to attract U.S. firms centers on development of Autlán's Noapa manganese ore deposit in Hildalgo, northeast of Mexico City, where the company already operates one open pit mine. Noapa ore contains about 28% manganese in the form of manganese carbonate. Only an open pit and a calcining kiln would be needed to develop it. Other proposals include development of the company's lower grade Molango deposit, and the expanding of Autlán's refining capacity at its ferroalloy plant in Tampico. Autlán holds the largest manganese ore reserves in North America. The United States currently imports most of its ferromanganese from the Republic of South Africa, with a large part of the cost due to transportation charges. A substantial increase in Autlán's ferromanganese capacity would likely result in the company gaining a larger share of the U.S. market.[22]

New Caledonia.—Société Métallurgique le Nickel (SLN) was restructured in May because of high debts and massive losses on its nickel mining operations. Entreprise de Recherches et d'Activites Petrolieres took a 70% interest, while Société Nationale Elf Aquitaine and Imetal reduced their holdings from 50% to 15% each. The French Government also granted SLN a 15-year, $95.5 million loan at reduced rates in order to consolidate an estimated $341 million in SLN debts. The loan will convert SLN's short-term debt into a long-term loan, relieving the strain on its financial position. SLN announced that 1983's production would be increased by 8% to about 28,600 tons annually to meet increased demand and build up inventories.

New Zealand.—Owing to economic reasons, Voest-Alpine AG, Austria, dropped its interest in a joint venture with New Zealand Nickel Smelters Ltd. for a proposed ferronickel plant. The 44,000-ton-per-year plant was scheduled for startup in the late 1980's with output to go mainly to the Japanese market.

Norway.—In April, Elkem, Orkla Metall AS, Bjölvefossen AS, Hafslund AS, and Ila og Lilleby Smelteverker AS called off their merger discussions, which began in December 1982. A major obstacle was the question of transfer of power rights to the proposed new company; power rights can be transferred only with parliamentary approval. Tinfos Jernverk AS, which produces ferrochromium, silicomanganese, and ferromanganese, did not participate in the merger talks. Bjölvefossen announced that it would stop ferrochromium production by the end of 1983, owing to stringent new pollution regulations scheduled to take effect at the beginning of 1984. The company said that renovations necessary to comply with the new regulations would be too costly. The four ferrochromium furnaces were to be converted to ferrosilicon production.[23]

The Finnfnes plant, previously owned by Fesil-Nord & Co., was brought back on-line in June under new ownership, Finnfjord Smelterverk AS, which brought the last of its three furnaces back into production in October, resulting in an additional 24,000 tons per year of ferrosilicon production. Tinfos converted one of its ferrosilicon furnaces to the production of silicon metal, resulting in a loss of about 6,000 to 11,000 tons of alloy production. Orkla Metall, which was forced to shut down one of its two ferrosilicon furnaces owing to weak demand and high electricity costs, was able to negotiate much cheaper power rates in the first quarter of the year. The cheaper power rates combined with firmer ferrosilicon prices allowed the company to restart the furnace.[24] Elkem resumed silicon metal production in its 28,000-ton-per-year furnace at its Fiskaa Works in March, after a shutdown to repair the furnace lining. The stoppage caused some delays in meeting shipments.

Philippines.—Acoje Mining Co. Inc., Pangasinan, Zambales Province, Luzon, asked the Philippine Securities and Exchange Commission to place the company in receivership to protect it from debt collection suits initiated by creditors. The company suffered large losses in 1982 and 1983 and was heavily in debt. Acoje proposed a plan for restructuring its debt.[25] Benguet Consolidated Inc., the leading refractory chromite producer, started a plant modernization and expansion program at its Masinloc, Zambales, operations. The expansion and development program was intended to increase output by about 23% and to upgrade product specifications, especially to produce material with lower silica specifications.

Ferrochrome Philippines Inc. (FPI) began production at its new smelter operations at Tagoloan, Misamis Oriental Province, Mindanao. The plant's production capacity was rated at about 66,000 tons per year. Specifications for the ferrochromium product are 61.5% chromium, 8% carbon, 2.9% silicon, and 0.2% phosphorus and sulfur. The ferrochromium was marketed by Voest-Alpine Intertrading. The ore for the plant was to be supplied by Acoje. FPI would be totally dependent on imports if Acoje were forced to close its chromite mine owing to financial problems. FPI's attempt to obtain an import permit to buy small amounts of Indian and New Caledonian chromite for blending purposes was stalled by the Government's introduction of import control measures limiting the amount of money foreign exchange banks can extend in letters of credit per day. The ferroalloy industry, designated an export industry, was subject to special treatment.

FPI, Ferro-Chemicals Inc., and Maria Christina Chemical Industries Inc. (MCCI) suffered critical power shortages early in the year, owing to drought conditions on Mindanao, amounting to cutbacks of about 50%. By yearend, water levels were about normal. However, it was reported that of three hydroelectric plants in the region, one was out of operation and one was running at reduced rates because of the lack of spare parts.

MCCI and two Japanese companies, Nippon Kokan K.K. and Marubeni Corp., formed a new company to produce 15,000 tons per year of ferrosilicon. The company, Mindanao Ferroalloy Corp., will modify an MCCI electric carbide furnace to produce ferrosilicon. The new plant, 60% owned by MCCI, was on Mindanao Island to take advantage of the low electricity costs. However, existing ferroalloy producers in the region already had problems in getting enough power allocated for full production. Production was scheduled to begin in October 1984, with output going to the Japanese market.[26]

Portugal.—Milnorte-Metalurgia do Norte S.A.R.L.'s two silicon metal furnaces were out of operation in 1983. Cia. Portuguesa de Fornos Electricos S.A.R.L. announced that its production of silicon metal remained at about 13,000 tons per year. Fornos Electricos also was reported to have prepared a 13,000-ton-per-year furnace for production and was awaiting Government approval for startup. Output would go to the Western market.

Romania.—The Tulcea ferroalloy complex has a total capacity of slightly more than 308,000 tons per year. This includes capacity for 162,000 tons per year of ferromanganese, 114,000 tons per year of ferrochromium, 30,000 tons per year of ferrosilicon, and 5,200 tons per year of silicon metal.[27]

Saudi Arabia.—Arabian Shield Development Co. reported the completion of prefeasibility studies on developing a nickel and iron deposit at Wadi Qatan. Klöckner Werke AG, Federal Republic of Germany, was examining the possibility of developing the mine to produce 220,000 tons per year of ferronickel and 220,000 tons per year of sponge iron.[28]

South Africa, Republic of.—General Mining Union Corp. Ltd. (Gencor) acquired a controlling interest, about a 30% share, in South African Manganese Amcor Ltd. (Samancor) through an exchange of assets with South African Iron and Steel Industrial Corp. Ltd. Gencor, which already held a 7% share of Samancor directly and a 1.4% share through its affiliate Union Corp. Investments, obtained 50% of African Metals, which owns a 39.6% share of Samancor. Samancor is the world's largest integrated ferroalloys producer. Gencor is the Republic of South Africa's largest producer of chrome ore and a large ferrochromium producer.[29]

Tubatse Ferrochrome (Pty.) Ltd., jointly owned by Gencor and Union Carbide Corp., restarted a charge chrome furnace in July and another in September at its Steelpoort, Transvaal, facility, bringing the plant into full production. Middleburg Steel & Alloys Holdings (Pty.) Ltd. (MSA), a member of the Barlow Rand Group, reopened one of its two 7.5-MV•A, low-carbon ferrochromium furnaces at the Middleburg plant in July. Samancor moved up its planned April 1984 operation of its 48-MV•A charge chrome furnace with a capacity of 30,000 tons per year at its Witbank plant in Transvaal to January, in response to increased demand. Consolidated Metallurgical Industry Ltd. put its idle furnace back on-line in April and has since been operating both of its furnaces.[30]

Work on the development and application of thermal plasma technology for ferrochromium production was carried out by the Council for Mineral Technology, MSA, and Samancor. The most important features of the plasma furnace are the ability to use fines and any type of coal. Transvaal chrome ores are friable, and during mining and transport, as much as 30% of the original ore may end up as fines. Such fines require briquetting or pelletizing before feeding to a conventional furnace, a costly process. Samancor started operation of an 8-MV•A plasma furnace at its Metalloys plant at Meyerton. The furnace is a transferred arc type.[31] MSA has been investigating and developing the use of plasma technology for ferrochromium production. The company was installing a 20-MV•A plasma dc arc furnace at its Palmiet plant in Krugersdorp. The furnace, built by ASEA AB, Sweden, will have an initial production capacity of about 20,000 tons per year. The company would double its capacity by converting its conventional electric arc furnaces to the plasma arc process.[32]

Spain.—The Spanish Ministry of Economics and Finance established a base price of 42,000 pesetas per ton for imported ferromanganese containing less than 75% manganese (Mn) and more than 2% carbon. For ferromanganese imports containing 78% Mn and 79% Mn, base prices of 43,882 pesetas and 44,471 pesetas per ton, respectively, were established.[33]

Hidro Nitro Españolas S.A. notified the Spanish Government in midyear that it planned to cease ferrosilicon production unless some agreement was reached on reduced electricity tariffs for the industry. Spanish ferroalloy producers claimed that they were forced to pay higher electricity prices than their European competitors. In their efforts to obtain reduced electricity rates, producers have devised a plan to restructure the industry that would reduce the country's current production capacity by 50%.[34] Silicio de Sabon planned to resume silicon metal production for export, after an interval of over a year. The startup was made possible by a reduction in electricity costs of 1.40 pesetas per kilowatt hour and sharply improved prices for silicon metal in the world market. Ferroaleaciones Españolas S.A. (Fesa) planned to bring its second ferrochromium furnace into operation. The company has operated only one furnace since August 1982. Fesa purchased its ore from Albania and exported one-third of its output to other European countries.[35]

Sweden.—SKF Steel Engineering AB (SKF) was studying the possibility of building a 86,000-ton-per-year ferrochromium plant near Malmo. The company was negotiating with the Swedish Energy Ministry a power arrangement in which waste heat from the plant would be fed into the district heating system. SKF was also discussing the project with potential partners to defray capital costs.[36] Scan Dust AB broke ground for a plasma recycling plant in Landskrona, southern Sweden. SKF's process was to be used. The plant was to process about 80,000 tons per year of ironworks and steelworks baghouse dust and other raw material supplied from mills in the Federal Republic of Germany, Sweden, and the United Kingdom. The plant was to recover about 40,000 tons per year of chromium, nickel, molybdenum, and other metals. Full commercial operation was expected to begin early in 1985.[37]

Vargon Alloys AB reported operating close to capacity, producing charge chrome at a rate of 110,000 to 130,000 tons per year and high-carbon ferrochromium at a rate of up to about 33,000 tons per year. The company claims that the high production rate was possible owing to the plant's high efficiency. Vargon operates a 105-MV•A furnace fitted with a heat recovery system and a second 24-MV•A furnace, with low-cost electricity available from Sweden and chromite from nearby Finland.

Electro-Invest and HIMIC, Greece, was establishing a joint venture, Hellenic Scandinavian Corp. of Industrial Investment (Helsca) to investigate industrial and mining projects in Greece. Helsca was expected to trade Swedish equipment and technology for Greek metals and minerals, especially ferrochromium and ferronickel.[38]

Turkey.—Outokumpu Oy was awarded a contract to modernize and expand the Kafdag chrome ore concentrator operated by Etibank, the Turkish state-owned mining company. Outokumpu Oy will supply planning, equipment supplies, and installation supervision. The new concentrator was scheduled for completion in 1986. The purpose of the project was to ensure supplies of chrome ore concentrates to the ferrochrome smelter at Elazig, also built using the Finnish company's technology.[39]

Etibank and China's National Metal and Minerals Import and Export Corp. signed a contract that calls for Etibank to supply China with 50,000 tons of chrome ore. The transaction was part of an economic and technical cooperation agreement reached in December 1982. The central Bank of Turkey and the Bank of China agreed to open up reciprocal accounts to handle bilateral trade deals between the two countries.[40]

U.S.S.R.—Construction of the sixth new electric furnace sold to the U.S.S.R. by Mitsui, Japan, was completed in the fall. Of the six furnaces, four were installed at the Nikopol Electric Steel Mill, Ukraine, and two at the Zestafon Steelworks, Georgia. The furnaces, which were built by Tanabe Kakoki, Osaka, Japan, each have a 75-MV•A transformer capacity and a production capacity of 130,000 tons per year. The furnaces were to be used mainly to produce ferromanganese but were also to produce some silicomanganese.[41]

The Soviet Union reportedly began buying high-grade manganese ore early in the year from Gabonese and Australian producers. Initial contracts were for 110,000 tons each from COMILOG, France, and The Broken Hill Pty. Ltd. Co., Australia. This alloy-grade manganese ore was to be used as feedstock for the new electric furnaces.[42]

The U.S.S.R. shipped 16,647 tons, gross weight, of 50%-grade ferrosilicon to the United States in 1983.

United Kingdom.—The British Government announced to Parliament in February the establishment of a strategic materials stockpile. The British Department of Trade and Industry, which was responsible for the stockpiling program, contracted Brandeis-Intsel Ltd. of London to procure the strategic materials. The materials picked for stockpiling included chromium and manganese, among others. The stockpile purchases were the result of studies started in 1980 by the Institute of Geological Sciences on the vulnerability of British industry to material supply interruption and a subsequent report by the House of Lords in October 1982.[43] The major recipients of stockpiled manganese and chromium materials are British Steel Corp. and British Chrome.

Yugoslavia.—The new FENI ferronickel plant in Kavadarci, Macedonia, had not raised production above about 3,500 tons per year by yearend. The plant was designed to produce approximately 24,000 tons per year of nickel contained in ferronickel. The company cited power restrictions and low prices as reasons for the low production rates and ceased exporting in midyear.

Feronikl at Glogovac, Kosovo, was expected to begin trial production capacity runs in July and planned to produce about 2,000 tons by yearend 1983. Total production capacity is about 13,000 tons per year of contained nickel.

Dalmacija Metallurgical Industry planned to bring on-line a new 30-megawatt ferrosilicon furnace at its ferroalloy plant at Dugi Rat. The furnace, supplied by Elkem, Norway, was to provide an additional 28,000 to 33,000 tons of ferrosilicon for the export market.[44]

Zimbabwe.—Mineral Marketing Corp. (MMC), the new state marketing corporation, began operation on March 7. Ultimately, MMC will take over all export marketing from private mining companies. Only sales of gold will be exempt from MMC's supervision. MMC was to handle most sales as an agent and was to charge producers a commission of less than 1% to cover costs.

Zimbabwe Alloys Ltd. planned to close one of its ferroalloy furnaces beginning October 1. The 30-MV•A furnace has a production capacity of about 55,000 tons per year of high-carbon ferrochromium. The shutdown was attributed to a high buildup of inventories. The surplus power made available was to be used to produce low-carbon ferrochromium, a product more in demand. The company has a capacity of approximately 24,000 tons per year of the low-carbon material.[45] Zimbabwe Mining and Smelting Co. (Zimasco), the Union Carbide subsidiary, will restart its fifth ferrochromium furnace on January 1, 1984. Zimasco's high-carbon ferrochromium output was to be raised by about 30,000 tons per year to 150,000 tons. The company indicated that demand for the product had improved steadily in the last few months of the year. The company has a sixth furnace, which has not yet been commissioned. However, if the sixth furnace was put on-stream, some expansion of mine capacity would be required.

Table 9.—Ferroalloys: World production, by country, furnace type, and alloy type[1]

(Thousand short tons)

Country,[2] furnace type,[3] and alloy type[4]	1979	1980	1981	1982[p]	1983[e]
Albania: Electric furnace, ferrochromium[e]	NA	4	31	33	39
Argentina: Electric furnace:					
Ferromanganese	38	26	25	26	25
Silicomanganese	17	13	14	17	17
Ferrosilicon	15	13	11	10	10
Other	3	2	3	11	10
Total	73	54	53	64	62
Australia: Electric furnace:[5]					
Ferromanganese	95	104	70	[r,e]61	87
Silicomanganese	22	20	[e]21	[e]20	22
Ferrosilicon	21	20	35	[r,e]30	24
Total	138	144	[r,e]126	[r,e]111	133
Austria: Electric furnace, undistributed[e]	[e]10	[r]11	[r]13	[r]15	22
Belgium: Electric furnace, ferromanganese[7]	99	94	99	99	99
Brazil: Electric furnace:					
Ferromanganese	147	155	119	132	[e]127
Silicomanganese	141	148	157	190	[e]184
Ferrosilicon	[r]74	120	133	127	[e]178
Silicon metal	[r]7	[r]15	21	20	[e]23
Ferrochromium	93	103	131	107	[e]86
Ferrochromium-silicon	8	9	10	3	[e]2
Ferronickel	13	12	12	12	[e]29
Other	43	47	41	29	[e]25
Total	[r]526	[r]609	624	620	[e]654
Bulgaria: Electric furnace:[e]					
Ferromanganese[8]	31	31	37	37	37
Ferrosilicon	18	18	22	22	22
Other	1	1	1	1	1
Total	50	50	60	60	60
Canada: Electric furnace:					
Ferromanganese[e 8]	45	95	120	116	118
Ferrosilicon	105	153	121	[e]116	118
Silicon metal	29	43	31	[e]30	33
Other[e 9]	14	28	38	36	35
Total	193	319	310	[e]298	304
Chile: Electric furnace:					
Ferromanganese	6	6	5	3	4
Silicomanganese	([10])	([10])	([10])	([11])	([10])
Ferrosilicon	6	6	3	2	2
Other	1	1	1	1	1
Total	13	13	9	6	7
China: Furnace type unspecified:[e 12]					
Ferromanganese[8]	375	[r]650	[r]580	[r]520	540
Ferrosilicon	180	[r]220	[r]220	215	215
Silicon metal	10	[r]23	[r]25	25	25
Ferrochromium[13]	100	[r]130	[r]130	130	130
Other[9]	55	[r]80	[r]80	80	80
Total	720	[r]1,103	[r]1,035	[r]970	990
Colombia: Electric furnace, ferrosilicon[e 14]	1	1	1	1	1
Czechoslovakia: Electric furnace:					
Ferromanganese[e 8]	110	110	110	110	110
Ferrosilicon[e]	36	35	35	35	35
Silicon metal[e]	6	6	6	6	6
Ferrochromium[e]	31	30	30	30	30
Other[e 9]	10	10	10	10	10
Total[15]	193	191	191	191	191

See footnotes at end of table.

Table 9.—Ferroalloys: World production, by country, furnace type, and alloy type[1] —Continued

(Thousand short tons)

Country,[2] furnace type,[3] and alloy type[4]	1979	1980	1981	1982[p]	1983[e]
Dominican Republic: Electric furnace, ferronickel	[r]72	[r]51	54	16	60
Egypt: Electric furnace, ferrosilicon[e]	[r]6	[r]6	[r]6	[r]7	[6]7
Finland: Electric furnace, ferrochromium	54	58	57	60	[6]65
France:					
Blast furnace:					
Spiegeleisen	2	--	1	1	1
Ferromanganese	493	529	344	365	365
Electric furnace:					
Silicomanganese[16]	14	22	11	32	32
Ferrosilicon	300	283	208	186	[6]212
Silicon metal	61	66	66	63	60
Ferrochromium[13]	105	49	30	16	[6]20
Other[17]	157	137	131	115	[6]148
Total	1,132	1,086	791	778	838
German Democratic Republic: Electric furnace:					
Ferromanganese[e 8]	[r]83	[r]77	[r]77	[r]70	72
Ferrosilicon[e]	33	[r]30	[r]30	[r]26	28
Silicon metal[e]	4	4	4	[r]3	3
Ferrochromium[e]	23	[r]20	[r]20	22	22
Other[e 9]	22	[r]20	[r]18	[r]17	18
Total[15]	[r]165	[r]151	149	138	143
Germany, Federal Republic of:					
Blast furnace:					
Ferromanganese	257	220	236	220	220
Ferrosilicon	87	71	55	46	55
Electric furnace:[e]					
Ferromanganese[8]	33	28	21	21	21
Ferrosilicon	55	55	46	[r]37	36
Ferrochromium	66	66	55	[r]46	45
Other[9]	56	55	47	[r]40	40
Total	554	495	460	410	417
Greece: Electric furnace, ferronickel	60	57	56	[e]56	55
Hungary: Electric furnace:					
Ferrosilicon	9	11	12	[e]12	11
Silicon metal[e]	2	2	2	2	2
Other	5	3	3	[e]3	2
Total[15]	16	16	17	17	15
Iceland: Electric furnace, ferrosilicon	[r]18	[r]31	37	46	[6]55
India: Electric furnace:					
Ferromanganese	206	179	230	166	170
Silicomanganese	6	14	[e]11	15	15
Ferrosilicon	59	47	66	40	44
Silicon metal	3	3	4	[e]4	4
Ferrochromium	24	18	34	44	46
Ferrochromium-silicon	4	4	5	[e]4	4
Other	1	1	1	1	1
Total	303	266	351	[r e]274	284
Indonesia: Electric furnace, ferronickel	20	20	22	24	22
Italy:					
Blast furnace:					
Spiegeleisen	3	6	1	1	1
Ferromanganese	74	[e]67	65	63	60
Electric furnace:					
Ferromanganese	24	[e]24	14	18	18
Silicomanganese	60	50	60	64	60
Ferrosilicon	89	79	61	70	70
Silicon metal[e]	17	17	17	17	15
Ferrochromium	47	45	11	40	40
Other[18]	12	16	14	13	10
Total[18]	326	304	243	286	274

See footnotes at end of table.

Table 9.—Ferroalloys: World production, by country, furnace type, and alloy type[1] —Continued

(Thousand short tons)

Country,[2] furnace type,[3] and alloy type[4]	1979	1980	1981	1982[p]	1983[e]
Japan: Electric furnace:					
Ferromanganese	665	627	626	593	[6]430
Silicomanganese	330	342	312	297	[6]245
Ferrosilicon	352	335	259	212	[6]174
Silicon metal	17	17	13	11	--
Ferrochromium	403	444	337	362	[6]335
Ferrochromium-silicon	14	23	12	11	[6]8
Ferronickel	335	305	269	236	[6]199
Other	24	26	16	17	[6]12
Total	2,140	2,119	1,844	1,739	[6]1,403
Korea, North: Furnace type unspecified:[e] [12]					
Ferromanganese[8]	72	77	77	77	77
Ferrosilicon	33	33	33	33	33
Other[9]	15	22	22	22	22
Total	120	132	132	132	132
Korea, Republic of: Electric furnace:					
Ferromanganese	58	60	71	[e]71	58
Ferrosilicon	42	33	39	[e]39	36
Other	23	[r]28	31	[e]29	48
Total	123	[r]121	141	139	142
Mexico: Electric furnace:					
Ferromanganese	136	138	144	155	145
Silicomanganese	34	34	29	33	33
Ferrosilicon	27	30	31	32	28
Ferrochromium	5	--	--	7	6
Other	1	2	2	1	1
Total	203	204	206	228	213
New Caledonia: Electric furnace, ferronickel	136	145	121	[e]116	78
Norway: Electric furnace:					
Ferromanganese	372	[r]326	257	224	[6]247
Silicomanganese	203	[r]185	236	238	[6]199
Ferrosilicon	[r]371	[r]353	346	326	[6]381
Silicon metal[e]	77	94	61	59	[6]83
Ferrochromium	13	12	13	11	[6]9
Ferrochromium-silicon	1	(10)	1	2	[6]1
Other	[r]33	[r]22	5	12	[6]17
Total[15]	[r]1,070	[r]992	919	872	[6]937
Peru: Electric furnace:					
Ferromanganese	1	(11)	(10)	(11)	--
Ferrosilicon	1	1	(11)	(11)	--
Total	2	1	(10)	(11)	--
Philippines: Electric furnace:[e]					
Ferrosilicon	20	22	25	30	22
Ferrochromium	11	11	11	13	24
Total	31	33	36	43	46
Poland:					
Blast furnace:					
Spiegeleisen	9	8	8	8	8
Ferromanganese	143	131	131	131	131
Electric furnace:[e]					
Ferromanganese[8]	54	52	52	52	52
Ferrosilicon	60	55	55	55	55
Silicon metal	11	11	11	11	11
Ferrochromium	54	52	52	52	52
Other[9]	15	17	17	17	17
Total[15]	346	326	326	326	326
Portugal: Electric furnace:					
Ferromanganese[e] [19]	83	82	72	[r]30	30
Silicomanganese[e] [19]	17	19	20	19	18
Ferrosilicon[e]	28	28	26	24	25
Silicon metal[e]	35	36	35	35	36
Other[e]	(10)	(10)	(10)	(10)	(10)
Total[15]	163	165	153	[r] [e]108	109

See footnotes at end of table.

Table 9.—Ferroalloys: World production, by country, furnace type, and alloy type[1] —Continued

(Thousand short tons)

Country,[2] furnace type,[3] and alloy type[4]	1979	1980	1981	1982[p]	1983[e]
South Africa, Republic of: Furnace type unspecified:[12]					
Ferromanganese[e]	617	573	496	485	385
Silicomanganese[e]	50	77	55	44	33
Ferrosilicon[e]	164	179	121	110	110
Silicon metal[e]	39	33	33	33	25
Ferrochromium[e]	860	882	827	661	640
Ferrochromium-silicon[e]	31	42	22	22	20
Other[e 20]	(10)	(10)	(10)	(10)	(10)
Total[15]	1,761	1,786	1,554	1,355	1,213
Spain: Electric furnace:					
Ferromanganese	157	135	106	96	94
Silicomanganese	131	104	77	77	75
Ferrosilicon	126	136	94	70	70
Silicon metal[e]	22	22	20	20	20
Ferrochromium	22	18	19	17	15
Other	8	7	7	6	5
Total[15]	466	422	323	286	279
Sweden: Electric furnace:					
Silicon metal[e]	14	20	18	18	18
Ferrochromium	209	159	208	[e]208	208
Ferrochromium-silicon	32	9	22	[e]22	22
Other	3	2	3	[e]3	3
Total[15]	258	190	251	[e]251	251
Switzerland: Electric furnace:[e]					
Ferrosilicon	3	3	3	3	3
Silicon metal	2	2	2	3	3
Total	5	5	5	6	6
Taiwan: Electric furnace:					
Ferromanganese	28	23	20	19	16
Ferrosilicomanganese	17	25	16	23	20
Ferrosilicon	[r]34	[r]31	16	15	23
Total	79	79	52	57	59
Thailand: Electric furnace:					
Ferromanganese	2	(10)	(10)	(11)	--
Ferrosilicon	3	(10)	1	(11)	--
Total	5	(10)	1	(11)	--
Turkey: Electric furnace:					
Ferrosilicon	--	--	--	5	5
Ferrochromium[e]	33	35	36	[6]44	[6]33
Total[e]	33	35	36	[6]49	38
U.S.S.R.:					
Blast furnace:					
Spiegeleisen[e]	55	55	55	55	55
Ferromanganese[e]	606	606	606	606	600
Other	110	110	--	--	--
Electric furnace:[21]					
Ferromanganese[e]	1,003	[r]1,070	[r]1,140	[r]1,200	1,270
Silicomanganese[e]	33	35	35	35	40
Ferrosilicon[e]	694	694	717	750	800
Silicon metal[e]	63	65	[r]70	[r]70	70
Ferrochromium[e]	610	661	661	661	680
Ferrochromium-silicon[e]	11	11	11	11	15
Other[17]	214	220	230	248	250
Total	3,399	[r]3,527	[r e]3,525	[r e]3,636	3,780
United Kingdom:					
Blast furnace, ferromanganese	150	57	93	[e]67	90
Electric furnace, undistributed[e]	18	13	14	12	16
Total	168	70	107	[e]79	106

See footnotes at end of table.

Table 9.—Ferroalloys: World production, by country, furnace type, and alloy type[1] —Continued

(Thousand short tons)

Country,[2] furnace type,[3] and alloy type[4]	1979	1980	1981	1982[p]	1983[e]
United States: Electric furnace:[22]					
Ferromanganese	317	189	193	119	[6]86
Silicomanganese	165	188	173	69	W
Ferrosilicon	712	559	580	299	[6]315
Silicon metal	145	127	130	77	[6]122
Ferrochromium	247	184	164	92	[6]20
Ferrochromium-silicon[23]	48	54	62	27	[6]16
Other[24]	241	245	219	136	[6]199
Total	1,875	[25]1,547	1,521	819	[6]758
Uruguay: Electric furnace, ferrosilicon[e]	([10])	[r]([10])	[r]([10])	[6]([10])	([10])
Venezuela: Electric furnace:					
Ferromanganese	1	2	2	[e]2	2
Silicomanganese	1	2	2	[e]2	2
Ferrosilicon	39	52	24	[e]52	52
Total	41	56	28	[e]56	56
Yugoslavia: Electric furnace:					
Ferromanganese	50	37	56	43	43
Silicomanganese	32	36	32	23	26
Ferrosilicon	75	73	88	78	90
Silicon metal	35	33	31	33	40
Ferrochromium	72	76	76	55	65
Ferrochromium-silicon	7	11	6	7	7
Other	4	1	1	4	5
Total	275	267	290	243	276
Zimbabwe: Electric furnace:					
Ferromanganese[e]	3	3	2	[r]2	2
Ferrochromium[e]	220	287	231	[r]210	155
Total	223	290	233	212	157
Grand total	[r]17,664	[r] [25]17,646	16,599	15,332	15,162
Of which:					
Blast furnace:					
Spiegeleisen[26]	69	[r]69	65	65	65
Ferromanganese[26]	1,723	1,610	1,475	1,452	1,466
Other[27]	197	181	55	46	55
Total blast furnace	1,989	[r]1,860	1,595	1,563	1,586
Electric furnace:[12]					
Ferromanganese[28]	[r]3,847	[r]3,673	3,668	3,465	3,363
Silicomanganese[28 29]	[r]1,273	[r]1,314	1,261	1,198	1,021
Ferrosilicon	[r]3,809	[r]3,745	3,505	3,115	3,290
Silicon metal	[r]599	[r]639	600	540	599
Ferrochromium[30]	[r]3,302	[r]3,344	3,164	2,921	2,765
Ferrochromium-silicon[23 30]	156	163	151	109	95
Ferronickel[31]	[r]636	[r]590	534	460	443
Other[31]	[r]961	[r]993	941	852	960
Undistributed	28	[r]24	27	27	38

See footnotes at end of table.

Table 9.—Ferroalloys: World production, by country, furnace type, and alloy type[1] —Continued

(Thousand short tons)

Country,[2] furnace type,[3] and alloy type[4]	1979	1980	1981	1982[p]	1983[e]
Total electric furnace	[r]14,611	[r]14,485	13,851	12,687	12,574
Furnace type unspecified:					
Ferromanganese[12]	1,064	[r]1,300	1,153	1,082	1,002

[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 3, 1984.

[2]In addition to the countries listed, Romania is known to produce electric-furnace ferroalloys, but output is not reported quantitatively and no basis is available for estimation.

[3]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.

[4]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."

[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]Less than 1/2 unit.

[11]Revised to zero.

[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 1979-83 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]Estimated figures based on reported exports and an allowance for domestic use.

[20]Ferrovanadium only; other minor ferroalloys may be produced, but no basis is available for estimation.

[21]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.

[22]U.S. production of ferronickel cannot be reported separately in order to conceal corporate proprietary information.

[23]U.S. output of ferrochromium-silicon includes chromium briquets, exothermic chromium additives, other miscellaneous chromium alloys, and chromium metal.

[24]Includes ferronickel.

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

[26]Spiegeleisen for the Federal Republic of Germany is included with blast furnace ferromanganese.

[27]Includes the following quantities specifically identified as ferrosilicon: 1979—87; 1980—71; 1981—55; 1982—46; and 1983—55. The remainders are not identified except that they are not spiegeleisen or ferromanganese.

[28]Ferromanganese includes silicomanganese (if any was produced) for countries carrying footnote 8 on ferromanganese data line.

[29]Includes silicospiegeleisen for France.

[30]Ferrochromium includes ferrochromium-silicon (if any was produced) for countries carrying footnote 13 on ferrochromium data line.

[31]"Other" includes ferronickel production for France, Norway, the U.S.S.R., and the United States.

TECHNOLOGY

Because of escalating power costs and depletion of high-grade deposits of raw materials, research investigations have been directed toward development of processes that are less energy intensive or incorporate waste heat recovery systems, and are capable of using lower grade raw materials. Process fines and fine ores normally require costly beneficiation either by briquetting or pelletizing before being fed to a conventional submerged arc furnace. Plasma arc smelting is currently being investigated as a method of producing ferroalloys. The plasma process can directly process fines without agglomeration.

Kawasaki Steel Corp., Japan, has developed an alternative process to the energy-intensive, submerged arc furnace method for production of bulk ferroalloys. The new technology breaks up the blast furnace operation into two processes: a prereduction furnace and a main smelting-reduction furnace. The new process can treat fine ores directly using low-grade coke and nonmetallurgical-grade coal, supplemented with hydrocarbons such as methane to achieve the high temperatures necessary to convert such ores as chromite to the ferroalloy form. Chromium ores are 30% to 50% reduced before leaving the prereduction furnace, and then injected into the high-temperature zone inside the lower portion of the main smelting-reduction furnace. When applied to ferroalloy production such as ferrochromium and ferromanganese, it eliminates electric arc smelting, with a consequent claimed energy savings of as much as 50%. The system is also adaptable to the production of pig iron.[46]

The General Electric Co. is involved in a $6.6 million development program that entails producing 1,000 25-kilovolt-ampere amorphous metal transformers within a period of 39 months. The Electric Power Research Institute (EPRI), Palo Alto, CA, is the main sponsor of the program, with the balance of the funds coming from the Empire State Electric Energy Research Corp. Core losses can be reduced by about 70% using amorphous metal instead of the usual silicon steel strip, greatly enhancing the transformer's overall efficiency in changing electricity from one voltage to another. Amorphous metals have a random structure achieved by rapid cooling. Molten alloy at about 2,300° F is squirted onto a rapidly spinning wheel at about 60° F. The alloy hardens into a 1-mil ribbon in about one-thousandth of a second before it has time to crystallize. However, the material becomes very brittle after it is annealed and is very stress sensitive. Ease of magnetization is the key property of the amorphous metal used for transformer cores. Very little heat energy is generated and lost in the process of magnetizing the core to induce voltage in the transformer's secondary windings. Melting and casting are the only steps required for producing amorphous ribbon, while production of silicon steel strip requires up to six steps. Allied Corp., Morristown, NJ, is supplying 100 tons of amorphous metal ribbon for the program under a separate contract with EPRI.[47]

Nippon Mining, Japan, has reduced the cost of producing ferronickel at its 1,400-ton-per-year smelter at Saganoseki. The company began using a new technology in November 1982 that employs only a blast furnace rather than a combination of a blast furnace and converter.[48]

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[1]Physical scientist, Division of Ferrous Metals.
[2]U.S. Congress. Congressional Budget Office. Strategic and Critical Nonfuel Minerals: Problems and Policy Alternatives. Aug. 1983, 85 pp.
[3]Cantor, D. J., B. A. Gelb, G. L. Guenther, and D. K. Nanto. The Ferroalloy Industry: Current Conditions and Policy Options. The Library of Congress, Congr. Res. Serv., May 10, 1983, 74 pp.
[4]Metal Bulletin (London). No. 6837, Nov. 11, 1983, p. 13.
[5]———. No. 6838, Nov. 15, 1983, p. 11.
[6]American Metal Market. V. 91, No. 89, May 6, 1983, p. 1.
[7]Metals Week. V. 54, No. 50, Dec. 12, 1983, p. 1.
[8]Metal Bulletin Monthly (London). No. 156, Dec. 1983, p. 83.
[9]Metal Bulletin (London). No. 6829, Oct. 14, 1983, p. 19.
[10]33 Metal Producing. V. 21, No. 9, Sept. 1983, p. 20.
[11]Engineering and Mining Journal. V. 184, No. 7, July 1983, pp. 27-28.
[12]Metal Bulletin (London). No. 6806, July 22, 1983, p. 11.
[13]Metal Bulletin Monthly (London). No. 155, Nov. 1983, pp. 21-25.
[14]The Tex Report. V. 15, No. 3519, July 29, 1983, p. 16.
[15]Metal Bulletin Monthly (London). No. 149, May 1983, p. 65.
[16]Page 21 of work cited in footnote 13.
[17]Metals Week. V. 54, No. 29, July 18, 1983, p. 7.
[18]Japan Metal Journal. V. 13, No. 5, Jan. 30, 1984, p. 8.
[19]Metals Weeks. V. 54, No. 51, Dec. 19, 1983, p. 6.
[20]Metal Bulletin (London). No. 6820, Sept. 13, 1983, p. 22.
[21]Work cited in footnote 20.
[22]Metal Bulletin (London). No. 6828, Oct. 11, 1983, p. 23.
[23]———. No. 6775, Mar. 29, 1983, p. 15.
[24]———. No. 6790, May 24, 1983, p. 17.
[25]Engineering and Mining Journal. V. 184, No. 8, Aug. 1983, p. 86.
[26]Metals Week. V. 54, No. 42, Oct. 17, 1983, p. 2.
[27]Metal Bulletin (London). No. 6832, Oct. 25, 1983, p. 15.
[28]Mining Magazine. V. 149, No. 41, Oct. 1983, p. 223.
[29]Pages 85 and 86 of work cited in footnote 25.
[30]The Tex Report. V. 15, No. 3584, Nov. 4, 1983, p. 2.
[31]Metal Bulletin (London). No. 6798, June 24, 1983, p. 15.
[32]Metal Bulletin Monthly (London). No. 151, July 1983, p. 93.
[33]Metal Bulletin (London). No. 6822, Sept. 20, 1983, p. 15.
[34]———. No. 6792, June 3, 1983, p. 15.
[35]———. No. 6791, May 27, 1983, p. 21.
[36]———. No. 6840, Nov. 22, 1983, p. 15.
[37]———. No. 6797, June 21, 1983, p. 17.
[38]———. No. 6821, Sept. 16, 1983, p. 19.
[39]Metal Bulletin Monthly (London). No. 154, Oct. 1983, p. 132.
[40]Mining Journal. V. 300, No. 7704, Apr. 15, 1983, p. 257.
[41]Metal Bulletin (London). No. 6810, Aug. 5, 1983, p. 11.
[42]Metals Week. V. 54, No. 32, Aug. 8, 1983, p. 8.
[43]Mining Magazine. V. 148, No. 3, Mar. 1983, p. 187.
[44]Metal Bulletin (London). No. 6833, Oct. 28, 1983, p. 8.
[45]———. No. 6817, Sept. 2, 1983, p. 17.
[46]Iron and Steel Engineer. V. 60, No. 5, May 1983, p. 68.
World Mining. V. 36, No. 5, May 1983, p. 19.
[47]Iron Age. V. 226, No. 23, Sept. 5, 1983, p. 68.
Chemical and Engineering News. V. 61, No. 30, July 25, 1983, p. 19.
[48]Metals Week. V. 55, No. 2, Jan. 9, 1984, p. 7.

Fluorspar

By Lawrence Pelham[1]

Shipments of domestic fluorspar decreased by an estimated 21% to a 50-year record low. Fluorspar was recovered by one major producer and three small producers. Domestic fluosilicic acid (H_2SiF_6) recovery, a byproduct of some phosphoric acid and hydrofluoric acid (HF) plants, increased. In the chemical industry, fluosilicic acid continued to augment fluorspar as a source of fluorine.

The United States continued to depend on foreign sources for over 85% of its fluorspar requirements. Imports decreased by 17%. Mongolia surpassed Mexico as the world's largest producer of fluorspar.

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, 20 fluosilicic acid producers, and 4 briquet producers to which a survey request was sent for the 3 production surveys, 100% responded, representing 100% of the production data shown in table 1. The consumption survey was sent to approximately 160 operations quarterly and 44 additional operations annually. Of the operations surveyed quarterly, 75% responded for both the first and second quarters; 71% responded for the third quarter; and 64% responded for the fourth quarter. Of the 44 operations surveyed annually, 39% responded. Together, quarterly and annual responses represented 92% of the apparent consumption data shown in table 1.

Table 1.—Salient fluorspar statistics[1]

	1979	1980	1981	1982	1983
United States:					
Production:					
Mine production short tons	407,054	372,092	415,862	199,714	W
Material beneficiated do	355,655	321,219	419,058	231,726	W
Material recovered do	106,099	88,831	111,281	76,316	W
Finished (shipments) do	109,299	92,635	115,404	77,017	[e]61,000
Value f.o.b. mine thousands	$12,162	$12,611	$18,412	$13,293	[e]$10,000
Exports short tons	14,454	17,865	11,261	10,573	9,236
Value thousands	$1,339	$1,660	$1,194	$1,084	$962
Imports for consumption short tons	1,021,085	899,219	826,783	543,723	453,314
Value[2] thousands	$80,090	$94,103	$104,938	$67,665	$47,032
Consumption (reported) short tons	1,135,451	976,644	932,855	530,565	564,187
Consumption (apparent)[3] do	1,090,665	1,017,559	897,572	618,493	613,705
Stocks, Dec. 31:					
Domestic mines:					
Crude do	166,619	213,204	200,698	164,094	W
Finished do	5,400	8,930	12,924	10,816	W
Consumer do	226,423	182,853	216,207	207,880	99,253
World: Production do	[r]5,083,475	[r]5,309,592	5,259,983	[p]4,713,330	[e]4,741,408

[e]Estimated. [p]Preliminary. [r]Revised. W Withheld to avoid disclosing company proprietary data.
[1]Does not include fluosilicic acid (H_2SiF_6) or imports of hydrofluoric acid (HF) and cryolite.
[2]C.i.f. U.S. port.
[3]Apparent consumption includes finished shipments plus imports, minus exports, minus consumer stocks difference.

Legislation and Government Programs.—At yearend, the National Defense Stockpile inventory was unchanged from 1982 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 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 chlorofluorocarbons 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, was introduced in the U.S. House of Representatives on May 9 to suspend the duty on all grades of imported fluorspar.

DOMESTIC PRODUCTION

Shipments of finished fluorspar from domestic mining operations were at their lowest level in 50 years. Illinois remained the leading producing State, accounting for well over 90% of all U.S. shipments. Data on shipments of fluorspar by State and grade are withheld to avoid disclosing company proprietary data.

Ozark-Mahoning Co., the Nation's largest fluorspar producer, continued to operate mines and plants in Pope and Hardin Counties, IL. The only other active fluorspar producer in Illinois was the Hastie Trucking and Mining Co., which operated near Cave-In-Rock. The Inverness Mining Co. mines near Cave-In-Rock remained closed except for a skeleton work force and supervisory personnel who maintained custodial care of the mine pumps and ventilating fans.

In the West, J. Irving Crowell, Jr. and Sons continued to operate its Crowell-Daisy Mine in Nye County, NV, and D & F Minerals Co. continued operations at its Paisano Mines, south of Alpine, TX.

Reported shipments of fluorspar briquets for use in steel furnaces were approximately 74,000 tons—the same as in 1982. Briquets were produced by two plants owned by Cametco Inc., one plant owned by Mercier Corp., and one plant owned by Oglebay Norton Co.

Eighteen plants processing phosphate rock for the production of phosphoric acid and 2 plants producing hydrofluoric acid sold or used nearly 66,600 tons of byproduct fluosilicic acid valued at $4.6 million.

CONSUMPTION AND USES

Acid-grade fluorspar, containing greater than 97% calcium fluoride (CaF_2), was used as feedstock in the manufacture of hydrofluoric acid, the key ingredient in the manufacture of fluorine chemicals for the aluminum, fluorochemical, and uranium industries. Ceramic-grade fluorspar, containing 85% to 95% calcium fluoride, was used in the ceramics industry for the production of glass and enamel. Metallurgical-grade fluorspar, containing 60% to 85% or more calcium fluoride, was used primarily by the iron and steel industry as a flux. Traditionally, U.S. steelmakers have used metallurgical-grade fluorspar containing a minimum of 70% effective calcium fluoride; however, lower grade material and briquets have gained widespread usage.

Reported domestic consumption of fluorspar increased 6%. Consumption by chemical manufacturers in Texas increased significantly. The hydrofluoric acid and steel industries accounted for 64% and 34%, respectively, of demand. According to the American Iron and Steel Institute (AISI), raw steel production increased 14% to 83.4 million tons. A comparison of the AISI data with fluorspar consumption data collected in the Bureau of Mines canvass of U.S. steel producers shows, on the average, a decreasing rate of fluorspar consumption per ton of raw steel produced during 1981-83. 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)		
	1981	1982	1983
Open hearth	9.90	9.89	6.44
Basic oxygen	6.59	5.65	4.19
Electric	3.20	3.69	3.80
Industry average	6.02	5.43	4.30

Steel production in electric furnaces shows an increasing rate of fluorspar consumption.

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 hydrofluoric acid in 11 plants. The U.S. Department of Commerce, Bureau of the Census, reported that hydrofluoric acid "produced and withdrawn from the system" amounted to approximately 146,800 tons on an anhydrous basis, compared with 138,500 tons in 1982. Imports of hydrofluoric acid amounted to 92,000 tons, an 11% decrease.

Chlorofluorocarbons production, by five companies, was a major end use of hydrofluoric acid. According to revised U.S. International Trade Commission data, production of trichlorofluoromethane (F-11) increased 13% to 80,600 tons; dichlorodifluoromethane (F-12) output increased 13% to 148,000 tons; and chlorodifluoromethane (F-22) production increased 26% to 117,800 tons. Total estimated U.S. demand for all fluorocarbons increased 12% to 421,000 tons. Reportedly, refrigerants accounted for 48% of demand; foam blowing agents, 17%; solvents, 15%; fluoropolymers, 10%; sterilant gas, 3%; aerosol propellants, 3%; food freezants, 1%; and miscellaneous, 3%.[2]

Another major use of hydrofluoric acid 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.

Hydrofluoric acid was consumed 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 in water fluoridation (44%), the aluminum industry (20%), the production of sodium silicofluoride (14%), and miscellaneous (22%).

E. I. du Pont de Nemours & Co. Inc., the largest producer of fluorocarbon intermediates and derivatives, announced construction by 1985 at its Corpus Christi, TX, plant to increase capacity for manufacture of fluorocarbon precursors. Du Pont also increased its production capacity at Richmond, VA, for Teflon fluorocarbon fiber by nearly 40% to 2 million pounds per year.[3]

Warner-Lambert Co. acquired worldwide marketing rights to a synthetic fluorinated macrolide antibiotic developed by Italy's Pierrel S.p.A. The new macrolide is synthesized from erythromycin. Initial studies suggested that the substance resists breakdown by gastric acid. Warner-Lambert planned to conduct the required tests to gain approval from the U.S. Food and Drug Administration for U.S. distribution of the product.[4]

Air Product & Chemicals Inc. has completed construction of the world's largest tetrafluoromethane (CF_4) plant at Hometown, PA, and the first commercial plant to produce the gas by direct fluorination of carbon. Du Pont, the only other producer, was making tetrafluoromethane by a hydrogen fluoride exchange process. Tetrafluoromethane was used in plasma etching, a rapidly developing technology for etching and stripping semiconductors. The semiconductor industry was switching to dry production processes in which radio frequencies excite tetrafluoromethane and other fluorine and chlorine compounds into highly reactive plasmas.[5]

3M Corp.'s Specialty Chemical Div. brought on-stream a new plant in Decatur, AL, designed to manufacture two chemical-resistant products for the rubber industry—a fluoroelastomer used in nonmetallic ducting-system expansion joints for pollution control and a general purpose gumstock without curatives.[6]

Allied Chemical Co., a subsidiary of Allied Corp., began operation of a pilot plant in Metropolis, IL, to develop products based on fluorinated carbon (CF_x). The plant, with a design capacity of several thousand pounds per year, was built to provide another domestic source of fluorinated carbon, stimulate faster development of uses for fluorinated carbon, and provide operating experience of a commercial plant. One use of fluorinated carbon had been in high-energy batteries.

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	
	1982	1983	1982	1983	1982	1983
Hydrofluoric acid (HF)	311,641	360,832	--	--	311,641	360,832
Glass and fiberglass	3,877	4,063	1,996	1,628	5,873	5,691
Enamel and pottery	W	W	1,009	1,227	1,009	1,227
Welding rod coatings	480	475	1,382	1,282	1,862	1,757
Primary aluminum and magnesium	W	--	--	W	W	W
Iron and steel castings	--	--	10,403	16,882	10,403	16,882
Open-hearth furnaces	--	W	30,201	19,174	30,201	19,174
Basic oxygen furnaces	W	--	127,955	109,084	127,955	109,084
Electric furnaces	11,222	16,442	28,429	32,094	39,651	48,536
Other	180	114	1,790	890	1,970	1,004
Total	327,400	381,926	203,165	182,261	530,565	564,187
Stocks, Dec. 31	103,057	46,493	104,823	52,760	207,880	99,253

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

Table 3.—U.S. consumption (reported) of subacid grades of fluorspar in 1983, by end use

(Short tons)

End use or product	Containing not more than 97% calcium fluoride (CaF_2)		
	Flotation concentrates	Lump or gravel	Briquets or pellets
Chemicals and allied products: Welding fluxes	1,282	--	--
Glass, ceramic, bricks:			
Glass	1,613	15	--
Other glass, clay products	1,227	--	--
Primary metals:			
Iron and steel foundries	41	10,381	6,460
Steel mills:			
Basic oxygen furnaces	--	71,735	37,349
Electric furnaces	2,232	28,091	1,771
Open-hearth furnaces	178	18,856	140
Other identified end uses	76	813	--
Total	6,649	129,891	45,720

Table 4.—U.S. consumption of fluorspar (domestic and foreign), by State

(Short tons)

State	1982	1983
Alabama, Kentucky, Tennessee	63,371	62,829
Arizona, Colorado, Utah	9,677	8,033
Arkansas, Kansas, Louisiana, Missouri	48,806	25,355
California	4,380	W
Connecticut, Massachusetts, New York, Rhode Island	8,365	9,577
Illinois	10,585	12,561
Indiana	38,627	31,608
Michigan	6,252	W
New Jersey	13,396	W
Ohio	66,605	54,088
Oregon and Washington	190	--
Pennsylvania	51,955	40,949
Texas	167,568	264,097
West Virginia	29,648	23,977
Other[1]	11,140	31,113
Total	530,565	564,187

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes Iowa, Maryland, Virginia, Wisconsin, and data indicated by symbol W.

STOCKS

Fluorspar consumer stocks decreased 52% to about 99,000 tons.

PRICES

Domestic producer prices of ceramic-grade and acid-grade fluorspar reported in the Engineering and Mining Journal (E&MJ) remained at 1982 levels during the year. Reported prices of metallurgical-grade fluorspar increased by 14%. 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 hydrogen fluoride and $43.00 per 100 pounds for aqueous hydrofluoric acid, 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)

	1982	1983
Domestic, f.o.b. Illinois-Kentucky:		
Metallurgical: 70% effective CaF_2 briquets	110	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	180
88% effective CaF_2 briquets	179	179
European and South African:[1] Acid, term contracts	175-180	140-180
Mexican:[2]		
Metallurgical:		
70% effective CaF_2, f.o.b. vessel, Tampico	111.84	80.06
70% effective CaF_2, f.o.b. cars, Mexican border	107.40	75.63
Acid, bulk: 97+%, Mexican border	135.47-141.02	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. 1982 and 1983.

FOREIGN TRADE

According to Bureau of the Census data, U.S. fluorspar exports of all grades decreased 13% to 9,200 tons. Synthetic cryolite exports totaled 31,500 tons valued at $5.2 million.

Imports for consumption of fluorspar declined by 17%. Acid-grade imports were down 6%, and imports of subacid-grade material were down 50%. Imports from Mexico, the largest foreign supplier, were 48% of the combined fluorspar total. The Republic of South Africa supplied 25%; Italy, 8%; China, 7%; Spain, 6%; and Morocco, 4%. Small quantities were also imported from Denmark and France.

Imports for consumption of hydrofluoric acid decreased 11%. Mexico and Canada continued to be the major suppliers of imported hydrofluoric acid. Imports for consumption of natural and synthetic cryolite increased 16%. Japan, Denmark, and Canada were the leading suppliers.

Table 6.—U.S. exports of fluorspar, by country

Country	1982 Quantity (short tons)	1982 Value	1983 Quantity (short tons)	1983 Value
Australia	30	$2,990	26	$2,619
Canada	9,702	973,449	8,516	855,119
Chile	104	10,434	16	3,264
Colombia	--	--	9	880
Dominican Republic	224	32,334	47	16,618
Germany, Federal Republic of	105	10,450	19	1,920
Ghana	67	14,520	31	7,370
Leeward and Windward Islands	--	--	9	873
Malaysia	17	1,700	--	--
Mexico	--	--	477	65,163
United Kingdom	--	--	15	1,480
Venezuela	324	37,678	71	7,028
Total	10,573	1,083,555	9,236	962,334

Table 7.—U.S. imports for consumption of fluorspar, by country and customs district

Country and customs district	1982 Quantity (short tons)	1982 Value (thousands) Customs	1982 Value (thousands) C.i.f.	1983 Quantity (short tons)	1983 Value (thousands) Customs	1983 Value (thousands) C.i.f.
CONTAINING MORE THAN 97% CALCIUM FLUORIDE (CaF_2)						
Canada:						
Buffalo	4	$1	$1	--	--	--
Laredo	--	--	--	--	--	--
Seattle	37	3	4	--	--	--
Total	41	4	5	--	--	--
China:						
Baltimore	220	27	46	--	--	--
Houston	6,216	636	683	5,953	$666	$710
Total	6,436	663	729	5,953	666	710
Denmark: Detroit	--	--	--	4,630	283	285
France: Houston	--	--	--	250	63	83
Italy: Houston	40,481	5,135	5,811	37,042	4,186	4,786
Mexico:						
Detroit	1,328	99	108	--	--	--
El Paso	65,733	8,827	8,827	76,254	7,781	7,781
Laredo	80,120	9,747	9,747	83,386	7,783	7,783
New Orleans	--	--	--	15,476	1,673	1,804
Total	147,181	18,673	18,682	175,116	17,237	17,368
Morocco: New Orleans	13,393	1,991	2,132	19,761	2,910	3,129
South Africa, Republic of:						
Houston	22,653	2,349	2,872	21,302	1,341	1,504
Laredo	10,194	1,151	1,376	--	--	--
New Orleans	112,663	12,846	16,075	87,312	8,675	10,132
Philadelphia	15,214	1,777	1,948	4,641	500	530
Total	160,724	18,123	22,271	113,255	10,516	12,166
Spain:						
Cleveland	33,282	3,756	4,365	18,749	1,672	1,917
El Paso	--	--	--	1	[1]	[1]
New Orleans	6,549	899	999	10,381	942	1,050
Total	39,831	4,655	5,364	29,131	2,614	2,967
Grand total	408,087	49,244	54,994	385,138	38,475	41,494
CONTAINING NOT MORE THAN 97% CALCIUM FLUORIDE (CaF_2)						
China:						
Baltimore	15,636	951	1,523	7,737	462	745
New Orleans	63,510	3,599	5,251	16,639	925	1,020
Total	79,146	4,550	6,774	24,376	1,387	1,765

See footnotes at end of table.

Table 7.—U.S. imports for consumption of fluorspar, by country and customs district —Continued

Country and customs district	1982			1983		
	Quantity (short tons)	Value (thousands)		Quantity (short tons)	Value (thousands)	
		Customs	C.i.f.		Customs	C.i.f.
CONTAINING NOT MORE THAN 97% CALCIUM FLUORIDE (CaF_2)—Continued						
Italy: Los Angeles	26	$8	$10	--	--	--
Mexico:						
Baltimore	3,381	240	323	--	--	--
El Paso	14,128	1,253	1,253	11,024	$659	$659
Laredo	30,463	3,270	3,270	12,010	1,086	1,086
New Orleans	5,836	652	841	20,546	1,606	2,005
San Diego	--	--	--	220	23	23
Total	53,808	5,415	5,687	43,800	3,374	3,773
South Africa, Republic of: New Orleans	2,656	157	200	--	--	--
Grand total	135,636	10,130	12,671	68,176	4,761	5,538

[1]Less than 1/2 unit.

Table 8.—U.S. imports for consumption of hydrofluoric acid (HF), by country

Country	1982		1983	
	Quantity (short tons)	Value, c.i.f. (thousands)	Quantity (short tons)	Value, c.i.f. (thousands)
Belgium	1	([1])	--	--
Canada	34,259	$35,389	31,709	$31,512
Germany, Federal Republic of	1	4	([1])	1
Japan	3,560	3,087	2,990	2,546
Korea, Republic of	--	--	17	14
Mexico	65,132	63,192	56,232	45,194
Spain	--	--	568	443
United Kingdom	--	--	50	43
Total	102,953	101,672	91,566	79,753

[1]Less than 1/2 unit.

Table 9.—U.S. imports for consumption of cryolite,[1] by country

Country	1982		1983	
	Quantity (short tons)	Value, c.i.f. (thousands)	Quantity (short tons)	Value, c.i.f. (thousands)
Canada	892	$519	1,437	$816
China	276	181	92	53
Denmark	1,082	925	2,390	1,756
Germany, Federal Republic of	49	36	62	25
Greenland	66	53	--	--
Japan	3,681	2,460	2,395	1,853
Netherlands	89	54	102	81
Norway	--	--	36	13
Sweden	61	28	--	--
United Kingdom	22	8	685	187
Total	6,218	[2]4,266	7,199	4,784

[1]Only the material from Denmark is natural cryolite; all other material is synthetic.
[2]Data do not add to total shown because of independent rounding.

WORLD REVIEW

World production of fluorspar remained near 4.7 million tons. Based on revised 1982 data and 1983 estimates, Mongolia surpassed Mexico as the world's leading fluorspar producer, followed by, in descending order, the U.S.S.R., China, and the Republic of South Africa. Fluorspar was produced commercially in approximately 30 nations worldwide.

Mexico.—Mexican fluorspar producers began the year by reducing the price of acid-grade and metallurgical-grade fluorspar by 29% and 23%, respectively. The price reduction was the first since the inception of the Mexican Fluorspar Institute and the official Mexican Producer Price in 1974. Cía. Minera Las Cuevas S.A., operating the world's largest fluorspar mine, concentrated on mine development. About 7 major fluorspar mines dominated the Mexican industry, which included over 150 other small mines and workings throughout the country.

Table 10.—Sales of Mexican fluorspar, by grade

(Short tons)

Grade	1979	1980	1981[r]	1982[r]	1983
Acid	588,572	564,608	532,765	338,732	339,740
Ceramic	85,523	96,167	100,511	27,202	49,182
Metallurgical	306,494	312,218	250,121	120,478	116,944
Submetallurgical	196,436	236,470	211,505	116,030	93,367

[r]Revised.

Source: Instituto Mexicano de la Florita.

Netherlands.—Du Pont de Nemours (Nederland) BV was building a fluoroelastomer plant at its Dordrecht works, which, when completed in 1986, is to be one of the largest and most fully integrated fluoroproducts manufacturing facilities in the world. The facility was designed to nearly double Du Pont's worldwide annual capacity for the fluoroelastomer product to more than 10 million pounds, enlarge facilities for fluorocarbon copolymers, and double capacity for fluorochemical intermediates.[7]

U.S.S.R.—A simplified technique devised by Soviet researchers for the production of magnesium fluoride (MgF_2), reacting ammonium fluoride with magnesium hydrocarbonate, yielded a 95%-pure product with not more than 0.5% each of calcium, ferric oxide, and ammonia. Tests indicated that the lower purity magnesium fluoride could be substituted for more expensive reagent-grade magnesium fluoride in the salt-bath tempering of high-speed steel.[8]

Recovery of fluorine from Soviet phosphate rock resources was reported to be complicated by environmental considerations and technical problems. Fluorine could be recovered either by (1) concentrating the phosphoric acid and subsequent fluorine extraction in the gas phase or (2) binding the fluorine in silicon fluoride salts of alkaline-earth metals such as magnesium silicofluoride. Tests of the first approach yielded no more than 50% of the fluorine in the phosphoric acid, but the second approach yielded approximately 90% of the fluorine.[9]

United Kingdom.—Imperial Chemical Industries planned to build a new hydrofluoric acid plant to replace existing capacity at Runcorn, Cheshire. The plant, scheduled for completion in 1985, was in response to a wider use of chlorofluorocarbons as refrigerants. According to the United Kingdom Customs and Excise Statistical Office, the United Kingdom imported 12,000 tons of fluorspar from France, the Republic of South Africa, and Spain, and exported 13,000 tons to the Federal Republic of Germany and the Netherlands.

Table 11.—Fluorspar: World production, by country and grade[1]

(Short tons)

Country[2] and grade[3]	1979	1980	1981	1982[p]	1983[e]
Argentina	41,972	17,050	22,878	26,155	26,500
Brazil:[4]					
Acid grade	29,599	36,078	39,932	42,439	43,000
Metallurgical grade	28,161	24,956	19,184	22,539	23,000
Total	[r]57,760	[r]61,034	59,116	64,978	66,000
China:					
Acid grade[e]	66,000	88,000	88,000	88,000	88,000
Metallurgical grade[e]	440,000	440,000	440,000	440,000	440,000
Total	506,000	528,000	528,000	528,000	528,000
Czechoslovakia[e]	106,000	106,000	106,000	106,000	106,000
Egypt	[r]752	1,931	590	99	110
France:					
Acid and ceramic grades	173,504	178,133	185,960	177,725	176,000
Metallurgical grade	112,218	106,814	96,452	90,825	88,000
Total	285,722	284,947	282,412	268,550	264,000
German Democratic Republic[e]	110,000	110,000	110,000	110,000	110,000
Germany, Federal Republic of (marketable)	69,635	86,148	86,685	[e]79,300	80,000
Greece	397	[e]440	822	330	330
India:					
Acid grade	12,115	[r]13,612	14,711	13,676	13,000
Metallurgical grade	7,021	[r]5,301	5,924	6,294	6,600
Total	19,136	[r]18,913	20,635	19,970	19,600
Italy:					
Acid grade	148,094	137,540	142,019	147,850	143,300
Ceramic grade	7,589	1,060	--	--	--
Metallurgical grade	45,809	28,912	39,018	36,180	33,000
Total	201,492	167,512	181,037	184,030	176,300
Kenya:					
Acid grade	74,727	102,932	105,849	97,804	88,200
Metallurgical grade	10,266	--	--	--	--
Total	84,993	102,932	105,849	97,804	88,200
Korea, North, metallurgical grade[e]	44,000	44,000	44,000	44,000	44,000
Korea, Republic of, metallurgical grade	9,315	7,619	7,125	7,716	4,400
Mexico, all grades	964,759	1,010,218	1,019,476	695,983	667,000
Mongolia, metallurgical grade[e]	625,000	666,000	656,000	[r]739,000	761,000
Morocco, acid grade	69,666	70,989	73,524	55,336	70,200
Pakistan	461	1,305	391	903	880
Romania, metallurgical grade[e]	22,000	22,000	22,000	22,000	22,000
South Africa, Republic of:					
Acid grade	426,930	517,735	497,819	323,882	263,600
Ceramic grade	9,344	9,798	6,744	10,613	7,300
Metallurgical grade	60,991	48,664	42,758	30,188	31,200
Total	497,265	576,197	547,321	364,683	302,100
Spain:					
Acid grade	171,164	225,528	235,471	173,289	165,000
Metallurgical grade	41,469	44,261	47,963	40,868	41,000
Total	212,633	269,789	283,434	214,157	206,000
Thailand:					
Acid grade	62,362	66,258	60,827	89,314	90,000
Metallurgical grade	195,914	190,461	173,405	176,084	193,000
Total	258,276	256,719	234,232	265,398	283,000
Tunisia, acid grade	37,267	43,487	38,409	36,607	37,500
Turkey, metallurgical grade	6,834	[r]2,144	2,189	[e]2,200	2,200
U.S.S.R.[e]	573,000	573,000	585,000	595,000	595,000

See footnotes at end of table.

Table 11.—Fluorspar: World production, by country and grade[1] —Continued

(Short tons)

Country[2] and grade[3]	1979	1980	1981	1982[p]	1983[e]
United Kingdom:					
Acid grade	114,640	151,016	97,000	NA	NA
Metallurgical grade	13,228	11,023	5,512	NA	NA
Unspecified	41,888	26,455	25,353	NA	NA
Total	169,756	188,494	127,865	108,026	220,000
United States (shipments)	109,299	92,635	115,404	77,017	61,000
Uruguay[e]	85	89	89	88	88
Grand total	[r]5,083,475	[r]5,309,592	5,259,983	4,713,330	4,741,408

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

[1]Table includes data available through May 2, 1984.

[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]Series revised. Data presented are marketable concentrates.

TECHNOLOGY

Allied Corp. was awarded the National Environmental Industry Award presented by the President's Council on Environmental Quality and the Environmental Industry Council for creating a usable product from two wastes. At its plant in Metropolis, IL, Allied developed a technology to treat one plant waste stream with a second hazardous waste stream to produce 8,000 tons annually of synthetic fluorspar. This was to be used for anhydrous hydrofluoric acid production at another Allied plant. The Metropolis plant produced uranium hexafluoride and numerous other inorganic fluorides, including sulfur hexafluoride.[10]

The Los Alamos National Laboratory developed a new method of bonding diamonds to metal that was used to produce diamond grinding wheels. The process consisted of reacting fluorine atoms with the surfaces of diamonds, bonding the fluorinated diamonds together with a fluorocarbon resin, and bonding the dried material to an aluminum grinding wheel. The diamond fluorocarbon material was then physically compressed and embedded into the aluminum using a hot press. Grinding wheels made by the new process proved effective and long wearing and were less expensive to produce than traditional diamond wheels.[11]

Researchers at the State University of New York, Stony Brook, tested steroid fluoroderivatives as possible highly specific insecticides that would be nontoxic to other organisms.[12]

The Oak Ridge National Laboratory was conducting research on high-dielectric and nontoxic fluorinated compounds as insulating media for electric power transmission facilities.

Researchers at the Argonne National Laboratory in Illinois measured for the first time the rate of reaction between fluorine and water. The reaction half-time was determined to be 7×10^{-6} second, or more than 1,000 times faster than the reactions of the heavier halogens—chlorine, bromine, and iodine—with water. The reaction was so fast that stirring and convection did not affect it, yet it was slow enough for other molecules to capture the fluorine before it reacted with the water. The researchers suggested the possibility of using fluorine in aqueous solution as a fluorinating agent, a reaction previously believed too violent and difficult to control.[13]

[1]Physical scientist, Division of Industrial Minerals.

[2]Chemical Marketing Reporter. V. 223, No. 10, 1983, p. 54.

[3]Chemical Week. V. 133, No. 7, 1983, p. 9.

[4]———. V. 133, No. 12, 1983, p. 21.

[5]———. V. 132, No. 20, 1983, p. 56.

[6]———. V. 132, No. 8, 1983, p. 19.

[7]Chemical Processing. V. 46, No. 14, 1983, p. 10.

[8]Lopatkina, G. A., T. N. Kolosova, Y. A. Smol'nikov, and L. M. Sarmanova. Production of Magnesium Fluorine for Use in Instrument Industry. Khim. Promst., Moscow, No. 9, 1983, pp. 553-554 (Engl. sum.).

[9]Rodin, V. I., M. N. Tsybina, N. I. Kraynev, L. N. Arkhipova, and A. A. Novikov. Extracting Fluorine in Producing Extraction Phosphoric Acid From New Forms of Phosphate Raw Materials. Khim. Promst., Moscow, No. 7, 1983, pp. 412-416 (Engl. sum.).

[10]Chemical Marketing Reporter. Allied Corp. Wins Environmental Award for Its Pollution Control Efforts in Illinois. V. 224, No. 19, 1983, p. 27.

[11]Chemical and Engineering News. Fluorine Method Bonds Diamonds to Metal. V. 61, No. 3, 1983, p. 48.

[12]———. Fluorinated Plant Steroids Kill Insect Pest. V. 61, No. 10, 1983, p. 6.

[13]———. V. 61, No. 14, 1983, p. 18.

Gallium

By Luke Baumgardner[1]

Gallium in the form of metal or metallic compounds was used in the United States primarily in the production of solid-state electronic devices. Although the predominant use was in light-emitting diodes, a large potential market may be developed in the manufacture of microwave devices, solar cells, lasers, and integrated circuit chips.

Domestic Data Coverage.—Domestic consumption data for gallium were developed by the Bureau of Mines from a voluntary survey of U.S. operations. Of the 41 operations to which a survey request was sent, 17 responded, representing an estimated 42% of the total consumption shown in tables 1, 2, and 3. Consumption for the 24 nonrespondents was estimated using 1983 import data and information on production and domestic consumption trends.

Table 1.—Salient U.S. gallium statistics

(Kilograms unless otherwise specified)

	1979	1980	1981	1982	1983
Production	NA	NA	NA	NA	NA
Imports for consumption	6,401	6,175	5,536	5,199	7,294
Consumption	r9,050	r8,810	r6,810	r6,660	6,425
Price per kilogram	$510	$510-$630	$630	$630	$525

rRevised. NA Not available.

DOMESTIC PRODUCTION

The sole U.S. producer of gallium metal in 1983 was Eagle-Picher Industries Inc. The company's plant in Quapaw, OK, recovered gallium from zinc production residues. Domestic demand and production both apparently declined in 1983. A Canadian firm, Musto Explorations Ltd., Vancouver, British Columbia, planned to recover gallium and germanium from an abandoned copper mine near St. George, UT, by the first quarter of 1985.[2] According to the company's plans, material from the mine dump was to be treated in a newly constructed mill during the first 2 years of operation. Underground ore in place, developed by diamond drilling, was expected to provide feed to the mill after the first 2 years.

CONSUMPTION

Gallium and its compounds, particularly gallium arsenide (GaAs), received considerable attention during the year from research and development units of the electronics industry. Because gallium arsenide chips can handle very high frequencies and can operate at more than five times the speed of silicon chips, there are a number of applications that could materially increase the demand for gallium. These include integrated circuits, lasers, solar cells, infrared light-emitting diodes, and amplifiers in fiber optic communication systems.

Table 2.—U.S. consumption of gallium, by end use

(Kilograms)

End use	1981	1982	1983
Specialty alloys	2	27	43
Electronics[1]	r6,261	r6,136	5,915
Research and development	r490	r440	410
Unspecified	57	57	57
Total	r6,810	r6,660	6,425

rRevised.
[1]Light-emitting diodes, semiconductors, and other electronic devices.

Table 3.—Stocks, receipts, and consumption of gallium[1]

(Kilograms)

Purity	Beginning stocks	Receipts	Consumption	Ending stocks
1982:				
97.0%-99.9%	119	15	28	106
99.99%	4	14	14	4
99.999%	5	75	75	5
99.9999%-99.99999%	1,785	r6,498	r6,543	1,740
Total	1,913	r6,602	r6,660	1,855
1983:				
97.0%-99.9%	106	48	45	109
99.99%	4	14	14	4
99.999%	5	19	20	4
99.9999%-99.99999%	1,740	6,368	6,346	1,762
Total	1,855	6,449	6,425	1,879

rRevised.
[1]Consumers only.

PRICES

In January 1983, the American Metal Market (AMM) quoted a price of $630 per kilogram for 99.999%-pure gallium metal in 100-kilogram lots. On August 1, 1983, Eagle-Picher announced a reduction in its price to $525 per kilogram for 99.99999%-pure metal in lots of 100 kilograms, and this price was quoted by AMM through yearend.

FOREIGN TRADE

Significant quantities of gallium metal and its compounds are exported in the form of electronic and electrical components. Export data on gallium waste, scrap, and crude metal are combined with other metal exports and cannot be separately identified.

U.S. imports of gallium increased by more than 40% over 1982 imports, with Switzerland, the Federal Republic of Germany, and France supplying about 80% of the total. The average value increased to $438 per kilogram in 1983 from $377 per kilogram in 1982.

Table 4.—U.S. imports for consumption of gallium (unwrought, waste and scrap), by country

Country	1982 Kilograms	1982 Value	1983 Kilograms	1983 Value
Canada	379	$177,074	279	$130,640
China	--	--	500	157,264
France	480	170,066	829	304,334
Germany, Federal Republic of	1,448	669,406	918	415,094
Japan	48	16,267	146	62,465
Spain	148	21,402	--	--
Switzerland	2,429	807,087	4,154	1,956,778
United Kingdom	267	97,129	468	168,001
Total	5,199	1,958,431	7,294	3,194,576

WORLD REVIEW

During 1983, world production and consumption of gallium appeared to decline moderately. This did not, however, delay the construction of new gallium processing capacity in Europe and Japan.

Germany, Federal Republic of.—Preussag Metall AG announced the October opening of a new plant in Langelshiem that will recover and refine to 99.9999% purity about 5 tons per year of gallium from gallium arsenide scrap. Also in Germany, International Gallium GmbH, jointly owned by NV Billiton Maatschappij and Vereinigte Aluminium Werke AG (VAW), planned to startup at yearend 1983 a new plant at Lunen to produce 99.9999%- and 99.99999%-pure gallium and gallium oxide. The latter plant was designed to produce 5 tons of high-purity gallium annually using crude gallium recovered from VAW's Bayer alumina plant at Schwandorf.

Japan.—Sumitomo Chemical Co. announced the opening in October of a new plant to extract and refine from Bayer plant liquor 99.9%- to 99.99%-pure gallium. The designed annual capacity of 10 tons of gallium was the largest in the world. In northern Japan, Dowa Mining Co. Ltd. was installing gallium and indium recovery systems at its zinc smelting plant. Gallium capacity was not announced.

TECHNOLOGY

Sumitomo Electric Industries Ltd., Japan, reportedly developed a method to produce large 2- to 3-inch-diameter gallium arsenide crystals that are virtually free of dislocations. High dislocation density, which degrades the efficiency of the semiconductor chip, has been a major barrier to broad acceptance by the electronics industry of gallium arsenide crystals. Electrical and bulk characteristics following heat treatment of crystals produced by both the Bridgeman and Chochralski methods were discussed.[3] Chemical vapor deposition techniques for fabricating high-efficiency gallium arsenide solar cells, with a high power-to-weight ratio, were described.[4]

[1]Physical scientist, Division of Nonferrous Metals.
[2]Mining Journal. V. 301, No. 7735, Nov. 18, 1983, p. 365.
[3]Sekinobu, M., and K. Matsumoto. GaAs Crystal Growth Technology for Wider Communication Use. Jpn. Electron. Eng., v. 20, No. 201, Sept. 1983, pp. 32-37.
[4]Zwerdling, S., K. L. Wang, and Y. C. M. Yeh. High Efficiency, Thin-Film GaAs Solar Cells. J. Solar Energy (Engl. Transl. ASME), v. 105, No. 3, Aug. 1983, pp. 237-242.

Gem Stones

By J. W. Pressler[1]

The value of gem stones and mineral specimens produced in the United States during 1983 was estimated to be $7.4 million, a 3% increase compared with that of 1982. 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 were developed by the Bureau of Mines from the production of Gem Stones survey, a voluntary survey of U.S. operations. Of the 46 operations to which a survey request was sent, 43% responded, representing an estimated 35% of the total production indicated in the text. Production for the 23 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. Eleven States supplied 91% of the total value as follows: Arizona, $2.8 million; Nevada, $1.2 million; Oregon, $600,000; Maine, $500,000; California and Montana, $300,000 each; Wyoming, $250,000; Texas, $225,000; and Arkansas, New Mexico, and Washington, $200,000 each. Estimated production increased 33% in Idaho and Montana, 20% in California and Oregon, and 13% in Texas.

Park authorities at the Crater of Diamonds Park in Pike County, AR, reported that 89,500 people visited the park and recovered, by washing, screening and panning, 1,501 diamonds, a 9% increase over that of 1983, with a total weight of 315 carats. The largest was a 6.2-carat white stone of undetermined value. The next four largest diamonds, one white, two yellows, and one brown, ranged from 4.2 to 5.63 carats. The total diamonds recovered averaged 21 points compared with 19 points in 1982. The "dig for fee" operations remained popular.

In Emerald Creek, ID, the U.S. Forest Service issued 867 permits to diggers and panners who found 735 pounds 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 ranged from 4 to 18 ounces. Because of the cold weather, the area was opened for about 100 days from May to September during 1983.

About 100 kimberlite pipes, 14 of them yielding diamonds, were discovered in Wyoming since 1960 by private companies and the Wyoming Geological Survey, utilizing heavy mineral stream sediment sampling, detailed geological mapping, and bulk sample testing. In 1983, the University of Wyoming, the Wyoming Geological Survey, and the National Aeronautics and Space Administration were working on an airborne remote-sensing project for detection of kimberlite. Three 100-square-mile plots near the Wyoming-Colorado border had been covered from an altitude of 2,000 feet and the images received were being analyzed by computer. This airborne technique may provide a more efficient and rapid means of exploring for additional kimberlite occurrences.[2] Bulk sampling and testing of about 10,000 short tons from the 14 diamondiferous kimberlites to date had yielded only an average of 0.01 carat per short ton, well below economic viability. The largest stone found weighed about 1 carat, and was of industrial grade.

The Michigan Department of Natural Resources announced that there was evidence that kimberlite had been found in the Crystal Falls area of Iron County, MI. Dow Chemical Co. planned to mine a 30-ton sample for processing at the Michigan Technological University laboratory to determine its diamond content.[3]

Montana continued to be the largest producer of gem-quality sapphire in the United States. Two companies, Intergem Inc. of Denver, CO, and Big Blue Sapphire Co. Inc. of Great Falls, MT, tested their properties on Yogo Gulch, near Lewiston, Fergus County, MT. Some high-quality Kashmiri-blue sapphires were recovered, although the total corundum content of the ore was less than 10 carats per ton.

CONSUMPTION

Domestic gem stones 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 30% to $2,132 million.

Jewelry store sales increased 5% to $8.9 billion, and jewelry containing pearls and diamonds increased almost 10%. The Christmas trade was particularly good. Demand for small, lower quality diamond goods was high, but the demand for larger stones of good quality was restricted.

U.S. consumption of colored stones increased slightly. However, the value of all imported gem stones, other than diamond, increased 24%, with sapphire leading the way. Annual sales of emerald continued to be almost equal to those of ruby and sapphire combined.

PRICES

The U.S. price of 1.0-carat, D-flawless, investment-grade diamond fluctuated between $13,000 and $19,000 per carat, and at yearend was $13,500 per carat, a decrease of 32% 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.

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 1983	Median price per carat[3] January 1983	Median price per carat[3] December 1983
0.04-0.08	G-I	VS_1	$400- $613	$501	$490
.04- .08	G-I	SI_1	400- 520	400	450
.09- .16	G-I	VS_1	450- 770	525	560
.09- .16	G-I	SI_1	410- 610	450	475
.17- .22	G-I	VS_1	700- 1,300	750	835
.17- .22	G-I	SI_1	500- 1,195	650	690
.23- .28	G-I	VS_1	775- 1,470	940	965
.23- .28	G-I	SI_1	650- 1,350	750	770
.29- .35	G-I	VS_1	875- 1,700	1,250	1,260
.29- .35	G-I	SI_1	735- 1,570	1,000	1,050
.46- .55	G-I	VS_1	1,450- 2,350	1,900	2,000
.46- .55	G-I	SI_1	900- 1,845	1,480	1,545
.69- .79	G-I	VS_1	1,800- 3,010	2,250	2,500
.69- .79	G-I	SI_1	1,400- 2,465	1,750	1,950
1.00-1.15[4]	D	FL	13,000-19,000	19,750	13,500
1.00-1.15	E	VVS_1	6,800- 8,200	7,300	7,500
1.00-1.15	G	VS_1	3,500- 5,200	3,900	4,200
1.00-1.15	H	VS_2	2,400- 4,800	3,200	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; 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; SI_1—slightly included.
[3]Jewelers' Circular-Keystone, v. 155, No. 2, Feb. 1984, p. 124. 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. 14, No. 1, Dec. 31, 1982, and v. 15, No. 1, Jan. 1984.

Prices for colored stones experienced little change during the year.

The unit value of Colombian and Zambian emerald continued at a median price of $1,500 per carat.

Table 2.—Prices of U.S. cut colored gem stones, by size[1]

Gem stone	Carat weight	Price range per carat in 1983	Median price per carat[1 2] January 1983	Median price per carat[1 2] January 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[3]		550-1,500	NA	550
Garnet, tsavorite	1	350-1,100	725	725
Opal, black			NA	
Opal, white			NA	
Peridot			NA	
Ruby:				
Medium to better	1	500-2,200	1,200	1,200
Commercial[3]	1	330- 660	NA	330
Sapphire:				
Medium to better	1	150-1,500	700	700
Commercial[3]	1	220- 440	NA	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

NA Not available.
[1]Medium to better quality.
[2]Jewelers' Circular-Keystone, v. 153, No. 2, Feb. 1982, p. 154; v. 154, No. 2, Feb. 1983, p. 87. 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. 11, No. 2, Jan. 1984.

FOREIGN TRADE

The declared customs value of U.S. imports of rough and polished natural diamond, excluding industrial diamond, increased 19% to $2.3 billion. Total polished diamond imports, principally from Belgium-Luxembourg, 32%; Israel, 24%; and India, 23%; were valued at $2.0 billion. Imports in the over-0.5-carat category, mostly from Belgium-Luxembourg, 38%; Israel, 18%; and Switzerland, 15%; increased 17% in value to $741 million. Imports in the less-than-0.5-carat group, mostly from India, 36%; Belgium-Luxembourg, 29%; and Israel, 28%; increased 23% in value to $1.2 billion. Imports of rough natural diamond, 84% from the Republic of South Africa, increased 15% in caratage and 6% in value. A slight decrease in carat value for South African imports, from $345 to $336, was indicated.

The total value of emerald imports increased 11% to $134 million. The total value of ruby imports increased 2% to $67 million, and sapphire imports increased 35% to $85 million. Average carat values increased 14% for emerald to $63, but decreased 30% for ruby to $24, and remained virtually unchanged for sapphire at $25.

Export value of all gem materials other than diamond remained virtually unchanged at $66.8 million. Of this total, other precious and semiprecious stones, cut but unset, were valued at $33.3 million; other natural precious and semiprecious stones, not set or cut, $14.3 million; synthetic gem stones and materials for jewelry, cut, $3.7 million; pearls, natural, cultured, or synthetic, not strung or set, $1.8 million; and other, $13.7 million. Reexports of all gem materials, other than diamond, remained almost unchanged at $42.2 million. Reexport categories were precious and semiprecious stones, cut but unset, $31.1 million; and other, $7.9 million.

Table 3.—U.S. exports and reexports of diamond (exclusive of industrial diamond), by country

Country	1982 Quantity (carats)	1982 Value (millions)	1983 Quantity (carats)	1983 Value (millions)
Exports:				
Belgium-Luxembourg	40,655	$33.6	103,106	$50.5
Canada	10,193	5.8	16,134	10.0
France	4,990	9.8	4,094	9.9
Germany, Federal Republic of	1,961	3.5	3,626	5.0
Hong Kong	47,395	100.0	58,851	87.0
Israel	20,353	5.6	75,092	39.2
Japan	27,411	52.0	30,911	62.3
Singapore	8,528	17.0	5,996	11.5
Sweden	123	.3	1,198	1.1
Switzerland	13,649	48.4	12,473	76.8
Thailand	426	.7	3,504	3.3
United Arab Emirates	879	.5	1,035	.7
United Kingdom	4,180	9.1	5,441	9.5
Other	r4,128	r6.5	2,912	6.0
Total	184,871	292.8	324,373	372.8
Reexports:				
Belgium-Luxembourg	[1]1,368,040	108.0	[1]1,317,578	84.6
Canada	5,117	1.6	10,145	1.7
China	11,864	.6	10,613	.1
Germany, Federal Republic of	1,781	1.5	25,919	2.2
Hong Kong	112,431	54.8	83,800	28.0
India	370,863	7.2	226,987	6.1
Israel	338,034	66.7	212,557	34.7
Japan	77,687	26.8	92,934	11.0
Netherlands	27,824	4.6	54,407	4.7
Switzerland	43,727	39.3	31,667	43.7
United Kingdom	69,113	25.2	73,474	26.9
Other	r71,697	r9.4	24,095	5.9
Total	2,498,178	345.7	2,164,176	249.6

rRevised.
[1]Artificially inflated in 1982 by auction of approximately 1.2 million carats of U.S. Government stockpile diamond stones with subsequent reexports as gem stones to Belgium-Luxembourg. In 1983, 1 million carats was similarly auctioned and reexported to Belgium-Luxembourg.

Table 4.—U.S. imports for consumption of diamond, by kind and country

Kind and country	1982 Quantity (carats)	1982 Value (millions)	1983 Quantity (carats)	1983 Value (millions)
Rough or uncut, natural:[1]				
Belgium-Luxembourg	77,117	$25.3	111,211	$14.7
Brazil	251	.3	2,290	.7
Cape Verde	23	(2)	3,400	.1
Colombia	--	--	21,413	.1
Congo	3,878	1.1	8,690	2.7
Dominican Republic	--	--	2,331	.1
Guyana	1,768	.1	4,989	.3
Israel	25,123	4.9	9,651	1.6
Netherlands	6,581	4.4	1,585	2.1
South Africa, Republic of	579,815	r199.9	729,547	245.3
Switzerland	6,955	6.8	13,035	2.6
United Kingdom	77,818	19.3	41,234	13.4
Venezuela	38,156	2.8	65,908	3.2
Other	r73,235	r11.7	10,366	5.8
Total	890,720	276.6	1,025,650	292.7
Cut but unset, not over 0.5 carat:				
Belgium-Luxembourg	954,156	323.6	1,126,400	358.7
Hong Kong	27,196	11.0	29,957	8.9
India	1,229,187	271.4	2,153,148	440.8
Israel	832,168	315.4	1,047,471	342.4
South Africa, Republic of	49,611	24.2	45,187	24.3
Switzerland	44,734	15.4	44,864	18.0
United Kingdom	39,080	16.5	31,417	17.2
Other	87,427	30.4	110,438	31.1
Total	3,263,559	1,007.9	4,588,882	1,241.4

See footnotes at end of table.

Table 4.—U.S. imports for consumption of diamond, by kind and country —Continued

Kind and country	1982 Quantity (carats)	1982 Value (millions)	1983 Quantity (carats)	1983 Value (millions)
Cut but unset, over 0.5 carat:				
Belgium-Luxembourg	232,263	$250.7	281,064	$284.2
Hong Kong	9,177	28.4	9,135	23.8
India	27,299	7.6	58,871	18.1
Israel	111,084	95.7	165,641	132.1
Netherlands	12,322	16.5	10,841	18.8
South Africa, Republic of	36,045	51.7	33,936	47.4
Switzerland	14,539	91.8	27,364	111.1
United Kingdom	22,089	46.4	29,544	58.8
Other	15,717	44.3	33,501	47.0
Total	480,535	633.1	649,897	741.3

[r]Revised.
[1]Includes some natural advanced diamond.
[2]Less than one-tenth unit.

Table 5.—U.S. imports of natural precious and semiprecious gem stones, other than diamond, by kind and country

Kind and country	1982 Quantity (carats)	1982 Value (millions)	1983 Quantity (carats)	1983 Value (millions)
Emerald:				
Belgium-Luxembourg	5,392	$1.5	34,027	$1.6
Brazil	328,976	5.7	174,314	8.0
Colombia	116,272	37.6	203,485	44.1
France	12,963	2.9	7,806	2.2
Germany, Federal Republic of	19,167	2.2	28,293	3.7
Hong Kong	100,955	15.5	44,289	6.1
India	1,136,247	11.5	1,274,765	12.8
Israel	238,543	17.1	87,145	17.9
South Africa, Republic of	15,702	.4	7,979	.3
Switzerland	76,377	14.5	41,518	17.4
Taiwan	61	([1])	78,853	([1])
Thailand	43,246	1.9	64,590	2.2
United Kingdom	18,442	3.9	36,273	11.0
Other	[r]54,507	[r]6.1	33,662	6.8
Total	2,166,850	120.8	2,116,999	134.1
Ruby:				
Austria	14,267	.2	163,361	.2
Colombia	17	([1])	37,070	.2
Germany, Federal Republic of	35,994	1.3	53,343	1.5
Hong Kong	203,379	9.1	125,447	4.9
India	303,205	4.7	230,186	3.3
Israel	25,258	.7	28,376	1.2
Switzerland	45,876	16.4	221,416	8.8
Thailand	1,175,698	25.2	1,840,758	36.0
United Kingdom	47,395	3.6	19,472	4.1
Other	[r]82,194	[r]4.6	67,243	6.6
Total	1,933,283	65.8	2,786,672	66.8
Sapphire:				
Australia	3,819	.3	43,493	.6
Austria	14,521	.2	44,945	.1
Belgium-Luxembourg	10,922	1.4	28,462	1.0
Brazil	4,022	([1])	11,080	([1])
Canada	12,919	.4	15,146	.6
Colombia	800	.3	14,656	.1
France	11,036	1.8	11,026	2.5
Germany, Federal Republic of	40,381	1.6	121,800	2.5
Hong Kong	179,616	8.0	167,305	9.9
India	360,810	2.4	130,481	2.7
Israel	41,597	.6	48,966	.8
Sri Lanka	41,938	4.0	48,377	4.3
Switzerland	66,575	13.4	244,025	11.8
Thailand	1,749,651	22.3	2,456,096	32.7
United Kingdom	25,800	3.0	33,959	8.3
Other	[r]16,543	[r]3.6	50,736	7.3
Total	2,580,950	63.3	3,470,553	85.2

See footnotes at end of table.

Table 5.—U.S. imports of natural precious and semiprecious gem stones, other than diamond, by kind and country —Continued

Kind and country	1982 Quantity (carats)	1982 Value (millions)	1983 Quantity (carats)	1983 Value (millions)
Other:				
Rough, uncut:				
Australia	NA	$0.9	NA	$1.0
Belgium-Luxembourg		.4		.4
Brazil		4.4		11.1
Canada		(1)		1.4
Colombia		3.4		7.3
Hong Kong		1.1		.9
Pakistan		.7		.5
Switzerland		2.9		.7
Zambia		.9		.9
Other		r5.0		2.5
Total	NA	19.7	NA	26.7
Cut, set and unset:				
Australia	NA	2.4	NA	2.1
Brazil		15.7		12.5
China		1.6		2.5
Germany, Federal Republic of		10.0		11.8
Hong Kong		19.7		22.6
India		3.7		4.5
Japan		84.7		152.8
Switzerland		3.4		4.5
Taiwan		1.1		4.8
Thailand		2.2		2.6
Other		r14.4		6.8
Total	NA	158.9	NA	227.5

rRevised. NA Not available.
[1]Less than one-tenth unit.

Table 6.—Value of U.S. imports of synthetic and imitation gem stones, by country

(Million dollars)

Country	1982	1983
Synthetic, cut but unset:		
Austria	1.0	1.3
France	1.3	1.0
Germany, Federal Republic of	5.9	6.1
Japan	.4	1.0
Korea, Republic of	11.1	6.7
Switzerland	3.0	3.2
Other	r1.5	1.2
Total	24.2	20.5
Imitation:		
Austria	7.2	10.9
Czechoslovakia	.8	1.2
Germany, Federal Republic of	3.0	4.4
Japan	1.3	2.4
Other	r1.1	1.4
Total	13.4	20.3

rRevised.

Table 7.—U.S. imports for consumption of precious and semiprecious gem stones

(Thousand carats and thousand dollars)

Stones	1982 Quantity	1982 Value	1983 Quantity	1983 Value
Diamonds:				
Rough or uncut[1]	891	276,577	1,026	292,687
Cut but unset	3,745	1,641,035	5,239	1,982,686
Emeralds: Cut but unset	2,167	120,809	2,117	134,130
Coral: Cut but unset, and cameos suitable for use in jewelry	NA	2,804	NA	2,584
Rubies and sapphires: Cut but unset	4,514	129,794	6,257	151,931
Marcasites	NA	38	NA	121
Pearls:				
Natural	NA	3,003	NA	3,019
Cultured	NA	92,741	NA	162,833
Imitation	NA	1,458	NA	3,015
Other precious and semiprecious stones:				
Rough, uncut	NA	19,769	NA	26,700
Cut, set and unset	NA	r60,300	NA	58,983
Synthetic:				
Cut but unset[2]	26,703	23,238	36,787	18,948
Other	NA	896	NA	1,536
Imitation gem stones	NA	r11,990	NA	17,281
Total	XX	2,384,452	XX	2,856,454

rRevised. NA Not available. XX Not applicable.

[1]Includes 4,985 carats of other natural diamond, advanced, valued at $837,000 in 1982, and 16,799 carats valued at $759,200 in 1983.

[2]Quantity in thousands of stones.

WORLD REVIEW

Angola.—It was estimated that diamond production by Companhia de Diamantes de Angola (DIAMANG) remained unchanged at 1.2 million carats, with a reduced value because of the depressed state of the international diamond market. DIAMANG had retained over 600 expatriate workers since 1978 in an effort to improve productivity, principally in Lunda-Norte Province, near the Zairean border. Illicit theft and trafficking was reportedly encouraged by the Unita insurgents, who almost certainly derived substantial income from these activities.[4]

DIAMANG's total work force, about 17,000, operated several mines within a 50,000-square-kilometer concession in Lunda-Norte Province, with three mining divisions, at Andrada, Lucapa, and Cuango. Most of the diamonds were recovered from alluvial terrace and riverbed gravels. The average grade was about 0.2 to 0.3 carat per cubic meter, with some rich pockets yielding up to 100 carats per cubic meter. Ample alluvial reserves remained, and there was no haste to work the extensive kimberlite discovered during operations. Limited mining of the weathered kimberlite tops was carried out, and one of the largest pipes in the world—Camofuca Camazombo—was still being explored. Alluvial diamond recovery methods were conventional, with some heavy media separators being employed.[5]

Australia.—The Western Australia State Government approved the Argyle Diamond Mines Joint Venture's mining project commencement of the AK-1 kimberlite pipe, with an estimated $440 million investment. The project involves preparation of the Argyle kimberlite pipe for commercial mining and construction of a 3.3-million-short-ton-per-year treatment plant, together with ancillary infrastructure and services. Expected to be in production in 1986, the project's annual output will eventually reach 25 million carats of diamond per year, with a minimum life of 20 years. Reserves are over 500 million short tons. Argyle was the richest diamond mine in the world in terms of carats per ton of ore.[6]

Shortly after it approved the project, the state purchased Northern Mining Corp. N.L.'s 5% interest in the Argyle project for $38 million, most of which was to be covered by advance royalties on production. Western Australia's Prime Minister stated that the investment was the first step in the creation of the Western Australian Development Corp. designed to hold equity stakes in all natural resource projects.[7]

Commercial production of diamond from Argyle's Upper Smoke Creek alluvial deposit commenced on January 1, 1983, at an expanded rate of 4,400 short tons of ore per day. By yearend, 1.18 million short tons of ore had yielded 6.15 million carats of diamond. It was planned to continue alluvial operations for 3 years, and to phase in with the kimberlite mining operation.[8]

Argyle's diamond quality had been estimated through the testing and exploration phase as 10% gem and 20% to 25% near-gem. However, a yearend report by the Australian Bureau of Mineral Resources reestimated the quality to be 45% gem and cheap-gem, with the balance being industrial stones and grit.[9]

De Beers Central Selling Organisation (CSO) had a purchasing and marketing contract with the Argyle Diamond Sales Ltd. for 95% of the gem and 75% of the cheap-gem and industrial diamond stones covering the period of alluvial production and 5 years of large-scale mining of the AK-1 kimberlite pipe through 1990, which was estimated to have an annual production rate of 25 million carats. It was expected that Australia would be the world's largest producer of natural diamond commencing in 1986.

Two other companies reported diamond production from their exploration activities. The Bow River joint venture of Freeport of Australia Pty. Inc. and Gem Exploration & Minerals Ltd. recovered 2,177 diamonds with a total weight of 367 carats from 2,250 tons of ore at Limestone Creek near the Argyle deposit. Afro-West Mining Ltd. also reported recovery of diamonds from claims along Smoke Creek, downstream from the Argyle project.[10]

Botswana.—Botswana not only became the world's second largest producer of natural diamond, but the world's second largest producer of gem diamond. Three mines—Jwaneng, Letlhakane, and Orapa—reported production of 10.73 million carats, valued at $491 million, of which 4.3 million carats was of gem quality. The new Debswana's (De Beers-Government of Botswana joint venture) Jwaneng diamond mine west of Gabarone exceeded its nameplate capacity, and because of improved recovery processes, greatly increased its production ratio of small gem diamonds. Jwaneng produced almost 5.9 million carats of diamond, and another increase of up to 6.5 million carats was predicted for 1984, after which production would level off. In 1983, the Government of Botswana was forced to stockpile about one-third of its gem production, and the total value of its cumulative stockpile at yearend was about $600 million. This was principally because the world market for larger stones was weak, while the small gem and near-gem material was very strong. Botswana's diamond exports constituted about two-thirds of its total foreign exchange earnings.[11]

New diamond sorting and evaluation facilities were established for all of Botswana's production, and Mabrodium of Belgium was granted permission to establish a small diamond cutting and polishing factory. The first polished stone was produced in 1981 by the company's subsidiary, Diamond Manufacturing Co., in Gabarone.[12]

Evaluation of the DK7 kimberlite pipe near Jwaneng was near final evaluation at yearend 1983, and an agreement by De Beers and Falconbridge Explorations Botswana resulted in continuing examination and evaluation of other licensed areas.

Central African Republic.—The principal mining industry of the Central African Republic was diamond. State revenues from this production continued to erode. Illicit mining and trafficking was substantial. Reported production has been as high as 524,000 carats in 1974, but in 1982, this had fallen to 277,000 carats. This decrease had encouraged the Government to attract foreign investment. The major marketing cooperative consisting of nine companies produced 264,900 carats in 1983, and five other companies produced 30,500 carats. A 1981 World Bank International Development Association's $4 million technical assistance project loan had included a portion for diamond exploration and a feasibility study. The final report, submitted in 1983 by a Canadian contractor, was confidential.[13]

China.—A new diamond cutting and polishing plant was installed in Beijing in 1981, financed by the Dresdner Bank of the Federal Republic of Germany. The joint venture consisted of the China National Arts and Crafts Import and Export Corp. and the export firm F. K. Narasimham from Frankfurt Main, and Franz Amann of Brucken Pfalz. The plant consisted of several hundred cutting and polishing machines from Franz Amann and included a training school for several hundred students. It was estimated that the indigenous supply of rough diamond consisted of 20% gem and near-gem quality, thus making approximately 500,000 carats available for cutting. There was no domestic demand for cut diamond or diamond jewelry.

China had an ambitious plan for development of modern cutting and polishing plants using low-cost labor for an export-oriented industry. The plan also included manufacture of diamond machinery and tools.[14]

Colombia.—Smuggling of valuable emeralds from Colombia continued to make true production and revenues difficult to assess. Export revenues from all precious stones, principally emeralds, declined in 1982 by 17% to $43 million.[15]

Gabon.—The Government of Gabon reported that 25,913 carats of diamond had been produced in 1979 with a unit value of $16.53 per carat. No diamond production has been reported in recent years.[16]

Ghana.—Ghana Consolidated Diamonds Ltd., a Government corporation that operated a diamond placer deposit at Akwatia, reported that production of primarily industrial diamond decreased to an estimated 300,000 carats from 836,000 carats in 1981. The original Akwatia Valley placer gravel deposits were essentially depleted. Mining in 1983 was within a thin Akwatia terrace gravel pay zone. Current reserves were expected to be mined out within 10 years. Additional lower grade placer resources averaging 1 to 1.4 carats per cubic meter were known to occur in the Birim Valley. A United Nations Development Program team investigated these resources and found that development would require substantial new foreign investment.

Guinea.—Aredor-Guinea S.A. was expected to begin commercial production of its $80 million alluvial diamond project in the first quarter of 1984. The Aredor-Guinea alluvial gravel mining was to be accomplished by three 7-cubic-yard draglines with 140-foot booms, and loaded into 40-ton articulated vehicles for delivery to the nearby recovery plant. The plant consisted of a main recovery facility containing a heavy media separator, a washing section, a feed section, and a separator house.

Fifty percent of the Aredor-Guinea was owned by the Government of Guinea, and 50% by Aredor Holdings Ltd. of Australia. Aredor Holdings in turn was owned 79.2% by Bridge Oil Ltd., 11.3% by the World Bank's International Finance Corp., 5% by Industrial Diamond Co. of the United Kingdom, 3.5% by Bankers Trust Australia (UK) Ltd., and 1% by Simonius Vischer of Basel, Switzerland. With a production rate of 250,000 carats per year from 440,000 short tons of gravel, Aredor-Guinea had sufficient reserves for 14 years of operations. The alluvial deposit is located in the Kissidougou area in southeast Guinea near the Sierra Leone border. Initial prospecting and exploration indicated that average expected size of stone was 0.8 to 1 carat with an estimated value of $185 to $200 per carat. Marketing of the stones was to be done by Aredor Sales Pty. Ltd. of Basel, Switzerland, and managed by Industrial Diamond of London.[17]

The U.S. Overseas Private Investment Corp., after a detailed feasibility survey, was providing political risk insurance to Bridge Oil's investment.[18]

India.—The flourishing diamond cutting and polishing industry exported 5.4 million carats of finished stones valued at $1.1 billion, which required 27 million carats of imported rough stones as the raw material. This indicated an approximate recovery of 20% from rough to finished stone. The number of Indian gem skilled workers had increased to 350,000, most of whom reside in the Palanpur-Bombay area. The trade and industry was dominated by 250 related families, also from the Palanpur area.[19] India was the leading importer and exporter of diamonds in the world. Both private and governmental buyers were searching the world to establish continuous supplies of rough. India's Minerals and Metals Trading Corp. (MMTC) continued its attempts to conclude agreements with African diamond producing countries to bypass the hold De Beers' Diamond Trading Corp. and CSO have on the world market. However, little progress had been achieved. Recent reports from Australia showed similar failure of the MMTC for direct buying.

Despite efforts by the Indian Government to increase diamond mining, annual production had averaged only about 14,700 carats during the 1981-83 period. The largest single diamond found during the period was a 29-carat gem quality from Majhgawan.[20]

Indonesia.—The Anaconda Co. was exploring for diamond in central Kalimantan. Indonesia had produced about 15,000 carats of principally gem diamond from the alluvial gravels in recent years, and had been a producer of diamond since the 17th century.[21]

Israel.—Imports of rough diamond in Israel increased 37% to $782 million. Exports of cut and polished diamond goods increased 11% to 1.0 billion. However, about $100 million of the commodity trade deficit increase could be traced to the diamond trade.[22]

Ivory Coast.—The Government of Ivory Coast reported that 48,000 carats of diamond had been produced in 1979. No apparent production has been reported in recent years.

Liberia.—Two alluvial diamond mining areas were in operation, at Takpormah on the Lofa River 130 kilometers northwest of Monrovia and at Gbapa south of Nimba. Most gravels were screened, washed, and jigged or panned by hand. In 1982, 780 diamond mining licensees produced 433,000 carats valued at $26 million. Gem-quality, 2-carat diamonds were produced from Takpormah and up to 6 carats from Gbapa. Reported production decreased 24% in 1983 compared with that of 1982.

Mali.—The Malian Ministry of Energy and Mines and the French Office for Geological and Mining Exploration signed an agreement in Bamako to conduct diamond exploration and extraction in the Kenieba area.[23]

Namibia.—Despite the De Beers' CDM (Pty.) Ltd.'s temporary cutback near Oranjemund, 10.6 million short tons of gravel and conglomerate were processed to produce 963,000 carats of diamond, a reduction of 5%. The No. 4 plant foreshore mining face was maintained in operation throughout the year and extended about 130 meters seawards of the high water mark, and mining operations were starting to extend the seawall further westward into the sea. Operational bedrock depth was 15 meters below mean sea level. The ratio of gem to industrial quality was maintained at 95%.[24]

Pakistan.—In the previous few years, Pakistan had emerged as an important world producer of precious gem stones. In 1981, exports were $6.2 million of principally aquamarine, emerald, ruby, and topaz. The Gemstone Corp. of Pakistan, a Government corporation, had been set up in 1979 to promote the production of gem materials. Most of the gem stones were found in the northern areas of the country close to the Himalayas.[25]

Sierra Leone.—Sierra Leone's diamond production decreased from about 800,000 carats annually in 1978-79 to an estimated 275,000 carats in 1983. Estimated to be 70% gem quality, illicit mining and trafficking in Yengema and Tonge was reported to be uncontrollable. A new Kono kimberlite mining project was organized in 1983 by Sierra Leone Selection Trust and the Government of Guinea, which was projected to cost in excess of $100 million. The project was to be handled by the Guinean National Diamond Mining Co., which was 60% owned by the Government, and 40% owned by Sierra Leone Selection Trust (a subsidiary of British Petroleum Minerals Co.). Financing was to be obtained from European banking institutions, with loan guarantees by U.S. Overseas Private Investment. The feasibility of sinking a cheaper inclined shaft, rather than a vertical shaft, was being investigated.[26]

South Africa, Republic of.—Substantial increases in diamond production at the largest mine of De Beers, the Finsch, resulted in a 13% increase in South African diamond production to 10.3 million carats. Higher throughput and grade improvements resulted in recovery of more small gem diamond for the improving world market. However, De Beers' rough diamond stocks increased 10% to a total of $1.85 million. The farm Letitia kimberlite exploration was terminated at yearend by De Beers, but exploration of the farm Venetia continued. De Beers was also a successful bidder in two deepwater marine diamond prospecting concessions situated off the Namaqualand coast. Preliminary investigation was to require profiling of the coastal shore for location of gravel beds or heavy mineral concentrations.[27] A 471-carat flawless white diamond was found in a crusher at De Beers' Premier Mine near Pretoria. A 72-carat flawless white diamond had been found earlier in the year.[28]

There was spirited bidding on the shallow, mid-, and deepwater concessions on the Namaqualand coastline offered and awarded by the South African Government during the year. Bid awards were made to large companies and small independents such as De Beers, Newmont Mining Corp., O'Okiep Copper Co. Ltd., Rio Tinto Zinc Corp. Ltd., Terra Marina Mining Co. Ltd., and Oceaneering International Ltd.

Mafikeng Diamonds Ltd. was test mining an alluvial diamond deposit near Mafikeng, Bophuthatswana. Rio Tinto's subsidiary, Rio Tinto South Africa, was managing the daily throughput of 1,400 short tons of gravel. The test duration was to be a full year. The 2,300-hectare lease contained about 27 million short tons of gravel.[29]

Two kimberlite pipes, previously abandoned by De Beers as uneconomic, were being retested by Trans Hex Group Ltd. of Cape Town. The Swaziland Government issued a license to Trans Hex for the mining of the Ehlane and Dokolwayo pipes.[30]

Sri Lanka.—Sri Lanka, previously Ceylon, has been a world-class producer of gem stones since ancient times. Most important are sapphire, ruby, chrysoberyl, beryl, and spinel. Other gem stones include aquamarine, garnet, moonstone, topaz, tourmaline, and zircon. These precious stones are found in the layers of older alluvium and river gravels of Quaternary age in the valleys of the Ratnapura district in southwest Sri Lanka. The operations are a mixture of Government corporations, overseas joint ventures, and private entrepreneurs. Some priority has been given to the areas to be inundated by the Majaweli and Samanala Wewa irrigation projects. Regular gem auctions have been held since 1980.[31] The State Gem Corp. is significantly involved in the industry, but most of the production comes from the small miners. Simple hand washing processes are employed. Estimated 1981 exports and tourist sales were $91 million, an increase of 31% compared with that of 1980.[32]

In 1983, a large deposit of high-quality blue sapphires was discovered near the village of Aluth Nuwara in southern Sri Lanka. It was reported that many millionaires were created overnight, and as many as 10,000 people became rich. As much as 90% of the gems were smuggled out of the country.[33]

U.S.S.R.—Soviet diamond output increased 1% to 10.7 million carats, with no indication of any new diamond mining development. The Soviet method of diamond marketing had not changed for 20 years, with both polished diamonds and rough gems sold via Geneva and Antwerp. The Antwerp Diamond Association reported that rough diamond supplies from the U.S.S.R. were larger in 1983 than those from De Beers. Shipments of packets of Soviet cut stones in Antwerp indicated a somewhat lower quality, which may be a market phenomenon because of the higher demand for lower quality goods.[34]

A 95-carat gem diamond was found in Yakutsk, Siberia.[35]

Zaire.—Zaire was the world's largest producer of natural and industrial diamond. Société Minière de Bakwanga's (MIBA) diamond mine was at Mbuji Mayi on the river of the same name. MIBA continued its program to develop kimberlite deposits, because of the declining alluvial reserves. A new $8 million dredge, put into operation on the river, was expected to extend MIBA's life for alluvial mining by allowing the mining of adjacent river flats and terraces. The new dredge had an annual capacity of 1 million cubic meters and an operating depth of 28 feet.[36]

MIBA, 20% owned by Sibeka of Belgium and 80% by the Zairean Government, mined 1.4 million cubic meters of alluvials for a production of 5.5 million carats of diamond. Fourteen private offices purchased 5.9 million carats of artisanal diamonds worth over $71 million. In previous years, most of these diamonds had been smuggled out of Zaire. The quality of the combined diamond production of MIBA and 14 private offices was estimated to be 71% industrial stones and bort and the balance gem and cheap-gem. The Société Zairoise de Commercialisation de Minerais (Sozacom), Zaire's diamond marketing organization, which had taken over the independent marketing companies in Kinshasa and Tshikapa, reported a 58% decrease in diamond sales for a total of 423,000 carats of diamond, 60% gem quality. Despite the Government's efforts, illicit mining and trafficking of gem diamonds continued to be substantial.[37] Sozacom moved the sorting and grading of diamond from the Centre National d'Expertise office in Kinshasa to the Miba Mine Headquarters in Mbuji Mayi.[38]

Zambia.—Since 1974, emerald production from the Kafubu area of the Copperbelt had increased significantly, with about 18 known deposits being mined in 1983. The estimated value of emerald production was $100 million, with only 10% of the output reaching the official market. The bulk of the emerald was reportedly being mined illegally and smuggled out of the country.[39]

Table 8.—Diamond (natural): World production, by country and type[1]

(Thousand carats)

Country	1979 Gem	1979 Industrial	1979 Total	1980 Gem	1980 Industrial	1980 Total	1981 Gem	1981 Industrial	1981 Total	1982[p] Gem	1982[p] Industrial	1982[p] Total	1983[e] Gem[2]	1983[e] Industrial	1983[e] Total
Angola	630	211	841	1,110	370	1,480	1,050	350	1,400	915	310	1,225	900	300	1,200
Australia	--	--	--	--	48	48	21	184	205	70	487	557	2,170	4,030	[3]6,200
Botswana	659	3,735	4,394	765	4,336	5,101	744	4,217	4,961	1,165	6,604	7,769	4,300	6,431	[3]10,731
Brazil[e 4]	236	384	620	253	414	667	163	926	1,089	80	450	530	80	450	530
Central African Republic	205	110	315	227	115	342	209	103	312	186	91	277	[3]230	[3]65	[3]295
China[e]	NA	NA	NA	360	1,440	1,800	380	1,520	1,900	400	1,600	2,000	400	1,600	2,000
Ghana	125	1,128	1,253	126	1,132	1,258	85	751	836	68	616	684	30	270	300
Guinea[e]	27	58	85	12	26	38	12	26	38	13	27	40	15	30	45
Guyana	6	10	16	4	6	10	4	6	10	[e]5	[e]6	[e]11	4	5	9
India	14	2	16	12	2	14	14	2	16	11	2	13	13	2	15
Indonesia[e]	3	12	15	3	12	15	3	12	15	3	12	15	5	22	27
Ivory Coast	24	24	48	--	--	--	--	--	--	--	--	--	--	--	--
Lesotho	48	4	52	50	4	54	49	4	53	39	3	42	--	--	--
Liberia	170	132	302	123	175	298	132	204	336	170	263	433	132	198	[3]330
Namibia	1,570	83	1,653	1,482	78	1,560	1,186	62	1,248	963	51	1,014	915	48	[3]963
Sierra Leone	434	451	885	317	275	592	208	97	305	203	87	290	192	83	275
South Africa, Republic of:															
Finsch Mine	465	2,120	2,585	465	2,442	2,907	1,002	3,463	4,465	847	3,003	3,850	1,765	3,278	[3]5,043
Premier Mine	468	1,613	2,081	407	1,632	2,039	510	1,530	2,040	615	1,845	2,460	800	1,844	[3]2,644
Other De Beers properties[5]	1,850	1,370	3,220	1,550	1,489	3,039	1,603	1,069	2,672	1,359	906	2,265	1,400	569	[3]1,969
Other	403	95	498	390	145	535	314	35	349	521	58	579	589	66	[3]655
Total	3,186	5,198	8,384	2,812	5,708	8,520	3,429	6,097	9,526	3,342	5,812	9,154	4,554	5,757	[3]10,311
Tanzania	157	157	314	137	137	274	110	107	217	[e]100	[e]120	[e]220	125	125	250
U.S.S.R.[e]	2,200	8,500	10,700	2,250	8,600	10,850	2,100	8,500	10,600	2,100	8,500	10,600	3,700	7,000	10,700
Venezuela	247	556	803	238	483	721	102	388	490	[r e]99	[r e]394	[r e]493	100	400	500
Zaire	294	8,440	8,734	345	9,890	10,235	450	8,550	9,000	[e]450	[e]8,550	[e]9,000	3,172	8,266	[3]11,438
World total	10,235	29,195	39,430	10,626	33,251	43,877	10,451	32,106	42,557	10,382	33,985	44,367	21,037	35,082	56,119

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

[1]Table includes data available through May 16, 1984. 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 (1980-83), the Central African Republic (1979-81), Liberia (1979-81), Sierra Leone (1979-81), the Republic of South Africa (1979), and Venezuela (1979-81), 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]Figures represent officially reported output plus official Brazilian estimates of output by nonreporting mines; officially reported output was as follows, in thousand carats: 1979—83; 1980—158; 1981—136; 1982—212; and 1983—not available.

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

TECHNOLOGY

Heat treatment was one of the first methods people used to alter the appearance of gem stones. The Romans soaked ordinary agate in honey and heated it to produce black stone capable of taking a high polish. Throughout history, low levels of heat have been used to alter or improve the color of aquamarine, quartz, sapphire, topaz, and zircon. High technology has now improved this technique so that much more dramatic changes can be effected. It is likely that most modern-colored gem stones are treated by heat, or other means, and that detection can only be done by professional gemologists. A tabulation of all gem stones and their reaction to heat treatment and/or radiation, including detection methods, was published. Ethical practices of the industry were discussed in light of the knowledge that the general public is not aware of this color enhancement as compared with a natural gem stone.[40]

The Confederation Internationale de la Bijouterie, Dimants, Perles et Pierres (CIBJO) is composed of jewelry trade associations from 23 countries. The American Gem Trade Association, the largest association of colored stone dealers in the United States, voted to adopt the CIBJO definitions and rules of application. One of the definitions was article 7 prohibiting use of the term "semiprecious," indicating that the term "semiprecious" is unauthorized and false and must never be used.[41]

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[1]Physical scientist, Division of Industrial Minerals.

[2]The Riverton Ranger. June 17, 1983, p. 1.

[3]Iron Mountain, Michigan, News. Evidence of Kimberlite in Iron County. Apr. 16, 1983, p. 1.

[4]Helmore, R. The Reorganization of Mining in Angola. Min. Mag. (London), v. 148, No. 4, Apr. 1983, pp. 298-303.

[5]Mining Week, Mining Journal (London). Smuggling Thwarts Efforts to Raise Diamond Output. V. 202, No. 7750, Mar. 2, 1984, pp. 137-138.

[6]CRA Limited. Argyle Diamond Mines Joint Venture, Production Report. Fourth Quarter 1983 Press Release, Jan. 31, 1984, 4 pp.

[7]Jewelers' Circular-Keystone. West Australia OK's Argyle Expansion; Buys 5% Stake. V. 154, No. 11, Nov. 1983, p. H.

[8]Industrial Minerals (London). World of Minerals. No. 198, Mar. 1984, p. 9.

[9]U.S. Embassy, Canberra, Australia. State Dep. Airgram A-57, Apr. 4, 1984, p. 3 of enclosure.

[10]Mining Journal (London). Industry in Action. V. 301, No. 7739, Nov. 4, 1983, p. 329.

———. Bow River JV Diamond Find. Industry in Action. V. 301, No. 7730, Oct. 14, 1983, p. 283.

[11]Mmusi, P. S. Vice President and Minister of Finance and Development Planning, Government of Botswana. Budget Speech, 1984, p. 5.

[12]Mining Journal (London). Sales and Contracts. V. 302, No. 7751, Mar. 9,1984, p. 161.

———. Botswana. 1983 Mining Annual Review. June 1983, p. 392.

De Beers Consolidated Mines Ltd. 1983 Annual Report. P. 23.

[13]U.S. Embassy, Bangui, Central African Republic. State Dep. Airgram A-06, Enclosure 1, July 30, 1983, p. 2.

Foreign Broadcast Information Service. Paris Marches Tropicaux ET Mediterranees. No. 1928, Oct. 22, 1982, p. 2818.

Secretariat General. Ministere De L'Energie Des Mines & Geologie. Statistiques De Diamants Et Or. Annee 1983, p. 1.

[14]Diamond World. Rapid, Resolute Chinese Diamond Strides. July-Aug. 1981, p. 36.

Diamond News and SA Jeweller (Johannesburg). China Finds Gem. V. 43, No. 9, June 1980, pp. 3, 11.

[15]Mining Journal (London). Colombia. Slow But Sure. V. 301, No. 7728, Sept. 30, 1983. p. 235.

[16]U.S. Embassy, Libreville, Gabon. State Dep. Airgram A-20, Apr. 16, 1980.

[17]Mining Journal (London). Diamond Project on Schedule. V. 301, No. 7740, Dec. 23, 1983, pp. 451-452.

Industrial Minerals (London). Diamond Start-Up and CSO Sales. No. 197, Feb. 1984, p. 10.

[18]Mining Magazine (London). Panorama. Aredor Diamond Project, Guinea Nears Start-Up. Feb. 1984, pp. 118-119.

[19]The New York Times. Gem Trade, Legal and Illegal, Blooms in Bombay. V. 123, No. 45916, Jan. 7, 1984, p. 2.

[20]U.S. Embassy, Delhi, India. State Dep. Telegram 00467, Sec. 1 of 2, Jan. 9, 1983.

[21]U.S. Embassy, Jakarta, Indonesia. State Dep. Telegram 16198, Oct. 6, 1983.

[22]U.S. Embassy, Tel Aviv, Israel. State Dep. Telegram 8635, Jan. 13, 1984, p. 1.

[23]U.S. Embassy, Bamako, Mali. State Dep. Telegram 1813, Mar. 31, 1983.

[24]De Beers Consolidated Mines Ltd. 1983 Annual Report. Pp. 5, 19, 22.

[25]World Mining. Gem Industry Has Made Recent Major Progress. V. 36, No. 10, Oct. 1983, p. 99.

[26]South (London). Sierra Leone's Open Sesame. Jan. 1984, p. 10.

[27]De Beers Consolidated Mines Ltd. 1983 Annual Report. 53 pp.

[28]Government Gazette. Republic of South Africa. No. 7676, July 24, 1981, p. 27.

Mining Journal (London). Republic of South Africa. 1983 Mining Annual Review. June 1983, pp. 386-387.

[29]Industrial Minerals (London). Test Diamond Mining by RTZ. No. 1983, Oct. 1983, p. 11.

———. Diamonds from Mafikeng. No. 195, Dec. 1983, p. 13.

[30]Mining Journal (London). Industry in Action. V. 301, No. 7725, Sept. 9, 1983, p. 188.

[31]———. Sri Lanka. 1983 Mining Annual Review. June 1983, p. 380.

[32]Clarke, G. Sri Lanka's Industrial Minerals—Much Potential To Be Realized. Ind. Miner. (London), No. 193, Oct. 1983, pp. 67, 71.

[33]Penny Stock Journal. Out of the Blue, A "Gem Rush" Hits a Poor Village in Sri Lanka. V. 2, No. 26, Dec. 1983, p. 25.

[34]Mining Journal (London). Gemstones. 1983 Mining Annual Review. June 1983, p. 120.

[35]Chamber of Mines, Manila, Philippines. Newsletter. Dec. 1983, p. 6.

[36]Mining Journal (London). Zaire. V. 300, No. 7712, June 10, 1983, p. 391.

[37]World Mining. What's Going on in World Mining. V. 36, No. 2, Feb. 1983, p. 57.

[38]The Economist. De Beers is Zaire's Best Friend. AF Press Clips. V. 18, No. 11, Mar. 25, 1983, p. 15.

[39]Mining Journal (London). Zambia. 1983 Mining Annual Review. June 1983, p. 405.

[40]Huffer, H. Treated Gems: Why Not Face the Facts? Jewelers' Circular-Keystone, v. 154, No. 5, May 1983, pp. 33-80.

[41]Jewelers' Circular-Keystone. CIBJO Definitions and Rules of Application. V. 155, No. 2, Feb. 1984, p. 120.

Gold

By J. M. Lucas[1]

The lingering effects of the world economic recession on the mineral industry encouraged many fuel and nonfuel mineral producers to focus their attention on exploration for gold and silver. Hence, 1983 was marked by new, mostly small, discoveries of gold.

Domestic gold mine production of about 2 million ounces,[2] was the highest since 1953. The tonnage[3] of gold-bearing ore mined in 1983 increased by over 30% as new mines began production or reached peak productive capacity. Conversely, the demand for gold-bearing products generally declined, both in the United States and abroad, reflecting the influence of international economic and political events as well as ongoing technological changes in the manner in which gold is consumed. The price of gold, though characteristically erratic in its daily progress, increased 13% over the average for 1982.

Table 1.—Salient gold statistics

	1979	1980	1981	1982	1983
United States:					
Mine production ______ thousand troy ounces__	964	970	1,379	r1,466	1,957
Value ________________ thousands__	$296,550	$594,050	$633,918	r$550,968	$829,929
Percentage derived from:					
Precious metals ores__________________	58	66	71	80	83
Base-metal ores __________________	41	32	27	17	14
Placers__________________________	1	2	2	3	3
Refinery production:					
Domestic and foreign ores thousand troy ounces__	878	787	805	719	892
Secondary (old scrap) ___________do____	1,675	2,184	1,610	r1,444	1,380
Exports:					
Refined ____________________do____	15,590	4,702	5,238	1,637	1,881
Other_____________________do____	902	1,417	1,199	1,333	1,258
Imports for consumption:					
Refined ____________________do____	4,374	4,090	4,164	4,238	3,599
Other_____________________do____	256	452	488	682	994
Gold contained in imported coins_______do____	2,790	3,081	2,612	2,908	1,948
Net deliveries from foreign stocks in Federal Reserve Bank ______________do____	40	1,785	1,181	1,330	-220
Stocks, Dec. 31:					
Industry[1] _______________do____	868	872	635	776	630
Futures exchange _____________do____	2,473	4,998	2,449	2,303	2,530
Department of the Treasury gold medallion sales[2] do____	---	338	189	63	634
Consumption in industry and the arts____do____	4,785	3,215	3,276	r3,423	3,060
Price:[3] Average per troy ounce ____________	$307.50	$612.56	$459.64	$375.91	$424.00
Employment[4] ______________________	3,200	5,500	7,500	6,800	5,200
World:					
Production, mine ____ thousand troy ounces__	r38,830	r39,205	41,249	p43,057	e44,533
Official reserves[5] ______million troy ounces__	1,145.1	1,149.0	1,148.3	r1,143.5	1,140.6

eEstimated. pPreliminary. rRevised.
[1]Unfabricated refined gold held by refiners, fabricators, and dealers.
[2]Sales program began July 15, 1980.
[3]Engelhard Industries quotation.
[4]Mine Safety and Health Administration.
[5]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	1979	1980	1981	1982	1983
Commodity Exchange Inc	New York	654.15	788.72	1,041.67	1,212.40	1038.28
New York Mercantile Exchange	do	.21	(1)	--	--	--
International Monetary Market[2]	Chicago	355.87	254.35	251.82	153.35	99.40
Chicago Board of Trade	do	10.30	7.15	1.47	1.96	10.15
Mid-America Commodity Exchange	do	6.65	14.86	15.59	12.73	11.59
Total		1,027.18	1,065.08	1,310.55	1,380.44	1,159.42

[1]Less than 5,000 troy ounces. Trading in gold futures was terminated in Jan. 1980.
[2]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 134 lode gold producers in operation in 1983 to which a survey request was sent, 51% responded, representing 96% of the total mine production shown in tables 3, 4, 6, and 7. Production for the 65 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 Nevada Legislature amended the State tax on minerals to ensure that when minerals, such as gold and silver, are removed from Nevada, whether sold or not, exchanged, or used in a manufacturing process, the mine operator must pay a tax on their value.

On September 13, the first U.S. gold coins to be minted since 1933 were struck at the U.S. Bullion Depository at West Point, NY. They were authorized by Public Law 97-220, the Olympic Commemorative Coin Act, which provided for the minting and sale of more than 50 million gold coins by the U.S. Department of the Treasury. In authorizing the Olympic coin program, which also authorizes the minting and sale of silver coins, Congress provided that at least $50 from the sale of each gold coin was to go toward the support of U.S. athletes at the Olympic games to be held in Los Angeles in 1984. Although the new Olympic Gold Eagle coin bearing a 1984 date and containing 0.484 troy ounce of gold, went on sale to the public in October 1982, actual delivery to purchasers was to begin in 1984.

On December 20, 1983, the Commodity Futures Trading Commission approved the trading of gold coin futures contracts on the Chicago Mercantile Exchange and the Commodity Exchange Inc. in New York. By yearend, neither exchange had begun to offer a gold-coin-based contract; however, both had prepared tentative arrangements under which contracts would be proffered.

DOMESTIC PRODUCTION

Nevada was once again the Nation's principal gold producer, and 1983 marked the fourth consecutive year in which that State's gold mine production exceeded that of the previous year. Exploration for new domestic sources of gold continued at record high levels throughout the country and especially in the Western States and Alaska. A number of base metal producers as well as some companies traditionally involved only with fuels and other nonmetallic minerals directed some of their exploration budgets toward precious metals exploration. The favorable domestic economic and political climate also served to attract foreign exploration companies, principally Canadian. Nevada was the focal point of attention for the exploration for gold.

The 25 largest domestic gold mines produced 90% of all the gold mined in the United States during 1983. The top 10 mines accounted for 69% of the total gold produced. The average recovery grade of gold ores mined in lode mines was 0.05 ounce per short ton, while placer mines averaged 0.009 ounce per cubic yard of gravel washed.

Table 3.—Mine production of gold in the United States, by State

(Troy ounces)

State	1979	1980	1981	1982	1983
Alaska	6,675	12,881	26,531	30,513	34,702
Arizona	101,840	79,631	100,339	61,050	61,991
California	5,010	4,078	6,271	10,547	38,443
Colorado	13,850	39,447	51,069	64,584	63,063
Idaho	24,140	W	W	W	W
Montana	24,050	48,366	54,267	75,171	161,436
Nevada	250,097	278,495	524,802	r757,099	920,331
New Mexico	14,966	15,847	65,749	W	W
Oregon	W	W	2,830	W	322
South Carolina	--	--	W	--	--
South Dakota	245,912	267,642	278,162	185,038	309,784
Tennessee	--	--	W	--	--
Utah	260,916	179,538	227,706	174,940	238,459
Washington	W	W	W	W	W
Total	964,390	969,782	1,379,161	r1,465,686	1,957,379

rRevised. W Withheld to avoid disclosing company proprietary data; included in "Total."

Alaska.—One lode mine, the Independence Mine near Palmer, produced a small quantity of lode gold, but most of the gold produced in Alaska was recovered in metallic form from placer mining operations. Eight bucketline dredges, three large and five smaller ones, mined gold near Nome, the Hogatza River, and Nyac. An estimated 2,000 people were employed by the placer mining industry. Active gold mining operations in the State, excluding recreational placer mines, probably numbered more than 300. More than 800 mining licenses, mostly for placer mining, were issued by the State during the year.

Reported gold production was 34,702 ounces, valued at about $15 million, compared with 30,513 ounces in 1982, valued at about $11.5 million. However, an informal field survey of Alaskan gold producers by the Alaska State Division of Geological and Geophysical Surveys suggested quite a different production figure. The survey indicated that nearly 169,000 ounces of gold, valued at about $70 million, was recovered from Alaskan gold deposits, mostly placer deposits, during 1983, compared with 175,000 ounces in 1982, indicated by a similar survey. Nearly 11,000 mining claims were recorded in 1983 compared with about 15,000 in 1982. An estimated $21 million was spent in the State on exploration for precious metals. The much lower production figure reported on a voluntary basis to the Bureau of Mines by producers reflects a perennial reporting problem aggravated by the remote location of most of the mining operations.

Near the Alaska Gastineau Mine, south of Juneau, Juneau Mining Co. completed construction of a retreatment plant designed to recover both gold and silver from the tailings dumps of the old mine. The dumps, which are largely offshore in the Gastineau Channel, contain a considerable quantity of gold left over from earlier, less efficient gold recovery operations.

At yearend, Noranda Mining Inc. was awaiting Government approval of its joint-venture plan of operation for the new Greens Creek Mine on Admiralty Island, southwest of Juneau. The planned 300- to 800-ton-per-day underground operation was expected to produce silver, gold, lead, zinc, and copper and was to employ about 300 people when it comes on-stream in 1987.

Further to the southwest of Juneau, on Chichagof Island, Queenstake Resources Inc. conducted an extensive program of underground and surface exploration and evaluation at the old Chichagof gold mine, which was one of Alaska's most productive gold mines until its closure by the War Measures Act in 1942. Queenstake discovered many favorable gold targets, and sampling of the old mine tailings yielded further promising results. One-half mile north, Enserch Exploration Inc. conducted further exploration at the old Hirst-Chichagof Mine.

On Unga Island, in the Aleutian Islands, about 550 miles west of Anchorage, Alaska Apollo Gold Mines Ltd. reported encouraging assays following completion of a 20,000-foot exploration drilling program at its island claims. A comprehensive drilling program, to fill in details missed by the earlier program, was planned.

Along Valdez Creek, 160 miles northwest of Anchorage, a consortium of Canadian-based miners, including Camindex Mines, conducted a drilling program that delineated two separate channels of payable placer gravels. Some gold was recovered incidentally during exploration of the 1,200-acre property.

Along Tobin Creek, in the Chandalar District, the mechanized placer mine of Canadian Barranca Corp. Ltd., consisting of 71 claims along 16 miles of creekbeds, reportedly yielded 2,129 ounces of gold during the 90-day operating season. Studies by the company indicated that a minimum of 100,000 ounces of recoverable gold exists on the property, which is jointly held with Little Squaw Gold Mining Co. Work on the complex underground lode deposits on the property was confined to the 200-foot level and to an associated surface prospect. Access to these remote claims, located about 200 miles north of Fairbanks, was both difficult and expensive; bulldozer sled trains were employed to bring in heavy equipment during the winter, and aircraft were used during the dry summer season to transport personnel and supplies.

Noranda Mining's 62.5%-owned Northland Gold Dredging Ltd., which recovered nearly 2,000 ounces of gold from Tuluksac River gravels in 1982, produced only 190 ounces in 1983. Delays in obtaining permits forced Noranda Mining to cancel funding for the seasonal operations.

Delta Smelting and Refining Inc., a subsidiary of Delta Smelting and Refining Ltd. of Richmond, British Columbia, Canada, filed for bankruptcy. Many Alaska placer miners with precious metals on deposit with the firm experienced difficulty in financing their upcoming seasonal operations.

Mining claim status packets were issued for 11 quadrangles of the Alaskan interior, which showed active and abandoned claims from 1900 to 1979.[4]

Arizona.—Despite the lower production of copper in Arizona, where gold is an important byproduct, gold production increased. Exploration for gold and silver continued throughout the State, but was especially intense in Yuma County and in the newly created County of La Paz, formed from the northern half of old Yuma County. Mining and exploration activities in the nearby Cargo Muchacho and other mining districts of Imperial County, CA, sparked some of the interest in geologically continuous adjoining districts in Arizona.

The Small Mines Div. of Phelps Dodge Corp. reported that it produced 5,600 ounces of gold and 250,000 ounces of silver from its several small mines in Arizona; one of these was at Ash Peak in Greenlee County, another was at Bisbee in Cochise County, and several new properties were under investigation in Cochise County. The Small Mines Div. was formed in 1981 to acquire and develop ore bodies, especially those with gold and silver, that can be brought into production quickly and with a relatively low capital expenditure.

Ranchers Gold and Silver Exploration Program, a New Mexico limited partnership, continued to investigate its Mystic property, 9 miles north of Sun City, near Phoenix. The partnership acquired rights to additional acreage near the original Mystic property. The southern portion of the property, including the original Mystic holdings, on which drilling was performed, contains about 4,600 acres, and was designated "Mystic I." The northerly portion, or about 18,000 acres, was designated "Mystic II."

Although drilling on the original Mystic property indicated significant gold mineralization, further study will reportedly be necessary to determine if a commercially minable deposit of gold exists.

California.—Site preparation and construction at Homestake Mining Co.'s $250 million McLaughlin gold mine in northern California proceeded smoothly toward the scheduled early 1985 startup date. Homestake's discovery of the 3.2-million-ounce deposit was the largest gold find in California to date in this century. Located north of Knoxville, at the juncture of Napa, Lake, and Yolo Counties, the new mining and milling complex was expected to produce over 200,000 ounces of gold per year; this production combined with the approximately 300,000 ounces produced annually at Homestake's principal gold mine in South Dakota would make Homestake the largest gold producer in the Nation. Recovery of gold from McLaughlin ore will entail oxidation of the finely ground ore at high pressure and temperatures in giant autoclaves. Use of the autoclave process to recover the McLaughlin gold will mark the first time that this technology has been used on a commercial scale. The company reportedly expected a gold recovery rate of better than 90% using the new process.

At Jamestown, in Tuolumne County, 200 miles east of San Francisco, Sonora Mining Co. purchased New Jersey Zinc Exploration Co.'s interests in the old Crystalline, Jumper, Harvard, and Dutch-App gold mines, then announced plans to begin surface mining at a rate of 5,000 tons per day by late

1984. The old mines, known collectively as the Jamestown Mine, were expected to yield about 120,000 ounces of gold and 140,000 ounces of silver per year.

Gold Fields Mining Corp. continued evaluation of its Mesquite gold deposit, discovered in 1981, and announced that preliminary studies at the Imperial County property point to a production rate of about 100,000 ounces of gold per year beginning about mid-1986. Open pit mining methods and heap leaching will be employed at the new mine.

A multitude of other gold prospects in California, many former producing mines, were undergoing extensive exploration and development. Among those approaching production in the near future were Inca Resources Inc.'s Rich Gulch property in Plumas County, Terramar Resources Corp.'s Reid Mine near Redding in Shasta County, and the San Juan Ridge placer property of Placer Services Corp. near Nevada City.

Individuals mining placer gold with small floating suction dredges, a popular full-time and recreational pursuit in many parts of California, had a relatively successful year as witnessed by the recovery of several large nuggets; the largest, a 53-ounce mass, was recovered from a small stream near Alleghany in Sierra County.

Colorado.—Gold continued to be sought with vigor in Colorado's historic mining districts. Exploration companies seeking or developing gold prospects were active in the Jamestown and Gold Hill-Sugarloaf mining districts of Boulder County, in the old Alma District of Park County near Fairplay, in the Cripple Creek District of Teller County, in the Montrose-Ouray region of west-central Colorado, and in Custer County in south-central Colorado.

The decades-old discovery by State highway workers of fine gold in a sand and gravel deposit along the Arkansas River eventually led to the 1983 startup of a small gold dredging operation by the Petro Funding Corp. and its partner, Colorado Gold Brokers. The mine operators estimated that the small deposit, located near Las Animas in southeastern Colorado, contains in excess of 12,000 ounces of gold.

Near Silverton, Standard Metals Corp. of New York, operator of Colorado's largest gold mine, the Sunnyside, operated at a new record high level, producing an average of 25,000 to 28,000 tons of ore per month throughout the year.

In August, Hecla Mining Co. of Wallace, ID, signed an agreement with Texasgulf Inc. under which Hecla assumed active management of properties held by Texasgulf and the Golden Cycle Corp., operating jointly as the Cripple Creek and Victor Gold Mining Co. The properties, including the Ajax and Cresson Mines and the Carlton mill, are all in the Cripple Creek mining district of Teller County. Hecla agreed to increase the productive capacity of the existing mines and conduct further exploration and development.

Idaho.—At Yellow Pine, on Thunder Mountain in Valley County, Arivaca Silver Mines Ltd. and Copper Lake Explorations Ltd., both of Vancouver, British Columbia, Canada, completed modifications to the Dewey gold mill and began milling stockpiled ore from the nearby Dewey open pit. Also in Valley County, near the old settlement of Stibnite, the West End gold mine of TRV Minerals Corp., operated by majority partner Superior Mining Co., resumed seasonal production in mid-May; this surface-mining, heap-leaching operation, which began producing in 1982, was expected to yield over 30,000 ounces annually. Operators of the Golden Chest group of patented claims near Murray, north of the Coeur d'Alene mining district, began limited placer mining operations adjacent to the workings of the old Golden Chest Mine, a former producer. The feasibility of recovering gold from the old mine dumps on the property was also studied. As in previous years, exploration for precious metals continued throughout geologically favorable areas of the State.

An open file report by the U.S. Geological Survey indicated that traces of gold and other metals detected in Douglas fir trees and certain grasses on Red Mountain, in Valley County, may indicate the presence of low-grade gold deposits as well as serve as a guide for biogeochemical exploration in other areas with similar suites of vegetation.[5]

Montana.—In February, Placer U.S. Inc.'s (formerly Placer Amex Inc.) wholly owned Golden Sunlight Mines Inc. began full-scale open pit mining operations at the new Golden Sunlight gold mine east of Whitehall in Jefferson County. No major problems were encountered during startup, and design throughput of 5,000 tons per day was maintained throughout the year. A total of 79,700 ounces of gold was produced during this first year of operation.

In the Little Rockies District of Phillips

County, Zortman & Landusky Mining Co. continued to increase its rate of precious metals production. The company's two open pit, heap-leaching operations, which operate on a seasonal basis from February or March through mid-September, produced a record high 77,000 ounces of gold and 186,000 ounces of silver, up 10,000 ounces and 46,000 ounces, respectively, over 1982 production. The cutoff grade of the ore, bearing microscopic particles of gold, is 0.01 ounce per ton.

In Silver Bow County, southwest of Butte, Montoro Gold Co. was in the public-hearing stage of permitting for its proposed 50,000-ounce-per-year open pit, heap-leaching operation at German Gulch. Montoro Gold, of Vancouver, British Columbia, Canada, hoped to have the new mine, designated "Beal Mine," in operation by late 1985.

Three miles north of Cooke City, in Carbon County, Ranchers Exploration and Development Corp. of Albuquerque, NM, reported that drilling at the Golden Grizzly deposit appeared to have delineated a relatively small deposit, which is uneconomical at current gold prices.

In Park County, Homestake continued development and environmental assessment studies on the Jardine gold deposit, an old gold mining camp near Gardiner next to Yellowstone National Park.

The number of exploration licenses granted by the State increased from 161 licenses to 64 companies in 1982 to 201 licenses to 73 companies in 1983. Exploration activity, as well as activity associated with the opening or development of small lode and placer mines, was concentrated in the western half of the State.

Nevada.—At least seven new mines were opened and several new deposits were discovered. A few established producers announced plans to expand their productive capacities. Of the top 25 gold producers in the Nation during 1983, 10 were in Nevada.

Freeport Gold Co.'s Enfield Bell (Jerritt Canyon) Mine, in the Independence Mountains north of Elko, achieved record high production in 1983 of 262,000 ounces, 31% greater than its rated capacity of 200,000 ounces. The 2-year-old mining and milling complex was the largest gold producer in Nevada and the second largest in the Nation. Ownership of the operation is divided between Freeport Gold (70%), a subsidiary of Freeport-McMoRan Oil & Gas Co., and FMC Gold Co. (30%), a subsidiary of FMC Corp. During the year, Freeport converted the original dual-circuit mill to an improved single-circuit design that was expected to improve overall gold recovery and afford greater flexibility in handling the carbonaceous and oxide ores being mined. The average grade of the ore mined was 0.274 ounce per ton.

Carlin Gold Mining Co., a wholly owned subsidiary of Newmont Mining Corp., produced about 165,000 ounces of gold, mostly from the Carlin, Maggie Creek, and Blue Star pits. Included in this total was 37,000 ounces recovered by heap leaching lower grade ores from several company properties in the area, including test ores from the Gold Quarry deposit, which has been undergoing evaluation and engineering studies since its discovery by Newmont geologists in 1980. Mining of this large, complex ore body, estimated to contain about 8 million ounces of gold, was planned to begin in late 1985. Pending finalization of the program to develop the Gold Quarry deposit, the company deferred further evaluation of its Rain deposit, located 20 miles south of the Gold Quarry.

In February, Nerco Minerals Co., a wholly owned subsidiary of Nerco Inc., a mining subsidiary of the Pacific Power and Light Co., bought out Occidental Minerals Corp., including Occidental's 50% interest in the Alligator Ridge gold mine in White Pine County. The remaining 50% interest in the mine, which began production in 1981, was controlled by the operating partner, Amselco Minerals Inc.

At the Round Mountain gold mine, the operator, the Smokey Valley Div. of Louisiana Land & Exploration Co., continued to achieve dramatic increases in gold output, with production rising from about 72,000 ounces in 1982 to over 93,000 ounces in 1983. Production at the heap-leaching facility was scheduled to exceed 100,000 ounces in 1984.

At Battle Mountain, near Lander, the Metals Div. of the Duval Corp. continued premining stripping of the company's Fortitude gold discovery announced in 1981. Gold production at Duval's nearby Battle Mountain gold mine amounted to approximately 80,000 ounces in 1983.

Early in the year, Cortez Gold Mines, a subsidiary of Placer U.S. Inc., began open pit mining of gold ore from its new Horse Canyon ore body. Prior to the opening of the mine, feed for the mill at Cortez was derived from old dumps in the nearby Gold Acres area of the Bullion mining district. In May, the Cortez carbon-in-leach mill switched from the lower grade dump material to the higher grade Horse Canyon ore. The company expects to recover about 40,000 ounces of gold per year once the mine is fully operational and the mill has been tuned to accommodate the higher grade feed.

On the famed Comstock Lode, old underground dumps of gold-bearing gob or waste as well as new areas of commercial mineralization were the objectives of mining operations begun by the United Mining Corp. (UMC) in tunnels of the New Savage Mine underlying Virginia City. In April, the company began processing gold-bearing ores at its newly acquired 750-ton-per-day mill at American Flat. In January, the new mill and several nearby surface and underground properties were acquired by UMC, with the result that for the first time, all the operating mining properties in the Comstock Lode were controlled by a single owner. However, the subsequent discovery in May of high-grade gold elsewhere on the Comstock resulted in a flurry of claim staking and exploration by other companies.

In midyear, under an exploration and development agreement with Klondex Gold and Silver Mining Co., Minex Resources Inc. of Riverton, WY, began mining and heap-leaching operations at Klondex's Fire Creek gold property southwest of Carlin. In October, as the first part of a three-phase exploration and development plan, Minex completed leaching 10,000 tons of ore and poured its first bar of gold. In a joint venture between Centennial Minerals Ltd. and Electra Northwest Resources Ltd., both of Vancouver, British Columbia, Canada, open pit mining and heap-leaching operations were begun at the Aurora gold and silver property in Mineral County. The consortium expected to produce about 7,000 ounces from the property during 1983, and more in 1984. A number of other small open pit, heap-leaching operations similar to those above also began operating in the State in 1983.

At the Gooseberry Mine in Storey County, underground rehabilitation and infrastructural upgrading were completed, and the mine was returned to productive status in August by its new owner, Asamera Inc. Both mine production and mill throughput increased steadily toward yearend, with the mill attaining its fully rated capacity of 350 tons per day and an 85% recovery of the contained precious metal values.

During the year, there were numerous gold prospects throughout the State in various stages of exploration and development. Included among the recent discoveries were the Bluebird property of Kinetic Minerals Inc., adjacent to Battle Mountain in Lander County; the Santa Fe Prospect of Westley Mines Ltd. and Lacana Mining Inc.; Dee Gold Mining Co.'s new mine complex under construction at Boulder Creek in western Elko County; Placer U.S. Inc.'s Bald Mountain property in White Pine County where heap-leaching tests on crude ore began in October; the Buckhorn property of Cominco American Incorporated in Eureka County, southwest of Carlin, due on-stream in 1984; and Pacific Silver Corp.'s underground Buckskin Mine near Yerington, which was undergoing rehabilitation after having been closed for over 60 years.

Oregon.—Nearly 60% of the active mining operations in Oregon, excluding producers of sand and gravel and stone, listed gold as their principal product. Several small lode gold mines were intermittently worked during the spring and summer of 1983; the Pyx Mine in Grant County and the Thomason Mine in Baker County continued small-scale operations. In southwestern Oregon, the Sunny Valley Mining and Development Co. shipped a small amount of gold ore from the Greenback Mine in Josephine County, while small-scale placer operations in Josephine and adjoining Douglas Counties provided most of the State's production. In Baker County, UNC Resources Inc. acquired full ownership of the Cornucopia gold mine and planned to begin operations there in 1985.

The level of gold exploration activity noted in Oregon in 1983 increased over that of 1982. Exploration was conducted at nearly 50 sites, concentrated mostly in southwestern Oregon and in east-central Oregon on the Grant-Baker County line. The principal thrust was directed not only toward the old established gold districts, but also toward favorable ground in Harney, Lake, and Malheur Counties where many new gold prospects have been discovered since the recognition there, in 1978, of epithermal gold mineralization. Among the companies actively engaged in advanced stages of gold exploration in Oregon were the American Copper and Nickel Co., a subsidiary of Inco Ltd.; Nerco, a subsidiary of the Pacific Power and Light of Portland; and Silver King Mines Inc., which acquired the two-thirds interest that Texasgulf held in the

Iron Dyke Mine, a recent past producer of gold and copper.

South Dakota.—Despite the increasing number of large new gold mines starting up in other Western States, South Dakota's Homestake Mine at Lead retained its position as the Nation's number one producer. Homestake reported the production of 307,494 ounces of gold in 1983, compared with 185,039 ounces in 1982, when 4 months of production was lost owing to a strike. During 1983, the average grade of ore mined at Homestake increased 7%. Productivity increased by an average of 1.01 tons per worker-shift, or 13%. The gold recovery rate also improved by 2%, to 96.1%. Exploration of the mine's original opencut, first opened in 1877, continued throughout the year.

West of Lead, at an elevation of 6,000 feet, Wharf Resources USA Inc., of Helena, MT, advanced from an experimental stage to full production at the Annie Creek gold mine. Production at the new open pit, heap-leaching operation was expected to be about 18,000 ounces per year initially. Over 500,000 tons of ore was to be mined and processed annually. The company, in partnership with Homestake, also holds the adjoining Bald Mountain property, a potential gold producer.

Also west of Lead, Viable Resources Inc. of Casper, WY, and Freeport Exploration Co. were reported to have intersected significant gold values on their Richmond Hill Prospect. Near Galena, Lacana Mining Corp., of Ontario, Canada, acquired the Gilt Edge gold property, which contains open pit ore reserves of 10 million tons grading 0.05 ounce per ton. Exploration and metallurgical evaluation were expected to continue into 1984.

Utah.—The principal development relating to gold in Utah in 1983 was the July 22 dedication of the new Mercur gold mine by Getty Mining Co., a subsidiary of Getty Oil Co., and Getty's joint-venture partner, Gold Standard Inc., of Salt Lake City. The new mine, which was expected to produce 80,000 ounces of gold per year for 14 or 15 years, is at the old mining camp of Mercur, about 25 miles south of Tooele. Construction of the $90 million open pit mine began in August 1981, and its first gold bar was poured in April 1983. Vat leaching, carbon-in-leach, and electrowinning were employed at the 3,000-ton-per-day mill to recover gold, which occurs in the ore as micron-sized particles at an overall ore grade of 0.09 ounce of gold per ton.

The Utah Copper Div. of Kennecott, owner of the Bingham Canyon Mine, near Salt Lake City, was again the largest producer of byproduct gold, and ranked third among all gold producers.

Noranda Mining's small open pit gold property at Tecoma, UT, progressed to the point where a production decision was expected in 1984. Gold exploration in Utah continued to expand in 1983. In the East Tintic mining district in Utah County, Sunshine Mining Co., of Idaho, took an option on a large tract of land containing the Trixie Mine, a former gold producer closed in late 1982, and the Homansville Fault area, targeted by Sunshine for exploratory drilling. To the southwest, in Beaver County, a joint venture between Horn Silver Mines Inc. and Toledo Mining Co. was formed to explore the base and precious metals potential of properties held by Toledo near Milford; many of the properties were former precious metals producers.

Washington.—Of the nine mining projects under production or development in Washington, five were properties where gold was the principal commodity. Similarly, gold and silver were the commodities most sought after by the 60 to 80 mining companies actively exploring in the State. Predevelopment exploration was funded at essentially the same level as in 1982, but there were more firms contributing to the effort in 1983. The area around Wenatchee, Chelan County, continued to be the focal point of both exploration and of mineral land acquisition. More than one-half of the money spent for gold and silver exploration was invested in Chelan County as numerous companies responded to the spectacular drilling results announced early in the year from what is now the Cannon Mine, under development near Wenatchee. The news from the Cannon Mine led to the filing of over 1,000 mining claims in March alone. State sources reported that 19 companies were actively exploring for gold in Chelan County, whereas a similar report in 1982 listed only 2. At least 45 other companies were known to hold land positions in the county by yearend.

Encouraged by the results of their exploration at the Cannon Mine, joint venturers Asamera Inc., of Calgary, Alberta, Canada, and Breakwater Resources Ltd., of Vancouver, British Columbia, Canada, forged ahead with both exploration and development, adding new gold reserves and more than 1 mile of new underground workings, as well as initiating the construction of a new decline and a 22-foot-diameter shaft. Milling and surface support facilities were also in the initial stages of development toward yearend. Initial production was targeted to begin in early 1985.

Elsewhere in Washington, Hecla announced in late 1983 that it would close its Knob Hill Mine at Republic in mid-1984. The mine produced about 14,000 ounces of gold and about 80,000 ounces of byproduct silver during 1983, but ore reserves were near depletion. Nearby, Crown Resources Corp., of Denver, began producing gold and silver from the old Seattle Mine and was involved in joint-venture developments at the South Penn and Granny properties. In northern Ferry County, Vulcan Mountain Inc., of Lamona, WA, began gold and silver production using heap-leaching technology at the Gold Dike Mine. Considerable attention was drawn to the Junction Reef Prospect of Veronex Resources Ltd., of Vancouver, British Columbia, Canada, and Rexcon Inc., of Spokane, where exploration discovered anomalously high gold values disseminated in a stockwork system and some visible gold in an associated vein system. The prospect is geologically interesting as a potentially mineralized basement high surrounded by Columbia River basalt flows.

Other States.—In Marquette County, MI, Callahan Mining Corp. completed its study on reopening the Ropes gold mine and announced its decision to spend $3.1 million for rehabilitation of the former gold producer. Production was expected to begin, at a rate of 30,000 to 35,000 ounces per year, in 1985. Total capital costs required to bring the property on-stream at a rate of 1,000 tons per day was expected to range from $17 to $20 million.

Gold exploration activity in northern Minnesota intensified during the year as numerous major mining and exploration companies expanded their search there for precious metals. Thousands of acres of land thought to be underlain by gold-bearing greenstone formations similar to those being explored around Hemlo in nearby southern Ontario, Canada, have been leased from the State in Beltrami, Itasca, Koochiching, Lake, Lake of the Woods, Roseau, and St. Louis Counties. Geological and geophysical surveys were proceeding in this northern State area, generally between International Falls and Ely.

The Piedmont areas of Virginia, North Carolina, South Carolina, Georgia, and Alabama continued to receive attention from a number of companies seeking gold. Some of the major gold producers have maintained exploration offices in the South for several years. Near Goldvein in Fauquier County, VA, Callahan Mining Corp. drilled exploratory holes around the old Franklin Mine, a former producer first opened in 1835, and explored the Little Elliot Mine several miles to the south. In the same general area, Phelps Dodge was reported to have conducted geological reconnaissance around its holdings encompassing the old Culpeper Mine near Mine Run, off the Rapidan River in Culpeper County. Walnut Creek Mining Inc. continued to develop its gold interests in Orange County, VA, near Rhodesville and Wilderness. There were persistent rumors reported during the year to the Virginia State Geologist of coarse gold being recovered by recreational panners operating along various streams in Buckingham County.

Table 4.—Mine production of gold in the United States, by month

(Troy ounces)

Month	1979	1980	1981	1982	1983
January	71,827	77,922	98,887	106,956	131,404
February	68,850	78,301	93,385	109,407	128,668
March	75,567	87,040	115,200	138,066	150,340
April	75,222	89,477	110,366	[r]136,674	158,566
May	76,153	93,054	108,291	[r]143,212	175,893
June	76,500	83,279	119,676	[r]116,925	174,895
July	79,557	59,595	126,675	[r]114,845	175,474
August	92,974	57,130	125,505	[r]114,538	187,764
September	88,654	73,888	124,629	[r]109,024	184,971
October	92,331	84,161	123,201	[r]127,928	179,387
November	85,370	83,366	119,386	[r]127,843	162,163
December	81,385	102,569	113,960	[r]120,268	147,854
Total	964,390	969,782	1,379,161	[r]1,465,686	1,957,379

[r]Revised.

Table 5.—Twenty-five leading gold-producing mines in the United States in 1983, 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	Utah Copper (Bingham Canyon)	Salt Lake, UT	Kennecott	Copper ore.
4	Carlin & Maggie Creek Pit	Eureka, NV	Carlin Gold Mining Co	Gold ore.
5	Round Mountain	Nye, NV	Copper Range Co	Do.
6	Battle Mountain	Lander, NV	Duval Corp	Do.
7	Golden Sunlight	Jefferson, MT	Golden Sunlight Mines Inc	Do.
8	Alligator Ridge	White Pine, NV	Amselco Minerals Inc	Do.
9	Pinson	Humboldt, NV	Pinson Mining Co	Do.
10	Ortiz	Santa Fe, NM	Gold Fields Operating Co	Do.
11	Cortez	Lander, NV	Cortez Gold Mines	Do.
12	Landusky Project	Phillips, MT	Pegasus Gold Ltd	Do.
13	Sunnyside	San Juan, CO	Standard Metals Co	Do.
14	Mercur	Tooele, UT	Getty Minerals Co	Do.
15	Zortman Project	Phillips, MT	Pegasus Gold Ltd	Do.
16	Borealis Project	Mineral, NV	Tenneco Minerals	Do.
17	Jaime's Ridge	do	do	Do.
18	West End	Valley, ID	Superior Mining Co	Do.
19	DeLamar	Owyhee, ID	Mapco Minerals Corp	Gold-silver ore.
20	Northumberland	Nye, NV	Cyprus-Northumberland Project	Gold ore.
21	San Manuel	Pinal, AZ	Magma Copper Co	Copper ore.
22	Morenci	Greenlee, AZ	Phelps Dodge Corp	Do.
23	Nome Unit	Seward Peninsula, AK	Alaska Gold Co	Placer.
24	America	San Bernardino, CA	America Mine Operator	Gold ore.
25	Sterling	Nye, NV	Saga Exploration Co	Do.

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		Gold-silver ore		Silver ore		Copper ore	
		Short tons	Troy ounces of gold	Short tons	Troy ounces of gold	Short tons	Troy ounces of gold	Short tons	Troy ounces of gold
1979	9,527	7,045,714	516,747	756,220	35,184	962,289	5,816	234,631,289	383,348
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	r38,466	17,918,046	r1,124,225	1,213,247	37,697	5,318,490	13,539	162,286,553	233,093
1983:									
Alaska	34,649	--	--	--	--	--	--	--	--
Arizona	W	50,000	1,750	W	W	W	W	106,109,828	54,534
California	W	W	W	846	42	W	W	--	--
Colorado	W	W	W	3,189	65	28,842	198	--	--
Idaho	W	W	W	W	W	857,484	3,868	--	--
Montana	W	5,824,421	157,413	7,872	673	3,393,354	1,567	6,926,315	1,383
Nevada	W	12,079,819	878,059	W	W	2,644,301	27,401	--	--
New Mexico	--	W	W	13,294	888	97,515	985	W	W
Oregon	--	3,400	322	--	--	--	--	--	--
South Dakota	--	1,952,023	309,784	--	--	--	--	--	--
Utah	--	W	W	W	W	285,145	353	W	W
Washington	W	W	W	--	--	--	--	--	--
Total[1]	49,066	23,516,207	1,553,206	1,129,756	43,795	7,392,289	34,931	154,950,481	258,222
Percent of total gold	3	XX	79	XX	2	XX	2	XX	13

Year and State	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
1979	3,379,021	434	1,002,073	12,497	42,493	[2]837	247,819,099	964,390
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	r1,465,686

See footnotes at end of table.

Table 6.—Gold produced in the United States, by State, type of mine, and class of ore —Continued

Year and State	Lode —Continued						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
1983:								
Alaska	--	--	--	--	49	53	49	34,702
Arizona	--	--	--	--	W	W	106,370,155	61,991
California	--	--	--	--	--	--	562,101	38,443
Colorado	--	--	W	W	--	--	1,042,895	63,063
Idaho	--	--	--	--	--	--	W	W
Montana	--	--	--	--	W	W	16,276,142	161,436
Nevada	--	--	--	--	W	W	15,352,262	920,331
New Mexico	--	--	--	--	--	--	W	W
Oregon	--	--	--	--	--	--	3,400	322
South Dakota	--	--	--	--	--	--	1,952,023	309,784
Utah	--	--	--	--	W	W	34,310,991	238,459
Washington	--	--	--	--	--	--	W	W
Total[1]	--	--	(3)	(3)	[4]856,549	[6]18,159	187,845,282	1,957,379
Percent of total gold	XX	--	XX	(3)	XX	1	XX	100

[r]Revised. W Withheld to avoid disclosing company proprietary data; included in "Total." XX Not applicable.
[1]Data may not add to totals shown because of items withheld to avoid disclosing company proprietary data.
[2]Includes gold recovered from tungsten ore.
[3]Included in "Old tailings, etc." to avoid disclosing company proprietary data.
[4]Includes lead-zinc ore.
[5]Includes gold recovered from lead-zinc and molybdenum ores.
[6]Includes gold recovered from lead-zinc 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)
1979	7,676	1,238	7,674,000	518,554	270,523,587	r4,916,839	415,968	[2]643,408	19,103	278,848,671	954,863
1980	128,334	9,015	11,779,580	603,255	235,024,840	r5,556,520	324,132	[2]566,204	16,412	247,498,958	952,814
1981	186,790	14,945	15,899,228	912,742	294,297,268	r6,213,345	404,750	[2]486,916	[3]17,859	310,870,202	[3]1,350,296
1982	236,000	25,416	19,910,268	r1,101,721	193,630,280	r3,937,951	290,023	[2]353,088	[3]10,143	214,129,636	r [3]1,427,303
1983:											
Alaska	--	--	--	--	--	--	--	85	53	85	53
Arizona	--	--	50,000	1,750	128,234,846	2,251,830	54,616	149,777	[3]5,625	128,434,623	[3]61,991
California	W	W	W	W	W	W	W	W	W	W	W
Colorado	W	W	W	W	W	W	W	W	W	W	W
Idaho	--	--	W	W	W	W	W	W	W	W	W
Montana	--	--	5,807,045	156,778	10,463,178	120,214	3,662	6,426	[3]996	16,276,649	[3]161,436
Nevada	--	--	14,947,960	918,432	404,290	5,196	1,394	12	[3]505	15,352,262	[3]920,331
New Mexico	--	--	W	W	W	W	W	W	W	W	W
Oregon	W	W	--	--	W	W	W	W	W	3,414	322
South Dakota	--	--	1,952,023	309,784	--	--	--	--	--	1,952,023	309,784
Utah	--	--	977,405	37,996	33,310,215	694,908	198,876	23,386	1,587	34,311,006	238,459
Washington	--	--	--	--	W	W	W	--	--	W	W
Total	137,200	24,689	27,211,504	1,567,021	193,173,739	3,817,671	306,607	284,196	[3]10,494	220,806,639	[3]1,908,811

rRevised. W Withheld to avoid disclosing company proprietary data; included in "Total."

[1]Includes old tailings and some nongold-bearing ores not separable, in amounts ranging from 0.15% to 0.25% of the totals for the years listed. Excludes molybdenum and tungsten ores from which gold was recovered as a byproduct and ores leached for recovery of copper.

[2]Revised to exclude copper precipitates smelted.

[3]Includes some placer production to avoid disclosing company proprietary data.

Table 8.—Gold produced in the United States by cyanidation[1]

Year	Leaching in vats, tanks, and closed containers[p] [2]		Leaching in open heaps or dumps[3]	
	Ore treated (thousand short tons)	Gold recovered[4] (troy ounces)	Ore treated (thousand short tons)	Gold recovered (troy ounces)
1979	6,058,973	457,740	1,615,027	60,814
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	11,485,384	1,066,513	15,726,120	500,508

[p]Preliminary.
[1]May include small quantities recovered by leaching with thiourea, by bioextraction, and by proprietary processes.
[2]Includes autoclaves.
[3]May include old 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:						
1979	2	3	475	3	$977	$2.056
1980	2	3	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
Dragline dredging:						
1979	3	10	[3]86	[4]4	1,110	[5]4.019
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	[r] [3]29	[4]3	[r]1,188	[r] [5]18.960
1983	2	13	[3]110	[4]3	1,333	[5]3.481
Hydraulicking:						
1979	8	8	176	2	613	3.480
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
Nonfloating washing plants:						
1979	7	8	[3]42	[4]1	225	[5]2.988
1980	7	10	[3]314	[4]4	2,605	[5]7.811
1981	9	13	[3]894	[4]9	4,438	[5]4.869
1982	10	11	805	13	4,829	6.000
1983	5	5	646	13	5,406	8.364
Underground placer, small-scale mechanical and hand methods, suction dredge:						
1979	3	3	4	([6])	5	1.281
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
Total placers:[7]						
1979	23	32	[3]784	[4]10	2,930	[5]2.639
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	[r] [3]5,584	[4]38	[r]14,460	[r] [5]2.475
1983	34	47	[3]5,711	[4]49	20,804	[5]3.454

[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 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)

Source	1979	1980	1981	1982	1983
Concentrates and ores:					
Domestic	795	773	801	718	885
Foreign	83	14	4	1	7
Old scrap[1]	1,675	2,184	1,610	[r]1,444	1,380
New scrap	1,208	1,640	1,475	1,596	1,580
Total[2]	3,761	4,612	3,890	[r]3,760	3,853

[r]Revised.

[1]Excludes upgrading of U.S. Government-owned gold (mostly coin gold) by the U.S. Assay Office, amounting to 3,000,068 ounces in 1979, 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.

In North Carolina, the Canadian-based companies Petromet International Inc. and Canorex International Inc. optioned the old Portis Mine in Franklin County, north of Raleigh. The partners completed some drilling and trenching during the year. To the southwest in Montgomery County, Corvette Petroleum Corp. and Harlin Resources Inc., both of Vancouver, British Columbia, Canada, conducted drilling and geophysical tests on their holdings at the old Montgomery Mine, while the old Howie gold mine in nearby Union County received attention from Yellowknife Bear Resources, also of Canada. There were also reports of corporate gold exploration activities in Rowan and Cabarrus Counties.

In South Carolina, Amselco Minerals, a subsidiary of British Petroleum Ltd., was exploring and evaluating gold prospects near Ridgeway, while Piedmont Land and Exploration pursued development permits and exploration interests at the old Haile Mine, 3 miles northeast of Kershaw in Lancaster County. There was also some activity centered around the old Brewer Mine in adjoining Chesterfield County.

Developments in Georgia and Alabama were generally restricted to recreational gold mining and some unobtrusive exploration by various corporate interests.

Refinery production of gold recovered from foreign and domestic ores increased substantially during the year as domestic mines increased their output. Gold refined from old scrap declined somewhat from the 1982 level, while gold recovered from new scrap was essentially unchanged. In Salt Lake City, UT, Johnson Matthey Refining Co. began operating its new gold and silver refinery. The new $10 million facility had an annual capacity of 1 million ounces of gold and 4 million ounces of silver.

CONSUMPTION

The decline in domestic gold jewelry demand, where gold may assume a dual role as an item of adornment and one of investment, may perhaps be attributed in part to the widespread availability of a wide range of alternative investments. Declines in those sectors where gold is an important, if not vital, constituent of many industrial products such as electronics, probably mirrors the poor demand for many industrial products in 1983.

The net quantities of gold bullion and gold in coins for investment purposes that flow to or from the private sector, excluding industry, are not reported. It was estimated that the purchases of gold bullion for investment purposes were more than offset by sales by investors to industrial purchasers or for export. An estimated 2.5 million ounces of gold coin was believed to have been absorbed by the private sector, exclusive of industry.

The volume of gold futures contracts traded on U.S. futures exchange markets began 1983 at record levels; in January, nearly 160 million ounces was traded. However, trading activity generally trailed off toward yearend, with December volumes down by one-half or more from January levels on most exchanges. Following a Commodity Futures Exchange Commission ruling that allowed the trading of gold options to begin in 1982, gold option trading began in earnest in 1983, increasing in popularity toward yearend.

Table 11.—U.S. consumption of gold,[1] by end use

(Thousand troy ounces)

End use	1979	1980	1981	1982	1983[2]
Jewelry and the arts:					
Karat gold	2,276	1,249	1,420	r1,638	1,413
Fine gold for electroplating	32	30	24	17	18
Gold-filled and other	380	226	286	301	237
Total	2,688	1,505	1,730	r 31,954	1,668
Dental	646	341	314	358	360
Industrial:					
Karat gold	64	38	50	64	44
Fine gold for electroplating	797	592	528	r389	344
Gold-filled and other	545	657	633	r649	640
Total	1,406	1,287	31,210	r1,102	1,028
Small items for investment[4]	45	82	22	9	4
Grand total	4,785	3,215	3,276	r3,423	3,060

rRevised.
[1]Gold consumed in fabricated products only; does not include monetary bullion.
[2]Data may include estimates.
[3]Data do not add to total shown because of independent rounding.
[4]Fabricated bars, medallions, coins, etc.

STOCKS

Official.—The decline in stocks of bullion held by the U.S. Department of the Treasury was attributed in part to the use of bullion stocks to satisfy the minting requirements of both the Department's gold medallion sales program and the new gold coin commemorating the 1984 Olympic Games.

Official gold reserves of the market economy countries, including stocks held by the International Monetary Fund (IMF) and the Bank for International Settlements, totaled 1.141 billion ounces at yearend 1983. IMF bullion stocks at yearend 1983 were essentially unchanged from stocks held at the close of 1982.

Commercial.—The substantial liquidation of industrial stocks of refined gold probably reflected reduced expectations and a decision by the industry to maintain lower inventories.

Table 12.—Yearend stocks of gold in the United States

(Thousand troy ounces)

	1979	1980	1981	1982	1983
Industry	868	872	635	776	630
Futures exchange	2,473	4,998	2,449	2,303	2,530
Department of the Treasury[1]	264,614	264,330	264,116	264,046	263,406
Earmarked gold[2]	359,285	354,453	350,640	348,555	341,402

[1]Includes gold in Exchange Stabilization Fund.
[2]Gold held for foreign and international official accounts at New York Federal Reserve Bank.

PRICES

The Engelhard Industries price for gold, though lower in 1981 through 1983 than the record high level of $850 set in early 1980, remained well above levels established prior to 1980. The Engelhard-London daily final gold price began 1983 at $449.50, peaked at $509.25 in mid-February, declined erratically to the year's low of $374.65 in

November, and closed the year at $382.25. The average price for the year was $424.00 per troy ounce. Since 1979, nearly all of the industrialized nations have adopted market-related prices for evaluation of their bullion reserves; in 1983, the United States was the only holder of large gold stocks still valuing its bullion at a fixed price ($42.22 per ounce).

Table 13.—U.S. gold prices[1]

(Dollars per troy ounce)

Period	Low	High	Average
1979	217.15	517.00	307.50
1980	481.50	850.00	612.56
1981	391.25	599.25	459.64
1982	276.75	481.00	375.91
1983:			
January	449.50	499.50	479.84
February	408.50	509.25	490.41
March	408.75	434.75	419.70
April	417.00	443.00	432.09
May	431.00	443.75	437.67
June	400.25	423.50	412.84
July	410.75	430.50	423.41
August	408.25	426.40	416.27
September	401.75	418.25	411.46
October	382.00	401.40	393.98
November	374.65	405.00	382.35
December	375.00	401.00	388.02
Average	374.65	509.25	424.00

[1]Engelhard Industries daily quotation.

FOREIGN TRADE

In addition to 3.6 million ounces of refined gold imported during the year, an estimated 2 million ounces of gold in coins was also imported; of this total, 52% came from the Republic of South Africa, 32% from Canada, and 4% from Mexico.

Table 14.—U.S. exports of gold, by country

Year and country	Ore, base bullion, scrap		Refined bullion		Total	
	Troy ounces	Value (thousands)	Troy ounces	Value (thousands)	Troy ounces	Value (thousands)
1979	901,527	$287,361	15,589,872	$4,620,503	16,491,399	$4,907,864
1980	1,416,634	860,501	4,702,197	2,787,431	6,118,831	3,647,932
1981	1,199,421	570,549	5,237,585	2,501,337	6,437,006	3,071,886
1982	1,333,210	498,139	1,637,184	590,947	2,970,394	1,089,086
1983:						
Belgium-Luxembourg	127,485	51,104	--	--	127,485	51,104
Brazil	226	92	27,045	12,110	27,271	12,202
Canada	578,044	218,183	1,490,610	658,351	2,068,654	876,534
France	131,039	54,775	84	31	131,123	54,806
Germany, Federal Republic of	22,286	8,980	1,033	434	23,319	9,414
Israel	59	10	8,507	3,597	8,566	3,607
Japan	6,347	2,118	81,420	33,933	87,767	36,051
Kuwait	--	--	3,535	1,495	3,535	1,495
Sweden	16,080	6,480	2	1	16,082	6,481
Switzerland	33,499	11,160	197,541	84,777	231,040	95,937
United Kingdom	339,869	146,901	895	303	340,764	147,204
Uruguay	--	--	63,797	27,990	63,797	27,990
Other	2,866	1,213	6,764	2,397	9,630	3,610
Total[1]	1,257,800	501,016	1,881,233	825,418	3,139,033	1,326,434

[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, base bullion, scrap		Refined bullion		Total[1]	
	Troy ounces	Value (thousands)	Troy ounces	Value (thousands)	Troy ounces	Value (thousands)
1979	255,896	$79,534	4,373,802	$1,400,669	4,629,698	$1,480,203
1980	451,509	243,230	4,090,488	2,506,889	4,541,997	2,750,120
1981	487,675	214,927	4,164,476	1,942,560	4,652,151	2,157,487
1982	682,661	242,885	4,237,669	1,650,719	4,920,330	1,893,604
1983:						
Argentina	3,122	1,223	15,478	6,882	18,600	8,105
Belgium-Luxembourg	8,172	3,491	111,583	50,934	119,755	54,425
Bolivia	25,157	8,439	25,083	10,137	50,240	18,576
Canada	358,497	149,417	1,918,262	837,351	2,276,759	986,768
Chile	154,078	62,229	157,105	69,437	311,183	131,666
Colombia	1,672	694	7,011	2,881	8,683	3,575
Dominican Republic	207,903	88,197	37,086	15,750	244,989	103,947
France	13,112	5,568	2,191	940	15,303	6,508
Germany, Federal Republic of	14,952	7,740	317	235	15,269	7,975
Guyana	10,234	3,569	2,326	856	12,560	4,425
Hong Kong	2,710	984	65,377	28,479	68,087	29,463
Japan	1,430	450	73,841	32,537	75,271	32,987
Korea, Republic of	1,369	338	16,459	7,459	17,828	7,797
Malaysia	6,418	2,372	--	--	6,418	2,372
Mexico	12,404	4,811	5,428	2,377	17,832	7,188
Netherlands	57	11	20,972	10,615	21,029	10,626
Nicaragua	--	--	5,069	2,381	5,069	2,381
Panama	446	35	15,000	5,692	15,446	5,727
Peru	45,685	17,149	83,343	35,744	129,028	52,893
Philippines	41,151	15,923	--	--	41,151	15,923
South Africa, Republic of	8,146	3,394	26,546	12,161	34,692	15,555
Switzerland	1,434	607	335,170	147,103	336,604	147,710
United Kingdom	20,683	8,689	13,128	5,436	33,811	14,125
Uruguay	2,353	460	603,644	266,519	605,997	266,979
Venezuela	31,185	9,100	17,248	5,894	48,433	14,994
Yugoslavia	--	--	29,695	12,889	29,695	12,889
Other	21,423	6,660	11,826	4,879	33,249	11,539
Total[1]	993,793	401,548	3,599,188	1,575,570	4,592,981	1,977,118

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

Table 16.—Value of U.S. gold trade

(Thousand dollars)

Year	Exports	Imports[1] for consumption
1979	4,907,864	1,480,203
1980	3,647,932	2,750,120
1981	3,071,886	2,157,487
1982	1,089,086	1,893,604
1983	1,326,434	1,977,118

[1]Values of general imports were as follows: $1,506,716,888 (1979), $2,795,549,207 (1980), $2,197,944,569 (1981), $1,940,356,813 (1982), and $1,995,529,387 (1983).

WORLD REVIEW

The upward course of world mine production continued in 1983, with the Republic of South Africa accounting for about 50% of the world mine output, and the U.S.S.R., Canada, the United States, China, Brazil, and 58 other countries accounting for the remainder.

Consolidated Gold Fields' annual summary of world gold supply and demand reported that the supply of gold (excluding most secondary gold) available to commercial purchasers in the market economy countries in 1983 was about 42 million ounces;[6] of this total, about 35 million ounces was mined in the market economy countries; 3 million ounces originated as net trade with the centrally planned economy countries such as the U.S.S.R., China, and North Korea; and net sales of gold to the market from official or governmental sources amounted to about 3.8 million ounces. Again, as in years past, most of the gold entering the market from the Republic of South Africa, the U.S.S.R., and several other producing countries continued to be traded through Switzerland, England, and other Western European countries.

According to the Consolidated Gold Fields' report, the demand for gold in the commercial sector of the market economy countries during 1983 was about 32.2 million ounces, a decline of about 2.3 million ounces from the demand level estimated for 1982. Gold consumed in the developed and developing countries, combined, of the market economy world was divided, in millions of troy ounces, between the following end-use categories: jewelry, 19.2; electronics, 3.1; dental, 1.7; other industrial and decorative uses, 1.9; medallions and unofficial coins, 1.0; and official coins, 5.3.

Table 17.—Gold: World mine production, by country[1]

(Troy ounces)

Country[2]	1979	1980	1981	1982[p]	1983[e]
Argentina	10,140	10,622	14,757	20,319	21,000
Australia	596,910	[r]547,687	590,737	866,815	1,035,250
Bolivia	30,319	52,075	66,372	40,146	[3]49,678
Brazil[e 4]	320,000	1,300,000	1,200,000	[r]1,500,000	1,600,000
Burundi	133	130	[e]100	[e]100	100
Cameroon	147	72	316	[r e]300	300
Canada	1,644,265	1,627,477	1,672,893	2,081,230	2,274,480
Central African Republic	2,181	[e]2,000	1,386	1,000	[3]2,492
Chile	111,405	219,773	400,479	543,569	562,600
China[e 5]	200,000	225,000	1,700,000	1,800,000	1,900,000
Colombia	269,369	510,439	529,214	481,846	[3]428,779
Congo	(6)	(6)	48	83	80
Costa Rica[e]	[r]16,700	[r]18,000	[r]20,000	[r]27,000	30,000
Dominican Republic	352,982	369,603	407,813	380,254	[3]348,065
Ecuador	[r]2,251	[r]2,476	2,347	[r e]2,300	2,100
El Salvador	2,720	2,492	3,883	3,300	3,000
Ethiopia	[7]7,970	[e]9,000	11,930	[r e]12,000	14,000
Fiji	[r]31,765	[r]23,939	30,595	46,821	50,000
Finland	28,325	41,828	31,893	36,780	37,000
France	54,109	37,391	36,362	67,967	70,000
French Guiana[e]	5,000	4,000	4,000	[r]4,000	4,000
Gabon	964	553	[e]550	[e]550	550
Germany, Federal Republic of	2,357	2,964	3,051	1,813	1,900
Ghana	[r]357,000	353,000	341,000	331,000	303,000
Guyana	10,593	11,003	19,263	8,643	9,000
Honduras	1,501	2,027	1,579	1,711	1,700
Hungary[e]	60,000	60,000	60,000	50,000	30,000
India[8]	84,781	78,834	79,875	71,935	69,000
Indonesia[9]	[r]61,278	[r]58,383	54,240	71,879	73,800
Japan	127,626	102,339	99,242	104,136	[3]100,921
Kenya	[e]200	125	[e]100	21	20
Korea, North[e]	160,000	160,000	160,000	160,000	160,000
Korea, Republic of[8]	[r]24,081	[r]41,217	43,146	55,749	60,000
Liberia	1,086	7,243	[10]16,864	[10]12,656	[10]15,400
Madagascar	125	114	[e]110	[r e]110	110
Malaysia:					
Peninsular Malaysia	5,493	4,621	5,691	5,814	5,600
Sabah	55,292	60,905	69,915	[e]70,000	70,000
Sarawak	1,063	379	82	26	100
Mali[e]	[r]5,000	[r]10,000	[r]16,000	[r]13,000	13,000
Mexico	190,364	195,991	203,160	196,248	209,000
New Zealand	6,998	6,419	6,071	7,775	8,000
Nicaragua	61,086	59,994	[e]62,000	51,849	[3]46,742
Papua New Guinea	630,496	451,707	540,325	563,538	[3]582,000
Peru	[r]141,656	[r]142,041	176,057	164,547	165,000
Philippines	535,166	[r]643,806	753,451	834,439	801,710
Portugal	10,706	8,855	10,931	6,783	7,000
Romania[e]	65,000	65,000	65,000	65,000	65,000
Rwanda	472	944	1,204	286	[3]623
Sierra Leone[11]	NA	407	3,435	8,730	9,000
Solomon Islands	1,076	1,093	1,050	[r e]1,110	1,100
South Africa, Republic of	22,617,179	21,669,468	21,121,157	21,355,111	[3]21,847,310
Spain	91,404	108,154	98,381	108,508	110,000
Sudan[e]	300	300	300	400	500
Suriname	300	350	[e]380	599	600
Sweden[e]	70,000	70,000	70,000	[r 3]77,160	77,000
Taiwan[8]	14,243	13,278	56,695	71,770	[3]52,361
Tanzania	322	246	[r e]400	[r e]600	800

See footnotes at end of table.

Table 17.—Gold: World mine production, by country[1] —Continued

(Troy ounces)

Country[2]	1979	1980	1981	1982[p]	1983[e]
U.S.S.R.[e]	8,160,000	8,300,000	8,425,000	8,550,000	8,600,000
United States	964,390	969,782	1,379,161	1,465,686	1,957,379
Venezuela	14,989	[r]13,565	18,326	27,993	25,000
Yugoslavia[8]	138,987	106,226	115,164	[e]122,000	120,000
Zaire	[r]73,368	[r]40,864	64,430	62,233	60,000
Zambia	7,933	10,576	10,545	13,439	[3]10,159
Zimbabwe	388,000	368,000	371,000	426,000	430,000
Total	[r]38,829,566	[r]39,204,777	41,249,456	43,056,677	44,533,309

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

[1]Table includes data available through May 30, 1984.

[2]Gold is also produced in Bulgaria, Burma, Czechoslovakia, the German Democratic Republic, Guinea, Norway, Poland, Senegal, Thailand, and several other countries. However, available data are insufficient to make reliable output estimates.

[3]Reported figure.

[4]Officially reported figures are as follows, in troy ounces; major mines: 1979—107,158; 1980—131,432; 1981—140,691; 1982—148,408; small mines (garimpos): 1979—36,234; 1980—310,704; 1981—414,744; 1982—671,982.

[5]Very conservative estimate of output 1979-80; total national production probably is much greater than these estimates, but no basis for quantification of the balance of output is available; 1981-83 based on estimates prepared by the Gold Institute, Washington, DC.

[6]Revised to zero.

[7]Data are for year ending July 6 of that stated.

[8]Refinery output.

[9]Excludes production from so-called "people's mines."

[10]These figures are based on gold taxed for export and include gold entering Liberia undocumented from Sierra Leone and Guinea.

[11]Excludes estimates of gold produced in Sierra Leone, which is moved through undocumented channels for sale in Liberia.

Australia.—Gold exploration, especially in Western Australia, was unusually intense; scores of both new and long-familiar gold prospects were under investigation, and efforts to discover or rediscover new commercial deposits continued to be rewarded. According to Government sources, most of the mining companies operating in 1983 were either directly or indirectly involved in gold exploration; as in other countries, principal corporate exploration objectives were the discovery of additional gold reserves at established mines and/or the discovery of large near-surface, low-grade deposits suitable for mining by open pit methods and processing by heap-leaching techniques.

Western Australia was the principal gold-producing State. Kalgoorlie Mining Associates (KMA), Australia's largest gold-producing company, operated two mines in Kalgoorlie, Western Australia; the largest, the 1,800-foot-deep Mount Charlotte operation, produced 121,842 ounces of gold in 1983, compared with 134,543 ounces in 1982. Work on the new 4,000-foot Cassidy production and service shaft at Mount Charlotte was ahead of the scheduled 1987 completion date. The smaller mine, the Fimiston, located 3 miles from the Mount Charlotte property, produced 68,643 ounces in 1983 and 62,622 ounces in 1982. At KMA's Oroya mill, which serves both the Fimiston leases and Mount Charlotte, construction of a new carbon-in-pulp plant adjacent to the mill was begun and completed in 1983. An additional 18,000 ounces of gold per year was expected from this new facility. On the Western Leases area of the Fimiston property, a new open pit operation was being developed to recover shallow, remnant, oxidized vein material, small gold lodes not mined in previous underground work, and gold-bearing fill material.

Western Mining Corp. Holdings Ltd. (WMC), with a long history of involvement in Australian gold mining, continued, through various group affiliations, to increase its gold production to 431,554 ounces in the 1982-83 financial year versus 290,840 ounces in 1981-82. Several new gold mining operations in the area from Kalgoorlie south to Kambalda were developed by WMC over the past 3 years to produce over 100,000 ounces per year. Gold production from the Victory, Great Boulder, and Sand King Mines, operated by WMC's 100%-owned subsidiary, Great Boulder Holdings Ltd., increased from 26,520 ounces in 1981-82 to 87,184 ounces in the 1982-83 reporting period; production from the company's Lancefield Mine near Laverton, Western Australia, nearly tripled to 29,000 ounces during the same period.

Sharply increased production was also a feature of several medium-sized Western Australia mines, such as Hill 50's mines at Mount Magnet, Whim Greek Consolidated's mines at Meekathara, and Metana Mineral N.L.'s placer operation at Nullagine. East of Nullagine, at the Telfer gold mine of Newmont Pty. Ltd. and Dampier Mining Co. Ltd., declining ore grade was reflected in a 15% decline in production. Newmont planned to begin heap-leaching operations in 1984 to recover gold values from Telfer's low-grade reserves. At Lake Grace, southwest of Kalgoorlie, Otter Exploration N.L. commissioned a new carbon-in-pulp plant and began producing gold from ore mined at Griffin's Find. Numerous other small operations began production throughout the goldfields of Western Australia as well as those of other Australian States.

Near the town of Leonora, north of Kalgoorlie, at the Harbour Lights gold deposit, which is due on-stream in 1985, Carr Boyd Minerals Ltd. and Esso Australia Inc. of Australia started shaft sinking and the lateral development necessary to obtain bulk ore samples for testing. Also near Leonora, at the famous old Sons of Gwalia Mine, a new company, Sons of Gwalia N.L., conducted exploration around the old deposit and evaluated the considerable tailings dumps for possible retreatment. Another former gold producer under evaluation for possible reopening was the Big Bell Mine near Cue, Western Australia. At Cowarna Downs Station near Karonie, Western Australia, 60 miles east of Kalgoorlie, Freeport of Australia Pty. Inc., a subsidiary of Freeport-McMoRan, reported that generally disappointing results were obtained by a drilling program at its Karonie Prospect. The company was also working on 15 other, mostly gold, prospects in Australia.

Elsewhere in Australia, Placer Development Ltd.'s $135 million Kidston gold property in northeast Queensland was scheduled to begin production in 1985 at an annual rate of about 270,000 ounces each of gold and silver. To comply with Australia's foreign investment regulations, Placer Development must sell a 45% interest in the mine to Australian interests. In the Northern Territory, Peko-Wallsend Ltd. produced over 80,000 ounces of gold at the Tennant Creek Mine; some copper and bismuth were also recovered. The company was considering the possible development of its Explorer 46 gold deposit near Tennant Creek.

In Victoria's Central and Western gold districts, CRA Ltd. of Australia researched the possibility of applying in situ solution mining techniques to recover deeply buried alluvial gold from Victoria's so-called "deep leads." To date, this new approach to gold recovery, which eliminates problems associated with ore removal, faces many technical and environmental hurdles before gold production can be realized.

Bolivia.—At the end of 1982, the Bolivian Government, through the Ministry of Mines and Metallurgy and the Corporacíon Minera de Bolivia, started a program to develop the nation's gold resources. The program, named "The March Towards Gold," was given top priority. Primary objectives of the program were to explore placer gold deposits along the Itenez-Guaporé River Valley along the Bolivian-Brazilian border as well as promising areas along the Madre de Dios River flowing northeastward out of the rich placer mining areas of neighboring Peru. A Government commission reported that a brief study of the targeted areas indicated a favorable potential for substantial gold production. Most of the gold presently recovered in Bolivia is produced by gold mining cooperatives operating along the Tipuani River, 75 miles north of La Paz, and by a 30-year-old dredge operated by Compañía Minera del Sur S.A. on the Kaka River. The Bolivian Geological Survey has been actively exploring gold areas of Bolivia since 1962 and has assembled a roster of gold deposits with possible commercial value.

Early in the year, ground was broken to commence open pit mining at the new Inti Raymi gold and silver deposit about 30 miles northwest of the city of Oruro. The project, located along the banks of the Desaguadero River, is a 50-50 joint venture between Bolivian-owned Empresa Minera Unificada S.A. and the U.S. company Westworld of Texas. This new project is the first in many years to be developed with foreign equity. The venture was expected to recover about 32,000 ounces of gold and 130,000 ounces of silver for each year of the estimated 10-year lifespan of the mine. The total capital investment was about $4 million. Toward yearend, the Government was planning to establish a Government-owned gold mining company to oversee operations on the Mapiri and Kaka Rivers in La Paz; the company was to be called Yacimientos Auriferos Bolivianos. The Government, through the Central Bank, also considered regulations and incentives aimed at reducing the smuggling of newly mined gold out of the country.

Brazil.—At the Serra Pelada gold mine in the State of Pará, where estimates of the numbers of independent miners, or garimpieros, working tiny individual claims ranged from 20,000 to 40,000, nearly 100,000 ounces of gold was recovered in 1983, entirely by age-old hand mining methods. Efforts by the Brazilian Government to improve the safety of the miners were set back in September when an earthslide took the lives of 19 miners and injured 56 others. Shortly thereafter, Government actions, intended to close the mining operation completely, were reversed after heavy opposition and lobbying by mining unions and Brazilian legislators. In September, in the midst of this controversial period, a garimpiero found Brazil's largest-ever gold nugget, which weighed over 137 pounds. The nugget was purchased by the Federal Savings Bank for nearly $1 million. Another nugget weighing nearly 80 pounds had been found earlier in June, also at Serra Pelada. Mining accidents, mostly mudslides, at unregulated diggings in the States of Minas Gerais, Pará, and Rondônia also claimed the lives of a number of prospectors. Bandits attacked exploration and mining camps and nearly one-half dozen garimpieros were killed by robbers. Nevertheless, gold seekers continued to pour into both the new and established gold mining camps along the rivers and in the jungles of Amapá, Amazonas, Goiás, Mato Grosso, Minas Gerais, Pará, Rondônia, and elsewhere. Corporations such as Paranapanema S.A. Mineração, Indústria e Construção, Brazil's largest tin producer, and Mineração Brumadinho S.A., Paranapanema's largest competitor, as well as both large and small domestic and foreign companies, operated dredges and other placer mining machinery throughout the same general area.

Lode gold mining in Brazil continued to increase but not as rapidly as placer mining had increased over recent years. Mineração Morro Velho S.A. (MMV), a subsidiary of Anglo American Corp. do Brasil Ltda. (which operates Brazil's largest underground mine, the Morro Velho, and other mines near Belo Horizonte, in Minas Gerais, and at Jacobina in Bahia), produced about 170,000 ounces in 1983. Near Sabará, in Minas Gerais, MMV began reopening the Cuiaba and Raposos gold mines and expected to double their combined productive capacities to about 110,000 tons of ore per month.

Geologists from Government-controlled mineral and exploration companies continued to conduct exploration for gold throughout the geologically favorable areas of the country, and several finds were reported during 1983. Corporate exploration for Brazilian gold deposits also flourished during the year. In the Crixas region of the State of Goiás, Inco and Kennecott agreed to jointly explore Inco's Crixas deposit, discovered as a result of extensive regional exploration and detailed surveys and drilling. Among the foreign companies exploring for gold, or developing deposits, were subsidiaries of British Petroleum, General Union Mining Corp., Utah International Inc., Aoki Construction Co. Ltd., and others.

Canada.—The recent Hemlo discovery and a general lack of interest in most other minerals served to further stimulate gold exploration during the year. The north shore area of Lake Superior, around the former Ontario railroad station of Hemlo, continued to be the scene of intensive land acquisition and prospecting, and, as noted in the "Domestic Production" section, this considerable interest spilled over into Minnesota. At yearend, over 200 companies were estimated to hold positions in the Hemlo area—more than double the number estimated to have been involved there at the close of 1982. At Hemlo, Noranda Mines Ltd., in a joint venture with Goliath Gold Mines Ltd. and Golden Sceptre Resources Ltd., began work on an estimated $200 million development project expected to lead to the production of 300,000 ounces of gold per year beginning in early 1985. Noranda Mines' 1983 work included beginning construction in a 3,200-foot shaft and a 1,100-ton-per-day mill to be known as the Golden Giant mill. Nearby, Teck Corp., in a joint venture with International Corona Resources Ltd., also began mill and shaft construction. The area's third developer, Lac Minerals Ltd., continued its drilling program while a feasibility study, nearly completed at yearend, focused on the capital projects required to develop Lac's claims. So far, these three companies alone proved over 15 million ounces in gold reserves.

In other developments in Ontario, the Detour Lake joint venture, 150 miles northeast of Timmins, began production; nearly 200,000 ounces per year was expected by 1987. Also near Timmins, ASARCO Incorporated decided to bring its new Aquarius gold mine into production beginning in early 1984. A number of small gold mines were brought on-stream elsewhere in the Province during the year.

In Quebec, Aiquebelle Resources Inc. and

Muscocho Explorations Ltd. began production at their gold properties. In the Atlantic and Prairie Provinces and British Columbia, several small gold mines began production, one closed, and several more were undergoing exploration. Placer mining activities in the Yukon continued at a brisk pace with nearly 200 placer sites near Dawson City, Mayo, and Burwash under production during the season between early May and the end of October. In the Northwest Territories, the small but high-grade Salmita Mine of Giant Yellowknife Mines Ltd. at Matthew Lake began production. At Contwoyto Lake, Echo Bay Mines Ltd. continued to bring its new Lupin Mine up to its planned capacity of nearly 160,000 ounces per year, and Camchib Resources Inc.'s Cullaton Lake Mine began commercial production in January.

Chile.—El Indio Mining Co., the leading gold and silver producer, owned by St. Joe International Corp. (82.15%), a subsidiary of Fluor Corp., and by private Chilean investors (17.85%), completed its first full year of full-scale production in mid-1983, shipping an estimated 24,000 tons of direct shipping ore bearing 8.2 ounces of gold per ton to smelters in the United States, and concentrates bearing gold, silver, and copper to smelters in the United States, Japan, Germany, and Chile. The mine is east of La Serena near the Argentine border at an elevation of 13,000 feet. In addition to having large ore reserves at El Indio, the company is exploring several nearby deposits containing gold, silver, and copper. Near Huasco, 150 miles north of El Indio, St. Joe Minerals Corp., Cía Minera Mantos Blancos S.A., and Anglo American conducted exploration and feasibility studies on their El Nevado gold, silver, and copper deposit. In its company annual report, CRA of Australia reported that bulk sampling of alluvial gravels at its Rio del Oro Prospect did not confirm the grade continuity indicated by earlier testing.

China.—The Government reportedly continued to encourage the discovery and development of gold deposits. Several sources reported that three major gold mines were under development by North American engineering contractors in the eastern Province of Shandong, utilizing imported technology and equipment. Shandong Province alone was reported to produce about 475,000 ounces of gold. Of the 26 mines operating in the Province's Yantai Prefecture, 22 reportedly were owned and operated by rural collectives. Gold prospectors were estimated to be active in over 200 Chinese counties. In Zhaoyuan County of Shandong Province, a large gold deposit was reported to have been discovered in late 1982 by the Number 6 Geological Team of the Shandong Province Bureau of Geology. The find, designated "Hedong Gold Mine," was discovered in an area known locally as "The Home of Gold." In a related 1982 development, a peasant in Heilongjiang, the northeastern-most Province, found a 107-ounce gold nugget—China's largest ever; 29-ounce and 48-ounce nuggets were also reported to have been found in Changsha and Shaanxi Provinces, respectively, during 1983. According to several sources, five bucketline dredges, three recently imported and two of older Chinese manufacture, were operating on placer deposits in Heilongjiang Province. In addition to news of gold developments in Shandong and Heilongjiang during 1983, reports of gold mining activities also covered seven additional Provinces. The cities of Beijing, Shanghai, and Tianjin were reported to have recovered about 4,500 ounces of gold and about 1 million ounces of silver from various collected waste materials. A new technique was reported to have been developed that improved the recovery of gold and silver from anode mud generated at a Yunnan copper smelter. Developers of the technique received an award from the Chinese Ministry of Metallurgy.[7]

Costa Rica.—Near Esperanza, Kappes, Cassiday and Associates, of Reno, NV, operators of the Santa Clara gold mine, installed a continuous-drum agglomerator, which produced a substantial increase in gold recovery from the clayey, gold-bearing saprolite being mined there. Heap leaching of the ore using the agglomeration technique entails binding finer ore particles together with a weak portland cement additive. The property owners, United Hearne Resources Ltd. of New York and Vancouver, British Columbia, Canada, expected that over 700 ounces of gold would be recovered per month utilizing the agglomeration technique, which reportedly raised the overall gold recovery rate to over 75%. In April, at Pueblo Nuevo, about 40 miles southeast of San Juan, Starmark Resources Ltd. began a 1-year drilling and sampling program aimed at assessing ore reserves thought to exceed 3.5 million tons grading 18% copper, 18 ounces per ton of silver, and 0.09 ounce per ton of gold.

Dominican Republic.—In early 1983, the

Government announced a new mining policy intended to stimulate private sector investment in mineral development; the Directorate General of Mining retained basic responsibility for identification, development, and control of the country's mineral resources. Gold production at the Pueblo Viejo gold and silver mine, administered by the Government, declined somewhat from that of 1982 to 348,065 ounces. Reserves of oxide ore were expected to be exhausted in 5 years at present rates of production, so studies were underway to develop a suitable process for recovering gold and silver from the, as yet unexploited, reserves of sulfide ore. The new $5 million gold refinery at the mine was completed and ready to operate in mid-1983; however, its use was postponed, apparently for economic reasons. The Government had several precious metals exploration projects underway throughout the country, including an offshore survey for favorable placer gold environments by the U.S. Geological Survey.

Fiji.—WMC of Australia, entered into a joint venture with Emperor Gold Mining Co. Ltd. and assumed operation and management of the Emperor Mine at Vatukoula on the northern end of the main island of Viti Levu. The company also acquired a 50% interest in a separate venture with Emperor to explore for gold near Vatukoula.

France.—The results of a completed modernization plan at France's oldest gold producer, the Salsigne Mine near Carcassonne, the startup of a new gold mine, the Bourneix Mine, in the Province of Haute Vienne, both in 1982, and the attainment of full-capacity production at both operations during 1983 were reflected in France's mine production for those 2 years. Recent exploration for gold by the state-owned Compagnie Française de Mines, which also owns shares in these two gold mines, resulted in the discovery of new gold deposits near the Bourneix Mine.

India.—Except for a small quantity of gold recovered as a byproduct of copper mining by Hindustan Copper Ltd., the entire gold production of India came from the Government-owned Bharat Gold Mines Ltd. (BGML) and the Karnataka State Government-owned Hutti Gold Mines Co. Ltd. During 1983, BGML, which operates mines in the Kolar Goldfield of the State of Andhra Pradesh, contended with drought conditions, labor unrest in July and October, disruption in the power supply, and a further decline in the grade of gold ore mined. At the present level of production, proven gold reserves of both the Kolar and the Hutti Goldfields will last for another 15 to 18 years. To supplement these depleting reserves, the Geological Survey of India, in collaboration with the Mineral Exploration Corp., conducted exploration in favorable areas of both goldfields. Other exploration conducted by Government agencies discovered significant gold mineralization in the States of Andhra Pradesh, Karnataka, and Kerala, and gold mines were under development in the Chittoor and Anantapur Districts of Andhra Pradesh. Smuggling of gold into India, intensified by high Indian prices, continued to be a problem.

Japan.—Mitsui Mining & Smelting Co. Ltd. announced the discovery of a new gold deposit, of undetermined size, on the southern island of Kyushu, near the town of Hishikari, in Kogashima Prefecture. Preliminary drilling at the prospect, which is located near a similar discovery made in 1982 by Sumitomo Metal Mining Co. Ltd., indicated gold values ranging as high as 3.7 ounces per ton. At its nearby deposit, Sumitomo planned to begin gold production as early as the fall of 1984. About 90% of Japan's reported primary gold production was derived as a byproduct from imported ores and concentrates, mostly copper.

Mali.—A contract to explore and develop lode and placer deposits in the Kalana region in the southwest was signed between the Malian Government and a U.S. firm, World Mining and Development Co. Inc. The concession area is near the Kalana gold mine where the state-owned Société Nationale de Recherches Minières mines gold, with technical assistance from the Soviet Union.

Papua New Guinea.—In the North Solomons Province, the largest gold producer, Bougainville Copper Ltd., produced 578,778 ounces of byproduct gold, up slightly from production reported in 1982. This large open pit copper mine is at Panguna in the highlands of north-central Bougainville Island. On the mainland, near the border with Indonesia, Ok Tedi Mining Ltd., a consortium of international mining companies and the Government, proceeded with construction of the gold processing plant, townsite, and other facilities needed to bring the new $1.8 billion Ok Tedi gold-copper mine into production. Despite delays resulting from landslides and drought, production was expected to begin at this remote minesite in early 1984. The first year's output from the gold-rich cap was expected to amount to about 850,000 ounces of unrefined gold and silver doré. At Wau, in the Province of North-East New Guinea, New Guinea Goldfields, a 50-50 joint venture between Consolidated Gold Fields PLC and Renison Goldfields Consolidated Ltd., produced a small quantity of gold and silver and completed a major assessment of its limited reserves of low-grade ore.

At the Porgera joint venture near Mount Hagen in the Central Highlands, Placer (PNG) Pty. Ltd., a subsidiary of Placer Development, reported that limited drilling over a length of over 1,600 feet had indicated an average undiluted gold grade of 0.23 ounce per ton. The geological reserves for the entire Porgera deposit were calculated to be 65 million tons containing, on average, 0.10 ounce of gold and 0.42 ounce of silver per ton. Further drilling was planned for 1984. At Misima Island, southeast of the mainland, a program of trenching, channel sampling, and drilling was carried out by Placer and its equal partner, CRA Exploration Pty. Ltd. Old underground workings on the property were reopened and sampled to test an extension of mineralization, which was expected to produce additional reserves of average-grade mineralization. Preliminary estimates of Misima Island reserves were 38.6 million tons bearing 0.042 ounce per ton of gold and 0.48 ounce per ton of silver. On Lihir Island, north of the island of New Ireland, Kennecott Explorations (Australia) Ltd. and Niugini Mining Ltd., of Australia, in a joint venture, 88% owned by Kennecott, explored a low-grade gold deposit. Drilling indicated significant intervals of near-surface gold mineralization.

Philippines.—Several copper-gold mining operations were idle during the year, but the largest copper-gold producers, Philex Mining Corp., Benguet Corp., and Atlas Consolidated Mining Development Corp., continued to recover gold in conjunction with their copper operations. Several copper-gold mines that began production in 1982 attained full byproduct gold production during 1983. As in recent years, exploration for new gold deposits was pursued by both domestic and foreign corporations as well as by individual prospectors. Renison Goldfields, an Australian subsidiary of Consolidated Gold Fields PLC., in a joint venture with Tirad Minerals Inc., a Philippine company, began drilling and exploration of a copper and gold prospect in Guinaoang, Mankayan, in Benguet Province, Luzon. Several areas of the island continued in the grip of a classic gold rush, and in one area, southwest of Manila, to where an estimated 7,000 gold seekers had rushed, a gold mine tunnel reportedly collapsed, trapping 70 persons and killing 13 others.

Saudi Arabia.—At Mahd adh Dhahab, 170 miles northeast of Jeddah, Gold Fields Mahd adh Dhahab Ltd. was granted a contract by General Petroleum and Mineral Organization (Petromin), the state-owned mining company, to commence preparations for starting up the Mahd adh Dhahab gold mine. The mine, which was officially opened on April 30, 1983, was developed around a group of gold deposits that have been mined on-and-off for over 3,000 years and that are known collectively as The Cradle of Gold. The 400-ton-per-day operation was expected to yield about 100,000 ounces of gold per year starting in late 1985 or early 1986; silver, copper, and zinc were also expected to be produced during the estimated 10-year lifespan of the deposit. In the extreme south of the Kingdom, in the region bordering Yemen (Sanaa), also an ancient center of gold mining, studies were underway at gold prospects at Jabal Guyan and Al Masane. The Al Masane deposit, which has been explored and evaluated by the Arabian Shield Development Co. and Petromin, was under study for possible development.

In early 1983, the Governments of Saudi Arabia and the Sudan had under consideration a proposal for a pilot plant for mining and processing metalliferous muds from the bottom of the Atlantis II Deep, a fault zone in the Red Sea. The targeted zone, which lies at a depth of 2,000 to 6,600 feet below sea level, may yield muds containing gold, silver, copper, lead, and cadmium. A gold price in excess of $450 per ounce would reportedly be necessary to make a recovery effort economically feasible; also, successful pilot plant tests of both metal recovery and environmentally acceptable mining processes would be required.

South Africa, Republic of.—Inflation, rising mining costs, relatively stagnant gold prices, and a severe prolonged drought combined to make 1983 a year of reduced expectations for South African gold mines. The cyclical economic downturn, which began in late 1981 and continued through 1982, deepened in 1983. Despite these negative events, many of the major South African gold mining houses continued to invest heavily in capital expenditures aimed at prolonging the life of operations, as well as enhancing productive capacities. In his budget address for 1983, the South African Director of Finance announced plans to reduce the State assistance program in which marginal gold mines can receive substantial aid from the Government. Since its inception 16 years ago, this aid had allowed some marginal mines, which might have otherwise been forced to close, to remain in production. In a move aimed at reducing the problems associated with the wide fluctuations that occur in the exchange value of the South African rand versus the U.S. dollar, the South African Reserve Bank began, on September 5, paying the country's gold mines in U.S. dollars rather than in rands for their bullion output. This change may allow some mines to participate in more currency trading and thereby increase their financial flexibility and enhance their earnings potential. To reduce their vulnerability to gold price fluctuations and stabilize their revenues, many gold producers again sold a portion of their production on various international futures markets.

The 34 mines and 1 metallurgical recovery operation that were members of the Chamber of Mines accounted for 97.7% of all South African gold production. The total ore milled, including ore milled by producers of byproduct and coproduct uranium, amounted to 110.1 million tons, averaging 0.22 ounce of gold per ton; in 1982, 104.7 million tons, averaging 0.20 ounce per ton was milled. Working costs for South African gold mines in 1983 averaged, in South African rands (R),[8] R238.88 (US$214.77) per ounce and ranged from R131.07 (US$117.84) per ounce at East Driefontein to R459.26 (US$445.29) per ounce at East Rand Pty. Ltd. Production by the six major mining groups was as follows, in million ounces: Anglo American of South Africa Ltd., 7.9; Gold Fields of South Africa Ltd., 4.4; General Mining Union Corp. Ltd. (Gencor), 3.6; Rand Mines Ltd., 2.2; Johannesburg Consolidated Investment Co. Ltd., 1.5; and Anglo-Transvaal Consolidated Investment Co. Ltd., 1.2.

The largest producing mines, in million ounces of gold output, were Vaal Reefs, 2.6; Driefontien Consolidated, 2.4; Western Holdings, 1.3; Western Deep Levels, 1.3; and Harmony, 1.0. Estimates of fully developed or blocked-out gold ore reserves reported by the Chamber of Mines at the close of 1983 totaled 594 million tons, containing, on average, about 0.30 ounce of gold per ton.

In the Orange Free State, Gencor brought its $410 million Beatrix Mine one step closer toward its scheduled startup in early 1984. The new mine was expected to produce about 2.2 million tons of gold ore per year, from which nearly 400,000 ounces of metal was to be recovered. At the mill of Gencor's St. Helena Mine, a new 300,000-ton-per-month carbon-in-pulp and pyrite flotation plant was commissioned in early 1983. These improvements were expected to increase the productive capacity and efficiency of both the St. Helena and Unisel Mines. Exploration for new gold deposits or for extensions to known producing horizons continued throughout the country. An intensive exploration and drilling program, begun some 5 years earlier by Gold Fields of South Africa, west of its Kloof Mine, continued; other mining companies were also showing an interest in this area, which lies west of Johannesburg, in the Potchefstroom region of Transvaal, and extends toward Fochville on the Far West Rand. In March, Rand Mines announced that the company planned to prospect for gold and other minerals under the southern suburbs of Johannesburg.

Sudan.—The gold potential of the Sudan has received an increasing amount of attention over the past few years. Many ancient gold mines, some dating back to Pharaonic times, are scattered throughout the hills and lowlands bordering the Red Sea as well as along the Nile River Valley. In March, limited small-scale mining and gold production was begun by a joint-venture team comprised of the state-owned Sudanese Mining Corp. and the U.S. company Minex Corp. at gold deposits near Gebeit in the Red Sea Hills. Toward yearend, Greenwich Resources of Canada, through its United Kingdom-based Minex Developments PLC, began diamond drilling at its gold prospects at Gabotilo, also near the Red Sea. A Belgian-Sudanese joint venture explored for placer gold near Kapoeta in south Sudan.

U.S.S.R.—Net exports of gold from the centrally planned economy countries to the market economy countries were estimated to have been about 3 million ounces in 1983, down from the nearly 7 million and 9 million net ounces during 1982 and 1981, respectively.

Gold nuggets of varying size and purity and of Soviet origin were reported to be available for sale to Westerners at the Soviet Union's Wozchod Bank in Zurich, Switzerland.

TECHNOLOGY

The Bureau of Mines continued to publish results of research conducted to improve methods of recovering gold from primary and secondary sources. A method to remove cyanide and heavy metals from mineral processing waste waters was developed, by which hydrogen peroxide and sodium thiosulfate are added to cyanide-bearing waste water to convert the cyanide to nontoxic thiocyanate.[9] The Bureau developed a new approach to the economic recovery of gold and silver from scrapped electronic equipment by utilizing a mechanical processing system adapted from current mineral processing technology. The Bureau operated a pilot plant at feed rates of up to 500 pounds per hour of scrap composed of obsolete military electronic gear, concentrating into marketable "fractions" the metals present in the electronic units.[10] Electronic scrap concentrates generated in the mechanical processing system referenced above were subjected to various hydrometallurgical processes to separate and remove the base metal fraction of the scrap and thereby produce a high-grade end product bearing essentially all of the contained precious metal values.[11] The Bureau presented information on five commercial gold mining operations that have benefited from the Bureau-developed agglomeration heap-leaching technology for extracting gold and silver from primary ore. The operations described represent a cross section of current state-of-the-art heap-leaching practice.[12]

A study by U.S. Geological Survey scientists of placer gold deposits in Alaska suggested that under certain optimum chemical and physical conditions, bacteria present at the deposit site may be instrumental in bringing about deposition of gold from gold-bearing waters draining or percolating through near-surface channels or fractures. The theory of bacterial participation in the development of some placer gold deposits helps to explain the common observation that some placer deposits can reconstitute themselves 20 or 30 years following mining.[13] Observations of this phenomenon have been made over the years in such diverse environments as Minas Gerais, Brazil, and in permafrost regions such as in the Brooks Range of Alaska.

A new type of electrical contact brush was patented for use in high-performance devices. The brush, which exhibits characteristics greatly superior to brushes available until now, consists of gold fibers finer than a human hair bunched or bundled together and protruding from a solid matrix, such as copper.[14]

The Gold Bulletin, a quarterly journal of the International Gold Corp. Ltd., contained a variety of articles and abstracts of patents on new or improved gold uses and technology.[15] Articles dealing with various historical aspects of gold technology were also presented.

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[1]Physical scientist, Division of Nonferrous Metals.

[2]Ounce means troy ounce.

[3]Short tons.

[4]For price and availability, contact the Alaska Department of Natural Resources, Division of Geological and Geophysical Surveys, Box 80007, College, AK 99708.

[5]Leonard, B. F., and J. A. Erdman. Preliminary Report on Geology, Geochemical Exploration, and Biogeochemical Exploration of the Red Mountain Stockwork, Yellow Pine District, Valley County, Idaho. U.S. Geol. Surv. OFR 83-151, 1983, 52 pp.

[6]DuBoulay, L. Gold 1984. Consolidated Gold Fields PLC, London, May 1984, 59 pp.

[7]Wang Shixin. Yunnan Smelting Plant and Kunming Metallurgical Research Institute Develop a New Technique to Treat Copper Anode Mud. Yunnan Ribao, Kunming, Feb. 19, 1983, p. 1 (Chinese).

[8]Values have been converted from South African rands (R) to U.S. dollars at the rate of R1.00=US$0.8991 for 1983, as shown in Int. Financial Stat., v. 37, No. 4, Apr. 1984, p. 400.

[9]Schiller, J. E. Removal of Cyanide and Metals From Mineral Processing Waste Waters. BuMines RI 8836, 1983, 8 pp.

[10]Dunning, B. W., Jr., F. Ambrose, and H. V. Makar. Distribution and Analyses of Gold and Silver in Mechanically Processed Mixed Electronic Scrap. BuMines RI 8788, 1983, 17 pp.

[11]Hilliard, H. E., B. W. Dunning, Jr., and H. V. Makar. Hydrometallurgical Treatment of Electronic Scrap Concentrates Containing Precious Metals. BuMines RI 8757, 1983, 15 pp.

[12]McClelland, G. E., D. L. Pool, and J. A. Eisele. Agglomeration-Heap Leaching Operations in the Precious Metals Industry. BuMines IC 8945, 1983, 16 pp.

[13]Watterson, J. R., J. C. Antweiler, and W. I. Campbell. U.S. Geol. Surv., Denver, CO. Paper entitled Bug Nuggets, presented at 6th Int. Symp. on Environ. Biogeochemistry, Santa Fe, NM, Oct. 10-14, 1983.

[14]Wilsdorf, D., H. G. F. Wilsdorf, and C. M. Adkins (assigned to The University of Virginia). An Electric Brush. U.S. Pat. 4,415,635, Nov. 15, 1983.

[15]International Gold Corp. Ltd. Gold Bulletin. Marshalltown, Republic of South Africa, v. 16, Nos. 1-4, 1983, 140 pp.

Graphite

By Harold A. Taylor, Jr.[1]

Apparent consumption of natural graphite decreased 20% in 1983 to 34,000 short tons. An amorphous graphite was mined domestically for the second consecutive year. All natural graphites, including crystalline flake, were in more than adequate supply as demand by industrial users lagged behind economic recovery. Prices of some kinds of imported graphites rose while others dropped.

Production of manufactured graphite increased 7% to 228,000 tons valued at $553 million. Production of graphite fibers increased 13% to 927 tons valued at $48 million.

Table 1.—Salient natural graphite statistics

	1979	1980	1981	1982	1983
United States:					
Production ---short tons--	W	--	--	W	W
Apparent consumption[1] ---do---	77,562	52,438	[2]54,315	[2]42,815	[2]34,151
Exports ---do---	8,623	8,880	11,344	10,335	9,435
Value ---thousands--	$3,741	$3,695	$4,433	$4,099	$3,455
Imports for consumption ---short tons--	86,185	61,318	[2]65,659	[2]53,150	[2]43,586
Value ---thousands--	$13,035	$15,765	[2]$19,093	[2]$15,676	[2]$11,921
World: Production ---short tons--	[r]690,522	[r]673,060	663,457	[p]646,674	[e]645,333

[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.

Domestic Data Coverage.—Domestic production data for synthetic graphite were developed by the Bureau of Mines from a voluntary survey of domestic producers, titled "Synthetic Graphite." Of the 39 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.

Legislation and Government Programs.—No acquisitions or disposals of strategic graphite occurred during the year.

Table 2.—U.S. Government stockpile goals and yearend stocks of natural graphite in 1983, by type

(Short tons)

Type	Goal	National stockpile inventory
Madagascar crystalline flake	20,000	17,891
Sri Lanka amorphous lump	6,300	5,443
Crystalline, other than Madagascar and Sri Lanka	2,800	1,933
Nonstockpile-grade, all types	--	935

Source: General Services Administration. Inventory of Stockpile Materials as of Dec. 31, 1983.

DOMESTIC PRODUCTION

United Minerals Co. again produced sizable amounts of low-grade amorphous graphitic material on an intermittent basis by open pit mining from the claims of National Minerals Corp. near Townsend, MT. Graphite Sales Inc. marketed the material, which averaged 25% fixed carbon and was sold to a variety of users, mostly steel-related. The material was not beneficiated before sale, but merely dried, crushed and sized. There is enough minable material to last indefinitely; reserves were estimated by the firm to be over 2 million tons.

Output of manufactured graphite increased 7% to about 228,000 tons, at 37 plants, with a likelihood of some unreported production for in-house use.

Production of all kinds of graphite fiber and cloth increased 13% to 927 tons.

Wickes Co. announced the sale of the Engineered Materials Div., its metallurgical product line including graphite, to McClain Corp., a closely held firm located in Woodstock, IL. The sale was approved by the U.S. Bankruptcy Court. Wickes retained its Graphitar product line of carbon-graphite parts, although it too was for sale.

Great Lakes Carbon Corp. announced plans to build a 400-ton-per-year capacity "Fortafil" graphite fiber plant in Roane County, TN. The plant, scheduled to go on-stream in June 1984, was designed to readily accommodate significant additional capacity. The same process that had been developed and used at the company's Elizabethton facility, and based on polyacrylonitrile as raw material, was being used in the new plant.

Courtaulds Ltd. formed a joint venture with Dexter Corp. of Windsor Locks, CT, to produce and market graphite fiber. Courtaulds would contribute its polyacrylonitrile precursor and graphite fiber production facilities in the United Kingdom and Dexter would contribute its resins business, technology, and marketing expertise to the venture, which was to be titled Hysol Grafil. A new 165-ton-per-year capacity aerospace-grade graphite fiber plant was scheduled to go on-stream in the United States in late 1984. Hysol Grafil would become the world's first vertically integrated producer of graphite fiber composites, manufacturing the fiber, the resin, and composites, tailored to fit customers needs.

The U.S. Department of Energy issued the results of its second study of the Narragansett Basin anthracite-amorphous graphite resources, this time emphasizing the mining aspects. In the Portsmouth, RI, area, 24 anthracite-amorphous graphite seams were discovered ranging from 2 to 12 feet thick with an average of 5.6 feet. The seams are part of a complex northeast-trending, southerly plunging fold. The ash content ranged from 14% to 56%, most of it quartz, and was probably removable by washing. The most feasible method of mining the deposits would be open pit because the incompetency of the roof and floor rock would make underground mining difficult. Some of the material is suitable for use as graphite and some as fuels.[2]

Table 3.—Principal producers of manufactured graphite in 1983

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	
Avco Corp., Avco Specialty Materials Div	Lowell, MA	High-modulus fibers.
The Carborundum Co., Graphite Products Div.	Sanborn, NY	Motor brushes, unmachined shapes, cloth.
Celanese Corp	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.
Pfizer Minerals, Pigments & Metals Div	Easton, PA	Other.
Ohio Carbon Co	Cleveland, OH	Motor brushes, unmachined shapes, other.

See footnote at end of table.

Table 3.—Principal producers of manufactured graphite in 1983 —Continued

Company	Plant location	Product[1]
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	Chicago, IL	Powder and other.
Do	Hopkinsville, KY	
Ultra Carbon Corp	Bay City, MI	Other.
Union Carbide Corp	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	1982 Quantity (short tons)	1982 Value (thousands)	1983 Quantity (short tons)	1983 Value (thousands)
Synthetic graphite products:				
Anodes	8,147	$15,379	4,178	$11,311
Cathodes	W	W	W	W
Cloth and fibers (low-modulus)	212	17,706	188	14,217
Crucibles, vessels, refractories	W	W	W	W
Refractories	W	W	W	W
Electric motor brushes and machined shapes	W	W	W	W
Electrodes	138,960	358,186	153,742	370,450
Graphite articles	--	29,894	--	35,481
High-modulus fibers	r605	r30,091	739	33,854
Unmachined graphite shapes	14,346	41,991	10,691	50,422
Other	31,584	59,411	28,636	29,712
Total	r193,854	r552,658	198,174	545,447
Synthetic graphite powder and scrap	19,645	8,196	29,487	7,372
Grand total	r213,499	r560,854	227,661	552,819

rRevised. 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)
1973	102	$6,300	46	$4,750	148	$11,050
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	r605	r30,091	r817	r47,797
1983	188	14,217	739	33,854	927	48,071

rRevised.

CONSUMPTION AND USES

Apparent consumption of natural graphite, excluding domestic production, decreased 20% to 34,000 tons. Reported consumption of natural graphite decreased 6% to about 36,000 tons. The three major customary uses of natural graphite—refractories, foundries, and steelmaking—accounted for 53% of reported consumption. The reported use of amorphous graphite in steelmaking decreased 73% to 2,571 tons.

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)
1982						
Batteries	W	W	W	W	1,669	$2,920
Brake linings	770	$869	1,860	$1,381	2,630	2,250
Carbon products[3]	201	378	r561	r501	r762	r879
Crucibles, retorts, stoppers, sleeves, nozzles	2,625	2,470	--	--	2,625	2,470
Foundries[4]	r202	r191	4,401	r1,811	r4,603	r2,002
Lubricants[5]	r1,002	r1,155	r2,309	r1,525	r3,311	r2,680
Pencils	1,366	1,850	301	187	1,667	2,037
Powdered metals	r313	r459	150	300	r463	r759
Refractories	W	W	W	W	7,667	2,119
Rubber	146	187	120	65	266	252
Steelmaking	288	139	9,368	2,709	9,656	2,848
Other[6]	r1,819	r1,122	r1,157	r694	r2,976	r1,816
Withheld uses	564	1,041	8,771	3,998	--	--
Total[2]	r9,296	r9,861	r28,998	r13,171	r38,294	r23,032
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

rRevised. 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.

PRICES

Because graphite prices were often negotiated between the buyer and seller, published price quotations have been given as a range. Another source of price information has been average customs unit values for imported graphites, mainly unprocessed material.

Average prices of natural graphite imports displayed no clear trend. Prices for crystalline flake graphite dropped 16% to $550 per ton. Prices for Mexican amorphous graphite rose slightly to $56 per ton. Average prices for all types of Sri Lankan lump graphite dropped 23% to $1,158 per ton. Prices for other natural imported graphite (mostly fine crystalline flake and dust) rose 9% from $518 (revised) to $564 per ton.

Union Carbide Corp. announced price increases for its "Thornel" pitch-based fibers, effective June 1, 1983: P25 4k, from $17 to $26 per pound; P50 1k, from $150 to $350 per pound; P55 2k, from $27.50 to $55 per pound; P55 4k, from $18 to $36 per pound; and P75 2k, from $170 to $225 per pound. The reason cited was that the sales volume necessary for low-cost production was not attained.

Table 7.—Representative yearend graphite prices[1]

(Per short ton)

	1982	1983
Flake and crystalline graphite, bags:		
China	$272-$1,542	$54-$1,542
Germany, Federal Republic of	318- 2,722	318- 3,175
Madagascar	249- 726	227- 544
Norway	272- 816	181- 635
Sri Lanka	544- 1,814	499- 1,367
Amorphous, nonflake, cryptocrystalline graphite (80% to 85% carbon):		
Korea, Republic of (bags)	82- 109	82- 109
Mexico (bulk)	77- 109	64- 91

[1]F.o.b. foreign port or border.

Source: Engineering and Mining Journal. V. 184, No. 12, Dec. 1983, p. 21.

FOREIGN TRADE

Exports of both natural and artificial graphite decreased. Exports to Canada and Venezuela decreased significantly. Exports of natural graphite to the Federal Republic of Germany increased significantly.

Imports of natural graphite decreased 18% to 43,586 tons. Shipments from Mexico, the largest supplier by volume, decreased significantly, 29%, to 22,124 tons. This was partially replaced by increased imports of amorphous graphite from China, Hong Kong, and Taiwan. The total tonnage of imported crystalline flake graphite, the largest category by value, decreased 35% by tonnage, mainly because of decreased shipments from Brazil and Madagascar.

Exports of graphite electrodes totaled 49,158 tons valued at $79.6 million, of which 6,269 tons ($10.3 million) went to Venezuela; 7,975 tons ($16.7 million) to Argentina; 4,353 tons ($7.4 million) to Brazil; 3,594 tons ($6.9 million) to Canada; and the balance, to other destinations.

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
1982:						
Canada	5,284	$1,605,612	1,465	$237,284	6,749	$1,842,896
Germany, Federal Republic of	254	167,653	630	249,142	884	416,795
Italy	76	31,156	53	27,564	129	58,720
Japan	490	448,907	481	592,525	971	1,041,432
Mexico	1,080	374,829	347	145,537	1,427	520,366
Netherlands	12	3,629	5	5,093	17	8,722
United Kingdom	386	208,950	208	148,491	594	357,441
Venezuela	1,723	631,109	42	27,361	1,765	658,470
Other	1,030	626,902	2,416	1,077,739	3,446	1,704,641
Total	10,335	4,098,747	5,647	2,510,736	15,982	6,609,483
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

[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)
1981	[r]10,687	[r]$6,853	1,471	$2,220	15,374	$8,228	38,127	$1,792	[2]65,659	[2]$19,093
1982:										
Australia	--	--	--	--	([3])	1	--	--	([3])	1
Austria	--	--	--	--	--	--	9	5	9	5
Brazil	3,794	2,918	--	--	1,033	677	--	--	4,827	3,595
Canada	2	3	--	--	276	27	--	--	278	30
China	4,003	2,243	--	--	5,470	2,153	--	--	9,473	4,396
Denmark	--	--	--	--	([3])	([3])	--	--	([3])	([3])
Finland	--	--	--	--	18	10	--	--	18	10
France	55	23	--	--	46	30	--	--	101	53
Germany, Federal Republic of	109	202	--	--	814	682	--	--	923	884
Hong Kong	--	--	--	--	551	210	--	--	551	210
India	211	130	40	41	161	161	--	--	412	332
Italy	--	--	--	--	1	3	--	--	1	3
Japan	130	125	--	--	69	156	--	--	199	281
Madagascar	2,467	1,412	--	--	1,229	579	--	--	3,696	1,991
Mexico	--	--	--	--	949	716	30,340	1,640	31,289	2,356
Netherlands	--	--	--	--	10	8	--	--	10	8
Norway	--	--	--	--	72	44	--	--	72	44
South Africa, Republic of	--	--	--	--	233	99	--	--	233	99
Sri Lanka	--	--	727	1,099	--	--	--	--	727	1,099
Sweden	--	--	--	--	63	135	--	--	63	135
Switzerland	--	--	--	--	([3])	1	--	--	([3])	1
Taiwan	--	--	--	--	151	91	--	--	151	91
United Kingdom	--	--	--	--	([3])	1	--	--	([3])	1
Zimbabwe	--	--	--	--	116	49	--	--	116	49
Total[1]	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

See footnotes at end of table.

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

Country	Crystalline flake		Lump or chippy dust		Other natural crude and refined		Amorphous		Total [1]	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1983 —Continued										
China	3,684	$1,740	--	--	3,311	$1,393	3,152	$200	10,147	$3,333
Gambia	--	--	--	--	5	6	--	--	5	6
France	--	--	--	--	617	358	--	--	617	358
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	43,586	11,921

[r]Revised.
[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)
1982:				
Australia	([1])	$3	--	--
Canada	718	233	3,578	$2,129
China	618	217	730	1,048
Germany, Federal Republic of	22	137	3,100	3,187
Italy	--	--	3,686	4,174
Japan	286	1,997	18,462	39,405
Mexico	([1])	([1])	--	--
Netherlands	23	58	--	--
Singapore	19	29	--	--
Switzerland	1,653	2,360	--	--
United Kingdom	([1])	2	--	--
Other	--	--	806	1,250
Total	[2]3,341	5,036	30,362	51,193
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	5,142	[2]8,128	34,127	57,040

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

WORLD PRODUCTION

World supplies of graphite were generally sufficient to meet demand. A number of new plants and expansions were announced for graphite fiber.

Australia.—Conzinc Riotinto of Australia Ltd., 53% owned by Rio Tinto Zinc Ltd., a major international mining conglomerate, was investigating a graphite deposit at Mikkira, in the State of South Australia. Laboratory tests showed a marketable product could be produced.

France.—Construction work on a graphite fiber plant, a joint venture of Hercules Inc. and Pechiney Ugine Kuhlmann, was stopped because of a low demand for the product. The plant structure had been completed but no equipment was installed.

The joint venture of Toray Industries Inc. and Société Nationale Elf Aquitaine selected a site at Abidos, near Lacq in southwest France, to construct a graphite fiber plant.

India.—Most graphite produced in India was the finer crystalline flake and its coproduct crystalline dust (functionally amorphous). Some lump graphite was sporadically produced, and some Sonoran-type amorphous graphite may have been produced. About 68% of the graphite was mined in Orissa State, and most of the balance in Bihar State. Most of the mines were small and shallow and used hand labor. The few beneficiation plants used simple processing technology.

Much of the graphite was consumed domestically, principally in the foundry, pencilmaking, steel, and refractory crucible industries. Tamil Nadu Minerals Ltd. reported opening a large mine, to be followed by a beneficiation plant expected to come on-stream in 1984.[3]

Japan.—Mitsubishi Chemical Corp. announced plans to build a 1,100-ton-per-year graphite fiber plant at an undisclosed location in Japan. The plant would utilize new technology to produce a pitch-based fiber at less than one-half the cost of producing state-of-the-art fibers made from polyacrylonitrile. The plant, scheduled to come onstream in 1984, was expected to market its fibers to the aerospace and automobile industries.

Kenya.—A dry beneficiation process utilizing air classification and pneumatic tabling followed by flotation was being developed for use at graphite mines in arid parts of Kenya by the Association of Geoscientists for International Development-Network for Small Scale Mining, an informal nongovernmental group linking government, academic, and the private sector.

Madagascar.—Société Minière de la Grand Ile, one of the two major Madagascan producers of crystalline flake graphite, was expected to expand its graphite production when the recently acquired Sahanavo Mine begins to produce. It also acquired $500,000 worth of mining equipment from a Swedish contractor that had completed its project in Madagascar. Other producers had idle equipment because of a lack of spare parts. Open pit mining was hindered by an unusual number of floods and cyclones. Improvements in Government fiscal and investment policies and a new Chinese-built road from the port of Tamatave to the interior made additional investment to expand graphite production more feasible.

Romania.—For the first time in many years, information was published in a prominent western journal on Romanian graphite. Graphite occurs in the geological unit called the Autochthonous Crystalline in the South Carpathian Mountains, near Baia de Fier and Polovragi. The graphite occurs in lens-shaped graphite schist bodies conformably intercalated between gneisses, mica schists, and carbonatic rocks. The graphite found in the schists runs from crystalline dust to fine crystalline flake and ranges from 26% to 42% carbon. It has been recovered from both underground and open pit mines and beneficiated by flotation to obtain a concentrate containing at least 70% carbon. Further processing has yielded concentrates containing over 80% carbon. Research was underway to obtain a concentrate containing over 90% carbon.[4]

South Africa, Republic of.—Kobar Mining (Pty.) Ltd. discovered an amorphous graphite deposit at Mtubatuba, 30 miles from Richards Bay. Reserves of 22 million tons were proven by drilling. The company planned to begin producing an unbeneficiated amorphous graphite product averaging 63.5% carbon and 30% ash by the latter part of 1984. The product was to be crushed to a range of minus 1-inch to dust and sold to various refiners and manufacturers as a raw feedstock. The company planned to erect a beneficiation plant if there was sufficient demand. The beneficiated product would average 85% carbon and 10% ash. Some associated low-volatile anthracite was expected to also be recoverable.[5]

Sri Lanka.—All graphite was recovered by the State Mining and Mineral Development Corp. (SMMDC) from two underground mines. Bogala, the larger, and Kahatagaha-Kolongaha, were both located northeast of the capital city of Colombo. The lump graphite was beneficiated by hand sorting, although some graphite was recovered from mine waste by flotation at Bogala.

An Asian Development Bank project to expand lump graphite mining was delayed because Sri Lanka lacked the funds to finance its portion of the project. Small miners were encouraged to open abandoned workings, with SMMDC handling sales and providing technical advice. A private sector plant to convert up to 1,300 tons per year of lump graphite into flake was being set up. SMMDC was looking for foreign associates to set up graphite product plants that would ship to overseas markets. A small graphite crucible plant, owned by the Ceylon Ceramic Corp., served only local markets.[6]

Sudan.—For the first time, the existence of a graphite mine in the Sudan was made known. The Sudanese Mining Corp. of Khartoum owns a 1,100-ton-per-year capacity graphite and mica mine in the Shereik area through its Mica Project subsidiary.

United Kingdom.—Courtaulds announced plans to expand the capacity of its graphite fibers plant near Coventry by fall 1983 from 220 to 385 tons per year at a cost of $4.6 million. Part of the cost was covered by a Government grant under the Industry Act of 1972. Courtaulds planned to market a sizable part of its output in the United States through a joint venture with Dexter Corp. Courtaulds was a large producer of the polyacrylonitrile precursor used in the plant.

Table 11.—Graphite: World production, by country[1]

(Short tons)

Country[2]	1979	1980	1981	1982[p]	1983[e]
Argentina	11	6	2	13	14
Austria	44,664	40,454	26,243	26,953	27,560
Brazil (marketable)[3]	11,979	23,473	19,289	16,990	22,000
Burma[4]	295	482	1,568	308	330
China[e]	[r]201,000	176,000	[r]203,000	[r]204,000	204,000
Czechoslovakia[e]	49,600	49,600	49,600	49,600	49,600
Germany, Federal Republic of[5]	4,047	6,270	9,024	12,845	13,000
India (mine)[6]	58,225	60,391	62,004	57,735	38,600
Italy	4,522	4,362	3,897	3,538	3,700
Korea, North[e]	28,000	28,000	28,000	28,000	28,000
Korea, Republic of:					
Amorphous	59,789	65,209	37,533	29,033	33,100
Crystalline flake	2,704	1,575	928	691	880
Madagascar	15,699	13,506	14,698	16,925	[7]14,934
Mexico:					
Amorphous	56,086	[r]49,059	45,351	37,886	37,500
Crystaline flake	--	384	1,270	1,989	1,650
Norway	13,109	11,471	9,552	8,200	[7]8,885
Romania	13,670	13,800	[e]13,800	[e]13,800	13,900
South Africa, Republic of	434	--	--	--	--
Sri Lanka	10,364	8,591	8,348	9,704	8,800
Thailand	--	2,286	1,984	694	880
Turkey	NA	NA	NA	3,704	3,700
U.S.S.R.[e]	110,000	110,000	115,000	115,000	120,000
United States	W	--	--	W	W
Zimbabwe	6,324	8,141	12,366	9,066	14,300
Total	[r]690,522	[r]673,060	663,457	646,674	645,333

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available. W Withheld to avoid disclosing company proprietary data.

[1]Table includes data available through May 23, 1984.

[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: 1979—93,840; 1980—6,600; 1981—17,988; 1982—6,758; 1983—not available.

[4]Data are for fiscal year beginning Apr. 1 of that stated.

[5]Data presented represent estimated marketable product derived from raw graphite mined indigenously, assuming that marketable output equals one-half of officially reported raw graphite production.

[6]Indian marketable production is about 30% of mine production.

[7] Reported figure.

RK Technologies Ltd., formerly RK Textiles, built and brought on-stream a 220-ton-per-year capacity graphite fiber plant near Inverness, Scotland. The location was chosen because of a Government investment grant covering 35% of the construction cost. The plant was expected to be brought up to full capacity over several years to serve demand for a cheaper, lower quality fiber suitable for certain automotive, sporting goods, and industrial markets. Some aerospace-grade graphite fiber was also expected to be made. About 80% of the output was to be exported; much of it to the United States.

TECHNOLOGY

Three major new technologies were announced, two of which have the potential of increasing the long-term demand for graphite fiber and one of which could greatly decrease the long-term demand for graphite electrodes. At present, processes for manufacturing graphite fiber are expensive, and also require use of expensive raw materials. Further, the methods of fabrication of graphite fiber composite parts are complex, requiring extensive use of hand labor, and are not easily automated. A relatively simple manufacturing process for producing graphite fiber using natural gas as a raw material and a simple fabrication process that gives better graphite fiber composite parts by weaving the fiber are both major new developments in graphite fiber technology. The electric arc furnace now has a full-scale competitor that does not use graphite electrodes, the plasma arc furnace.

General Motors Research Laboratories discovered a method for growing graphite fibers by pyrolysis of natural gas. The discovery came about during an experiment to determine the speed that carbon diffuses through stainless steel. The experimental apparatus continuously introduced carbon in the form of natural gas to the inside surface of a steel tube while simultaneously extracting carbon from the outside surface of the tube. After running the experiment for some hours during one trial, graphite fibers were discovered inside the tube. Fiber growth began as tiny hollow filaments about 0.1 micrometer in diameter. Even though the phenomenon was studied extensively, the fiber growth mechanism remained unknown. However, most of the filaments contained a metal or metal carbide particle that apparently catalyzed growth. The particle itself appeared to form at or be released from the inner surface of the steel tube through a type of high-temperature surface erosion called metal dusting corrosion. This process could be of great commercial significance if it could be developed into an inexpensive full-scale operation. Commercially important processes for making graphite fiber utilize expensive textile threads such as polyacrylonitrile, rayon, or cheaper but more impure pitch that can cause imperfections in the graphite fiber. Another new process reported last year involves heating benzene to a high temperature to deposit carbon on a metal catalyst in strands that are then heat treated and graphitized.

A new process called Magnaweave that weaves graphite fiber into multidimensional reinforcements was announced. Unlike the prepreg in common use with significant tensile strength only in the fiber direction, the Magnaweave reinforcement has significant tensile strength in all three directions. Therefore, the graphite fiber composites made with Magnaweave cannot delaminate and are much less limited in the torsion or shear stress modes. The working principle of Magnaweave involves weaving the graphite fiber with no sudden directional changes of the sort that would prevent the weaving of a stiff fiber such as graphite fiber; the process forms a braid of graphite fiber. Magnaswirl, the circular counterpart of Magnaweave, makes reinforcements for parts such as pipe, cylinders, and domes. The processes can be used to produce low-cost, high-performance composites simply and rapidly. Cost savings result from a reduced need for labor, eliminating the layup step in prepregging, and being able to make the reinforcement at high speed.[7]

Plasma arc steel furnaces that do not use graphite electrodes have been developed. Several small units were in use in steel production in Europe, and Voest-Alpine AG was studying it for full-scale production at its Linz, Austria, steelworks. The plasma furnace is an electric arc furnace in which the graphite electrodes are replaced by water-cooled metallic electrodes that are only slightly consumed. The conventional electric arc is replaced by a plasma arc. The advantages of the plasma furnace are minimal electrode consumption, higher yield of steel because of an inert gas atmosphere and the ability to melt with a minimum of slag, a lower noise level, and less dust and waste gas generated. The plasma arc furnace also has advantages when applied to ferroalloy production, instead of the electric arc furnace, because any fines used as feed do not have to be agglomerated and higher product quality is obtained. If plasma arc furnaces replaced the conventional arc furnace on a broad scale, consumption of graphite electrodes would drop drastically.[8]

Use of graphite fiber composites in liquid rocket engines could result in a significant weight reduction and therefore improved payload capabilities and better engine thrust to weight ratios. The types of engines studied were earth-to-orbit hydrocarbon engines and orbit-to-orbit LOX/H_2 engines. Graphite fiber composites could be used directly for some components, and additional research could lead to the use of additional components.[9]

The impact strength of a graphite fiber composite was improved by coating the fiber surface with a rubber. The elastomeric particles were made into lattices and deposited ionically on surface-treated graphite fiber in order to obtain a surface containing discrete rubber particles. Elastomer flow and filament agglomeration during drying caused some trouble.[10]

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[1]Physical scientist, Division of Industrial Minerals.

[2]Skehan, J. W., G. E. Gill, J. D. Raben, N. Schapiro, and D. P. Murray. Exploration of Coal and Anthracitic Carbonaceous Shale Resources, Narragansett Basin, MA, and RI. Final Report, Oct. 1, 1979-Apr. 30, 1981. Weston Observatory, MA, May 1981, 81 pp; NTIS DE 82018223.

[3]Clarke, G. M. The Industrial Minerals of India. Ind. Miner. (London), No. 191, Aug. 1983, pp. 34-35.

[4]Avramescu, C., I. Calugaru, and M. Angelescu. The Industrial Minerals of Romania. Ind. Miner. (London), No. 186, Mar. 1983, p. 35.

[5]Industrial Minerals (London). A New Graphite Deposit at Mtubatuba. No. 192, Sept. 1983, p. 17.

[6]Clark, G. Sri Lanka's Industrial Minerals. Ind. Miner. (London), No. 193, Oct. 1983, pp. 61, 65-66.

[7]Wehrenberg, R. H. Composites Get Stronger With 3-D Reinforcement. Mater. Eng., v. 97, No. 1, Jan. 1983, pp. 27-31.

[8]Metal Bulletin Monthly. Voest-Alpine's Plasma Plant. No. 150, June 1983, pp. 45-49.

[9]Heubner, S. W. Composite Material Application for Liquid Rocket Engines. Rockwell Int., Canoga Park, CA, Dec. 1982, 145 pp.; NTIS N83-16382/4.

[10]Paul, J. T., and G. A. Buntin. Graphite Fiber Surface Treatment to Improve Impact Strength and Fracture Resistance in Subsequent Composites. Hercules Inc., Wilmington, DE, Dec. 1982, 43 pp.; NTIS N83-16392/3.

Gypsum

By J. W. Pressler[1]

The gypsum industry, spurred by lower interest rates and released pent-up demand for housing, with 1.7 million public and private housing unit starts in 1983, ended the year with record shipments of gypsum wallboard, 16.8 billion square feet, an increase of 28%. Output of crude gypsum and calcined gypsum also increased. Sales of gypsum products increased 26% to 21.8 million short tons valued at $1.6 billion. Imports of crude gypsum increased 20% to 8 million tons. Total value of gypsum product exports increased 9% to $32.1 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 an 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)

	1979	1980	1981	1982	1983
United States:					
Active mines and plants[1]	113	114	113	109	111
Crude:					
Mined	14,630	12,376	11,497	10,538	12,884
Value	$99,868	$103,059	$98,101	$89,131	$101,361
Imports for consumption	7,773	7,365	7,593	6,718	8,031
Byproduct gypsum sales	828	663	696	697	760
Calcined:					
Produced	14,543	11,848	11,687	11,243	13,902
Value	$442,157	$270,324	$243,140	$196,488	$270,136
Products sold (value)	$1,391,993	$1,241,949	$1,196,236	$1,121,775	$1,605,605
Exports (value)	$22,388	$27,222	$35,434	$29,550	$32,088
Imports for consumption (value)	$65,079	$51,880	$51,720	$53,646	$87,880
World: Production	[r]88,589	[r]86,530	83,948	[p]78,970	[e]85,824

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

[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 15% of the total world output.

Forty-two companies mined crude gypsum at 69 mines in 22 States. Production increased 22%. Leading producing States were Texas, Iowa, Oklahoma, California, Michigan, and Indiana. These six States produced more than 1 million tons each and together accounted for 65% of total domestic production. Stocks of crude ore at mines and plants at yearend were 3 million tons.

Leading companies were 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 80% 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 Shoals Mine, Martin County, IN; United States Gypsum's Alabaster Mine, Iosco County, MI; Georgia-Pacific's Acme Mine, Hardeman County, TX; Weyerhaeuser's Briar Mine, Howard County, AR; National Gypsum's Sun City Mine, Barber County, KS; National Gypsum's Shoals Mine, Martin County, IN; United States Gypsum's Southard Mine, Blaine County, OK; and United States Gypsum's Fort Dodge Mine, Webster County, IA. These 10 mines accounted for 44% of the national total. Average output per mine for the 69 U.S. mines increased 24% to 186,700 tons.

Fourteen companies calcined gypsum at 70 plants in 30 States, principally for the manufacture of gypsum wallboard and plaster. Calcine output increased 24% in tonnage and 37% in value. Leading States were Texas, California, Iowa, and Florida. These 4 States, with 20 plants, accounted for 37% 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 85% of the national output.

Leading individual plants were United States Gypsum's Plaster City plant, Imperial County, CA; United States Gypsum's Sweetwater plant, Nolan County, TX; United States Gypsum's Jacksonville plant, Duval County, FL; Weyerhaeuser's Briar plant, Howard County, AR; Georgia-Pacific's Acme plant, Hardeman County, TX; United States Gypsum's Shoals plant, Martin County, IN; National Gypsum's Tampa plant, Hillsborough County, FL; United States Gypsum's Stony Point plant, Rockland County, NY; National Gypsum's Schoals plant, Martin County, IN; and National Gypsum's Medicine Lodge plant, Barber County, KS. These 10 plants accounted for 30% of the national production. Average calcine production for the 70 U.S. plants was 198,600 tons, a 22% increase.

The following companies sold a total of 760,000 tons of byproduct gypsum, valued at $7.1 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; Glidden Pigments Div. of SCM Corp. in Maryland; and Texasgulf Inc. in North Carolina. 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's Glidden Pigments' plant in Baltimore.

Owing to increased demand for gypsum wallboard, all plants that had been closed in 1982 were reopened in 1983. The capacity of one new gypsum wallboard plant combined with the capacities of the reopened plants resulted in an 8% increase in domestic capacity of operating wallboard plants to 20 billion square feet. Total wallboard production was 16.8 billion square feet, indicating an 84% utilization of operating capacity. This was a new record, slightly more than that produced in 1979.

Windsor Gypsum Co. brought its new gypsum wallboard plant in McQueeney, TX, on-stream in the fourth quarter. Based on purchased gypsum rock, it had a capacity of 500 million square feet of wallboard per year.

Domtar Inc. of Montreal, Canada, had purchased the Grand Rapids Mine and wallboard plant of Grand Rapids Gypsum Co. for $2.7 million in 1981. It remained dormant until Domtar rehabilitated the underground mine, and renovated the 120-million-square-foot capacity wallboard plant in 1983 at a cost of $3.8 million. It was operational at yearend. The La Porte County, IN, Plan Commission approved a rezoning permit in September for United States Gypsum to operate a gypsum mine and install a gypsum wallboard plant in Center Township. It was estimated by the company that the facilities would be operational in 2 to 3 years.

The Hamlim wallboard plant of Southwest Gypsum Co. in Fisher County, TX, was dismantled.

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 & Sons' Lidy Hot Springs Mine in Lemhi County, ID, was closed. Raymond Schweitzer Gypsum Co.'s Cement Mine in Caddo County, OK, and Walton Gypsum Co.'s O'Keene Mine in Blaine County, OK, were dormant.

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.

Victor Material Co. sold its Amboy Mine in San Bernardino County, CA, to CV Organic Fertilizers Co. The ore was used for agricultural purposes.

United States Gypsum reopened the Fremont wallboard plant in Alameda County, CA, which it had previously purchased from Genstar. It was scheduled to operate on calcine from United States Gypsum's Empire plant in Pershing County, NV.

Table 2.—Crude gypsum mined in the United States, by State

State	1982			1983		
	Active mines	Quantity (thousand short tons)	Value (thousands)	Active mines	Quantity (thousand short tons)	Value (thousands)
Arizona	4	175	$1,205	4	265	$1,929
Arkansas, Kansas, Louisiana	5	1,085	8,152	5	1,328	8,038
California	10	1,088	10,614	10	1,213	10,668
Colorado, Idaho, Montana, South Dakota, Washington	10	264	2,381	7	349	2,865
Indiana, New York, Ohio, Virginia	5	1,491	12,936	5	1,766	13,699
Iowa	6	1,177	11,345	6	1,612	13,518
Michigan	4	682	5,150	4	1,097	8,104
Nevada	4	656	4,523	4	998	7,896
New Mexico	3	198	887	3	169	1,016
Oklahoma	5	1,254	10,089	6	1,351	11,571
Texas	7	1,954	16,681	7	2,049	16,357
Utah	4	231	2,363	5	305	2,736
Wyoming	3	283	2,805	3	382	2,963
Total	70	10,538	89,131	69	12,884	[1]101,361

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

Table 3.—Calcined gypsum produced in the United States, by State

State	1982			1983		
	Active plants	Quantity (thousand short tons)	Value (thousands)	Active plants	Quantity (thousand short tons)	Value (thousands)
Arizona, Colorado, New Mexico, Utah	6	513	$7,383	6	588	$11,571
Arkansas, Illinois, Indiana, Kansas, Louisiana, Oklahoma	12	2,226	35,787	12	2,778	49,565
California	7	1,172	22,667	6	1,487	31,561
Delaware, Maryland, North Carolina, Virginia	6	1,182	20,857	6	1,326	26,085
Florida	3	717	14,231	3	1,004	21,351
Georgia	3	539	11,363	3	666	14,574
Iowa	5	847	13,475	5	1,090	19,752
Massachusetts, New Hampshire, New Jersey, Pennsylvania (1983)	4	576	11,399	5	630	13,312
Michigan	3	245	3,915	3	335	6,000
Montana, Washington, Wyoming	5	347	8,997	5	579	14,077
Nevada	3	499	7,491	3	671	11,398
New York	4	840	13,480	4	949	17,556
Ohio	3	213	5,128	3	291	6,480
Texas	5	1,326	20,318	6	1,509	26,852
Total[1]	69	11,243	196,488	70	13,902	270,136

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

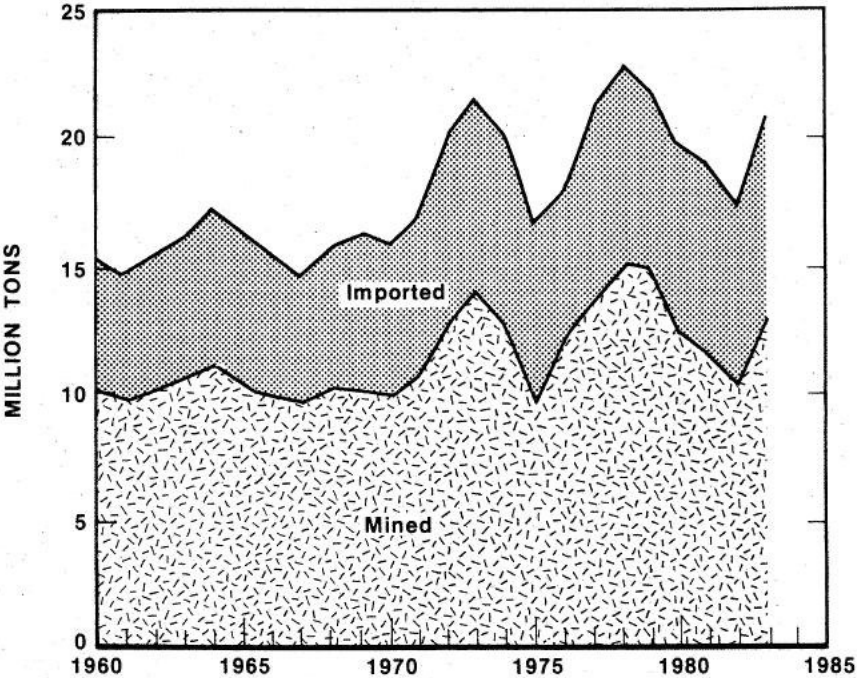

Figure 1.—Supply of crude gypsum in the United States.

CONSUMPTION AND USES

Apparent consumption, production plus net imports plus industry stock changes, of crude gypsum increased 26% to 21.8 million tons. Net imports provided 36% of the crude gypsum consumed. Apparent consumption of calcined gypsum increased 24% to 13.8 million tons.

Yearend stocks of crude gypsum at mines and calcining plants were 3 million tons. Of this, 61% was at calcining plants in coastal States.

Of the total gypsum products sold or used, 5.5 million tons, 25%, was uncalcined. Of the total uncalcined gypsum, 72% was used for portland cement and 24% was used in agriculture. Leading sales regions for gypsum used in cement were the South Atlantic, West South-Central, and Pacific; these three regions accounted for 65% of the total. For agricultural gypsum, the Pacific region accounted for 58% 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, 70% was regular wallboard, 19% was fire-resistant Type X wallboard, 5% was 5/16-inch mobile home board, and 6% was lath, veneer base, sheathing, and predecorated wallboard. Of the regular wallboard, 83% was 1/2-inch and 11% 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	1982 Quantity	1982 Value	1983 Quantity	1983 Value
Uncalcined:				
Portland cement	3,067	35,685	3,955	39,770
Agriculture[1]	1,301	16,951	1,309	18,284
Fillers and miscellaneous	123	5,768	197	5,967
Total	4,491	58,404	5,461	64,021
Calcined:				
Industrial plaster	358	30,953	388	37,558
Building plaster:				
Regular base coat	187	15,512	158	14,906
Poured gypsum cement and concrete	51	4,347	46	4,391
Veneer plaster	66	8,628	83	11,219
Gaging plaster and Keene's cement	25	2,826	25	3,150
Other	([2])	34	9	1,186
Total	329	31,347	321	34,852
Prefabricated products[3]	12,222	1,001,071	15,673	1,469,174
Total calcined	12,909	1,063,371	[4]16,381	1,541,584
Grand total	17,400	1,121,775	[4]21,843	1,605,605

[1]Includes most of 697,201 tons of byproduct gypsum in 1982 and most of 760,116 tons in 1983.
[2]Less than 1/2 unit.
[3]Includes weight of paper, metal, or other materials, and some byproduct gypsum.
[4]Data do not add to total shown because of independent rounding.

Table 5.—Prefabricated gypsum products sold or used in the United States

Product	1982 Thousand square feet	1982 Thousand short tons[1]	1982 Value (thousands)	1983 Thousand square feet	1983 Thousand short tons[1]	1983 Value (thousands)
Lath:						
3/8 inch	37,377	29	$3,360	47,530	36	$4,981
1/2 inch	2,105	2	174	99,180	91	9,930
Total[2]	39,482	31	3,534	146,710	126	14,912
Veneer base	285,045	291	21,299	369,019	386	33,784
Sheathing	265,128	247	25,654	338,839	316	38,315
Regular gypsumboard:						
3/8 inch	560,921	459	38,627	480,106	392	40,850
1/2 inch	7,346,516	6,522	496,846	9,695,968	8,679	774,993
5/8 inch	1,020,294	925	83,158	1,313,854	1,205	127,593
1 inch	21,177	23	3,115	53,570	91	9,794
Other[3]	128,348	131	10,148	130,269	114	11,744
Total[2]	9,077,256	8,061	631,893	11,673,767	10,481	964,974
Type X gypsumboard	2,810,491	3,077	233,377	3,266,579	3,546	306,175
Predecorated wallboard	161,070	152	45,400	112,480	109	33,920
5/16-inch mobile home board	436,298	352	37,868	853,314	706	76,593
Other	11,131	11	2,048	2,380	3	502
Grand total[2]	13,085,901	12,222	1,001,071	16,763,088	15,673	1,469,174

[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.

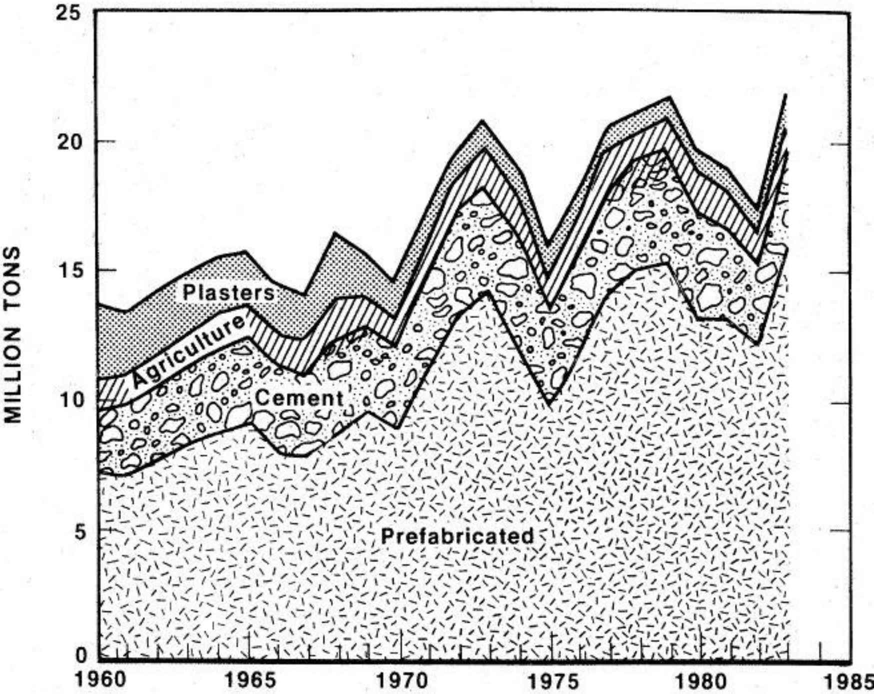

Figure 2.—Sales of gypsum products, by use.

ENERGY

Efficient production scheduling, superior insulation, and energy-saving processing equipment such as one-step drying and calcining continued to approximate the same utilization of energy per unit of wallboard as in the past few years. Energy consumption per thousand square feet of gypsum wallboard sales remained virtually the same at 2.62 million British thermal units.

As reported by the Gypsum Association, fuel sources for the gypsum industry were natural gas, 81.6%; electricity, 6%; propane, 3%; No. 2 fuel oil, 2.6%; No. 4 and No. 6 fuel oil, 3%; and coal, 3.8%.

PRICES

On an average value per ton basis, crude gypsum decreased 7% to \$7.87, calcined gypsum increased 11% to \$19.43, and byproduct gypsum sold increased 19% to \$9.39.

The average value of gypsum products sold or used increased 14% to \$73.51 per ton. Prefabricated products were valued at \$93.74 per ton, industrial plasters at \$96.80 per ton, building plaster at \$108.57 per ton, and uncalcined products at \$11.72 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 \$108 per thousand square feet at Los Angeles to \$190 at Atlanta. Average price in December for 20 cities was \$139.20 per thousand square feet, with some minor discounts for prompt payment.

FOREIGN TRADE

The gypsum industry continued to rely on imports of crude gypsum rock for a significant fraction, 36%, of apparent consumption. Imports of crude gypsum, principally from Canada, 68%; Mexico, 19%; and Spain, 12%, increased 20% to 8 million tons. Spanish imports into the South Atlantic Coast States increased significantly. Most of the imported crude gypsum was mined by subsidiaries of U.S. companies in Canada and Mexico.

Total value of gypsum and gypsum products imported was $87.9 million, an increase of 64%. Gypsum wallboard imports from Canada were 314 million square feet, an 87% increase. Total value of gypsum product exports to all countries was $32 million, a 9% increase.

Table 6.—U.S. exports of gypsum and gypsum products

(Thousand short tons and thousand dollars)

Year	Crude, crushed, or calcined		Other manufactures, n.e.c. (value)[1]	Total value
	Quantity	Value		
1981	157	14,590	20,844	35,434
1982	123	13,319	16,231	29,550
1983	117	13,621	18,467	32,088

[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		Ground or calcined		Alabaster manufactures[1] (value)	Plaster-board[2] (value)	Other manufactures, n.s.p.f.[3] (value)	Total value
	Quantity	Value	Quantity	Value				
1981	7,593	39,266	2	339	1,169	8,419	2,527	51,720
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

[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 articles, n.s.p.f., of plaster of paris, with or without reinforcement (TSUSA 512.3100, 512.3500, 512.4100, and 512.4400).
[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	1982		1983	
	Quantity	Value	Quantity	Value
Canada[1]	5,283	28,887	5,476	43,231
Dominican Republic	28	350	10	119
Jamaica	14	163	27	154
Mexico	1,124	4,842	1,563	6,463
Spain	269	1,716	955	6,895
Other	(2)	23	(2)	99
Total	6,718	35,981	8,031	[3]56,960

[1]Includes anhydrite.
[2]Less than 1/2 unit.
[3]Data do not add to total 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.—Australia has been a net exporter of crude gypsum in recent years. Of the 2 million tons produced in 1983, an estimated 35% was exported, principally as a cement set retardant, to Indonesia, New Zealand, and Singapore.

Canada.—Canada was the second leading producer of crude gypsum, accounting for 10% of the world total with shipments of 7.5 million tons, a 19% increase. United States Gypsum merged the gypsum rock and wallboard interests of its Canadian Gypsum Co. Ltd. subsidiary with Westroc Industries Ltd. Westroc was a subsidiary of BPB Industries Ltd., of the United Kingdom, which also owns British Gypsum Ltd. United States Gypsum was to have 70% of the merged company, and BPB the balance.[2]

Canada exported 5.5 million tons of crude gypsum from Nova Scotia and Newfoundland to the Atlantic and Gulf Coast States, principally to gypsum wallboard plants. Canada also exported over 300 million square feet of wallboard into the northern States, only 9% less than the record year of 1979. All Canadian gypsum wallboard manufacturers were members of the Gypsum Association in the United States, which announced that yearend Canadian wallboard capacity was 3.5 billion square feet, a 2% decrease.

China.—An estimated 440-million-short-ton gypsum deposit had been discovered in 1982 in Longyao County, Hubei Province, 4 miles from the Peking-Canton railway. Approximately 880,000 tons was consumed in 1983 in Hubei by the cement and building materials industries.[3] Additional gypsum reserves of 200 million tons each were discovered in 1983 in Xiangfen County and in northern Tibet in Ngari and Nagqu Prefectures.[4]

Egypt.—Sinai Manganese Co. had selected a contractor for construction of a 330,000-ton-per-year calcining plant at the Ras Malaab gypsum mine in the Sinai Peninsula. Equipment costs were to be financed by a $10 million U.S. Agency for International Development Loan.[5]

India.—Rajasthan was the major gypsum producing State with about 94% of India's production. The balance was accounted for by Tamil Nadu State. Over 90% of the natural gypsum output was consumed by the cement industry, with small amounts used in fertilizers, ceramics, and plaster of paris. Five companies operated eleven mines in Rajasthan, and 1 company had several operations in Tamil Nadu. In addition to the natural gypsum production, India had substantial production of phosphogypsum, 1.6 million tons, and 300,000 tons of marine gypsum, a byproduct of salt production. Only 400,000 tons per year of phosphogypsum was used as agricultural fertilizer and cement, but most of the marine gypsum was used in the cement industry.[6]

Laos.—The Vietnamese Government has assisted the Laos Government in the development and operations of an open pit gypsum mine at Dong Hen, near Savannakhet. Production has been over 190,000 tons for the 4-year period 1980-83, principally for use as a set retarder in cement.[7]

Pakistan.—The Dera Ghazi Khan Hills in Punjab, Pakistan, were estimated to contain 20 million tons of commercial gypsum. A recent survey was completed for the Government with a preliminary reconnaissance of gypsum deposits in Sufaid Koh, Rakhi Munh, Spintangi, Khewra, Burihkel, and Kohat. Sufficient reserves for anticipated market needs was indicated. A $36 million joint venture, prepared by the Punjab Mineral Development Corp. and financed by the Asian Development Bank, was being solicited from the private sector for production of 750,000 tons of gypsum per year.[8]

Thailand.—Thailand's gypsum production increased 1% to 838,000 tons. Over 518,000 tons was exported to Southeast Asian countries—Indonesia, 32%; Malaysia, 28%; Taiwan, 21%; and the Philippines, Hong Kong, and Singapore, the remaining 19%—principally for use as a set retarder in cement.[9]

U.S.S.R.—In order to utilize its extensive reserves of gypsum and phosphogypsum, the Soviet Union was continuing the construction of gypsum block manufacturing plants to supply building blocks for agricultural buildings. The first plant was built in Krasnoufimsk, Sverdlovsk Oblast', for use in the construction of over 1,000 agricultural buildings in the Urals. The gypsum blocks were to replace cement blocks, manufacture of which requires four times the fuel cost and twice the labor cost of gypsum blocks.[10]

United Kingdom.—Nuclear Industry Radioactive Waste Executive, the British state-owned nuclear waste agency, was conducting a safety and feasibility study for the disposal of radioactive waste in an unused Imperial Chemical Industries Ltd.'s anhydrite mine in the northeast of England.[11]

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

(Thousand short tons)

Country	1979	1980	1981	1982[p]	1983[e]
Afghanistan	--	--	--	3	6
Algeria[e]	210	220	220	220	275
Angola[e]	28	28	22	[r]22	20
Argentina	648	1,028	739	679	[2]667
Australia	1,356	1,443	1,897	[e]1,907	1,980
Austria[3]	880	919	882	802	[2]828
Belgium[3]	212	192	170	[r] [e]154	150
Bolivia	[e]1	1	1	1	1
Brazil[4]	515	601	659	750	770
Bulgaria	341	343	386	414	410
Burma[4]	42	41	34	29	[2]38
Canada (shipments)[3]	8,927	[r]8,087	7,744	6,000	8,250
Chile	179	218	262	99	75
China	4,000	3,700	3,800	3,900	4,000
Colombia	283	289	298	331	[2]331
Cuba[e]	100	134	[r]148	140	145
Cyprus	51	48	44	33	[2]35
Czechoslovakia	809	834	845	875	880
Dominican Republic	193	259	225	[e]230	230
Ecuador	7	7	2	2	2
Egypt	877	1,036	1,047	1,026	[2]795
El Salvador	8	10	7	6	5
Ethiopia	1	1	5	5	5
France[3]	6,754	[r]7,155	6,776	6,657	6,600
German Democratic Republic	397	397	397	397	400
Germany, Federal Republic of (marketable)[3]	2,481	2,480	2,122	1,897	2,000
Greece	666	535	551	551	550
Guatemala	28	37	32	31	30
Honduras[e]	25	25	[r]22	[r]22	25
India	967	[r]955	1,045	1,070	[2]1,145
Iran	7,700	7,700	6,600	[e]5,500	6,000
Iraq[e]	180	190	190	190	190
Ireland	460	421	397	[e]400	400
Israel	80	[e]90	46	47	50
Italy	1,630	[r]1,801	1,702	1,472	1,400
Jamaica	52	116	206	207	[2]119
Japan[5]	6,915	6,730	6,765	7,014	7,300
Jordan	40	[e]50	58	44	[2]45
Kenya[3]	([6])	([6])	([6])	([7])	1
Korea, Republic of[e 5]	680	700	700	800	1,000
Laos	--	22	45	[e]70	80
Lebanon	11	11	10	6	80
Libya	[r]181	[r]180	180	170	165
Luxembourg	1	1	1	([7])	([7])
Mauritania	18	13	2	[e]6	4
Mexico	2,228	[r]2,393	2,635	2,057	2,600
Mongolia[e]	31	[r]33	[r]35	35	35
Nicaragua[e]	40	44	33	[2]22	22
Niger	3	[e]3	3	[e]3	3
Pakistan	378	626	433	341	[2]358
Paraguay	[e]12	13	11	7	7
Peru	[r]240	309	386	[e]400	400
Philippines[5]	121	121	122	121	121
Poland[e 8]	1,500	1,430	1,430	[r]1,430	1,430
Portugal	265	261	268	[e]300	300
Romania	2,061	1,776	[e]1,800	[e]1,800	1,800
Saudi Arabia	331	331	386	400	400
South Africa, Republic of	416	499	612	590	[2]571
Spain	[r]5,918	[r]5,815	5,757	5,566	5,500
Sudan[3]	11	11	17	17	17
Switzerland[e]	77	88	95	90	90
Syria	70	87	88	[e]90	[2]428
Taiwan[5]	3	9	7	2	[2]3
Tanzania	10	12	13	[e]13	13

See footnotes at end of table.

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

(Thousand short tons)

Country	1979	1980	1981	1982[p]	1983[e]
Thailand	388	454	596	831	[2]838
Tunisia	66	83	83	83	95
Turkey	[e]70	80	100	100	[2]83
U.S.S.R.[e 5]	6,000	6,000	6,000	6,000	6,000
United Kingdom[3]	3,858	3,800	3,245	3,021	3,400
United States[9]	14,630	12,376	11,497	10,538	[2]12,884
Venezuela	287	129	241	175	190
Vietnam[e]	15	17	17	[r]30	30
Yemen Arab Republic	--	--	[e]22	24	24
Yugoslavia	626	682	737	705	700
Zaire	--	([6])	([6])	([6])	--
Zambia	([7])	--	--	--	--
Total	[r]88,589	[r]86,530	83,948	78,970	85,824

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through June 27, 1984.
[2]Reported figure.
[3]Includes anhydrite.
[4]Data are for years beginning Apr. 1 of that stated.
[5]Includes byproduct gypsum. (In the case of Japan, byproduct gypsum was virtually all gypsum consumed during 1979-83.)
[6]Revised to zero.
[7]Less than 1/2 unit.
[8]Series revised to represent sum of (1) mine product sold without beneficiation and (2) output of concentrates.
[9]Excludes byproduct gypsum.

TECHNOLOGY

Norgips BV of the Netherlands was constructing a $2.2 million pilot plant for the production of α-hemihydrate gypsum at the Veendam site of Magnesia International BV, which planned to utilize byproduct gypsum from its magnesia plant. If successful, Norgips expects to build a 110,000-ton-per-year commercial plant by 1985. The technology is based on a West German patent for the production of α-hemihydrate gypsum for use in high-volume markets such as fireproof doors and cement for chipboard production.[12]

Research testing conducted by the Texas Transportation Institute at College Station, TX, indicated that large tonnages of byproduct phosphogypsum and fluorogypsum can be used as road base material for as little as one-third the cost of crushed limestone. Comparison of road bases on residential streets in La Porte, TX, indicated that byproduct base sections performed very well. The phosphogypsum was stabilized by additions of 15% to 30% of fly ash and 5% to 10% of portland cement, followed by spreading, rototilling, and compacting. Fluorogypsum stabilization required no additional cementitious materials. Cost savings came primarily from lower delivery costs.[13]

The U.S. Bureau of Mines conducted research at its Tuscaloosa Research Center to identify and develop more extensive uses for phosphogypsum. Mixtures containing a maximum of 50% phosphogypsum, 6% to 10% lime, and the remainder fly ash had aggregate compressive strengths as high as 4,800 pounds per square inch.[14]

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[1]Physical scientist, Division of Industrial Minerals.
[2]Industrial Minerals (London). U.S. Canadian/British Gypsum. No. 189, June 1983, p. 11.
[3]———. Company News and Mineral Notes. No. 199, Apr. 1984, p. 79.
[4]———. Company News and Mineral Notes. No. 195, Dec. 1983, p. 77.
———. Company News and Mineral Notes. No. 196, Jan. 1984, p. 71.
[5]U.S. Embassy, Cairo, Egypt. State Dep. Telegram 10074, Apr. 1, 1984.
[6]Clarke, G. M. The Industrial Minerals of India. Ind. Miner. (London). No. 191, Aug. 1983, p. 31.
[7]Vietiane PASASON (Laos). SRV-Aided Gypsum Mining In Savannakhet Described. Jan. 1984, p. 2.
[8]Mining Journal (London). Pakistan's Mining Plans. V. 301, No. 7,730, Oct. 14, 1983, p. 275.
[9]U.S. Embassy, Bangkok, Thailand. State Dep. Airgram A-26, Apr. 23, 1984, table 6, p. 2.
[10]Industrial Minerals (London). Company News and Mineral Notes. No. 190, July 1983, p. 72.
[11]———. Company News and Mineral Notes. No. 195, Dec. 1983, p. 76.
[12]———. Test Plant for Alpha-Gypsum. No. 186, Mar. 1983, pp. 11-12.
[13]Engineering News-Record. Road Use for Waste By-Products? V. 211, No. 20, Nov. 17, 1983, pp. 13-14.
[14]May, A., J. S. Sweeney, and J. R. Cobble. Synthetic Construction Aggregate Developed From Phosphate Fertilizer Waste. Presented at Soc. Min. Eng. Fall Meeting and Exhibit, Salt Lake City, UT, Oct. 19-21, 1983, Soc. Min. Eng. AIME preprint 83-300, 15 pp.

Helium

By William D. Leachman[1] and Philip C. Tully[2]

Grade-A helium (99.995% or better) sales volume in the United States by private industry and the Bureau of Mines was 995 million cubic feet (MMcf) in 1983.[3] Grade-A helium exports by private producers were 368 MMcf for total sales of 1,363 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 $35 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 seven 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 data shown in table 2.

Legislation and Government Programs.—The Government's program for storage of private crude helium in the Government's helium storage facilities at the Cliffside Field near Amarillo, TX, was critical in supplying helium for the private helium market. Private 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 1983, there were 11 privately owned domestic helium plants, which were operated by 9 companies. One new crude helium plant, Phillips Petroleum Co.'s Dumas plant, was started during the year. Seven privately owned plants and one Bureau plant extracted helium from natural gas. Both private and Bureau plants use cryogenic extraction processes. Pr ssure-swing-adsorption is used for helium purification at two private helium plants and the Bureau's plant. Cryogenic purification is used by other producers. The Bureau and five of the six private plants that produce Grade-A helium also liquefy helium. They are Air Products and Chemicals Inc., Hansford County, TX; Cities Service Cryogenics Inc., Ulysses, KS; Kansas Refined Helium Co., Otis, KS; Helium Sales Inc., now owned by Union Carbide Corp. and operated by Helium Sales, Elkhart, KS; and Union Carbide, Linde Div., Bushton, KS.

The volume of helium recovered from natural gas increased because two private crude helium plants that were temporarily shut down owing to the lack of natural gas liquids markets resumed operation and Phillips Petroleum's Dumas plant initiated operations. Most of the natural gas processed for helium extraction came from gasfields in Kansas, New Mexico, Oklahoma, and Texas.

The Bureau awarded a contract for a pressure-swing-adsorption helium purification unit in 1979. The unit was installed at the Masterson, TX, Exell plant during 1980, accepted in 1981, and has operated satisfactorily. A new cryogenic helium purification unit and helium liquefier, also purchased under contract, were installed at the Bureau's Exell plant. The new cryogenic purifier was accepted in 1983. The liquefier was accepted in 1981 and has operated satisfactorily. A wet-expansion engine is presently being procured for the liquefier to increase its output.

Table 1.—Ownership and location of helium extraction plants in the United States in 1983

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]
Do	Ulysses, KS	Grade-A helium.[1]
Cities Service Helex Inc	do	Crude helium.
Kansas Refined Helium Co	Otis, KS	Grade-A helium.[1]
Navajo Refined Helium Co.	Shiprock, NM	Grade-A helium.
Northern Helex Co	Bushton, KS	Crude helium.
Phillips Petroleum Co.[3]	Dumas, TX	Do.
Do	Hansford County, TX	Do.
Union Carbide Corp., Linde Div.	Bushton, KS	Grade-A helium.[1]
Do[4]	Elkhart, KS	Do.

[1]Including liquefaction.
[2]Output is piped to Cities Service Cryogenics Inc. plant at Ulysses, KS, for purification.
[3]Phillips Petroleum Co.'s Dumas plant initially operated in June 1983.
[4]Grade-A helium facility sold to Union Carbide Corp. Aug. 17, 1983.

Table 2.—Helium recovery in the United States[1]

(Thousand cubic feet)

	1979	1980	1981	1982	1983
Crude helium: Bureau of Mines:					
Total storage	34,868	22,887	-257,799	r-350,235	-275,714
Private industry:					
Stored by Bureau of Mines	787,123	633,956	452,880	113,261	282,018
Withdrawn	-180,840	-266,898	-304,987	-724,113	-729,134
Total private industry storage	606,283	367,058	147,893	-610,852	-447,116
Total crude helium	641,151	389,945	-109,906	r-961,087	-722,830
Stored private crude helium withdrawn from storage and purified by the Bureau of Mines for redelivery to industry	-222,320	-200,612	-80,208	-51,234	-65,015
Grade-A helium:					
Bureau of Mines sold	209,680	187,735	240,880	305,071	241,733
Private industry sold	890,160	986,601	1,014,543	939,496	1,120,955
Total sold	1,099,840	1,174,336	1,255,423	1,244,567	1,362,688
Total stored	418,831	189,333	-190,114	r-1,012,321	-787,845
Grand total recovery	1,518,671	1,363,669	1,065,309	r232,246	574,843

rRevised.
[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)

	1981	1982	1983
Supply:			
Inventory at beginning of period[1]	14,510	14,375	20,368
Helium recovered:			
Exell plant: Grade-A[2]	237,719	362,298	308,780
Keyes plant:			
Crude	22,375	--	--
Grade-A[3]	49,346	--	--
Total recovered	309,440	362,298	308,780
Helium returned in containers (net)	33,888	--	--
Total supply	357,838	376,673	329,148
Disposal:			
Sales of Grade-A helium	240,880	305,071	241,733
Redelivered to private producers	80,208	51,234	65,015
Net deliveries to helium conservation system	22,375	--	--
Inventory at end of period[1]	14,375	20,368	22,400
Total	357,838	376,673	329,148

[1]At Amarillo and Exell helium plants.
[2]Includes 67,591 Mcf purified for private industry in 1981, 51,234 Mcf in 1982, and 65,015 Mcf in 1983.
[3]Includes 12,617 Mcf purified for private industry in 1981. Gas processing shut down Sept. 1981.

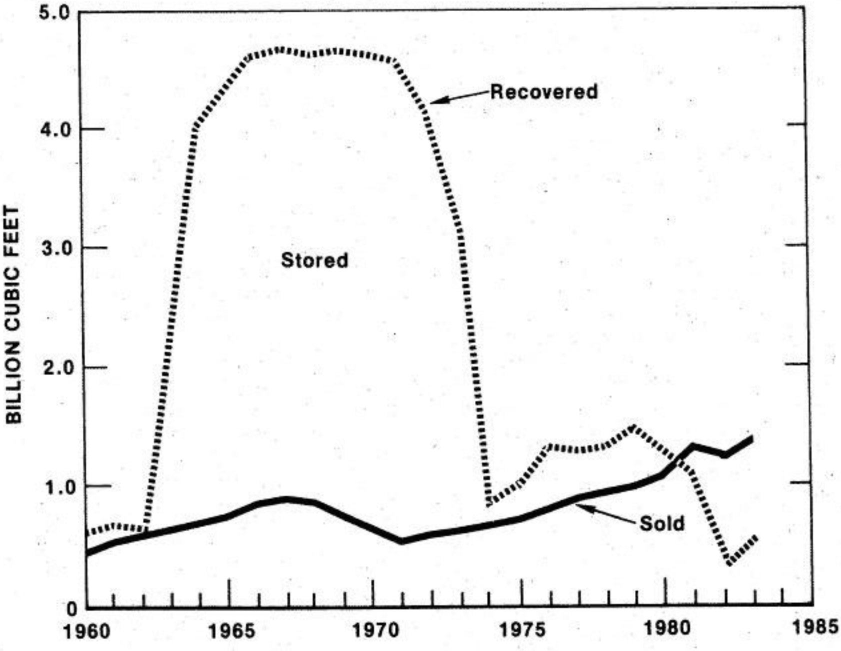

Figure 1.—Helium recovery in the United States, 1960-83.

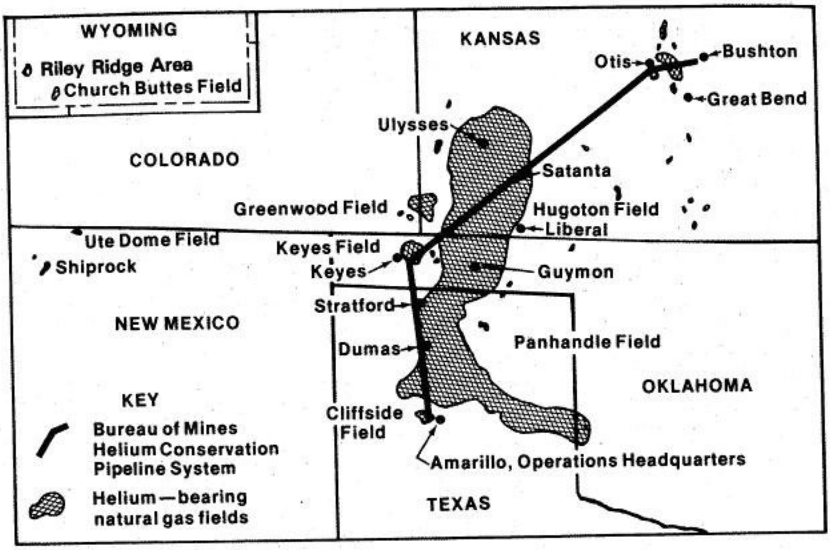

Figure 2.—Major U.S. helium-bearing natural gas fields.

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.

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.

The Bureau 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 1983. Private producers' price for Grade-A helium was about $35 per Mcf at yearend. The price of liquid helium averaged $55 per Mcf gaseous equivalent, plus possible surcharges.

All Grade-A gaseous helium sold by the Bureau was shipped in cylinders, special railway tank cars, or highway tube semitrailers. Liquid helium was shipped in dewars and semitrailers from the Exell helium plant. Private industrial gas distributors shipped helium as gas or liquid. Much of the private helium was transported in liquid form by semitrailers to distribution centers, where a portion was gasified and compressed into trailers and small cylinders for delivery to the end user.

Table 4.—Total sales of Grade-A helium in the United States

(Million cubic feet)

Year	Volume
1979	817
1980	863
1981	866
1982	867
1983	995

Table 5.—Bureau of Mines sales of Grade-A helium, by purchaser[1]

(Thousand cubic feet)

Purchaser	1981	1982	1983
Federal agencies:			
Department of Defense	92,405	93,535	105,372
Department of Energy	29,441	29,939	32,821
National Aeronautics and Space Administration	44,221	37,447	37,674
National Weather Service	1,002	1,077	874
Other	2,661	2,812	2,957
Total	169,730	164,810	179,698
Federal agency sales supplied by private-contract helium distributors[2]	68,551	136,359	59,059
Commercial sales	2,599	3,902	2,976
Grand total	240,880	305,071	241,733

[1]Table identifies purchaser, which is not necessarily a 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.

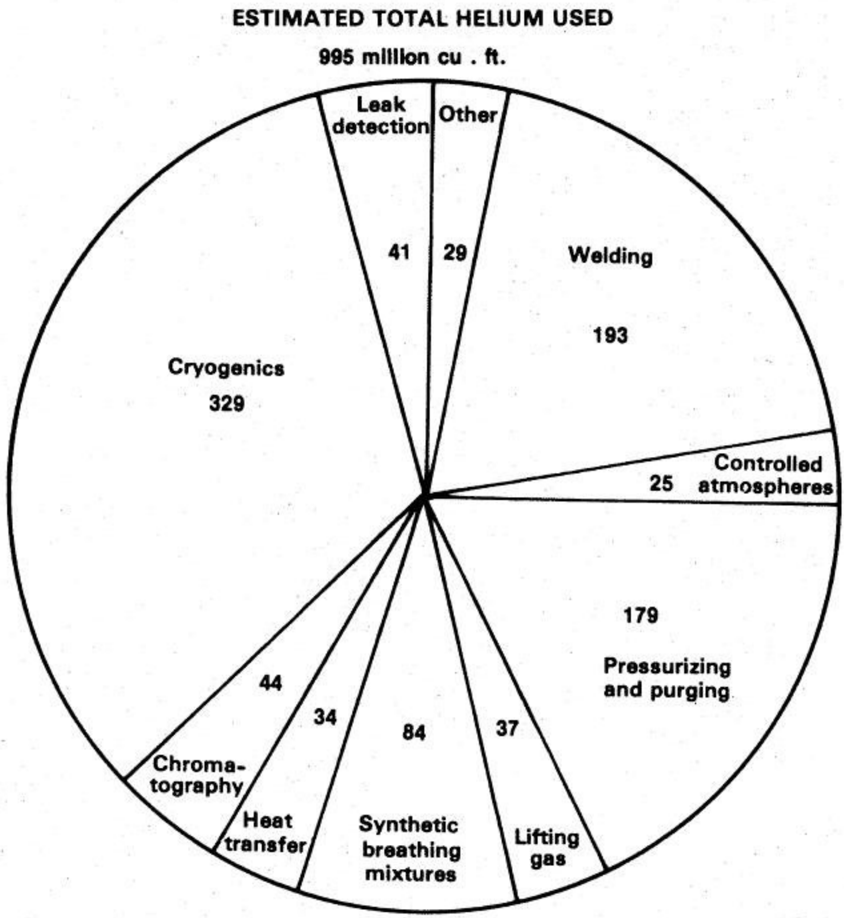

Figure 3.—Estimated helium consumption in the United States in 1983, by end use (million cubic feet).

CONSERVATION

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 under contract, Bureau helium extracted in excess of sales, and privately owned helium stored under contract. During 1983, 282 MMcf of private helium was delivered to the Bureau's helium conservation storage system and 794 MMcf was withdrawn, for a net decrease of 512 MMcf of private helium in storage.

Table 6.—Summary of Bureau of Mines helium conservation storage system[1] operations

(Thousand cubic feet)

	1981	1982	1983
Helium in conservation storage system at beginning of period:			
Stored under Bureau of Mines conservation program	37,883,314	36,137,610	35,787,375
Stored for private producers under contract	2,582,426	4,137,724	3,475,638
Total	40,465,740	40,275,334	39,263,013
Input to system:			
Net deliveries from Bureau of Mines plants[2]	[3]-1,745,704	-350,235	-275,714
Stored for private producers under contract	[3]1,940,492	113,261	282,018
Total[2]	194,788	-236,974	6,304
Redelivery of helium stored for private producers under contract[2]	-385,194	-775,347	-794,149
Net addition to system[2]	-190,406	-1,012,321	-787,845
Helium in conservation storage system at end 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

[1]Crude helium is injected into or withdrawn from the Government's underground helium storage facility, a partially depleted natural gas reservoir at Cliffside Field near Amarillo, TX.
[2]Negative numbers denote net withdrawal from storage.
[3]Includes 1,518,008 Mcf of helium (minus 2%) originally accepted under court order but returned to private producers under terms of court settlements.

RESOURCES

Domestic measured and indicated identified helium resources as of January 1, 1983, are estimated to be 449 Bcf. The resources included measured reserves and indicated resources estimated to be 222 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 45 Bcf. Indicated helium resources in natural gas with helium content of less than 0.3% are estimated to be 174 Bcf. Approximately 95% of the domestic helium resources under Federal ownership are in the Riley Ridge area and Church Buttes Field in Wyoming, and the Cliffside Field in Texas.

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 78 gasfields in 10 States. About 94% of these reserves is contained in the Hugoton Field in Kansas, Oklahoma, and Texas; the Keyes Field in Oklahoma; the Panhandle and Cliffside Fields in Texas; and the Riley Ridge area in Wyoming. The Bureau analyzed a total of 407 natural gas samples from 25 States and 2 foreign countries during the year in conjunction with a program to survey and identify possible new sources of helium.

FOREIGN TRADE

Exports of Grade-A helium, all by private industry, decreased by 2.7% to 368 MMcf. A little over 56% of the exported helium was shipped to Europe. Belgium-Luxembourg, France, and the United Kingdom, collectively, received more than 94% of the European helium imports. Twenty-four percent of the U.S. helium exports went to Asia, 6% to Central and South America, 4% to Australia, New Zealand, the Middle East, and North America, 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.

Table 7.—U.S. exports of Grade-A helium

(Million cubic feet)

Year	Volume
1979	245
1980	298
1981	389
1982	378
1983	368

Source: Bureau of the Census.

WORLD REVIEW

World production of helium, excluding the United States, was estimated to be 100 MMcf, most of which was extracted in Poland. The remainder was attributed to other central economy countries.

TECHNOLOGY

Four more successful space shuttle launches were made by the National Aeronautics and Space Administration using Bureau of Mines helium. The Challenger Space Shuttle was launched three times and the Columbia Orbiter was launched once.

The Fermi National Accelerator Laboratory near Batavia, IL, completed the installation of superconducting magnets in a 4-mile ring that is designed to accelerate protons to 1.0 trillion electron volts (TeV). The system was successfully cooled down and operated in 1983, accelerating protons to 0.8 TeV. The Department of Energy is currently planning a new accelerator called the Super Superconducting Collider (SSC), which will have a ring about 100 miles long and accelerate protons to 20 TeV. Liquid helium is expected to be used to attain temperatures required for superconducting magnets in the installation. The Brookhaven Colliding Beam Accelerator was canceled as a result of the inception of the SSC. Work on the Stanford Linear Accelerator will continue.

Bonneville Power Administration's superconducting magnetic energy storage project was canceled because of unreliable cryogenic refrigeration equipment. Erratic operation of the helium liquefier did not permit continuous stable operations needed for testing. The Electric Power Research Institute terminated its contract with Westinghouse Electric Corp. for the development of a 270-megawatt commercial superconducting generator in August. Superconducting magnet development for fusion and magnetohydrodynamic systems is proceeding at several other Department of Energy national laboratories.

In the field of medicine, nuclear magnetic resonance (NMR) is one of the most exciting new diagnostic techniques. NMR is the tendency for cores of atoms to vibrate when placed in a strong magnetic field and probed with radio waves. Liquid helium is used to provide cooling for superconducting magnets used in the equipment. Images are superior in some cases to those obtained using computerized axial tomography (CAT) scanners, but NMR does not emit radiation. There were 15 NMR systems being used in clinical research at the end of the year. This market is expected to grow rapidly.

[1]Chemical engineer, Helium Field Operations, Amarillo, TX.

[2]Program analysis officer, Helium Field Operations, Amarillo, TX.

[3]All helium volumes herein reported at 14.7 pounds per square inch absolute and 70° F.

Iodine

By Phyllis A. Lyday[1]

Apparent domestic consumption of iodine increased during the year. Three producers of crude iodine supplied less than one-half of domestic demand; the remainder was imported. The General Services Administration (GSA) continued sales of excess iodine from the National Defense Stockpile.

Domestic Data Coverage.—Domestic production data for iodine were 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, 67% responded, representing an estimated 88% of the total production. Production for the nonrespondent was estimated using reported prior year production levels adjusted by trends in employment and other guidelines.

Legislation and Government Programs.—The U.S. National Defense Stockpile contained 7.5 million pounds of crude iodine valued at $51 million in inventory at yearend. The stockpile goal remained at 5.8 million pounds. In 1981, the U.S. Congress had authorized GSA to sell 2,213,000 pounds of the excess iodine for domestic use. The authorization allowed the sale of 1 million pounds in fiscal years 1982 and 1983. In May 1982, GSA removed the domestic restriction clause. During 1983, 50,000 pounds of stockpile-grade excess iodine was sold for $244,300. At yearend, 1.2 million of the 7.5 million pounds in inventory remained available for disposal.

The U.S. Food and Drug Administration (FDA) reviewed the listing of Red No. 3 dye. Red No. 3, or erythrosine, 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.

The FDA continued to analyze foods for elements, including iodine, to determine the degree of chemical contamination in the diet of the U.S. population.

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 the year.

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 increased sales and reduced the large inventories accumulated during 1982. Woodward was a joint venture between Amoco Production Co., 49%, and PPG Industries Inc., 51%. 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.

Deepwater Chemical Co., one of the largest domestic consumers of crude iodine, announced the availability of periodates for use as oxidizing agents and alkyl iodides. Deepwater specialized in the production of more than 40 iodides, as well as high-purity elemental iodine. Shipments from the plant were primarily by truck.

West Chemical Products Inc. signed an exclusive licensing agreement for Dow B. Hickam Inc. to use West's low-iodine germicide. West also granted Mitsui of Japan an exclusive license for making and selling the same germicide. Mitsui was limited to selling the product in China, Hong Kong, and Japan.

Table 1.—Crude iodine consumed in the United States, by product

Product	1982		1983	
	Number of plants	Consumption (thousand pounds)	Number of plants	Consumption (thousand pounds)
Reported consumption:				
Resublimed iodine	4	117	8	442
Potassium iodide	5	987	8	1,320
Sodium iodide	4	215	4	242
Other inorganic compounds	9	1,136	10	1,071
Ethylenediamine dihydriodide	4	737	4	736
Organic compounds	14	1,990	20	1,890
Total	[1]28	5,182	[1]31	5,701
Apparent consumption	XX	6,900	XX	8,139

XX Not applicable.
[1]Nonadditive total because some plants produce more than one product.

PRICES

Published U.S. iodine prices remained between $6.35 and $7.26 per pound. Discounted market prices reported by industry were $5.50 per pound. Custom values of iodine imported from Japan ranged from $4.47 to $6.70 per pound; the average price was $5.66 per pound. Custom values for iodine imported from Chile ranged from $4.17 to $5.90 per pound; the average price was $4.97 per pound. GSA sold iodine during the year from stockpile excesses for prices that ranged from $4.70 to $5.31 per pound; the average price was $4.87 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	$6.54- 7.27
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. 224, No. 26, Dec. 26, 1983, pp. 28-37.

FOREIGN TRADE

The United States continued to be dependent on imports primarily from Chile and Japan to supplement domestic production. Imports of crude iodine increased significantly as a result of increased demand owing to the improved state of the economy.

On January 28, the U.S. International Trade Commission (ITC) announced a final determination that sodium nitrate imported in 1982 from Chile had been sold at less than fair market value. Chilean iodine was produced as a byproduct of nitrate production. The U.S. Customs Service was to require a cash deposit, bond, or other security in the amount of $0.45 per short ton for agricultural-grade sodium nitrate and $39.08 per short ton for industrial-grade sodium nitrate. According to the Chilean Nitrate Sales Corp., the dumping margin assessed on Chilean sodium nitrate by the ITC was minimal and did not affect sales of nitrate or iodine during 1983.

Table 2.—U.S. imports for consumption of crude iodine, resublimed iodine, and compounds, by country

(Thousand pounds and thousand dollars)

Country	1982		1983	
	Quantity	Value	Quantity	Value
Iodine, potassium:				
Canada	(1)	1	2	11
Germany, Federal Republic of	(1)	2	(1)	1
India	1	5	10	50
Israel	(1)	6	--	--
Italy	3	8	2	4
Japan	50	285	101	554
Spain	--	--	5	4
United Kingdom	1	21	1	22
Total[2]	55	329	121	647
Iodine, crude:				
Canada	r1	8	(1)	2
Chile	793	4,887	1,639	8,146
China	--	--	22	118
Japan	3,931	22,800	4,556	25,773
Mexico	2	14	--	--
Total[2]	r4,727	27,709	6,218	34,039
Iodine, resublimed:				
Canada	--	--	(1)	(1)
Japan	--	--	44	256
Sweden	2	16	1	10
Total	2	16	45	266
Grand total	4,784	28,054	6,384	34,952

rRevised.
[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.—Production of crude iodine, 99.5% pure, as a byproduct of nitrate and borax production, continued at the Maria Elena and Pedro de Valdivia Mines. The Chilean caliche deposits that contained the iodine were the only commercial-size deposits of nitrate in the world. The Sociedad Química y Minera de Chile (SOQUIMICH) was the sole iodine producer. The caliche was drilled and blasted using ANFO explosives and removed by bulldozers, draglines, shovels, and trucks. The ore was transported to a crushing plant that operated 20 hours per day. Both plants used the Guggenheim process. The salts were dissolved in hot water, sodium sulfate was extracted, and then nitrates were precipitated by lowering the temperature. The nitrate precipitate contained 90% sodium nitrate and 6% water. The nitrate was smelted in reverberatory furnaces to 500° C and sprayed through currents of cold air to form a prill. The iodine was contained in the form of sodium iodate and remained dissolved in the hot liquor. Sodium iodide was produced by burning sulfur to produce sulfur dioxide that reacted with the sodium iodate. The addition of leach liquor produced elemental iodine. Magnesium sulfate (Epsom Salts) was produced as a byproduct of the process in solar evaporative ponds located at Coya Sur.

Domestic consumption of iodine in 1982 was 79,000 pounds. During 1982, 2.6 million pounds was exported to Europe, 454,000 pounds to Latin America, and 534,000 to Asia.[2] During 1983, 5 million pounds of iodine was exported to Europe and 460,000 pounds went to Latin America.

Japan.—Japan continued to account for approximately 58% of the world production of crude iodine, exclusive of U.S. production, and maintained its place as the world's largest producer. Six companies operated seventeen plants with a total production capacity of 20 million pounds per year. All production was from subsurface brine as a byproduct of natural gas production. Ise Chemical Industry Co. operated seven plants in Chiba, Niigata, and Miyazaki Prefectures that used the blowing out process. The estimated capacity of these plants was 9 million pounds per year of iodine. United Resources Industry Co. operated two plants in Chiba Prefecture that used the blowing out process with an estimated iodine capacity of 4 million pounds per year. Nippon Natural Gas Industry Co. operated four plants in Chiba Prefecture that used the ion exchange process with 3 million pounds per year of iodine capacity. Kanto Natural Gas Development Co. operated two plants in Chiba Prefecture that used the ion exchange process with an estimated iodine capacity of 2 million pounds per year. Nippon Chemical Co. operated one plant in Chiba Prefecture that used the blowing out process with an estimated iodine capacity of 1 million pounds per year. Nippon Halogen Chemical Co. operated one plant in Niigata Prefecture that used the blowing out process with an estimated iodine capacity of 800,000 pounds per year.

Ise undertook a program to develop iodine derivatives. Iodine accounted for approximately 70% of the company's total sales. Ise signed an agreement with Asahi Glass Co. for basic research and introduced a prilled form of iodine that was chemically equivalent to the flaked form, but had physical advantages in that it was freer flowing and produced less dust.

Table 3.—Crude iodine: World production, by country[1]

(Thousand pounds)

Country[2]	1979	1980	1981	1982[p]	1983[e]
Chile	5,313	5,734	5,926	5,723	6,000
China[e]	1,000	1,000	1,000	1,000	1,000
Indonesia	[r]56	[r]65	56	64	57
Japan	13,779	[r]14,385	[r]15,128	15,829	[3]16,034
U.S.S.R.[e]	4,400	4,400	4,400	4,400	4,400
United States	W	W	W	W	W
Total[4]	[r]24,548	[r]25,584	26,510	27,016	27,491

[e]Estimated. [p]Preliminary. [r]Revised. W Withheld to avoid disclosing company proprietary data.
[1]Table includes data available through June 6, 1984.
[2]In addition to the countries listed, New Zealand also produces elemental iodine, but production data are not available and available information is inadequate for formulation of reliable estimates of output levels.
[3]Reported figure.
[4]Excludes U.S. production.

TECHNOLOGY

A U.S. patent claimed the use of an aqueous solution of hydrogen iodide and iodine to recover gold. The solution dissolved the gold but left associated elements such as molybdenum and tungsten in the solid state.[3]

Another U.S. patent claimed the use of an iodine-impregnated absorbent to recover silver from photographic and other solutions.[4]

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[1]Physical scientist, Division of Industrial Minerals.
[2]U.S. Embassy, Santiago, Chile. Industrial Outlook Report. State Dep. Airgram A-18, Dec. 6, 1983, 65 pp.
[3]Vanderpool, C. D., B. E. Martin, and R. G. W. Gingerich (assigned to GTE Products Corp., CT). Process for Recovering Gold. U.S. Pat. 4,397,690, Aug. 9, 1983.
[4]Rosene, M. R. (assigned to Calgon Carbon Corp., PA). Silver Removal With Halogen Impregnated Non-Carbon Absorbents. U.S. Pat. 4,396,585, Aug. 2, 1983.

Iron Ore

By F. L. Klinger[1]

U.S. production and consumption of iron ore increased moderately in 1983, owing to a rise in demand for iron and steel. Employment remained relatively low, and output of ore was less than 50% of capacity, but productivity increased. Several mines were closed, and the future of others was uncertain as the ore and steel industries sought to improve efficiency through company mergers and closure of ironmaking plants. By yearend, iron ore mining had virtually ceased in the western half of the country.

Iron ore production and trade continued to decline in the rest of the world as demand for iron and steel receded in Western Europe and Japan. Iron ore prices declined and ocean freight rates remained low. Iron ore production was substantially less than capacity, and except for Brazil and a few other countries, there was little investment in new production facilities. New markets for iron ore continued to grow in some less industrialized countries, owing to construction of direct-reduction plants.

Table 1.—Salient iron ore statistics

(Thousand long tons and thousand dollars unless otherwise specified)

	1979	1980	1981	1982	1983
United States:					
Iron ore (usable,[1] less than 5% manganese):					
Production	85,716	69,613	73,174	35,433	37,562
Shipments[2]	86,218	69,594	72,181	35,756	44,596
Value[2]	$2,814,440	$2,544,121	$2,915,239	$1,491,809	$1,944,988
Average value at mines dollars per ton	$32.64	$36.56	$40.39	$41.72	$43.61
Exports	5,148	5,689	5,546	3,178	3,781
Value	$178,749	$230,568	$244,685	$150,522	$182,744
Imports for consumption	33,776	25,058	28,328	14,501	13,246
Value	$923,426	$772,844	$947,977	$470,847	$445,731
Consumption (iron ore and agglomerates)	125,431	98,879	104,385	63,916	70,629
Stocks, Dec. 31:					
At mines[3]	11,266	11,725	12,734	12,129	[4]3,209
At consuming plants	38,969	35,706	36,203	29,923	25,494
At U.S. docks	5,416	6,095	6,571	5,750	3,174
Manganiferous iron ore (5% to 35% manganese): Shipments	215	155	156	28	30
World: Production	[r]888,789	[r]876,894	841,579	[p]769,149	[e]729,642

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Direct-shipping ore, concentrates, agglomerates, and byproduct ore.
[2]Includes byproduct ore.
[3]Excludes byproduct ore.
[4]These stocks are not comparable to those of previous years owing to the reclassification of some stocks from the usable to the byproduct category.

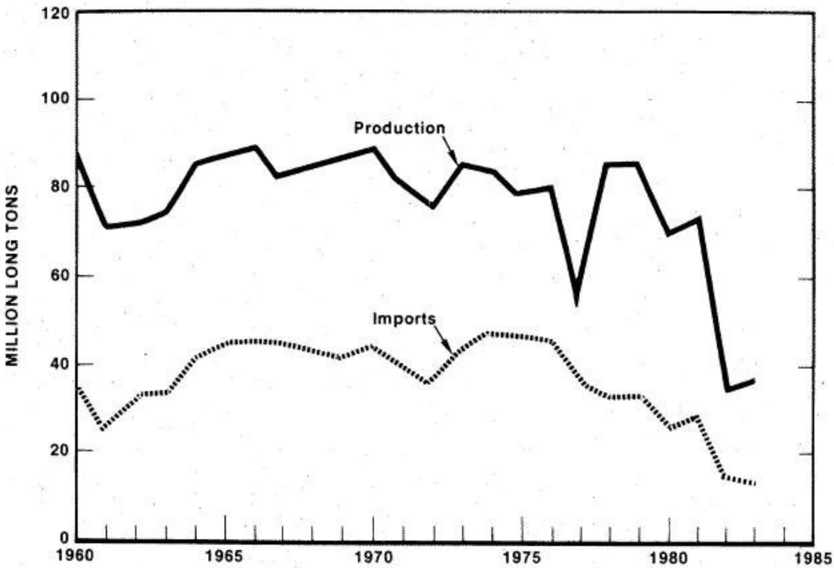

Figure 1.—U.S. iron ore production and imports for consumption.

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 approximately 71 addressees to whom the 1066-A form was sent, 55 responded, representing 99.9% of total production shown in tables 1 through 6. Production for nonrespondents was estimated 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 are 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.—Depletion allowances for domestic and foreign operations of the iron mining industry were to be reduced by 15%, effective January 1, 1984, under the Tax Equity and Fiscal Responsibility Act of 1982. The depletion allowance was to be reduced to 12.75% for domestic operations and to 11.9% for foreign operations.

Under the proposed Fair Trade in Steel Act of 1983 (H.R. 4352), U.S. imports of iron ore would be limited to 15% of apparent domestic supply. Apparent domestic supply was defined as domestic shipments plus imports minus exports. The 15% limitation excluded imports from Canada. By yearend, the proposed limitation on iron ore was raised to 25% including imports from Canada. The revised version of the proposed act was reintroduced as H.R. 5081 and S. 2380.

EMPLOYMENT

Statistics on employment and productivity in the U.S. iron ore industry in 1983 are shown in table 2. Quarterly employment data were supplied by the Mine Safety and Health Administration of the U.S. Department of Labor, from reports received from producers. The statistics include production workers employed at mines, concentrators, and pelletizing plants, and in repair and maintenance shops, but do not include approximately 1,000 persons engaged in management, research facilities, or in office work at mines and plants.

Average quarterly employment and total

hours worked in 1983 were about 13% less than in 1982, but production of crude and usable ore increased by 5%. The result was a marked increase in productivity compared with that of 1982. Productivity for usable ore appeared to increase by 28% for the industry as a whole, 30% for the Lake Superior district, and 32% for Minnesota. Such gains are unusual in the iron ore industry, where productivity has been relatively stable for the last 12 years, and they are also surprising because few mines operated continuously in 1983. Although employment data are not believed to be precise, it seems unlikely that the data could be understated by more than 5%; it is therefore assumed that productivity increased by at least 20% in 1983. Drastic cuts in employment have been made since 1981 by all of the major mining companies, and as employment is reduced to a minimum, the potential productivity of highly mechanized operations may be realized even at low production levels. This appears to have happened in 1983.

Production data for crude ore were revised by one producer after publication of the Minerals Yearbook for 1982. Consequently, productivity data for crude ore appearing in table 2 for that year have been revised. Production totals for crude ore (tables 3 and 4) in 1982 should read as follows, in thousand long tons:[2] 77,520 for Minnesota, 99,871 for the Lake Superior district, and 109,856 for the United States. Productivity data (table 2) for crude ore should read as follows, in thousand tons: 6.71 for Minnesota, 6.81 for the Lake Superior district, and 6.37 for the United States.

DOMESTIC PRODUCTION

U.S. production of iron ore increased in 1983, but the rise in output was less than the 13% increase in production of iron and steel, compared with that of 1982. The lag in production was caused by the availability of large stocks of ore that had accumulated at mines and consuming plants during 1982. Iron ore production rose sharply in the first 5 months of 1983 to keep pace with the surging production of iron and steel, but as demand for steel leveled off, mine production declined in the last 6 months of the year, and stocks were used to maintain a relatively high volume of shipments. By yearend, shipments exceeded production by 7 million tons and were 25% higher than shipments in 1982. The depletion of stocks at the mines set the stage for a rapid expansion of mine output if needed to support a rise in demand for steel in 1984. In 1983, however, output of usable ore was only about 40% of annual production capacity, which was estimated at 97 million tons on January 1.

Iron ore was produced by 20 open pit mines and 1 underground mine. Fourteen mines produced ore for the iron and steel industry, but only 2 were operated for the full 12 months. Eight mines were idle but shipped ore from stockpiles. Twelve of the country's fourteen pelletizing plants were operated and accounted for 97% of all usable ore produced. Two taconite mines and associated pelletizing plants were permanently closed by yearend, as were two mines that produced direct-shipping ore. U.S. production capacity at yearend was estimated at 93 million tons including 82 million tons of pellets. Owing to reduced employment levels, effective capacity for pellets was probably less than 70 million tons.

An average of 3.08 tons of crude ore was mined for each ton of usable ore produced compared with 3.1 tons in 1981 and 1982[3]. Leveling-off of this ratio results from the almost exclusive use of taconite-type ores for production of usable ore products. The ratio increased annually through 1980, as production of pellets from taconite-type ores gradually replaced production of direct-shipping ores and concentrates. Taconite-type crude ore mined in Minnesota, Michigan, and Wyoming accounted for 97% of the crude ore mined in 1983, and pellets produced from this ore accounted for 95% of usable ore output. U.S. output of pellets was 36.3 million tons, 97% of usable output. Minnesota produced 70% of the national output, Michigan produced 25%, and the remainder was produced in five other States. Average iron content of usable ore produced was 64.3%, compared with 63.6% in 1981 and 63.9% in 1982.

In Minnesota, all eight taconite mines and associated pelletizing plants were operated, but each was idle for part of the year. The pattern of sporadic production was similar to that of 1982, but production of pellets in 1983 was about 3 million tons higher. Operating periods of the various producers are shown in the accompanying tabulation.

Managing company	Mine	Operating period in 1983
Reserve Mining Co	Peter Mitchell.	Jan. 2-Apr. 17.
Pickands Mather & Co.	Erie Commercial.	Apr. 3-Oct. 1.
Do	Hibbing Taconite.	Jan. 1-29; Apr. 17-Oct. 8.
United States Steel Corp.	Minntac	Jan. 17-Sept. 11; Sept. 25-Dec. 31.
Oglebay Norton Co	Eveleth Mines.	Jan. 1-July 31; Oct. 12-Dec. 31.
Inland Steel Mining Co.	Minorca	Jan. 1-Aug. 7; Oct. 23-Dec. 25.
The Hanna Mining Co.	National Steel.	Mar. 20-Dec. 31.
Do	Butler Taconite.	Apr. 10-Oct. 29.

Several Minnesota producers operated well below the rated capacity of their mines and plants, and recalled only part of their work forces. Reserve Mining Co. and Erie Mining Co. operations, which were resumed after shutdowns of 6 months and 9 months, respectively, operated at about 40% of capacity. Pickands Mather & Co. indicated that effective capacity of Erie was reduced to 8 million tons of pellets per year compared with installed capacity of 11 million tons. United States Steel Corp. reduced effective capacity at Minntac by one-third to about 12.5 million tons of pellets per year, and recalled about one-half of its former work force of 4,000. Production capacity at the National Steel pellet plant was reduced to 4 million tons per year from the 5.8-million-ton level installed in 1977. Eveleth Mines operated at about 80% of its 6-million-ton-per-year pellet capacity.

Jones & Laughlin Steel Corp. (J&L) began production of hematite concentrates at the McKinley Extension Mine, near Aurora, MN, in May and produced nearly 900,000 tons before closing down for the winter. No other "natural ore" mines were in production on the Mesabi Range, although several shipped concentrates from stockpiles.

In a development affecting ownership of Eveleth Mines, Armco Inc. announced in September that an agreement in principle had been reached with Dominion Foundries & Steel Co. Ltd. (Dofasco) of Canada, to exchange ownership interests in Eveleth Expansion Co. and the Iron Ore Company of Canada (IOC). Armco would assume Dofasco's 16% interest in Eveleth Expansion, and Dofasco would assume Armco's 6.07% interest in IOC. The exchange would increase Armco's share in Eveleth Mines to approximately 33.6%, but because the production capacity of IOC is much larger than that of Eveleth Mines, Armco would reduce its overall iron ore commitments by up to 750,000 tons annually. Eveleth Mines is owned 60% by Eveleth Expansion and 40% by Eveleth Taconite Co.

A proposed merger of LTV Corp. and Republic Steel Corp., announced in 1983, would affect ownership of several iron ore mines in Michigan, Minnesota, and in eastern Canada. J&L, which is owned by LTV, operates the McKinley Extension Mine and owns a 35% share of Erie in Minnesota; it also owns 35% of the Empire Mine and 12% of the Tilden Mine in Michigan; and 15.6% and 6.29%, respectively, of Wabush Mines and IOC in Canada. Republic Steel owns 50% of Reserve and 16% of Hibbing Taconite Co. in Minnesota, in addition to 6.29% of IOC. Combined ownership of the companies in U.S. and Canadian mines was equivalent to an estimated 18 million tons of annual production capacity.

In Michigan, The Cleveland-Cliffs Iron Co. (CCI) operated the Empire and Tilden Mines throughout the year. Both mines were operated at less than capacity. The Republic Mine remained idle. Ownership of all three mine ventures was changed by yearend. CCI reduced its share of the Empire Iron Mining Co. to 15% from 60%; increased its share of Tilden Mining Co. to 39% from 20%; and became sole owner of the Marquette Iron Mining Partnership, which includes the Republic Mine. J&L acquired a 35% interest in Empire while reducing its share of Tilden to 12% from 27%. Wheeling-Pittsburgh Steel Corp. acquired a 10% interest in Empire and reduced its share of Tilden to 4% from 8%. Ownership shares of other participating companies were unchanged.

In Wisconsin, the Black River Falls taconite mine and pelletizing plant were permanently closed October 28 by Jackson County Iron Co., a subsidiary of Inland Steel Co. The mine and plant had been idle since April 1982. About 275 employees were affected. Nominal production capacity at Black River Falls was 750,000 tons of pellets per year.

In Wyoming and Utah, U.S. Steel announced that mines of its Western Ore Operations would be permanently closed. Although formal closure was scheduled for April 1984, mining and pelletizing operations at Atlantic City, WY, ended on October 1, and about 500 employees were laid off. Production capacity of the plant was about 1.7 million tons of pellets per year. The company's direct-shipping ore mines near Cedar City, UT, had been idle since mid-1982 when all but three employees were laid off. Production capacity of these mines was estimated at 1.5 million tons per year. By the end of October, U.S. Steel's Geneva works at Provo, UT, was being supplied with pellets from the Minntac Mine in Minnesota.

In December, the Crane Co. announced that blast furnaces of CF&I Steel Corp. at Pueblo, CO, would be closed permanently. The furnaces had been idle since 1982. Although mines were not specifically mentioned, the announcement made it virtually certain that CF&I's iron mines in Wyoming and Utah would not be reopened. The Sunrise underground mine at Guernsey, WY, had been idle since July 1980, and the Comstock open pit near Cedar City, UT, had been idle since January 1981. Annual production capacity was estimated at 750,000 tons of concentrates at the Sunrise Mine, and 1.5 million tons of direct-shipping ore at the Comstock Mine.

In Missouri, Pea Ridge Iron Ore Co. continued to operate its underground mine near Sullivan. After several months of intermittent operation, regular production was resumed by March 1983 and continued through yearend. The company changed its production process by substituting magnesia-rich olivine for quartz in the pelletizing mix. "Olivine pellets," as developed in Sweden and tested in European blast furnaces since 1981, were reported to increase smelting efficiency in some plants. The olivine pellets made at Pea Ridge were being tested in blast furnaces of Granite City Steel Corp., a division of National Steel Corp., in 1983.

In Texas, Lone Star Steel Co. resumed limited production of iron ore in December. The company's mines and blast furnace at Lone Star had been idle since August 1982. In California, Kaiser Steel Corp. continued to ship concentrates from stockpiles at Eagle Mountain to the Fontana steelworks. The shipments ended in October when the blast furnace was shut down. With termination of ironmaking at Fontana, the only blast furnaces operating west of the Mississippi River at yearend were located at Lone Star, TX, and Provo, UT.

CONSUMPTION

Consumption of iron ore and agglomerates increased moderately as demand for iron and steel recovered from the low levels of 1982. With the number of operating blast furnaces rising from 33 to 52 during the first quarter, monthly consumption of iron ore rose 34% to 5.2 million tons, then averaged 5.35 million tons during the rest of the year.

Pellets made up a larger share of furnace burdens in 1983, accounting for 73% of the iron ore and agglomerates charged, compared with 68% in 1982. Consumption of sinter totaled 16.2 million tons, slightly more than in 1982, but the proportion of sinter in total consumption was less. The quantity of natural coarse ore charged directly to ironmaking and steelmaking furnaces totaled 2.1 million tons, more than 50% less than in 1982. The quantity of iron ore used in production of sinter also increased to 9.6 million tons, although production of sinter declined slightly compared with that of 1982. These comparisons indicate that the average iron content of iron ore and agglomerates consumed in 1983 was probably higher than that of 1982. Although specific data were incompletely reported, the average iron content of ore and agglomerates charged to ironmaking and steelmaking furnaces was estimated at 61% compared with an estimated 60% in 1982. In addition, about 0.2 million tons of manganiferous iron ore was consumed in blast furnaces. Of the 61.2 million tons of primary ore consumed by the iron and steel industry, approximately 68% was of domestic origin, 19% came from Canada, and 13% came from other countries.

In table 11, the difference in weight between iron ore consumed and sinter produced is due to elimination of moisture and the addition of other materials to the sinter mix. Consumption of other materials reported in sintering plants in 1983, in million tons, was as follows: limestone, dolomite, and other fluxes, 3.6; mill scale, 2.1; slag, 1.5; and flue dust, 0.8. Consumption of coke breeze was estimated at 1 million tons.

Consumption of bentonite and coal in iron ore pelletizing plants was estimated at 292,000 tons and 200,000 tons, respectively.

STOCKS

Stocks of iron ore and agglomerates reported at U.S. mines, docks, and consuming plants declined by about 13.5 million tons, as producers and consumers sought to reduce inventories and associated carrying charges. The drawdown of stocks was about twice that of 1982 and accounted for about 20% of consumption. The increased use of stocks in 1983 was mainly responsible for the relatively weak increase in mine production, the strong increase in mine shipments, and the decline of imports, compared with those of 1982. Yearend stocks at mines and consuming plants were the lowest in many years. Stocks reported at U.S. receiving docks and consuming plants at yearend included 17.7 million tons of domestic ores, 6 million tons of Canadian ores, and 4.9 million tons of other foreign ores.

Total mine stocks reported in tables 1 and 13 at yearend are not comparable to those reported for previous years, owing to reclassification of some stocks from the usable to the byproduct category. This ore was previously classified as usable ore because it was used for production of iron and steel, but owing to its content of objectionable impurities, it is no longer likely to be used for this purpose; it was therefore reclassified as byproduct ore. The change in classification primarily affects mine stocks. Stock data for 1982 and previous years were not changed to avoid disclosing company proprietary information.

Mine stocks reported in these tables do not include unagglomerated concentrates at pelletizing plants because such concentrates are considered to be intermediate products. Stocks of this material at yearend totaled about 900,000 tons compared with 1.3 million tons reported on January 1.

TRANSPORTATION

Vessel shipments of iron ore from U.S. ports on the upper Great Lakes totaled 41 million tons, nearly 10 million tons more than in 1982. Approximately 90% was destined for U.S. consumers and the rest was destined for Canada. Shipments of iron ore from eastern Canada through the St. Lawrence Seaway to U.S. ports on the Great Lakes during the year were estimated at 6 million tons.

Ore shipments from all seven U.S. ports on the upper Great Lakes increased from the levels of 1982. Increases ranged from nearly 4 million tons at Two Harbors to 237,000 tons at Taconite Harbor. Tonnage shipped from each port is shown as follows, in thousand long tons:

Port	Date of first shipment	Date of last shipment	Total tonnage
Duluth, MN	Apr. 4	Dec. 16	6,560
Two Harbors, MN	Apr. 1	Dec. 28	8,336
Silver Bay, MN	Apr. 9	Dec. 21	2,717
Taconite Harbor, MN.	Apr. 2	Dec. 30	3,861
Superior, WI	Apr. 5	Dec. 21	8,668
Marquette, MI	Mar. 31	Jan. 3 (1984)	[1]3,509
Escanaba, MI	Apr. 13	Jan. 2 (1984)	7,366
Total			41,017

[1]Excludes 71,000 long tons shipped in Jan. 1984.

Sources: American Iron Ore Association and various issues of Skillings' Mining Review.

Efficiency of transportation of iron ore on the Great Lakes continued to improve, with increased use of larger self-unloading vessels and improved materials handling systems at loading and receiving ports. Construction of new ship-loading facilities at Duluth, MN, was completed in 1983, and the first 1,000-foot ore carrier was loaded in June. Previously, the largest cargo loaded at Duluth was about 31,000 tons, but cargoes of up to 62,000 tons were loaded during the latter part of the year. The trend toward increasing average size of cargoes loaded at upper lake ports between 1972 and 1982 is as follows, in long tons:

Port	Average cargo of iron ore shipped	
	1972	1982
Duluth, MN	15,550	22,489
Two Harbors, MN	18,569	49,211
Silver Bay, MN	17,332	59,007
Taconite Harbor, MN	22,943	24,821
Superior, WI	18,395	40,191
Marquette, MI	16,734	20,146
Escanaba, MI	15,699	31,290

Source: Lake Carriers' Association annual reports.

U.S. vessel freight rates for iron ore were unchanged from those in effect during 1982. Bulk vessel rates to lower lake ports, per long ton, were therefore $7.13 from Duluth and Superior, $5.75 from Marquette, and

$5.42 from Escanaba. The basic rate from Escanaba to lower Lake Michigan ports remained at $4.28. The vessel freight rate from the Gulf of St. Lawrence to Lake Erie ports remained at $3.01 per ton, but toll charges on the St. Lawrence Seaway between Montreal and Lake Erie increased by 9 cents in 1983 to $1.24 per ton.

Published railway freight rates for pellets from mines to shipping ports increased by 7% to 11% in Michigan and by about 6% in Minnesota compared with rates in 1982. The volume rate for pellets from the Marquette Range to Escanaba was $2.52 per long ton, while the rate from the western Mesabi Range to Duluth-Superior was $4.85 per ton. Volume rates from Lake Erie ports to the Pittsburgh and Wheeling districts increased about 14% to $10.14 per ton, but the rate from Toledo to Middletown was unchanged at $7.14 per ton. All-rail freight rates to major consuming districts from the Marquette and Mesabi Ranges, and from east and gulf coast ports, were unchanged. Volume rates from Michigan and Minnesota to Chicago and Granite City were $12 to $13 per ton. Storage charges for pellets at upper lake ports increased by 6% to 24%, while handling charges to lower lake ports increased only slightly, and some dockage charges for self-unloading vessels were sharply reduced.

Published ocean freight rates for iron ore, from eastern Canada to U.S. ports north of Hatteras were $3.50 to $3.75 per ton, but actual rates paid appeared to range from $1.75 to $2.75 per ton. Some shipments from Brazil were reported at about $5 per ton.

PRICES

Published prices for Lake Superior iron ore pellets remained at the levels established in early 1982. The price of pellets therefore 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 four producers quoting the higher price and Pickands Mather quoting the lower price. The range in unit price was equivalent to approximately $50.71 to $54.75 per long ton for pellets containing 63% iron.

Effective August 1, J&L reduced its prices for Mesabi non-Bessemer ore to $30.03 per long ton of coarse ore and $31.53 for fines. The new prices represented declines of 7.7% and 3%, respectively, compared with the previously published price of $32.53, and it was the first time that the price of fines was higher than the price of coarse ore of this grade. The price change appeared to be of little significance, however, because the market for Mesabi non-Bessemer ore was largely restricted to J&L's own plants. U.S. Steel and CCI continued to list prices for this grade of ore at the 1981 levels of $32.53 and $32.25 per long ton, respectively, although neither company produced it in 1983. The published price of other Lake Superior ores, including Old Range non-Bessemer and manganiferous grades, remained at $32.78 per gross ton, but no production was reported. As the prices of Lake Superior ore, other than pellets, are based on a natural iron content of 51.5%, delivered prices of the ores mentioned above ranged from 58.31 to 63.65 cents per ltu in 1983.

The average f.o.b. mine value of usable ore shipped from domestic mines was estimated at $43.61 per long ton, equivalent to about 68.8 cents per ltu of iron. This was about 5% higher than the average value in 1982, as pellets made up a larger share of production in 1983. Average values are principally based on producers' statements and should approximate the average commercial selling price less the cost of mine-to-market transportation. Because pellets now comprise more than 90% of usable ore shipments, the average value is not representative of other products such as concentrates and direct-shipping ore. Average f.o.b. mine value of the latter products in 1983 was about $21 per long ton.

Prices for most Canadian and other foreign ores marketed in the United States in 1983 were not available. The published price of Wabush pellets, f.o.b. Pointe Noire, Quebec, remained unchanged at 63.5 cents per ltu, equivalent to about $40.60 per long ton. 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 $38.44 per ton. Data from the same source indicated average f.o.b. values of $18.18 per ton for Liberian ores and $23.66 per ton for Brazilian ores. Comparable data for Venezuelan ores were not determinable, because the statistics include some shipments of direct-reduced iron (DRI) and a large tonnage of iron ore valued on a c.i.f. or higher basis. Prices for Canadian and other foreign ores are usually lower than published prices for U.S. Lake Superior ores, partly because foreign ore prices are quoted on an f.o.b. basis, whereas U.S. prices include transportation charges to lower lake ports.

Published prices of DRI, f.o.b. Georgetown, SC; Contrecoeur, Quebec; and Point Lisas, Trinidad, were unchanged from those reported in 1982.

FOREIGN TRADE

U.S. exports of iron ore increased by 19% compared with those of 1982, owing to rising demand from the Canadian iron and steel industry. Virtually all exports consisted of pellets shipped on the Great Lakes to Canadian steel companies that are partners in taconite projects in Minnesota and Michigan.

U.S. imports for consumption of iron ore declined for the second consecutive year and were the lowest in 29 years. The decline was partly due to efforts by steel companies to reduce the large stocks of ore at U.S. mines and consuming plants in the Great Lakes region, but it was partly due to shutdowns of blast furnaces at some integrated steel plants in the Southern and Eastern United States. The net reduction in imports through ports on the east and gulf coasts was 2.3 million tons, with the principal reductions occurring in the Philadelphia and Mobile districts. Net imports through the Great Lakes increased by 1.1 million tons owing to a large increase in shipments through the Cleveland district; imports through other districts declined, particularly through the Chicago district.

Imports of iron ore from Venezuela, which had ceased in August 1982, were resumed in May 1983 following negotiation of a new sales contract by the Venezuelan producer with U.S. Steel. The contract requires U.S. Steel to purchase 3 million tons of ore per year for 11 years.

WORLD REVIEW

World production of iron ore continued to decline in 1983 and was the lowest in 11 years. World trade declined to an estimated 300 million tons, about 2% less than in 1982. Although imports of iron ore by Japan, the European Communities, and the United States declined by a total of about 21 million tons, world exports fell by only about 7 million tons as some exporters were able to increase sales to alternative markets. Australia was the leading exporter, followed by Brazil, with each country reporting exports of more than 70 million tons. Japan remained the principal importer, receiving 107 million tons. Reduced demand for iron ore caused production to decline in most of the major producing countries.

World production of iron ore pellets was estimated at 157 million tons, about 60% of installed capacity. Owing to relatively high production costs, competition from lower priced lump ore and sinter fines, and generally weak demand, many plants were operated well below capacity and others were closed for most or all of the year. New plants were under construction, however, in Mexico, Bahrain, India, the U.S.S.R., and the Republic of South Africa.

World production of DRI was estimated by Midrex Corp. at 7.7 million tons, approximately 40% of production capacity. Relatively low prices for ferrous scrap continued to limit production of DRI, but several direct-reduction plants were completed and others were under construction in at least eight countries. These plants are creating a sizable market for iron ore containing upwards of 68% iron and have led to construction of special beneficiating plants in several countries. Direct-reduction plants consumed an estimated 12 million tons of ore, but the potential market is expected to exceed 30 million tons by 1986.

Most iron ore prices under Japanese and West European contracts were reduced by 11% to 14% compared with prices in 1982. The 1983 prices, f.o.b. per ltu of contained iron, ranged from about 22 to 31 cents for sinter fines, 26 to 34 cents for lump ore, 35 to 45 cents for pellets, and 22 to 23 cents for pellet fines.

Ocean freight rates remained low. Rates for spot charterings, as published by various sources, indicated the following ranges, per ton: for shipments to Western Europe from Brazil, \$5.75 to \$6.50 for cargoes of 50,000 to 65,000 tons, and \$4.50 to \$6.00 for cargoes of 80,000 to 155,000 tons; from eastern Canada, \$3.00 to \$4.25 for cargoes of 100,000 to 160,000 tons; from Norway, \$1.75 to \$2.30 for 90,000 to 100,000 tons; and from Australia, \$6.50 to \$8.75 for 100,000 to 150,000 tons.

Rates for cargoes destined for Japan ranged between \$7 and \$9 for 130,000 to 150,000 tons from Brazil and eastern Canada, and from \$5.25 to \$6 for 220,000 tons from Brazil. Rates of \$5 to \$6 were reported for shipments of 100,000 to 150,000 tons from Australia to the Republic of Korea.

Australia.—A sharp decline in production appeared to be caused mainly by strikes, which affected the two largest producing companies during the summer, but declining domestic demand and large stocks of ore were also contributing factors. Production by Mt. Newman Iron Ore Pty. Ltd. declined by 34%, and that by Hamersley Iron Pty. Ltd. was 11% less than in 1982. Production by company was as follows, in million tons: Hamersley, 29.4; Mt. Newman, 18.4; Cliffs Robe River Iron Associates, 12.9; The Broken Hill Pty. Co. Ltd. (BHP), 5.1; and Savage River Mines, 2.2. Production by Goldsworthy Mining Ltd. was estimated at 4.5 million tons.

Exports of Australian ore to Japan declined, but shipments increased to other countries in the Far East and also to Western Europe, compared with those of 1982. Exports totaled 73.1 million tons. Domestic consumption declined about 15% to less than 8 million tons.

BHP closed the Koolyanobbing Mine in August. The company also announced plans to purchase Utah International Inc. from the General Electric Co. Utah International's iron ore interests include one-third of Goldsworthy Mining, 49% of Samarco Mineração S.A. in Brazil, and a majority share of Waipipi Iron Sands Ltd. in New Zealand.

Port facilities in Western Australia were being improved by the Hamersley, Mt. Newman, and Robe River companies, to permit loading larger cargoes of iron ore for export. At Dampier, Hamersley's project at East Intercourse Island was completed in 1983, and a cargo of 196,000 tons was loaded in December. Robe River's project at Port Walcott and Mt. Newman's project at Port Hedland were expected to be completed in 1984.

Brazil.—Production and exports of iron ore declined owing to reduced shipments to Japan and Western Europe compared with those of 1982. By yearend, however, exports had risen to an estimated 71 million tons, only slightly less than in 1982, as shipments to Eastern Europe were increased by 60% to more than 7 million tons.

Consumption of iron ore in Brazil was estimated at 16.5 million tons, about 25% more than in 1982. Part of the increase was due to completion of a new steelworks by Cia. Siderúrgica de Tubarão (CST) in 1983. Cia. Vale do Rio Doce (CVRD) contracted to supply CST with 48 million tons of ore during a period of 10 years. The ore will be produced at the Capanema Mine, which began production in 1982, and the Timbopeba Mine, which was expected to begin production in 1984.

CVRD's Carajás project in northern Brazil was reported to be 53% completed in 1983. Production of iron ore at Carajás was expected to begin in 1986 at the rate of 15 million tons per year. Production capacity of 35 million tons per year was scheduled to be available in 1988.

Brazilian production of iron ore in 1983 included an estimated 14 million tons of pellets, most of which were produced at Tubarão by CVRD in joint ventures with Japanese, Italian, and Spanish companies. Production of pellets by Ferteco Mineração S.A. in Minas Gerais was 2.5 million tons, and Samarco produced 1.8 million tons at Ponta Ubu.

Iron ore shipments by Brazilian producers were as follows, in million tons: CVRD, 52.4; Minerações Brasileiras Reunidas S.A., 12.3; Ferteco, 8.8; S.A. Mineração da Trindade, 6.5; Samarco, 4.4; Cia. Siderúrgica Nacional, 4.0; and Wm. H. Müller S.A., 0.6.

Canada.—Production and exports of iron ore were slightly less than in 1982 as demand from the United States and Western Europe remained low. Canadian consumption increased to about 14 million tons, of which about 25% was imported from the United States.

Owing to weak export demand, most Canadian mines suspended operations for 1 to 3 months in the last half of the year, and about 1,800 employees were laid off by yearend. Total output of iron ore was estimated at about 55% of production capacity. Shipments of iron ore products, by producer, were as follows, in million tons: IOC, 13.5 including 6.7 of pellets, 5.5 of concentrates, and 1.3 of direct-shipping ore; Quebec Cartier Mining Co., 6.8 including 6.4 of concentrates from Mount Wright; Pickands Mather, 5.9 of pellets including 5.1 from Wabush Mines; Sidbec-Normines Inc., 3.5 of pellets including about 0.3 of low-silica pellets; Dofasco, 1.6 of pellets from the Adams and Sherman Mines; The Algoma Steel Corp. Ltd., 1.2 of sinter from Wawa; and Falconbridge Ltd., 0.5 from the Wesfrob Mine. Inco Ltd. shipped about 152,000 tons of pellets from its stockpile at Sudbury.

The Wesfrob Mine at Tasu, British Columbia, was closed October 5 owing to exhaustion of economic ore reserves. About 135 employees were affected. IOC's concentrator and pelletizing plant at Sept-Iles remained idle as did Stelco Inc.'s direct-reduction plant at Bruce Lake. Sidbec-Dosco Inc. produced 588,000 tons of DRI at Contrecoeur. Owing to financial losses, the commercial viability of Sidbec-Normines was being reviewed by the Quebec government, which owns a controlling interest in the company. Borealis Exploration Ltd. continued development work on magnetite deposits of the Melville Peninsula in Northwest Territories. Tests conducted on Melville ore at the Ontario Research Foundation indicated that concentrates containing 71% iron could be produced by magnetic separation.

Chile.—Shipments of iron ore products by Cía. Minera del Pacífico S.A. in 1983 totaled 5.5 million tons including 2.9 million tons of pellets and 1.5 million tons of lump ore. Exports to Japan totaled 4.6 million tons, and the remainder was shipped for consumption at Huachipato.

China.—The Chinese Government was considering direct investment in the Australian iron ore industry. Interest was indicated in high-grade deposits that have not yet been developed. China imported about 3 million tons of iron ore from Australia in 1983.

Egypt.—A contract for construction of a Midrex direct-reduction plant at El-Dikheila was awarded to Kobe Steel Ltd. of Japan by the Alexandria National Steel Co. An electric steelworks will also be built. Both plants were to be completed by 1987. Loans for the project included $165 million from the International Bank for Reconstruction and Development (World Bank) and $102 million from the International Finance Corp.

European Communities (EC).—Iron ore production, trade, and consumption in the EC continued to decline. Compared with that of 1982, production declined by 19% while imports from other countries declined by about 8% to an estimated 89 million tons. The decline in EC consumption, as estimated from production of pig iron, was only 3% because consumption increased in some member countries, notably the United Kingdom. Compared with 1979 levels, however, EC production of iron ore in 1983 declined by 21 million tons, imports of ore declined by 36 million tons, and consumption declined by an estimated 40 million tons.

Imports of iron ore from overseas sources by EC countries were as follows, in million tons: about 35 by the Federal Republic of Germany, 15 by Italy, 13 by the United Kingdom, 12 by Belgium-Luxembourg, 10 by France, and 5 by the Netherlands. France exported about 5 million tons of iron ore from the Lorraine district to Belgium-Luxembourg, but shipments to the Federal Republic of Germany stopped.

India.—Exports of iron ore totaled about 20.3 million tons, about 3.6 million tons less than in 1982, as shipments were reduced to Japan and Romania. Exports included 10.8 million tons from Goa, 5.7 million tons by the National Mineral Development Corp. Ltd. (NMDC) from the Bailadila and Donimalai Mines, and 1.3 million tons by Kudremukh Iron Ore Co. Ltd. The Kudremukh pelletizing plant was scheduled for completion in mid-1984; meanwhile, the company was exporting concentrates mainly to countries in Eastern Europe.

NMDC was preparing the Bailadila No. 11-C Mine to supplement and eventually replace production from Bailadila No. 14. Production capacity of the No. 11-C Mine is to be about 3.2 million tons annually of ore consisting of 45% lump and 55% fines. At Bailadila No. 5, the company was installing handling facilities to process 2 million tons of ore fines per year for domestic consumption and export.

The coal-based direct-reduction plant at Orissa Sponge Iron Ltd. was completed and began operating in March. The plant was designed by Allis-Chalmers Corp. and has a production capacity of 150,000 tons per year.

Indonesia.—P.T. Krakatau Steel, which operates a large direct-reduction plant at Cilegon, contracted with Luossavaara Kiirunavaara AB (LKAB) of Sweden for a supply of about 700,000 tons of iron ore pellets per year for 5 years beginning in 1984.

Japan.—Imports of iron ore totaled 107.5 million tons in 1983, about 12 million tons less than in 1982. Imports included 49 million tons from Australia, 23 million tons from Brazil, and 14.5 million tons from India. Consumption of imported ore was estimated at about 103 million tons including 9.6 million tons of pellets. Japanese long-term contracts with foreign iron ore producers covered about 780 million tons of ore from 1984 through 1992.

Korea, Republic of.—In 1983, Pohang Iron and Steel Co. Ltd. began construction of port facilities for an integrated steelworks at Kwangyang. A blast furnace was ordered, and a 4.3-million-ton-per-year sintering plant was scheduled to be built by 1987. The new plant could increase Korean import requirements to 15 million tons of iron ore annually by 1988. Imports and consumption of iron ore in 1983 were estimated at 10 million tons and 11 million tons, respectively.

Liberia.—Production and exports of iron ore continued to decline. Shipments by producers were as follows, in million tons: Bong Mining Co., 7.6 including 2.85 of pellets; Lamco Joint Venture (LJV), 6.8; and National Iron Ore Co. Ltd., 1.1.

Poor market conditions and rising costs forced LJV to reduce operating levels and to lay off one-third of its employees. Both LJV and Bong expected ore reserves at present mining locations to be exhausted by 1988. In 1983, a study funded by the EC examined the feasibility of integrating operations of LJV and Bong, using Bong's concentrating plant to process crude ore mined from LJV's western concession areas. The conclusion was that the cost would probably be too high.

Malaysia.—Construction of two direct-reduction plants was continued. On Labuan Island, Sabah Gas Industries Sdn. Bhd. (SGI) expected to begin production of DRI in early 1984. The plant will have a production capacity of 640,000 tons of briquets per year, intended primarily for export. SGI contracted with CVRD of Brazil for a supply of about 300,000 tons of iron ore per year for 5 years.

At Trengganu, on the east coast of the Malay Peninsula, a reduction plant being built for Heavy Industries Corp. of Malaysia Bhd. was scheduled for completion in 1985. Production capacity of this plant is to be about 590,000 tons of DRI per year.

Mexico.—Construction of iron ore concentrating and pelletizing plants was continued. In northern Mexico, a 3-million-ton-per-year pelletizing plant was completed at Monclova. This plant will receive concentrates by pipeline from La Perla, where a new concentrator was completed in 1982, and from the Hercules Mine where a new concentrator was under construction. The first shipment of concentrates by pipeline from La Perla took place in May 1983.

In Michoacán, several plants were expected to be completed in 1984 as part of the second stage of expansion of the steelworks at Lázaro Cárdenas. The plants include an iron ore concentrator at Ferrotepec and a large direct-reduction plant and a threefold expansion of pelletizing capacity at Lázaro Cárdenas.

In Colima, Las Encinas S.A. was increasing pelletizing capacity at Alzada to 1.8 million tons per year. In 1983, the company shipped 1.5 million tons of pellets to direct-reduction plants at Puebla and Monterrey.

New Zealand.—New Zealand Steel Mining Ltd. (NZS) was increasing production capacity for beach-sand magnetite concentrates to 1.5 million tons per year at Waikato North Head. Increased production was intended to supply concentrates to four new direct-reduction kilns being built at the Glenbrook steelworks. The concentrates contain small quantities of vanadium, which NZS plans to recover in slag from its ironmaking plant. Completion of the mine project was scheduled for August 1984. The reduction kilns and ironmaking plant were expected to be completed in 1985.

Norway.—Production and exports of iron ore increased. A/S Sydvaranger produced 2.3 million tons of pellets at Kirkenes and shipped 2.6 million tons, mostly to EC countries. A/S Norsk Jernverk produced 1.05 million tons of concentrate, exported 0.3 million tons, and consumed 0.85 million tons for production of pig iron. The company began producing special magnetite concentrates containing 71.7% iron, by flotation. Fosdalens Bergverks-Aktieselskab produced 232,000 tons of magnetite concentrates at Malm and exported about 272,000 tons, largely for use as heavy media in coal preparation plants.

Peru.—Exports of iron ore by Empresa Minera del Hierro del Perú (Hierro Perú) declined to 4.1 million tons, of which about 47% was shipped to the Republic of Korea and 40% was shipped to Japan. As in 1982, sinter fines made up about 58% of exports, 22% consisted of pellets, and the remainder consisted of pellet feed. About 195,000 tons was shipped for consumption at Chimbote.

Sulfide concentrates containing about 23% copper and small quantities of cobalt were being recovered by flotation of fine tailings from the magnetite concentrator. About 2,150 tons of sulfide concentrates was reportedly recovered in 1982. In 1983, a $400,000 grant was made to Hierro Perú, under the U.S. Trade Development Program, to study the feasibility of recovering copper and cobalt. The company will contribute up to $100,000. The study will be made by Bechtel Corp.

Saudi Arabia.—The second module of a Midrex direct-reduction plant was completed at Al Jubail in May for Saudi Iron and Steel Co. Production capacity of the plant is now about 785,000 tons of DRI per year; output in 1983 was about 345,000 tons. Imports of iron ore were estimated at 600,000 tons, mostly from Brazil.

A pilot beneficiation plant for concentrating iron ore from the Wadi Sawawin deposits was being assembled at Al Muwaylih on the Red Sea coast. The plant will treat up to 5 tons of ore per hour, using desalinated water and a process of selective flocculation and anionic flotation developed by the U.S. Bureau of Mines for beneficiation of oxidized taconite in Minnesota. The plant is to operate for about 1 year, and if tests are successful, a commercial plant may be built to produce 1.2 million tons of pellets per year. The project is being conducted by British Steel Corp. under a contract with the Saudi Arabian Government.

Sierra Leone.—After production of iron ore concentrates began at Marampa in late 1982, exports of about 350,000 tons were reported in 1983. Most shipments went to the Federal Republic of Germany, France, and Austria. The exports were the first from Sierra Leone since 1975.

South Africa, Republic of.—Production of iron ore was sharply reduced owing to declines of about 40% in exports and 20% in local sales compared with 1982 levels. Exports were estimated at 7 million tons, 4 million tons less than in 1982 owing to reduced sales to Japan and the EC. Consumption declined to an estimated 8 million tons as several blast furnaces were closed at Newcastle and Pretoria by Iscor Ltd. Shipments of iron ore by Iscor totaled 13.2 million tons including 10.9 million tons from the Sishen Mine and 2.3 million tons from the Thabazimbi Mine. Highveld Steel and Vanadium Corp. Ltd. reduced production at the Mapochs Mine to about 900,000 tons, and Associated Manganese Mines of South Africa Ltd. shipped 750,000 tons of iron ore from mines near Postmasburg.

One coal-based direct-reduction plant was completed and two others were under construction. Scaw Metals Ltd. began operating its 75,000-ton-per-year plant at Germiston, in July. Iscor's 600,000-ton-per-year plant at Vanderbijlpark was expected to be completed in 1984. Union Steel Corp.'s 250,000-ton plasma-arc plant at Vereeniging was scheduled for completion in mid-1985. Iron ore pellets for the latter plant will be made from byproduct magnetite recovered at the Palabora Mine. The pelletizing plant, also under construction at Vereeniging, is to have a production capacity of about 600,000 tons per year.

Spain.—Iron ore production, trade, and consumption declined in 1983. Imports were estimated at 3.8 million tons, mostly from Brazil and Liberia. Exports were about 1.7 million tons, including 1.2 million tons by Cía. Andaluza de Minas S.A. (CAM) from Almería and 468,000 tons by Cía. Minera de Sierra Menera from Sagunto. Spanish consumption declined about 10% to an estimated 9.8 million tons.

Plans to build a pelletizing plant at Fregenal de la Sierra in Badajoz appeared to have been canceled. Instead, construction of a concentrator was proposed for production of sinter fines from crude ore mined at the Cala and La Berrona Mines. At Alquife, CAM was installing high-intensity magnetic separators at its Marquesado plant to raise iron content of fines to a minimum of 54% and to reduce alkali content to a maximum of 0.4%. At Bodovalle, Altos Hornos de Vizcaya S.A. (AHV) produced 1.5 million tons of siderite concentrates containing 39.1% iron and 3.7% silica from 2.3 million tons of crude ore. Concentration was by heavy-media and high-intensity magnetic methods. AHV also produced 322,000 tons of oxide ore from mines in Santander and Murcia.

Sweden.—Iron ore shipments increased to 17.1 million tons, but production declined as producers reduced the large stocks of ore that had accumulated in 1982. Stocks were reduced 30% to 7.4 million tons by yearend. Exports totaled 14.4 million tons in 1983, with about 9.7 million tons destined for EC countries. About 2.7 million tons was shipped for consumption in Sweden.

LKAB produced 11 million tons of ore products including 4.9 million tons of pellets. Six million tons was produced at Kiruna and 4.8 million tons at Malmberget. The mine and pelletizing plant at Svappavaara were closed February 1, for an indefinite period. Exports by LKAB totaled 12.5 million tons including 3.5 million tons of pellets.

In central Sweden, Svenskt Stål AB shipped 1.6 million tons of ore products for export and 1.1 million tons for local consumption. About 80% of the total was shipped from Grängesberg and the rest was shipped from the Dannemora Mine.

Taiwan.—Imports of iron ore rose to 4.9 million tons in 1983, as China Steel Corp.'s new blast furnace at Kaohsiung was operated for the first full year. Production of pig iron in Taiwan was 30% more than in 1982.

U.S.S.R.—The first of four Midrex direct-reduction plants under construction at Stary Oskol, near Kursk, was completed late in the year. The plant has a production capacity of 400,000 tons of DRI per year. Earlier in the year, a pelletizing plant was completed at the same site. The plant has a production capacity of 2.5 million tons of pellets per year and was designed to supply ore to the four reduction plants. Ore feed for the pelletizing plant is to be supplied by slurry pipeline from the Lebedi iron ore complex, about 15 miles away. Production of iron ore concentrates containing 70% iron was reportedly underway at the Lebedi complex.

Venezuela.—Shipments of iron ore produced by C.V.G. Ferrominera Orinoco C.A. declined to about 9.4 million tons. Exports were estimated at 6 million tons, of which 3.8 million tons was shipped to EC countries and most of the remainder was shipped to the United States and Spain. Consumption was estimated at 3.8 million tons. C.V.G. Siderúrgica del Orinoco C.A. produced about 3.4 million tons of pellets at Matanzas, from ore fines supplied by Ferrominera.

Ferrominera continued preparations to begin mining at San Isidro in 1985. Ores from Cerro Bolívar and San Isidro will be blended to reduce the average phosphorus content of ore products shipped. Average phosphorus content of Cerro Bolívar ore mined in 1983 was 0.11%. Ore at San Isidro contains about 0.06% phosphorus.

Zimbabwe.—The Government announced that $180 million would be spent to improve operations of Zimbabwe Iron and Steel Co. Ltd. during the next 3 to 5 years. About one-half of this sum was intended for construction of a new sinter plant and to increase iron ore production from the Ripple Creek deposits near Redcliff. Most of the ore now smelted at Redcliff comes from the Buchwa deposits, about 125 miles to the south; under the new plan, Ripple Creek ore would make up about 80% of supply. Ore shipments to Redcliff in 1983 totaled 1.03 million tons, of which 84% was produced at Buchwa and the remainder was produced at Ripple Creek.

TECHNOLOGY

Economic recessions in the iron ore and steel industries reduced funds for research and development and delayed many investments in new plant and equipment, but technological improvements continued to be reported from various sectors of the iron ore industries in the United States and abroad.

Continuing trends included increased use of flotation and wet high-intensity magnetic separation (WHIMS) for production of iron ore concentrates, increased use of fine screens to upgrade concentrates before pelletizing, installation of heat recuperative systems to reduce fuel consumption in pelletizing plants, increasing number of direct-reduction plants, improvement of port facilities to permit loading and unloading of larger iron ore carriers, pipeline transport of concentrates, and increasing use of computers for mining and process control.

Several plants have been built in the last few years for production of high-grade hematite or magnetite concentrates containing 69% to 71% iron. Two plants were built in Norway, one each in Brazil and the U.S.S.R., and a fifth was nearing completion in Mexico. Most were expected to supply ore to direct-reduction plants. Flotation is used for magnetite, with flotation and/or WHIMS used for hematite.

Direct-reduction plants have been built in at least 20 countries. Total production capacity for DRI was about 19 million tons at yearend and another 7 million tons of capacity was expected to be completed by 1986.

WHIMS is used to concentrate hematite or other weakly magnetic iron minerals. In addition to the Mexican plant mentioned above, WHIMS was being installed at the Marquesado plant in Spain and was also installed in China by Jiuquan Iron & Steel Co. Since 1972, when the first commercial WHIMS plant was completed in Brazil, the process was installed at iron ore concentrators in Australia, Canada, Liberia, Spain, the U.S.S.R., and the United States, and more recently in Norway, Sierra Leone, and Mexico. Two plants operating in Brazil have a total processing capacity of about 40 million tons of crude ore per year. The only commercial unit operated in the United States was installed in 1976 at the Sunrise plant in Wyoming, but has not operated since 1980 when the mine was closed.

Beneficiation tests by the Bureau of Mines on oxidized taconite from the western Mesabi Range indicated that flotation, with or without WHIMS, can produce acceptable concentrates from this material.

The Bureau's flotation process will be used in a pilot plant in Saudi Arabia (see "World Review"). Research on oxidized taconite was continued in 1983. Geology, mineralogy, and liberation characteristics were compared with results of beneficiation tests. It was found that oxidized taconite in which the ratio of hematite to goethite was higher than 2 to 1, and which contained 1% or less of residual magnetite, yielded acceptable concentrates. The study concluded that oxidized taconite, selectively mined and beneficiated, represents a large subeconomic resource of recoverable iron.[4]

At the Minntac concentrator in Minnesota, fine screening has now been installed on most of the plant's 18 concentrating lines and has improved the grade of final concentrate. The use of vibrating sandwich-type screens was found to improve metallurgical results and to reduce space requirements compared to intermittently rapped screens.[5] Heat recuperation systems were also installed that substantially reduced fuel requirements of the pelletizing kilns.

At the Tilden concentrator in Michigan, consumption of bentonite was reduced to 8 pounds per long ton of concentrates in 1983, compared with 24 pounds in 1975 and 16 pounds in 1978. The reduction was achieved mainly by lowering the moisture content of filtered concentrate as fed to the balling drums, and partly by switching to bentonite having greater capacity to absorb water. Current savings per pound of bentonite reduction was estimated at $280,000 annually, assuming capacity production of 8 million tons of pellets. In addition to cost savings, the drop in bentonite consumption since 1976 reduced alkali content by about 360,000 pounds per million tons of pellets.[6]

In 1983, Pea Ridge Iron Ore Co. produced olivine pellets, in which magnesian olivine was substituted for the silica previously added to magnetite concentrate. The pellets were tested in blast furnaces of Granite City Steel Corp. Although detailed results were not available, the pellet producer stated[7] that use of the pellets contributed to lower carbon consumption in the blast furnace, and that the use of olivine improved low-temperature breakdown and intermediate reduction properties of the pellets without significantly affecting efficiency of pellet production. Olivine pellets were developed in Sweden in 1981. In subsequent tests at several European blast furnaces, use of pellets was reported to have increased output of pig iron by up to 2.9% and to have reduced consumption of coke by up to 14 kilograms per metric ton of hot metal. Test results at some furnaces were inconclusive, and an increase in coke consumption was reported at one furnace.[8]

Plasma technology will be used on the Mesabi Range to test the feasibility of producing iron directly from taconite concentrates. Pilot plant tests will be made by Pickands Mather at its Hibbing laboratory, with plasma technology supplied by Westinghouse Electric Corp. and electricity supplied by Minnesota Power. A loan of $1.38 million was granted for the project by the Iron Range Resources & Rehabilitation Board. Completion of testing was expected by late 1984. If the tests are successful, plans are to build a demonstration plant with production capacity of 100,000 tons of iron per year. Plasma technology was being installed in a reduction plant in the Republic of South Africa, and its possible use was being studied in Canada, Yugoslavia, and other countries because it permits flexibility in the choice of fuel, iron ore feed, and the type of iron produced. These advantages may offset relatively high requirements for electricity.

Drastic modifications of the Reserve concentrator at Silver Bay, MN, including introduction of dry cobbing, flotation, and fine screening sections, as well as a new system of tailings disposal, greatly increased process complexity and the need for monitoring and centralized control. This was achieved by the use of computers, through a distributed control system based on a network of independent control systems connected to a central control room. Through centralized display, personnel requirements to monitor operations are minimized. New process controls are designed to maintain final iron content of concentrate to within plus or minus 0.25%.[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]Reported in 1982 chapter as 3.01 tons; revised after publication when one producer indicated that production of crude ore in 1982 was 3.3 million tons greater than originally reported.

[4]Blake, R. L. Mineralogy and Liberation Characteristics of Western Mesabi Range Oxidized Taconites. BuMines RI 8813, 1983, 26 pp.

[5]Weinert, J. D., and R. W. Salmi. Recent Applications of Fine Screens at Minntac. Paper given at 45th Annual Mining Symposium, University of Minnesota, Duluth, MN, Jan. 19, 1984.

[6]Johnson, A. R., and P. E. Rosten. Bentonite Reduction at Tilden. AIME Preprint No. 84-138, Los Angeles, CA, Feb. 1984.

[7]Lherbier, L. W., Jr. Production and Quality of Olivine Pellets. Paper given by author at AIME (57th Annual Meeting of Minnesota Section), Duluth, MN, Jan. 18, 1984.

[8]Metal Bulletin Monthly. LKAB's Push for Olivine. No. 147, Mar. 1983, pp. 53-54.

[9]Schulz, R. N. Concentrating Process Control at Reserve Mining Co. Min. Eng., v. 35, No. 9, Sept. 1983, pp. 1296-1304.

Table 2.—Employment at iron ore mines and beneficiating plants, quantity and tenor of ore produced, and average output per worker in the United States in 1983, 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 and Wisconsin	1,795	3,371	27,154	9,339	6,024	64.5	8.06	2.77	1.79
Minnesota	5,085	9,603	84,416	26,255	16,916	64.4	8.79	2.73	1.76
Total or average	6,880	12,974	111,570	35,594	22,940	64.4	8.60	2.74	1.77
Other States[1]	687	1,261	3,963	[2]1,968	[2]1,227	[2]62.4	3.15	[2]1.56	[2].97
Grand total or average	7,567	14,235	[3]115,534	[2]37,562	[2]24,167	[2]64.3	8.12	[2]2.64	[2]1.70

[1]Includes California, Colorado, Missouri, Montana, Nevada, New York, Texas, and Wyoming.
[2]Includes byproduct ore, to avoid disclosing company proprietary data. Data for number of employees and hours worked, attributable to byproduct ore, were not available but would not likely be significant in regional or national productivity calculations.
[3]Data do not add to total shown because of independent ronding.

Table 3.—Crude iron ore[1] mined in the United States in 1983, by district, State, and mining method

(Thousand long tons and exclusive of ore containing 5% or more manganese)

District and State	Open pit	Under-ground	Total quantity[2]
Lake Superior:			
Michigan	27,154	--	27,154
Minnesota	84,416	--	84,416
Total	111,570	--	111,570
Other States:			
Missouri	--	1,288	1,288
Other[3]	2,676	--	2,676
Total[2]	2,676	1,288	3,963
Grand total[2]	114,246	1,288	115,534

[1]Excludes byproduct ore.
[2]Data may not add to totals shown because of independent rounding.
[3]Includes California, Montana, Nevada, Texas, and Wyoming.

Table 4.—Crude iron ore[1] mined in the United States in 1983, by district, State, and variety

(Thousand long tons and exclusive of ore containing 5% or more manganese unless otherwise specified)

District and State	Number of mines	Hematite	Limonite[2]	Magnetite	Total quantity[3]
Lake Superior:					
Michigan	2	11,121	--	16,033	27,154
Minnesota	9	1,462	--	82,954	84,416
Total	11	12,583	--	98,987	111,570
Other States:					
Missouri	1	--	--	1,288	1,288
Other[4]	8	429	W	2,246	2,676
Total[3]	9	429	W	3,534	3,963
Grand total[3]	20	13,013	W	102,521	115,534

W Withheld to avoid disclosing company proprietary data; included with "Hematite."
[1]Excludes byproduct ore.
[2]Includes siderite ore.
[3]Data may not add to totals shown because of independent rounding.
[4]Includes California, Montana, Nevada, Texas, and Wyoming.

Table 5.—Usable iron ore[1] produced in the United States in 1983, by district, State, and variety

(Thousand long tons and exclusive of ore containing 5% or more manganese)

District and State	Hematite	Limonite[2]	Magnetite	Total quantity[3]
Lake Superior:				
Michigan	4,331	--	5,008	9,339
Minnesota	865	--	25,390	26,255
Total[3]	5,195	--	30,399	35,594
Other States:				
Missouri	--	--	801	801
Other[4]	204	W	963	1,167
Total	204	W	1,764	1,968
Grand total[3]	5,399	W	32,162	37,562

W Withheld to avoid disclosing company proprietary data; included with "Hematite."
[1]Includes byproduct ore.
[2]Includes siderite ore.
[3]Data may not add to totals shown because of independent rounding.
[4]Includes California, Montana, Nevada, New York, Texas, and Wyoming.

Table 6.—Usable iron ore[1] produced in the United States in 1983, by district, State, and type of product

(Exclusive of ore containing 5% or more manganese)

District and State	Direct-shipping ore (thousand long tons)	Concentrates (thousand long tons)	Agglomerates (thousand long tons)	Average iron content (natural), percent
Lake Superior:				
Michigan	--	--	9,339	64.5
Minnesota	--	865	25,390	64.4
Total or average	--	865	34,729	64.4
Other States:				
Missouri	--	58	742	65.5
Other[2]	41	276	850	60.3
Total or average	41	334	1,592	62.4
Grand total or average	41	1,199	36,321	64.3

[1]Includes byproduct ore.
[2]Includes California, Montana, Nevada, New York, Texas, and Wyoming.

Table 7.—Shipments of usable iron ore[1] from mines in the United States in 1983

(Thousand long tons and thousand dollars and exclusive of ore containing 5% or more manganese)

District and State	Gross weight of ore shipped: Direct-shipping ore	Gross weight of ore shipped: Concentrates	Gross weight of ore shipped: Agglomerates	Gross weight of ore shipped: Total quantity[2]	Iron content of ore shipped: Direct-shipping ore	Iron content of ore shipped: Concentrates	Iron content of ore shipped: Agglomerates	Iron content of ore shipped: Total quantity[2]	Total value
Lake Superior:									
Michigan	28	--	10,685	10,713	14	--	6,762	6,776	W
Minnesota	--	1,113	29,586	30,699	--	580	18,981	19,561	1,342,455
Total reportable	28	1,113	40,271	41,412	14	580	25,743	26,337	1,342,455
Other States:									
Missouri	--	58	819	877	--	37	528	565	27,054
Other[3]	137	980	1,189	2,305	74	544	754	1,372	W
Total reportable	137	1,038	2,008	3,182	74	581	1,282	1,937	27,054
Total withheld	--	--	--	--	--	--	--	--	575,479
Grand total[2]	166	2,151	42,279	44,596	88	1,161	27,025	28,274	1,944,988

W Withheld to avoid disclosing company proprietary data; included in "Total withheld."

[1]Includes byproduct ore.

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

[3]Includes California, Colorado, Montana, Nevada, New Mexico, New York, Texas, Utah, and Wyoming.

Table 8.—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]
1854-1976	453,786	320,467	320,334	103,528	3,096,253	70,336	8,149	5,871	4,378,722
1977	9,800	2,520	--	--	30,943	--	--	690	43,952
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
Total	539,329	329,344	320,334	103,528	3,388,172	70,336	8,149	9,713	4,768,903

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

Table 9.—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
1979	77,837	62.55	0.031	6.24	0.22	0.35	2.61
1980	61,536	62.98	.023	5.88	.18	.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

[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 10.—U.S. consumption of iron ore and agglomerates in 1983, 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[4]
	Blast furnace	Steel furnace	Blast furnace	Steel furnace		
Alabama, Kentucky, Texas	W	W	W	W	W	W
California, Colorado, Utah	W	W	W	--	W	W
Illinois, Indiana, Michigan	56	--	33,082	W	W	33,138
Maryland, New York, Pennsylvania	1,543	82	13,389	91	W	15,107
Ohio and West Virginia	1,794	W	14,334	W	W	16,128
Undistributed	482	11	4,923	4	835	6,256
Total[4]	3,876	94	65,727	96	835	70,629

W Withheld to avoid disclosing company proprietary data; included with "Undistributed."
[1]Excludes pellets or other agglomerated products.
[2]Includes 43,849,216 long tons of pellets produced at U.S. mines and 5,737,369 long tons of foreign pellets and other agglomerates.
[3]Includes iron ore consumed in production of cement and direct-reduced iron, and iron ore shipped for use in manufacturing paint, ferrites, heavy media, cattle feed, refractory and weighting materials, and lead blast furnaces.
[4]Data may not add to totals shown because of independent rounding.

Table 11.—Iron ore consumed in production of sinter at iron and steel plants in the United States in 1983, 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	3,501	7,364
Maryland, New York, Pennsylvania	4,250	5,731
Ohio and West Virginia	898	1,618
Undistributed	968	1,147
Total[2]	9,616	15,859

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 12.—Beneficiated iron ore[1] shipped from mines in the United States

(Exclusive of ore containing 5% or more manganese)

Year	Beneficiated ore (thousand long tons)	Total iron ore (thousand long tons)	Proportion of beneficiated ore to total (percent)
1979	84,489	86,130	98.1
1980	68,272	69,562	98.1
1981	71,169	72,181	98.6
1982	35,381	35,756	99.0
1983	44,430	44,596	99.6

[1]Beneficiated by further treatment than ordinary crushing and screening. Excludes byproduct ore in 1979 and 1980.

Table 14.—Production[1] of iron ore agglomerates in the United States, by type

(Thousand long tons)

Type	Agglomerates produced	
	1982	1983
Sinter	[2]16,200	[3]15,859
Pellets	32,775	36,291
Total	48,975	[4]52,151

[1]Production at mines and consuming plants.
[2]Includes 7,536,459 long tons of self-fluxing sinter.
[3]Includes 7,982,969 long tons of self-fluxing sinter.
[4]Data do not add to total shown because of independent rounding.

Table 13.—Stocks of usable iron ore[1] at U.S. mines, December 31, by district

(Thousand long tons)

District	1982	1983
Lake Superior	7,809	2,820
Other States	4,320	[2]389
Total	12,129	[2,3]3,209

[1]Excludes byproduct ore.
[2]These stocks are not comparable to those of previous years owing to the reclassification of some stocks from the usable to the byproduct category.

Table 15.—Average value of usable iron ore[1] shipped from mines or beneficiating plants in the United States in 1983

(Dollars per long ton)

Type of ore	Lake Superior district	Other States[2]
Direct-shipping	W	13.54
Concentrates	17.70	23.58
Pellets	45.44	34.37

W Withheld to avoid disclosing company proprietary data.
[1]F.o.b. mine or plant. Excludes byproduct ore.
[2]Includes California, Colorado, Missouri, Montana, Nevada, Texas, Utah, and Wyoming.

Table 16.—U.S. exports of iron ore, by country

(Thousand long tons and thousand dollars)

Country	1981		1982		1983	
	Quantity	Value	Quantity	Value	Quantity	Value
Canada	5,529	243,527	3,173	150,200	3,780	182,490
France	(1)	2	(1)	6	(1)	6
Germany, Federal Republic of	(1)	3	--	--	(1)	1
Japan	(1)	2	--	--	--	--
Mexico	11	720	1	67	(1)	4
Norway	(1)	59	--	--	--	--
Taiwan	--	--	(1)	1	--	--
United Kingdom	(1)	21	(1)	21	(1)	5
Other	5	351	3	227	1	239
Total[2]	5,546	244,685	3,178	150,522	3,781	182,744

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

Table 17.—U.S. imports for consumption of iron ore, by country

(Thousand long tons and thousand dollars)

Country	1981		1982		1983	
	Quantity	Value	Quantity	Value	Quantity	Value
Australia	--	--	(1)	4	--	--
Brazil	1,738	52,267	972	26,339	1,276	30,192
Canada	18,845	707,974	9,281	359,708	8,832	339,472
Chile	342	6,329	47	673	--	--
Liberia	2,160	35,505	2,399	43,036	1,732	31,487
Peru	77	2,402	35	1,057	(1)	5
South Africa, Republic of	--	--	52	1,083	--	--
Sweden	87	2,318	71	2,171	68	1,540
Venezuela	5,071	140,931	[2]1,643	[2]36,768	[3]1,333	[3]42,934
Other	8	251	(1)	7	5	102
Total[4]	28,328	947,977	14,501	470,847	13,246	445,731

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

Table 18.—U.S. imports for consumption of iron ore, by customs district

(Thousand long tons and thousand dollars)

Customs district	1981		1982		1983	
	Quantity	Value	Quantity	Value	Quantity	Value
Baltimore	5,421	212,960	3,451	118,425	3,062	63,216
Buffalo	629	13,096	299	5,791	195	8,862
Chicago	3,854	128,320	2,667	91,454	1,625	52,357
Cleveland	4,995	179,616	2,087	77,001	4,491	179,771
Detroit	765	25,303	228	4,873	182	4,480
Galveston	123	2,579	--	--	--	--
Houston	775	30,809	376	14,654	37	1,169
Mobile	3,847	131,445	1,278	49,584	525	25,778
New Orleans	237	5,177	423	9,915	573	12,369
Philadelphia	7,218	203,969	3,497	92,002	2,463	93,963
Wilmington, NC	425	13,428	76	2,949	--	--
Other	38	1,275	118	4,198	91	3,768
Total[1]	28,328	947,977	14,501	470,847	13,246	445,731

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

Table 19.—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]				
	1979	1980	1981	1982[p]	1983[e]	1979	1980	1981	1982[p]	1983[e]
Albania[5]	[r]522	541	591	591	640	[r]183	[r]190	197	[e]197	217
Algeria	2,819	3,399	3,425	3,646	3,642	1,523	1,836	1,849	1,968	1,966
Argentina	601	430	392	578	619	390	271	245	361	387
Australia	[r]90,269	94,025	83,275	86,309	72,830	[r]56,933	[r]59,483	52,831	54,413	46,031
Austria	3,149	3,149	3,002	3,277	[e]3,484	[r]984	970	933	1,028	[e]1,090
Bolivia	25	6	6	8	13	16	4	4	5	8
Brazil	[r]102,440	112,920	96,315	93,500	87,594	[r]66,586	73,398	61,616	60,775	56,936
Bulgaria	2,070	1,856	1,726	1,527	1,476	641	581	529	467	443
Canada[7]	58,942	47,984	51,164	34,865	[e]32,966	37,086	30,316	32,126	22,174	20,964
Chile	7,006	8,139	7,621	[e]5,714	[e]5,880	4,316	5,014	4,695	[e]3,520	[e]3,545
China[e]	[r]65,000	[r]67,000	65,000	68,000	70,000	[r]32,500	[r]33,500	32,500	34,000	35,000
Colombia	391	498	412	463	443	180	229	190	[e]184	177
Czechoslovakia	1,980	1,938	1,904	1,832	1,772	524	504	494	476	463
Denmark	[r]8	8	8	8	8	[r]4	3	3	3	3
Egypt	1,412	1,748	1,912	2,106	2,188	706	874	871	1,053	1,083
Finland[8]	1,126	1,153	1,211	1,065	1,083	726	743	777	692	704
France	[r]31,128	[r]28,523	21,257	19,104	[e]15,715	9,645	8,956	6,693	6,102	[e]5,090
German Democratic Republic[e 9]	[r]55	[r]39	[r]39	[r]39	39	29	[r]20	[r]20	[r]20	20
Germany, Federal Republic of	[r]1,623	1,917	1,550	1,293	[e]964	518	588	469	381	[e]276
Greece[5]	1,803	1,428	[e]1,378	[e]1,380	1,476	[r]787	624	[e]600	[e]600	640
Hungary	524	419	415	460	[e]434	119	89	87	99	[e]93
India	[r]39,230	41,274	40,701	40,256	38,187	24,558	[r]25,837	25,479	[e]25,200	[e]23,905
Indonesia	79	62	86	142	[e]125	46	36	49	82	[e]72
Iran[e 10]	600	590	590	700	690	365	360	360	[r]390	340
Italy[11]	[r]216	182	[e]121	3	--	[r]87	[r]72	[r e]49	2	--
Japan[12]	453	[r]469	[e]435	356	[e]293	[r]280	[r]289	270	221	[e]182
Kenya[e 13]	20	[r]15	14	14	14	12	9	9	9	9
Korea, North[e]	7,300	7,900	7,900	7,900	7,900	3,000	3,200	3,200	3,200	3,200
Korea, Republic of	629	609	585	610	565	352	342	328	342	316
Liberia	18,055	17,900	19,393	17,980	14,701	11,194	11,000	12,000	10,413	8,878
Luxembourg	620	551	422	--	--	186	165	[e]148	--	--
Malaysia	[r]344	365	524	336	111	210	223	320	205	68
Mauritania	9,225	8,795	8,567	8,125	7,283	[r]5,719	5,248	5,160	4,675	4,183
Mexico[14]	5,965	7,510	7,893	8,026	[e]7,913	3,977	5,007	5,209	5,297	[e]5,222
Morocco	61	77	72	220	248	[r]37	49	44	137	153
New Zealand[15]	[r]3,471	[r]3,581	3,202	2,955	2,559	1,979	2,041	1,825	1,684	1,457
Norway	[r]3,943	3,823	4,000	3,214	3,582	2,601	2,434	2,642	2,089	2,328
Peru	5,358	5,614	5,973	5,683	4,278	3,565	3,735	3,944	[e]3,750	2,824
Philippines	[r]6	--	6	6	2	[r]3	--	3	3	1
Poland	245	102	103	48	44	71	30	29	14	12
Portugal[16]	59	56	[e]56	27	25	28	25	[e]26	9	8

Romania	2,483	2,296	2,268	2,112	1,968	646	597	591	551	512
Sierra Leone	--	--	--	64	295	--	--	--	40	187
South Africa, Republic of[17]	[r]31,067	25,896	27,872	24,166	16,343	19,883	16,574	17,837	15,467	10,459
Spain[18]	8,687	9,081	[e]8,430	8,132	[6]7,331	3,931	4,303	[e]4,151	3,632	[6]3,457
Sweden	[r]25,756	26,755	[e]22,858	15,883	[6]13,003	16,714	17,364	[e]14,835	10,324	[6]8,452
Thailand	101	84	61	27	[6]39	56	46	33	[e]15	[6]22
Tunisia	387	383	390	270	[6]311	197	211	202	[e]140	[6]162
Turkey	[r, e]2,953	[r]2,538	2,889	2,810	[6]4,085	1,532	[e]1,292	1,560	1,518	[6]2,207
U.S.S.R[e]	[r]237,921	[r]240,849	[r]238,589	[r]240,551	241,131	129,377	[r]130,787	[r]129,001	[r]129,970	130,309
United Kingdom	[r]4,201	[r]902	719	463	378	1,092	234	158	101	84
United States[18]	85,716	69,613	73,174	35,433	37,562	53,639	43,888	46,539	22,642	24,167
Venezuela	15,019	15,848	15,286	11,023	[6]9,562	9,312	9,826	9,477	6,834	[6]5,928
Yugoslavia	4,544	4,458	4,718	5,025	4,939	1,619	[e]1,600	1,680	1,557	1,479
Zimbabwe	1,182	1,596	1,079	824	[6]909	721	973	658	503	[6]555
Total	[r]888,789	[r]876,894	841,579	769,149	729,642	[r]511,385	[r]505,990	485,545	439,534	416,274

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through June 27, 1984.
[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, North Korea, and Zimbabwe.
[5]Nickeliferous iron ore.
[6]Reported figure.
[7]Series revised to represent gross weight and metal content of usable iron ore (including byproduct ore) actually produced, natural weight, except for 1983.
[8]Includes magnetite concentrate, pelletized iron oxide (from pyrite sinter), and roasted pyrite (purple ore).
[9]Includes roasted ore.
[10]Year beginning Mar. 21 of that stated.
[11]Excludes iron oxide pellets produced from pyrite sinter.
[12]Concentrate including concentrate derived from iron sand as follows, in thousand metric tons: 1979—2 and 1980 through 1983—no production reported.
[13]For cement manufacture.
[14]Gross weight calculated from reported iron content based on grade of 66% Fe.
[15]Concentrates from titaniferous magnetite beach sands.
[16]Includes manganiferous iron ore.
[17]Includes magnetite ore as follows, in thousand metric tons: 1979—4,068; 1980—4,289; 1981—4,242; 1982—4,321; and 1983—3,469.
[18]Includes byproduct ore.

Iron Oxide Pigments

By William I. Spinrad, Jr.[1]

U.S. mine production, shipments, and value of crude iron oxide pigments decreased in 1983, while total domestic shipments and value of finished iron oxides and iron oxides from steel plant wastes increased compared with those of 1982. Synthetic iron oxides, which comprised 63% of all iron oxides shipped, experienced increases in all grades of material. Most domestic producers of finished iron oxide pigments experienced increases in shipments, while one produced no iron oxide pigments. Columbian Chemicals Co. was sold by Cities Service Co. to Consolidated Mining and Industries Co., and E. I. du Pont de Nemours & Co. announced plans to sell its iron oxide facility in Newark, NJ, to Heubach Inc.

Consumption of iron oxide pigments continued to be greatest in paint and coatings followed, in order of ranking, by construction materials; colorants for plastics, rubber, paper, textiles, glass, and ceramics; ferrites and other magnetic and electronic applications; animal feed and fertilizers; and other varied end uses.

Domestic list prices for iron oxides remained stable for the first three quarters of the year, with price increases taking effect in the fourth quarter to counter inflationary costs in raw materials, labor, and energy.

U.S. imports for consumption of selected iron oxide pigments and U.S. exports of pigment-grade iron oxides and hydroxides increased over 1982 levels. An unfavorable trade balance continued, as U.S. imports greatly exceeded U.S. exports. World mine production of natural iron oxide pigments for reporting countries declined in 1983 compared with that of 1982.

Domestic Data Coverage.—Mine production and sales data for crude iron oxide pigments and sales data for finished iron oxide pigments and iron oxides from steel plant wastes were compiled from voluntary responses received from an annual survey of U.S. producers conducted by the Bureau of Mines. Responses for crude iron oxide mine production and sales data were received from five companies representing 100% of all producers that are known to mine and/or ship crude iron oxide pigments in the United States, as shown in table 1. Of the 19 companies canvassed for finished iron oxide pigments sales data in 1983, 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 100% of the total production shown

Table 1.—Salient U.S. iron oxide pigments statistics

	1979	1980	1981	1982	1983
Mine production __ short tons	87,869	49,078	46,213	48,828	24,647
Crude pigments sold or used __ do	74,548	62,642	67,214	67,294	40,023
Value __ thousands	$2,578	$3,272	$2,285	$2,702	$2,368
Iron oxides from steel plant wastes __ short tons	25,186	20,717	20,879	12,974	13,178
Value __ thousands	$1,703	$1,394	$1,637	$972	$1,141
Finished pigments sold __ short tons	156,036	136,336	141,252	r116,007	136,343
Value __ thousands	$94,175	$97,270	$110,859	r$108,164	$131,853
Exports __ short tons	4,852	5,046	4,967	9,065	12,661
Value __ thousands	$7,359	$9,132	$11,704	$17,795	$20,692
Imports for consumption __ short tons	55,377	39,446	39,661	25,855	30,747
Value __ thousands	$24,341	$20,035	$18,915	$13,330	$16,684

rRevised.

in the text discussion under Domestic Production. An additional small number of regenerator oxide plants are known to exist but do not participate in the Bureau of Mines annual canvass. No estimates are available for these plants.

DOMESTIC PRODUCTION

Mine production of crude iron oxide pigments decreased 50% and shipments decreased 41% in quantity and 12% in value from that of 1982. Most of these decreases were attributed to a loss of sales in a major product line by one producer. Four companies in Georgia, Missouri, and Virginia mined and shipped various grades of umber and ocher, magnetite, and sienna and umber, respectively. 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 increased 18% in quantity and 22% in value in 1983 compared with that of 1982. Synthetic iron oxide, which constituted 63% of all shipments, increased 25% in quantity and 23% in value, while natural iron oxide pigments increased 6% in quantity and 15% in value compared with 1982 levels. A notable increase in naturals occurred in ocher, which increased 58% in quantity over that of 1982. Most domestic producers canvassed showed increases in shipments of finished iron oxide pigments in 1983, with one producing no iron oxide pigments.

Iron oxides recovered from steel plant wastes, that is, steel plant dust and regenerator oxides, increased 2% to 13,178 short tons in 1983 compared with that of 1982 and was valued at $1.14 million. One of the five companies canvassed reported no production in 1983, and one producer permanently shut down because of economic reasons.

In 1983, Columbian Chemicals was sold by Cities Service to Consolidated Mining, a privately owned international company involved in mining, industry, and natural resource trading. Columbian Chemicals will continue to operate as an independent business under the present management. It was reported in 1983 that Du Pont planned to sell its color pigment businesses to various companies in early 1984. Included among

Table 2.—Finished iron oxide pigments sold by processors in the United States, by kind

Kind	1982 Quantity (short tons)	1982 Value (thousands)	1983 Quantity (short tons)	1983 Value (thousands)
Natural:				
Black: Magnetite	6,717	$1,023	5,074	$809
Brown:				
Iron oxide[1]	10,739	3,615	9,794	3,192
Umbers:				
Burnt	2,983	2,139	3,451	2,626
Raw	949	652	1,311	901
Red:				
Iron oxide[2]	20,162	2,403	22,019	3,602
Sienna, burnt	815	687	776	510
Yellow:				
Ocher[3]	4,774	857	7,537	1,441
Sienna, raw	285	241	329	256
Total	47,424	11,617	50,291	[4]13,336
Synthetic:				
Brown: Iron oxide[5]	r10,675	r13,485	14,705	19,109
Red: Iron oxide	r24,375	r31,793	31,519	43,224
Yellow: Iron oxide	r20,403	r24,373	24,104	30,081
Other: Specialty oxides[6]	r13,130	r26,895	15,724	26,103
Total	r68,583	r [4]96,547	86,052	118,517
Mixtures of natural and synthetic iron oxides	W	W	W	W
Grand total	r116,007	r108,164	136,343	131,853

rRevised. W Withheld to avoid disclosing company proprietary data.
[1]Includes Vandyke brown.
[2]Includes pyrite cinder.
[3]Includes yellow iron oxide.
[4]Data do not add to total shown because of independent rounding.
[5]Includes synthetic black iron oxide.
[6]Includes mixtures of natural and synthetic iron oxides.

these sales is Du Pont's iron oxide facility in Newark, NJ, which will be sold to Heubach, a newly formed U.S. branch of Dr. Hans Heubach GmbH & Co. KG, Langelsheim, Federal Republic of Germany, a producer of inorganic pigments.

Table 3.—Producers of iron oxide pigments in the United States in 1983

Producer	Mailing address	Plant location
Finished pigments:		
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.
Combustion Engineering Inc., CE Minerals Div.	901 East 8th Ave. King of Prussia, PA 19406	Camden, NJ.
DCS Color & Supply Co. Inc	1050 East Bay St. Milwaukee, WI 53207	Milwaukee, WI.
E. I. du Pont de Nemours & Co	Pigments Dept. Wilmington, DE 19898	Newark, NJ.
Ferro Corp., Ottawa Chemical Div	700 North Wheeling St. Toledo, OH 43605	Toledo, OH.
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; Valparaiso, IN.
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.
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

Iron oxide pigment data on consumption, shown as percentages by end use of reported shipments in table 4, are estimates since some producers keep less detailed data concerning end-use breakdowns than others.

Consumption of iron oxide pigments in paint and coatings continued to be the largest end use for iron oxide pigments, especially for synthetic iron oxides. This end use comprised 33% of total iron oxide usage in 1983 and totaled 45,339 tons, up 20% over the 1982 level of 37,772 tons. Rebounds were experienced in most areas of paint usage including automotive output, housing starts, do-it-yourself home improvement markets, household furniture, and household appliances. Shipments of paint, varnish, and lacquer, reported by the U.S. Department of Commerce,[2] totaled 923 million gallons valued at $8.6 billion in 1983, up 2% in quantity and 4% in value over 1982 levels. Of this total, architectural coatings comprised 463 million gallons, representing 50% of total shipments; product coatings and original equipment manufacture constituted 331 million gallons, representing 36% of total shipments; and 129 million gallons, or 14% of total shipments, were special-purpose coatings.

Construction materials accounted for 24% of iron oxide pigment consumption, increasing 44% in 1983 to 32,530 tons compared with 22,610 tons in 1982. According to the F. W. Dodge Div. of McGraw-Hill Information Systems Co., newly started construction in 1983 reached a record $193 billion, increasing 23% in value over 1982 levels. Residential housing, which represented the largest growth area of construction, grew 57% in volume and value to 1.7 million new dwelling units valued at $93.2 billion. Nonresidential building and nonbuilding construction grew 4% and 1% in value, respectively.[3]

Colorants for plastics, rubber, paper, textiles, glass, and ceramics accounted for 14% of reported iron oxide pigment consumption, increasing 20% in 1983 to 19,605 tons compared with 16,350 tons in 1982.

Iron oxide usage in ferrites and other magnetic and electronic applications, albeit capturing a smaller market share (12%) of reported iron oxide pigments consumed, increased slightly in quantity in 1983 to 15,851 tons compared with 15,448 tons in 1982. Increases in magnetic tape and magnetic ink applications were somewhat offset by decreased shipments of finished iron oxide for ferrite consumption.

The remaining 17% of reported iron oxide pigment consumption was used in the manufacture of industrial chemicals, animal feed and fertilizers, foundry sands, cosmetics, jeweler's rouge, and other end uses.

Table 4.—Estimated iron oxide pigment consumption, by end use, as a percentage of reported shipments

End use	All iron oxides		Natural iron oxides		Synthetic iron oxides	
	1982	1983	1982	1983	1982	1983
Coatings (industrial finishes, trade sales paints, varnishes, lacquers)	33	33	23	25	39	38
Construction materials (cement, mortar, preformed concrete, roofing granules)	r20	24	20	25	r19	23
Ferrites and other magnetic and electronic applications	13	12	6	4	r18	16
Colorants for plastics, rubber, paper, textiles, glass, ceramics	14	14	14	16	14	14
Industrial chemicals (such as catalysts)	r5	4	3	2	r6	5
Animal feed and fertilizers	8	5	18	12	1	1
Foundry sands	6	5	15	14	--	--
Other (including cosmetics and jeweler's rouge)	1	3	1	2	3	3
Total	100	100	100	100	100	100

rRevised.

PRICES

Domestic list prices for iron oxide pigments remained stable for the first three quarters of the year. Price increases were rumored as markets steadily improved, but competitive low-valued imports resulting from a strong U.S. dollar caused continued discounting within iron oxide lines. However, price firming through the removal of temporary discounts increased during this period. With continual improvement within iron oxide pigment markets, price increases were announced late in the fourth quarter by major producers to counter inflationary costs in raw materials, labor, and energy. On November 15, Pfizer Inc. reportedly increased its natural and synthetic iron oxide grades by 5%, with Mobay Chemical Corp. and Columbian Chemicals announcing similar 5% increases for their iron oxide products, effective December 1.

Table 5.—Prices quoted on finished iron oxide pigments, per pound, bulk shipments, December 31, 1983

Pigment	Low	High
Black:		
Natural	$0.2700	--
Synthetic	.6900	$0.7150
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

A net trade deficit for iron oxide pigments continued and increased in the United States in 1983. U.S. imports of selected iron oxide pigments for consumption exceeded U.S. exports of pigment-grade iron oxides by 18,086 tons. This was attributed, in part, to the combination of a strong U.S. dollar and import price trimming brought about by a strong rebound in the U.S. economy compared with foreign economies.

U.S. exports of pigment-grade iron oxides and hydroxides reached a record level in 1983, increasing 40% in quantity and 16% in value compared with that of 1982. U.S. exports were received by 49 countries, with Europe, Asia, and other North American countries representing the largest foreign markets. Chief destinations included the Federal Republic of Germany, Canada, and the United Kingdom. Exports of pigment-grade iron oxides to the Federal Republic of Germany increased 56% over 1982 levels and had an average value of 31 cents per pound, an 11% increase over 1982 values. Exports of other grades of iron oxides and hydroxides decreased 28% in quantity and 29% in value compared with that of 1982. Main destinations were Japan, Belgium-Luxembourg, Canada, and the United Kingdom.

U.S. imports for consumption of selected iron oxide pigments were received from 22 countries, increasing 19% in quantity and 25% in value compared with that of 1982. Unit values decreased in many of the natural and synthetic categories. Monthly import levels were above corresponding 1982 levels in all but the first month of 1983. Synthetic iron oxides, which comprised 73% of these imports, increased 8% in quantity and 26% in value compared with that of 1982, and were received mainly from the Federal Republic of Germany, Canada, Japan, and Mexico. U.S. imports of natural iron oxides increased 61% in quantity and 18% in value over 1982 levels to their highest levels in 4 years. These imports were received chiefly from Cyprus, the Federal Republic of Germany, and Spain, which accounted for 94% of all imports of natural iron oxides. Notable increases, which led to the large overall gain in imports of natural iron oxides, include an 85% increase in crude umber and an 82% increase in Vandyke brown. Sienna was received from Italy and all Vandyke brown imported was received from the Federal Republic of Germany. Minor amounts of crude and synthetic iron oxides were reportedly received and stored at bonded warehouses for future consumption.

Table 6.—U.S. exports of iron oxides and hydroxides, by country

Country	1982				1983			
	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	154	$103	43	$41	55	$37	--	--
Argentina	13	21	2	5	12	36	1	$3
Australia	131	209	163	682	159	207	246	645
Belgium-Luxembourg	12	65	237	435	92	161	381	664
Brazil	387	666	10	37	247	700	115	235
Bulgaria	--	--	--	--	--	--	20	78
Canada	1,963	2,266	547	644	1,920	2,888	324	490
China	--	--	14	18	--	--	112	363
Colombia	104	159	8	12	109	79	8	9
Czechoslovakia	--	--	--	--	(1)	1	20	77
Denmark	16	49	4	3	32	121	2	2
Ecuador	10	28	--	--	38	40	7	7
Egypt	28	20	--	--	--	--	30	18
El Salvador	17	37	--	--	21	48	--	--
Finland	17	22	16	18	31	41	--	--
France	344	449	150	272	380	581	72	135
Germany, Federal Republic of	3,849	2,132	138	466	5,999	3,689	163	823
Hong Kong	174	567	15	7	425	912	--	--
India	2	r8	14	33	23	81	--	--
Indonesia	(1)	1	81	27	452	629	--	--
Iraq	--	--	57	100	--	--	--	--
Israel	4	6	123	359	--	--	62	253
Italy	279	1,938	20	30	286	2,167	39	140
Jamaica	11	23	--	--	8	48	1	2
Japan	309	2,784	2,241	7,372	486	1,119	1,914	5,896
Korea, Republic of	69	122	101	457	558	720	44	138
Malaysia	14	13	--	--	19	13	30	66
Mexico	90	291	156	598	47	89	167	666
Netherlands	70	298	1,515	4,523	51	100	269	849
Norway	--	--	--	--	--	--	19	34
Oman	--	--	125	24	--	--	--	--
Panama	4	7	4	10	4	9	10	9
Peru	(1)	2	2	3	11	7	7	6
Philippines	10	13	3	6	11	19	4	9
Saudi Arabia	1	4	39	73	6	11	--	--
Singapore	46	333	15	25	34	106	290	336
South Africa, Republic of	16	109	1	1	24	65	--	--
Spain	15	47	--	--	9	41	(1)	1
Sweden	7	24	110	225	--	--	5	11
Taiwan	23	32	8	28	16	44	2	4
Thailand	23	23	--	--	32	30	--	--
Trinidad	--	--	105	361	3	4	--	--
Turkey	--	--	67	152	--	--	--	--
United Arab Emirates	--	--	119	266	--	--	22	30
United Kingdom	643	4,574	274	637	892	5,583	317	618
Venezuela	168	231	108	174	137	197	77	233
Other	r40	r116	r47	r113	34	68	18	28
Total[2]	9,065	17,795	6,679	18,237	12,661	20,692	4,799	12,882

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

Source: U.S. Bureau of the Census.

Table 7.—U.S. imports for consumption of selected iron oxide pigments

Pigment	1982 Quantity (short tons)	1982 Value (thousands)	1983 Quantity (short tons)	1983 Value (thousands)
Natural:				
Crude:				
Ochers	9	$9	(1)	(1)
Siennas	21	6	44	$18
Umbers	3,410	508	6,317	898
Other	84	112	54	53
Total	3,524	635	6,415	969
Finished:				
Ochers	22	11	(1)	3
Siennas	91	40	97	38
Umbers	358	141	323	98
Vandyke brown	423	153	769	309
Other	796	464	787	289
Total	1,690	809	1,976	737
Synthetic:				
Black	1,050	682	503	255
Red	4,763	3,136	4,453	2,731
Yellow	5,988	3,873	7,640	5,121
Other[2]	8,840	4,195	9,760	6,871
Total	20,641	11,886	22,356	14,978
Grand total	25,855	13,330	30,747	16,684

[1]Less than 1/2 unit.
[2]Includes synthetic brown oxides, transparent oxides, and magnetic and precursor oxides.

Source: U.S. Bureau of the Census.

Table 8.—U.S. imports for consumption of iron oxide and iron hydroxide pigments, by country

Country	Natural 1982 Quantity (short tons)	Natural 1982 Value (thousands)	Natural 1983 Quantity (short tons)	Natural 1983 Value (thousands)	Synthetic 1982 Quantity (short tons)	Synthetic 1982 Value (thousands)	Synthetic 1983 Quantity (short tons)	Synthetic 1983 Value (thousands)
Australia	--	--	20	$10	98	$44	53	$23
Austria	98	$63	59	37	9	5	--	--
Belgium-Luxembourg	22	6	21	6	--	--	58	17
Brazil	--	--	--	--	19	13	56	31
Canada	91	32	26	13	8,770	2,564	7,461	1,937
Cyprus	3,662	587	6,550	968	--	--	--	--
France	50	230	24	61	38	15	3	14
Germany, Federal Republic of	437	187	793	318	9,296	6,021	10,198	6,084
Italy	45	22	48	22	3	7	--	--
Japan	11	60	3	17	1,441	2,748	3,127	6,086
Mexico	--	--	23	9	647	290	786	313
Netherlands	1	25	24	17	--	--	20	6
Portugal	--	--	76	23	--	--	--	--
South Africa, Republic of	20	7	--	--	--	--	--	--
Spain	597	120	556	127	98	32	160	29
United Kingdom	157	75	147	73	220	138	424	239
Other	21	29	21	5	2	7	10	199
Total[1]	5,214	1,444	8,391	1,706	20,641	11,886	22,356	14,978

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

Source: U.S. Bureau of the Census.

WORLD REVIEW

World mine production of natural iron oxides for reporting countries decreased in 1983 compared with that of 1982. 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 principally by India and Spain; yellow ocher was produced primarily by the Republic of South Africa, France, Cyprus, Spain, and the United States; and sienna was produced mainly 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.

Of coloring agents, synthetic iron oxides accounted for approximately 75% of all colored inorganic world production capacity because of their variety of colors, overall properties, and low cost.[4] Principal world producers of synthetic iron oxides included the Federal Republic of Germany, Japan, the United States, Canada, and Mexico.

Japan.—Domestic sales of synthetic iron oxides were expected to increase 6% to 143,100 tons in 1983, compared with that of 1982. The main growth areas, magnetic materials, printing inks, and paper, were estimated to have increased 10%, 4%, and 3%, respectively, offsetting moderate declines expected in iron oxide pigment usage in roads, ceramics, and synthetic resins. Exports were estimated to have declined 2% from 1982 levels. Domestic end usage of iron oxide, based on estimated domestic sales, indicated that 79% of iron oxide sold was used in magnetic materials, 11% in paints, 3% in roads, and 2% in building materials, with the remaining 5% used in printing inks, synthetic resins, ceramics, paper, and other end uses. Major iron oxide producers in Japan include Rikon Sangyo, Chemelite Kogyo, Morishita Bengara Kogyo, Koden Kogyo, Nihon Bengara Kogyo, Nishiumi Kogyo, and Titanium Kogyo.[5]

Table 9.—Natural iron oxide pigments: World mine production, by country[1]

(Short tons)

Country[2]	1979	1980	1981	1982[p]	1983[e]
Argentina	963	1,053	815	1,027	1,050
Australia	245	58	925	--	--
Austria	13,556	12,080	12,478	10,549	10,600
Brazil	8,303	7,126	4,578	[r] [e]4,600	4,600
Canada[e]	3,000	3,100	3,100	3,100	3,100
Chile	2,855	4,906	5,390	2,695	2,900
Cyprus	28,660	22,046	22,046	22,046	22,046
Egypt	154	139	[e]140	[e]160	140
France[e]	18,200	17,600	16,530	15,400	14,300
Germany, Federal Republic of[3]	31,483	27,193	24,828	20,491	22,000
India	109,168	95,017	87,778	93,464	99,000
Iran[e] [4]	1,100	550	550	550	660
Italy[e]	1,100	1,100	[r]1,000	900	1,000
Morocco	28	133	--	--	--
Pakistan	1,133	359	483	[e]500	500
Paraguay[e]	220	220	220	220	220
Portugal[e]	65	[5]72	65	55	55
South Africa, Republic of	2,492	1,510	1,130	2,355	1,930
Spain:					
Ocher	16,621	15,097	17,110	12,907	11,000
Red iron oxide[e]	27,600	27,600	27,600	25,000	22,000
United States	87,869	49,078	46,213	48,828	[5]24,647
Zimbabwe[e]	[r]550	[r]1,100	[r]1,320	1,100	1,100

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

[1]Table includes data available through Apr. 12, 1984.

[2]In addition to the countries listed, a considerable number of others undoubtedly produce iron oxide pigments, but output is not reported, and no basis is available for formulating estimates of output levels. Such countries include (but are not limited to) China and the U.S.S.R. Because unreported output is probably substantial, this table is not added to provide a world total.

[3]Includes Vandyke brown.

[4]Iranian calendar year (Mar. 21 to Mar. 20), beginning in the year stated.

[5]Reported figure.

TECHNOLOGY

Conventional methods of shipping iron oxide pigments, that is, bulk dry shipments, are being replaced in some instances by slurries, aqueous solutions of 60% or more solids by weight. By using slurries, cost savings of 20% or more in handling and storage can be realized through the elimination of production processing steps, thus saving on energy, personnel, and housekeeping costs. Typical improvements offered include quick, clean, and dust-free unloading; reduction of necessary warehouse space; simplified inventory control; reduced dust and disposal problems; improved pigment distribution to use stations; and elimination of a dispersion step. High-solid solutions are employed to minimize the cost of shipping water, allow its use in high-solids paint formulation, and allow its compatability with other slurry products. These slurries, which can be used by most end users such as the coatings, construction, and chemical industries, can be shipped by tank trucks, tank cars, and drums and can be stored in bulk storage tanks, tote tanks, or drums.[6]

Pigments of consistent quality are a primary concern to pigment manufacturers, requiring continuing technology updates to ensure their compatability with a variety of color systems used by the various consuming industries. Color and chemical stability are of prime importance, as in-process temperatures for industries serviced range from room temperature to 1,300° C and product requirements include nonreactivity when subjected to ultraviolet light, heat, reducing atmospheres, molten glass, and repeated exposure to alkalies, acids, and organic solvents. To produce a high-quality pigment, numerous test measurements are conducted during the pigment processing steps to accomplish manufacturing controls, including tests for raw materials suitability, batch and blend integrity, proper calcining, particle size adjustment, effective washing, and blending. Other quality control parameters used are use-testing of a pigment for a particular customer plant process, quantitative color measurement by use of instrumentation, and color limits measurements for establishment of customer acceptable ranges.[7]

An efficient solvent extraction recovery process for the removal of high-purity iron and iron oxide during acid recovery from waste pickle liquors has been described by Nihon Solex Co. Ltd. (NSC), Tokyo, Japan. The process was developed by NSC in cooperation with Nishimura Laboratory of Kansai University, Osaka, and a pilot plant was built jointly with Kawasaki Steel Corp. in 1982 at their plant in Chiba under the financial assistance of the Research Development Corp. of Japan. The process involves selectively extracting ferric ions by an organic extractant, preferably an alkyl phosphoric acid; stripping the ferric ions from the organic extractant by use of an aqueous solution containing ammonium fluoride compounds; crystallizing the ammonium fluoride stripped from the organic extractant; and thermally decomposing the crystals, under low temperature, in an oxidizing environment to produce high-purity iron oxide or a reducing environment to produce iron. Thermal decomposition starts at 180° C, and finishes at 380° C producing a final product size ranging from 0.5 to 1.0 micrometer.

Two new standards concerning pigment usage in artist paints have been prepared by the American Society for Testing and Materials (ASTM) Subcommitee D01.57 on Artist Paints and Related Materials. The first, D4302, Specification for Artist Oil and Acrylic Emulsion Paints, lists pigments that are suitable for use in first-quality artist paints, along with labeling information for artist paint manufacturers and consumers. The second, D4303, Test Methods for Light Fastness of Pigments Used in Artist Paints, introduces the test methods that were employed to identify the list of pigments designated in D4302.[8]

The second edition of Classification and Chemical Description of the Mixed Metal Oxide Inorganic Colored Pigments, which provides classification and nomenclature for all colored inorganic mixed metal oxides manufactured, imported, and processed in the United States, has been published by the Dry Color Manufacturers' Association. This is the first time that these complex metal oxides known as porcelain enamel oxides, ceramic stains, ceramic colors, etc., have been classified and indexed according to their colors, use categories, crystal class, and metal content. Chemical Abstract Service Registry Numbers from the Toxic Substances Control Act Inventory and "Colour Index" Generic Names and Constitution Numbers published by the Society of Dyers and Colorists and the American Association of Textile Chemists and Colorists have also been included, where available. An appendix of crystal structure diagrams for the 14 crystal classes covered complete this publication.[9]

Volume 4 of the Raw Materials Data Handbook Series compiled by the National Printing Ink Research Institute and sponsored by the National Association of Printing Manufacturers was published in 1983. This 374-page handbook contains information on 253 generic pigments, including 176 organic and 77 inorganic pigments. Data covered include physical data, fastness data, color permanency, and sources of supply.[10]

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[1]Physical scientist, Division of Ferrous Metals.

[2]U.S. Bureau of the Census (Dep. Commerce). Paint, Varnish, and Lacquer. Rep. M28F (monthly), 1983.

[3]American Paint and Coatings Journal. '83 Construction Contracts Up 23%. V. 68, No. 33, Jan. 30, 1984, pp. 9, 12.

[4]Schmidt, L. K. Synthetic Inorganic Pigment Production and Application. Mod. Paint and Coatings, v. 73, No. 4, Apr. 1983, pp. 37-40.

[5]Roskill Information Services Ltd. (London). Roskill's Letter From Japan. Ferric Oxide: 6% Slump in 1982 Demand. RLJ No. 92, Dec. 1983, pp. 17-19.

[6]Touhill, D. M. Iron Oxide Slurries—An Overview. Am. Paint and Coatings J., v. 68, No. 33, Jan. 30, 1984, pp. 37-42.

[7]Millikin, B. L. Color Control in a Pigment Manufacturing Plant. Ceram. Bull., v. 62, No. 12, 1983, pp. 1338-1340.

[8]American Paint and Coatings Journal. ASTM Has New Standards Available for Artists Paints. V. 68, No. 38, Mar. 5, 1984, p. 31.

[9]Dry Color Manufacturers' Association. Classification and Chemical Description of the Mixed Metal Oxide Inorganic Colored Pigments. 2d ed., Jan. 1982, 68 pp.

[10]National Association of Printing Ink Manufacturers. NPIRI Raw Mater. Data Handbook. Volume 4—Pigments. 1983, 374 pp.

Iron and Steel

By Frederick J. Schottman[1]

Steel production and shipments recovered somewhat from the very low levels of 1982. However, production remained at less than 60% of capability. Shipments of steel to consumer goods industries increased but those to many capital goods industries decreased further because of unused capacity or excess inventories in those industries. The steel industry as a whole was unprofitable and some older plants were closed.

Imports from Japan and the European Economic Community (EEC), which have supplied one-half of U.S. imports, declined but the difference was made up by increased imports from other countries, particularly Canada and several developing countries. The U.S. specialty steel industry was granted import protection by extra tariffs and quotas, and other parts of the steel industry sought trade law protection against allegedly unfairly traded imports. The steel industries in most mature industrialized countries suffered from excess capacity. Although some new capacity was being added in developing countries, excess world capacity and international financial problems delayed other projects.

Domestic Data Coverage.—Domestic data for the iron and steel industry are developed by the Bureau of Mines from the

Table 1.—Salient iron and steel statistics

(Thousand short tons unless otherwise specified)

	1979	1980	1981	1982	1983
United States:					
Pig iron:					
Production	86,975	68,699	73,755	43,342	48,770
Shipments	87,781	69,445	74,218	43,449	49,081
Annual average composite price, per ton[1]	$203.00	$203.00	$204.66	$213.00	$213.00
Exports[2]	105	73	16	54	6
Imports for consumption[2]	476	400	468	322	242
Steel:[3]					
Production of raw steel:					
Carbon	116,226	94,689	101,462	64,143	73,783
Stainless	2,107	1,701	1,743	1,235	1,750
All other alloy	18,008	15,445	17,623	9,198	9,082
Total	136,341	111,835	120,828	[4]74,577	84,615
Capability utilization[5] percent	87.2	72.8	78.3	48.4	56.2
Net shipments of steel mill products	100,262	83,853	88,450	61,567	67,584
Finished steel annual average composite price cents per pound[1]	20.006	21.655	24.224	25.271	26.190
Exports of major iron and steel products[2]	3,400	4,729	3,557	2,367	1,589
Imports of major iron and steel products[2]	18,428	16,355	20,818	17,385	17,964
World production:					
Pig iron	[r]586,300	[r]564,800	551,900	[p]502,400	[e]505,000
Raw steel (ingots and castings)	[r]821,091	[r]786,831	776,905	[p]707,081	[e]724,480

[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.

annual Blast Furnace and Steel Furnace Report. Of the 46 steel operations to which a survey request was sent, 91% responded, representing 96% of the total production shown in table 1. Production for nonrespondents was estimated using data from prior year reports and from published information.

Legislation and Government Programs.—The U.S. Department of Transportation issued final regulations under the Surface Transportation Act of 1982 requiring that only domestic steel be used in highway projects built with Federal funds unless the use of imported materials would reduce the overall cost by at least 25%. States could request waivers from the regulations in special cases, but the regulations were expected to effectively ban foreign steel in this use.

The U.S. Supreme Court agreed to consider whether "bubble" plans are permitted for air pollution control in regions where air pollution already exceeds Federal standards. The Environmental Protection Agency (EPA) had approved several such plans but a lower court ruled that the plans are not permitted under the Clean Air Act. 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 of the plant is allowed to choose the most economical means to meet the overall standard, although emissions from some of the individual sources may exceed source standards.

A negotiated agreement apparently cleared the way for bubble plans for steel industry water pollution. A private group had objected to the plans originally proposed, but agreed not to challenge the plans in court if they resulted in an overall 15% reduction in ordinary pollutants and a 10% reduction in toxic pollutants compared with the application of source emissions standards. As originally proposed by EPA and industry, the bubble plans would reduce costs to industry but would result in the same total emissions.

The EPA issued proposed new air pollution standards for new, modified, or rebuilt electric arc furnaces and argon oxygen decarburization (AOD) vessels for steelmaking. The new standards were estimated to reduce emissions by almost one-half compared with those permitted under current regulations. EPA estimated that the strengthened regulations would add 21 cents per short ton of billet to the cost of carbon steel and 37 cents per ton to the cost of specialty steel.[2]

DOMESTIC PRODUCTION

Production and shipments of steel recovered from the very low levels of 1982, but remained below the levels of other recent years. Raw steel production was over 150 million tons in 1973 and over 120 million tons as recently as 1981, compared with less than 85 million tons in 1983. Steel production increased steadily during the first quarter of the year, from 34% of capability in December 1982 to 56% in March 1983, but then plateaued below 60% of capability the rest of the year and averaged only 56.2% of capability for the entire year.

Production continued to shift away from the older open-hearth furnaces, which produced only 7.0% of domestic steel, toward basic oxygen furnaces and electric furnaces, which produced 61.5% and 31.5%, respectively. The use of continuous casting rose to 32.1% of raw steel production.

Total shipments increased by only 10%, compared with those of 1982. Although shipments to most consumer goods industries increased strongly, shipments to some capital goods markets continued to decline. For example, shipments to the automotive and appliance industries rose 30% and 21%, respectively, but shipments to the machinery and rail industries each declined about 10%. Shipments to the oil and gas industry dropped a further 60% as the industry worked off excess stocks.

Domestic shipments of iron castings increased about 12% compared with those of 1982, but shipments of steel castings continued to decline, according to U.S. Department of Commerce data. Shipments included 7.24 million tons of gray iron, 1.99 million tons of ductile iron, 0.29 million tons of malleable iron, and 0.73 million tons of steel castings.

The steel industry continued to suffer heavy financial losses. According to an American Iron and Steel Institute (AISI) survey of companies that produce about 80% of domestic steel, these companies had a steel segment operating loss of $1.9 billion on sales of $27.3 billion. Although shipments of steel increased, the value of sales declined because of lower average prices.

Capital spending by these firms for their steel segments declined again to $1.9 billion from $2.2 billion in 1982 and about $2.4 billion in each of the 3 preceding years.

The steel industry continued to restructure to reduce costs and to adjust their capacity to the demand expected in years ahead. Less economical facilities were closed and mergers were proposed. Major U.S. steel companies negotiated with foreign companies as potential sources of investment capital and as a possible source of semifinished steel to replace higher cost raw steel now produced in domestic plants.

Many steel companies reduced employment costs by eliminating jobs and by reductions in wages, salaries, and other benefits. Most steel companies received concessions from their unionized workers during 1982 or 1983. In March 1983, the United Steelworkers of America and a bargaining group of seven of the largest steel companies agreed on a new 41-month contract that reduced the basic wage rates by $1.25 per hour at the beginning of the contract and reduced paid time off. Cost-of-living allowances were eliminated in the first year of the contract and limited in later years. In return, the companies provided additional funds for laid off workers' benefits. For the whole industry, AISI reported that the average total employment cost per hour worked by an hourly employee declined from $23.78 in 1982 to $22.21 in 1983. Meanwhile, average employment in the steel industry declined from 289,000 in 1982 to 242,700 in 1983, of which 198,500 were hourly employees in 1982 and 168,900 in 1983. Hourly employment had reached a low of 151,000 in November 1982 and had increased in 1983 as production increased.

Republic Steel Corp. and the Jones & Laughlin Steel Corp. (J&L), a subsidiary of LTV Corp., the fourth and third largest domestic steel companies, agr ed to merge. The two companies had a combined raw steel capacity of over 24 million tons per year, about one-sixth of the U.S. total. However, it was expected by industry analysts that if the merger were completed, a significant amount of capacity would be closed. During the year, J&L shut down its Warren, MI, stainless steel plant after it had reopened the melt shop at Midland, PA, that J&L bought from the Crucible Steel Div. of Colt Industries Inc. Republic permanently closed its inactive Buffalo, NY, steel mill.

Late in the year, United States Steel Corp. (USS) announced that it would permanently close about 20% of its raw steel capacity and 23 finishing and fabricating mills by April 1984. Full-capacity employment would be cut by about 15,000. The closures were to include blast furnaces at Fairfield, AL; Gary, IN; Chicago, IL; and the Mon Valley Works near Pittsburgh, PA; and basic oxygen furnace shops at Chicago and the Mon Valley Works. Various rod mills were to be closed and wire and rail were to be eliminated as USS products. A proposed rail mill for the South Works in Chicago was canceled and all other operations there except an electric furnace shop and a structural mill were to be closed.

Earlier in 1983, USS proposed and then dropped a deal with the British Steel Corp. (BSC) for BSC to invest in USS plants and to supply semifinished slabs to USS's Fairless, PA, plant. The proposal aroused strong opposition from labor despite USS's argument that the plant's blast furnaces and open-hearth furnaces were outdated and that the entire plant might be closed unless slabs were bought from outside.

Other companies closed integrated plants during the year. All operations except a rod mill and a galvanizing line at Bethlehem Steel Corp.'s Lackawanna, NY, plant were closed. Kaiser Steel Corp. ended all production operations at its Fontana, CA, plant, but there was outside interest to buy and reopen at least the finishing mills. CF&I Steel Corp. closed the blast furnaces and basic oxygen furnaces at Pueblo, CO. CF&I continued to operate its two electric furnaces but capacity was cut by more than one-half and certain products were discontinued. Armco Inc. began phasing out its 1.5-million-ton-per-year plant at Houston, TX. Armco also planned to consolidate operations at Ashland, KY, and Middletown, OH, and to phase out an open-hearth shop at Middletown and the hot strip mill at Ashland.

The domestic steel industry was greatly increasing its capacity for continuous casting. Wheeling-Pittsburgh Steel Corp. achieved capacity to continuously cast 100% of its raw steel production with a new slab caster at Steubenville, OH, and a bloom caster at Monessen, PA. J&L added 3.1 million tons per year of capacity with two new variable-width slab casters at the Indian Harbor Works, East Chicago, IN. Republic started a 1.8-million-ton-per-year slab caster at Cleveland, OH. USS completed a caster for 500,000 tons per year of rounds for the pipe mill at the Lorain-Cuyahoga (Ohio) Works. Armco's new caster at Ashland was designed to produce 720,000 tons per year of blooms for a pipe mill but modifications to allow casting slabs also were being studied. A horizontal caster for stainless steel was started at Armco's Baltimore, MD, plant. Newly approved or planned casters included two at Inland Steel Co.'s Indiana Harbor plant; one each at USS's Gary, IN, and Fairfield, AL, plants; one at the Dearborn, MI, plant of Rouge Steel Co.; and one each at Bethlehem's Sparrows Point, MD, and Burns Harbor, IN, plants.

Two continuous annealing lines for sheet steel began operations. Inland Steel started a line with a capacity of 400,000 tons per year at Indiana Harbor, IN, and Bethlehem started a similar line with a capacity of 600,000 tons per year at Burns Harbor, IN. Continuous annealing can produce steel with more uniform properties and can produce types of steel that are not practical using batch annealing.

Carpenter Technology Inc. and Armco began production of specialty steel using new rotary forges. Compared with conventional forging, the rotary forges have much higher productivity and produce products with superior dimension control and straightness.

Almost 1 million tons of seamless pipe capacity was added during the year. A new 600,000-ton-per-year plant was opened by USS at its Fairfield, AL, steel mill. J&L completed a renovation of its pipe mill at its Campbell Works, Youngstown, OH. Capacity of the plant was approximately doubled to 660,000 tons per year, while employment was reduced from 1,500 to 1,000. On the other hand, Armco canceled most of its $671 million project to increase pipe capacity because of the poor market since early 1982.

National Steel Corp. planned an electrolytic galvanizing line for sheet up to 72 inches wide at the Great Lakes Steel Div. at Ecorse, MI. It also planned to modify its 48-inch hot-dip galvanizing line at its Midwest Steel Div., Portage, IN, to increase capacity 75,000 tons per year. Galvanized steel was seen as a growing market because of efforts by the automotive industry to increase the corrosion resistance of their products. Newly designed automobiles made extensive use of galvanized steel.

In a corporate reorganization, National Steel Corp. was renamed National Intergroup Inc., emphasizing the diversification of the company outside the steel industry. The steel segment of the company became a subsidiary under the old name, National Steel Corp. The employees of the Weirton Div., Weirton, WV, of National agreed to buy the plant using an employee stock ownership plan (ESOP). National had announced that it would not make further investment at Weirton, implying that the plant would close unless it could be sold. ESOP's are a form of corporate ownership that are given special tax treatment to encourage employee participation. To obtain loans to finance the ESOP, the workers approved a new 6-year contract that reduced labor costs about 20%. The new company, to be called the Weirton Steel Corp., would be the largest employee-owned corporation in the United States and the 10th largest domestic steel company.

Several smaller steel companies entered bankruptcy during the year. Korf Industries Inc. was forced to sell its assets after its parent company in the Federal Republic of Germany went bankrupt. Korf's Georgetown Texas Steel Corp. subsidiary minimill in Beaumont, TX, was sold to Cargill Inc. which merged it into its North Star Steel Co. Korf's Midrex Corp., developer of one of the most successful direct-reduced iron (DRI) processes, was sold to Kobe Steel Ltd. of Japan. Korf retained its other minimill, Georgetown Steel Corp., Georgetown, SC, and other subsidiaries. However, a group of Kuwaiti investors that had held 30% interest in Korf increased their interest to 51%. The reorganized company was then renamed Georgetown Industries Inc.

Phoenix Steel Corp. filed for Chapter 11 bankruptcy after Creusot Loire S.A. of France, which owned 56% of Phoenix, declined to provide additional financial support. Phoenix produced plate and pipe, two products for which markets were particularly depressed and slow to recover.

Guterl Special Steel Corp., Lockport, NY, was forced into bankruptcy, and late in the year a court ordered the sale of the firm's assets to satisfy its debts. Marion Steel Co., Marion, OH, also filed for Chapter 11 bankruptcy. The plant was formerly owned by Armco and had reopened as an independent company in 1982. Two other minimills were sold. The Connors Steel Co. plant in Birmingham, AL, was closed by its parent, H. K. Porter Co. Inc., and then purchased by Commercial Metals Co. and reopened as SMI Inc. The Thomas Steel Corp. purchased the Lemont Manufacturing Co. minimill, Lemont, IL, from Ceso Corp.

Rhode Island Forging Steel Inc. reopened the former Washburn Wire Co., Providence, RI, to produce specialized ingots for forging. The company intended to provide types and sizes of ingots unavailable from larger producers. Similarly, McDonald Steel Corp., Youngstown, OH, was producing nonstandard section bars in a former USS plant. The company had started one bar mill in 1981 and reactivated a second in 1983.

Ohio River Steel Corp. opened a 400,000-ton-per-year structural mill in Calvert City, KY. Hunt Steel Corp. started its new pipe mill installed at the old Briar Hill Works of Youngstown Sheet and Tube near Youngstown, OH. The plant can produce 360,000 tons per year of seamless oil country casing.

Preliminary work was begun on a 250,000-ton-per-year seamless tube mill being built in Little Rock, AR, by York-Hanover Seamless Tube Inc., with production planned in 1986. The owners of Tubular Corp. of America were also planning a 250,000- to 300,000-ton-per-year seamless pipe mill for either Tennessee or Arkansas.

Materials Used in Ironmaking.—Domestic pellets charged to blast furnaces in 1983 totaled 49.0 million tons, and sinter charged amounted to 18.2 million tons. Pellets and other agglomerates from foreign sources amounted to 6.4 million tons. A total of 10.8 million tons of iron ore was consumed by agglomerating plants at or near blast furnaces in producing 17.8 million tons of agglomerates. Other materials consumed by agglomerating plants were 2.4 million tons of mill scale, 0.9 million tons of flue dust, 0.8 million tons of coke breeze, 7,000 tons of anthracite, and 4.1 million tons of fluxes.

Blast-furnace oxygen consumption totaled 16.2 billion cubic feet according to AISI. Blast furnaces, through tuyere injection, consumed 14.3 billion cubic feet of natural gas; 3.5 billion cubic feet of coke oven gas; 101 million gallons of oil; 41.1 million gallons of tar, pitch, and miscellaneous fuels; and 121,000 tons of bituminous coal.

Materials Used in Steelmaking.—According to AISI, steelmaking furnaces consumed 0.19 million tons of fluorspar, 0.70 million tons of limestone, 4.33 million tons of lime, 0.66 million tons of other fluxes, and 118 billion cubic feet of oxygen. Metalliferrous materials consumed in domestic steel furnaces, per ton of raw steel produced, averaged 1,142 pounds of pig iron, 1,070 pounds of scrap, 25 pounds of ferroalloys, and 6 pounds of ore and agglomerates. The revised figures for 1982 were 1,137 pounds of pig iron, 1,083 pounds of scrap, 25 pounds of ferroalloys, and 5 pounds of ore and agglomerates.

PRICES

The annual average composite price for finished steel in 1983, as reported by Iron Age, was 26.190 cents per pound. This price was 3.6% higher than that of 1982, the smallest increase since 1973. The composite price increased from 25.297 cents per pound at yearend 1982 to 26.822 cents per pound at yearend 1983. The composite price for pig iron remained unchanged at $213 per short ton.

Most steel continued to be sold at discounts from list prices because of continued weak demand and the availability of low-priced imported steel. Earlier in the year, discounts of 20% were common, and discounts up to 40% off list for certain products were reported.

Prices for sheet and strip strengthened during the year because of improved demand by consumer goods producers. List prices were raised about 6% in February and by about 7% in September, and discounts decreased. Galvanized steel was in relatively strong demand and list prices were increased by over 15%. Iron Age listed yearend prices for hot-rolled sheet and strip at 23.75 cents per pound, cold-rolled sheet at 28.15 cents per pound, and galvanized sheet at 30.30 cents per pound.

Demand for structural shapes and plates did not improve as much as that for sheet and strip, and prices for these steel products remained depressed. Most list prices for structurals remained unchanged during the year and one major producer reduced list prices about 5% to bring list prices closer in line with transaction prices. New production of medium-weight sections by some minimills put additional pressure on the major integrated mills to restrain prices on these products. Yearend prices for structural shapes and plates were 23.90 and 25.75 cents per pound, respectively.

List prices for minimill products such as reinforcing bars, merchant bars, and light shapes generally reflected true transaction prices. Prices for most of these products were increased several times during the year by small steps (0.5 to 1.0 cent per pound) as demand improved and the minimills' cost for scrap increased. However, there were exceptions as producers responded to competition from imports or other producers in local markets. Some reinforcing bars reportedly sold for less than 10 cents per pound with prices about 11 cents per pound common in the second half of the year. Merchant bars were priced at about 13 to 14 cents per pound.

FOREIGN TRADE

Exports of major iron and steel products from the United States continued to decline because of generally weak foreign markets, strong competition from foreign producers, and a strong U.S. dollar. As in earlier years, Canada and Mexico were the most important importers of U.S. steel. However, exports to Mexico and to other Latin American countries decreased by more than one-half. Saudi Arabia, Pakistan, Egypt, Taiwan, the Republic of Korea, and Italy were other important markets for U.S. steel.

Total imports of major iron and steel products increased slightly compared with those of 1982, but they represented a somewhat smaller share of the U.S. market. Steel continued to be available in the world market at depressed prices and the high value of the U.S. dollar for foreign exchange made imported steel attractive to U.S. consumers. Imports of pipe and tube were down significantly because of excess stocks of oil-country tubular goods on the market but imports of sheet increased, reflecting improved consumption in consumer goods industries.

Although imports of steel mill products from Japan and the EEC decreased, total imports increased. Imports of most steel products from the EEC were restricted by a trade agreement signed in late 1982. Imports from Japan declined from 5.2 million tons in 1982 to 4.2 million tons. Those from the EEC declined from 5.6 million tons to 4.1 million tons. Among the EEC countries, the Federal Republic of Germany, France, and Belgium-Luxembourg supplied 1.4 million tons, 0.9 million tons, and 0.6 million tons, respectively. Imports of steel mill products increased from Canada and from several newly industrialized countries. Imports from Canada and the Republic of Korea rose to 2.4 million tons and 1.7 million tons, respectively. Imports from Brazil doubled to 1.3 million tons and those from Mexico increased by a factor of 5 to 0.7 million tons. Brazil and Mexico, as well as other less developed countries, needed to export to pay their foreign debts, and currency devaluations effectively reduced the price of their products.

The domestic steel industry continued to request relief from allegedly unfairly traded steel using antidumping and countervailing duty cases. While Japan was reducing its exports and most exports from the EEC were restrained by the 1982 agreement, cases were pursued against other countries including Argentina, Brazil, the Republic of Korea, Mexico, the Republic of South Africa, Spain, and Trinidad and Tobago.

Relations with the EEC continued to be strained by steel trade issues. One U.S. company that was not a party to the 1982 agreement filed an antidumping case against steel plate from the EEC countries. U.S. producers were also concerned about imports of semifinished ingots and slabs and of pipes and tubes, products that were not controlled by the 1982 agreement, and diplomatic discussions were held with the EEC.

The U.S. Trade Representative declined to initiate an investigation based on a section 301 petition against Japan and the EEC. The petition alledged that trade agreements between Japan and the EEC had caused steel to be diverted to the U.S. market. Although there was evidence that Japan had agreed to limit its exports of steel to the EEC, the petition did not show that the agreement had injured the U.S. industry.

As the result of a section 201 investigation, restrictions were imposed in July on imports of various specialty steels. The restrictions were to last 4 years. They included a tariff (in addition to normal duties) of 10% ad valorem in the first year decreasing to 4% in the fourth year on stainless steel sheet and strip. A similar tariff beginning at 8% and staged down to 4% was applied to imports of stainless steel plates. Global quotas were set on imports of alloy tool steel and stainless steel bars and rods, with the quotas set to increase 3% per year.

In 1982, imports had supplied 30% to 50% of apparent consumption of the products covered by quotas. The quotas were set as much as 44% below 1982 import levels. Although the quotas were initially set on a worldwide basis, the United States offered to negotiate orderly marketing agreements (OMA's) with individual countries to give such countries specific quotas. Such OMA's were reached with Japan, Canada, Poland, Argentina, Spain, and Sweden. On the other hand, the EEC countries asked for compensation from the United States for their lost trade caused by the restrictions. Although trade restraints such as those under section 201 are permitted under the General Agreement on Tariffs and Trade, other countries affected by the restraints are entitled to compensation or are allowed to retaliate.

WORLD REVIEW

After 3 years of decline, world production of raw steel recovered slightly in 1983. However, much of the recovery was in Canada and the United States. Production declined in many European countries and Japan. Free market prices remained low and most steel producers operated at a financial loss. Governments increased their intervention in markets and their investments in steel companies in order to preserve employment. Capacity in most industrialized countries was reduced while some projects adding new capacity in developing countries continued. However, the weak market and the already heavy international debts of some countries caused other projects to be delayed.

Australia.—The Government of Australia announced a program to assist the Australian steel industry. The program was contingent on cooperation from the steel industry by investment in modernization and from labor by improved productivity. Beginning January 1984, and continuing for 5 years, the Government would pay a bounty to Australian steel companies on the sale of certain products. The bounty could be as high as 20% of the sale price if sales were very weak, but would decrease to zero if sales were very strong. The Government would also consider tariff quotas on imports if imports exceeded 20% of the market. The new program was at the request of The Broken Hill Pty. Co. Ltd. (BHP). Until 1983, BHP, including its subsidiaries, was the only steelmaker in Australia. However, one minimill began operations in 1983 and a second was expected to be built using equipment from an unused plant in France.

Belgium.—State-controlled Cockerill-Sambre S.A. (CS) was planning to reduce its capacity by 1.5 million tons per year down to about 5.5 million tons in 1985. Two oxygen furnace shops at Liège and Charleroi and various other operations were to be closed. Employment would be reduced by about 8,000 from the current 22,000. The Belgian Government in 1983 negotiated to integrate the operations of CS with ARBED SA of Luxembourg and Hoogovens IJmuiden BV of the Netherlands. Although an actual merger of the companies was unlikely, they may cooperate in trading off production quotas and in coordinating plant closings.

Brazil.—Production began at the new Cia. Siderúrgica de Tubarão plant in Vitória City. The plant has a single 160,000-cubic-foot blast furnace and two 310-ton oxygen furnaces and has a capacity of 3.7 million tons per year of raw steel and 3.3 million tons per year of slabs. The slabs are to be sent to other Brazilian mills and to be exported for finishing. Tubarão is owned by the Brazilian state steel company Siderúrgia Brasileira S.A. (51%), Kawasaki Steel Corp. (24.5%), and Societá Finanziaria Siderurgica p.A. (Finsider) of Italy (24.5%).

The new 700,000-ton-per-year electric furnace steel mill being built by Siderúrgica Mendes Junior S.A. was nearing completion and was expected to start production in early 1984.

Canada.—Two new hot-strip mills, each with a capacity of about 1 million tons per year, began operating in 1983. Stelco Inc. started its $250 million, 80-inch strip mill at the greenfield Lake Erie plant at Nanticoke, Ontario, and Dofasco Inc. completed a $360 million mill at its Hamilton, Ontario, plant. The Algoma Steel Corp. Ltd. suspended construction on a new $240 million seamless tube mill until the market improves. Algoma's tube division was reported operating at about one-half of capacity. Sydney Steel Corp. received $77 million in Provincial and Federal aid to modernize its plant at Sydney, Nova Scotia. However, only one of the plant's two blast furnaces will be rebuilt. As a result, the plant's capacity will be cut by one-half to 500,000 tons per year.

China.—Production of steel began at the the Baoshan steel mill near Shanghai. The first phase of the project will have a capacity of 3.3 million tons of raw steel per year and was expected to be in full operation in 1985. Work will also proceed with the second phase of the plant, which will double its capacity. The Baoshan project has been subject to many delays. The first phase was originally intended to start up in 1982 and in 1981 the second phase was suspended indefinitely.

Egypt.—Contracts were being negotiated for equipment for the new Alexandria National Steel Co. steelworks at El Dikheila. The plant will use a DRI plant and electric furnaces to produce 930,000 tons per year of raw steel for bars and rod. Completion is planned for 1986. Nile Steel Co. in 1983 received Government approval for a 490,000-ton-per-year minimill near Cairo. The plant will use imported scrap and is scheduled to begin operation in 1985.

European Economic Community.—Under a 1981 agreement, the EEC Commission directed EEC member countries to reduce their combined raw steel capacity by 30.4 million tons per year by 1985, a 16% reduction from the 1980 capacity of 186 million tons per year. The EEC countries had agreed in 1982 to reduce steel capacity, but national plans submitted to the Commission in June 1983 proposed cuts totaling only 20.4 million tons per year. The EEC ordered reductions of 6.6 million for the Federal Republic of Germany, 6.5 million for Italy, 5.0 million for the United Kingdom, 3.5 million for Belgium, 2.59 million for France, 1.1 million for the Netherlands, 1.1 million for Luxembourg, and 0.1 million for Denmark. The cuts ranged from 7% of 1980 capacity for Denmark to almost 20% for France and the United Kingdom. No cuts were ordered for Greece and Ireland, which have very small steel industries. The intent of the cuts was to make the EEC steel industry profitable by eliminating excess capacity and to eliminate state subsidies by the end of 1985.

The EEC was to strengthen its controls, beginning January 1984, on the EEC steel market by imposing minimum prices on products that make up about 40% of EEC production. At the insistence of the Federal Republic of Germany, the EEC was to impose a system requiring documents showing the origin of steel shipments. The Federal Republic of Germany had complained that its industry was threatened by subsidized steel from other member countries. The EEC in 1983 continued other market controls including production quotas, import agreements with nonmember countries, and pricing regulations.

Independent steel companies, usually small electric furnace steel mills, complained that the EEC regulations did not allow them to operate at profitable levels despite their lower costs compared with those of the state subsidized companies.

France.—The two major state-owned steel groups, Union Sidérurgique du Nord et de l'Est de la France and Aciéries et Laminoirs de Lorraine-SACILOR, further consolidated their ownership of the French steel industry. Privately owned Creusot Loire was near bankruptcy and sold almost all of its steelmaking plants to the two state groups.

A 1982 plan, which projected 1986 production of 26 million tons of steel and called for layoffs of 12,000 steelworkers, was reportedly viewed as unrealistic, and an additional 10,000 layoffs were expected.

Germany, Federal Republic of.—German steel companies planned restructuring programs to reduce capacity. A report commissioned by the industry recommended that the five largest steel companies be merged into two. However, merger negotiations between the companies were unsuccessful. Individual companies did announce major cutbacks. Thyssen Stahl AG, the largest German steelmaker, will cut its capacity by 30% to about 12 million tons per year. The German Government received approval from the EEC to provide up to $14 billion in financial assistance for restructuring but intended to provide about $1.2 billion for costs resulting from layoffs and for grants for capital investments to improve efficiency.

Korf Industries & Handel GmbH and some of its subsidiaries were forced into bankruptcy. The two Korf minimills, Badische Stahlwerke AG and Hamburger Stahlwerke GmbH were reorganized as independent companies.

India.—Construction and modernization projects of the Steel Authority of India Ltd. (SAIL) were reportedly delayed by a reduction in funds available for investment after SAIL lost $100 million in fiscal year 1982-83. Two 330-ton oxygen furnaces were commissioned at Bokaro raising capacity there to 4.4 million tons per year, but that expansion program was behind schedule. The three planned integrated steelworks at Visakhapatnam, Vijayanagar, and Daitari were expected to be delayed because of lack of funds.

Orissa Sponge Iron Ltd. began operation of its gas- and coal-fueled, 170,000-ton-per-year, Accar process DRI plant in Orissa. Meanwhile, the Government suggested that a network of DRI plants be built to supply India's electric furnace minimills with iron.

Italy.—State-owned Finsider planned to reduce employment by one-fourth in its plans to meet EEC required cuts in capacity. Blast furnaces, oxygen furnaces, and the hot-strip mill at Cornigliano were to be closed for a reduction in capacity of 2 million tons per year. The company was seeking higher production quotas from the EEC to allow the reopening of the newly renovated integrated steel mill at Bagnoli. Meanwhile, the Government offered financial incentives to the private sector to reduce their capacity. A group of private steel mills proposed a syndicate to operate one blast furnace, oxygen furnaces, and a continuous caster at Cornigliano to produce semifinished steel for their rolling mills. The companies would close their own melt shops.

Japan.—Steel production in Japan declined for the fourth year in a row. Capital investment by the six largest steel companies declined about 4% in fiscal year 1983 and planned investment in fiscal year 1984 was to be reduced a further 30%. Investment was being reduced in part because of the completion of several major projects, but also because of restructuring for lower demand. Most investment was in modernization or replacement capacity; however, new capacity was added for products such as galvanized steel that had growing markets. Nippon Steel Corp. and Nippon Kokan K.K. completed new seamless tube mills. These projects had begun when seamless tube was in short supply but were completed during a period of deeply depressed demand.

Korea, Republic of.—Pohang Iron and Steel Co. Ltd. (Posco) negotiated with equipment suppliers and contractors for contracts for a second integrated steel mill to be built at Kwang Yang. The first stage of the new Posco mill is planned to have a capacity of 2.7 million tons per year and is to be completed in 1988. Meanwhile, the Posco steel mill at Pohang was one of the world's lowest cost producers and operated near capacity despite the world steel recession.

Luxembourg.—The Government of Luxembourg became the largest shareholder in ARBED when it increased its holdings from about 2% to about 22% of the company's stock. ARBED is the major steel producer in Luxembourg and employs over 10% of Luxembourg's work force.

Mexico.—Production of seamless tube began at Tubos de Acero de México S.A. at Veracruz. The tube mill had an initial capacity of 290,000 tons per year but is intended to be expanded to over 700,000 tons per year. A new melt shop and a second DRI plant were under construction at the site. Although seamless tube from the plant was intended primarily for the Mexican petroleum industry; it was also exported to the United States and other countries.

Pakistan.—The first phase of the state-owned Bin Qasim integrated steel mill was expected to be completed in 1984. A blast furnace began production of pig iron in 1982 and steel production began in 1983. The initial phase has a capacity of 1.2 million tons per year, but the plant was designed to be expanded to 2.2 million tons per year. Private companies proposed a spiral weld pipe mill and a seamless pipe mill that would use the newly available domestically produced steel.

Philippines.—Contracts were signed for equipment for the new integrated Iligan City steelworks of the National Steel Corp. of the Philippines, but the project was threatened by lack of funds. Much of the estimated $1.5 billion needed for the project depended on loans from countries supplying equipment and from international financial organizations. The DRI-based plant had a planned capacity of 1.5 million tons per year.

South Africa, Republic of.—Iron production capacity in the Republic of South Africa was being shifted to DRI processes. Scaw Metals Ltd. started production at its new 80,000-ton-per-year, coal-fueled DRI plant. Work was continuing on a 330,000-ton-per-year plasma DRI plant for Union Steel Corp. with completion expected in 1985. The commissioning of new raw steel capacity at Highveld Steel and Vanadium Corp. Ltd. including three additional prereduction kilns and another electric smelting furnace, was delayed because of low demand. Meanwhile, the largest steel producer, South African Iron and Steel Industrial Corp. Ltd., reduced its capacity by 15% to about 7 million tons per year and planned to phase out a number of blast furnaces, obsolete steel furnaces, and other facilities as its new DRI units and electric furnace come on-stream.

Spain.—The Government announced a restructuring plan for the steel industry that included the elimination of 9,000 to 10,000 jobs and blast furnaces and steel furnaces of Altos Hornos del Mediterraneo S.A. at Sagunto. However, the plan also provided $4 billion in financial aid from the Government for restructuring and modernization.

Sweden.—The four largest stainless steel producers negotiated to consolidate into two groups, but had not completed the mergers by yearend. The plan would merge Fagersta AB, Nyby Uddeholm AB, Sandvik AB, and Avesta Jernverks AB into one group making raw stainless steel and plate and a second making coils, pipe, and tube. Completion of the merger was delayed by lack of final agreement on financial arrangements in the complex mergers.

Taiwan.—China Steel Corp. planned to go ahead in 1984 with construction of the third-stage expansion of its integrated steel plant. The expansion is expected to require 4 years and will increase capacity by 70% to 6.3 million tons per year.

U.S.S.R.—The first of four Midrex DRI units at the Oskol Electro-Metallurgical Combine began operations, and work continued on an electric furnace melt shop. The plant will have an initial capacity of 1.8 million tons per year of DRI and is planned to be expanded to 3.6 million tons in 1987. A new 2.4-million-ton-per-year oxygen furnace shop was completed at Dneprodzerzhinsk to replace open-hearth and Bessemer furnaces. Major renovations and expansion programs continued at the Magnitogorsk and Kuznetsk plants.

United Kingdom.—BSC continued to operate at a loss and some facilities were closed. The company and Government considered closing entirely one of the BSC's five integrated steel mills. Programs continued in the specialty steel sector and in the steel casting industry to reduce excess capacity. In specialty steel, BSC and private companies formed a joint venture to buy another plant with the expectation of closing it. A program in the steel foundry industry used money from the Government and private industry to provide financial incentives for other foundries to close.

Venezuela.—The first phase of the Empresa Siderúrgica de Zulia C.A., also known as Siderzulia, coal and steel project was postponed because of Venezuela's already heavy international debt and weak demand for steel. The first stage was to include a 530,000-ton-per-year rolling mill using semifinished steel from other Venezuelan plants.

TECHNOLOGY

Various Government agencies and the AISI are proceeding with a joint program to develop new types of sensors for the steel industry. Program goals include development of systems that can provide almost instantaneous chemical analyses of molten steel in a ladle or furnace, that provide three-dimension location of internal defects, that measure the internal temperatures of solid and solidifying steel, and that can inspect for surface defects during hot-rolling operations. If successful, the new sensors will improve quality control, increase productivity, and increase efficiency.[3]

Techniques to cast thin strip and sheet were under development. In contrast to conventional continuously cast slab, which is several inches thick, the product of the new processes would be much closer to the thickness of the finished product, and therefore would require less reduction during rolling. The U.S. Department of Energy was supporting four programs to cast strip about 0.05 inch thick, and a similar program was being carried out by private companies.[4] Thin slab casters were reported to be operating on an experimental basis that could produce slab as thin as 1-1/2 inches.[5]

Two rotary wheel-and-belt casting machines were in use in Japan. The machine is claimed to lower operating costs and the relatively high casting speed and a high billet temperature make the new caster better suited than a conventional casting machine to feed billet directly into a rolling mill. Such direct rolling could reduce energy consumption and increase yield of finished steel.[6]

High-quality heavy plates weighing between 20 and 110 tons can be produced using horizontal insulated molds that cause the ingot to solidify gradually from the bottom to the top. Inclusion and other defects accumulate near the top where they can be removed leaving a clean ingot suitable for critical applications such as pressure vessels or offshore platforms.[7]

Hot metal from the blast furnace was being treated to reduce the phosphorus and silicon content before refining in the oxgyen furnace. Like external desulfurization, which had become a well-established practice, external dephosphorization and desiliconization allowed the production of high-quality steel while improving the efficiency of steelmaking in the oxygen furnace.[8]

New variations of and applications for oxgyen steelmaking processes were developed. A top-and-bottom blown converter and top-blown, bottom-stirred converters were used to produce stainless steel.[9] Advantages of the AOD for carbon and low-alloy steels were reported.[10] The AOD process was modified to use air to replace part of the commercial nitrogen and oxygen normally used, resulting in lower raw materials cost.[11]

Several new electric-furnace technologies offer savings on electrode costs compared with conventional electric furnaces. The oxidation of electrodes in conventional furnaces can be reduced by protective coatings.[12] Direct current (dc) electric furnaces with conductive bottom refractories require only a single exposed electrode and lower electrode costs. Other advantages claimed for the dc furnaces include lower noise, and lower flicker loads on powerlines.[13] Commercial-scale tests were conducted with a 50-ton furnace using plasma torches rather than conventional electrodes. Wear of the tungsten electrodes in the plasma torches was reported to be minimal, and total cost for the torches was less than the cost of conventional carbon electrodes. The process reportedly results in higher yield from the metal charged; reduced noise, dust, and exhaust gas; and lower powerline flicker.[14]

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[1]Physical scientist, Division of Ferrous Metals.

[2]Federal Register. U.S. Environmental Protection Agency. Revision of Standards of Performance for New Stationary Sources; Steel Plants; Electric Arc Furnaces and Argon-Oxygen Decarburization Vessels. V. 48, No. 160, Aug. 17, 1983, pp. 37338-37357.

[3]McManus, G. J. Sensors in Steel: Where a Picture is Worth More Than a Thousand Words. Iron Age, v. 226, No. 13, May 2, 1983, pp. MP-16-MP-23.

[4]———. Can Sheet Be Continuously Cast? Iron Age, v. 226, No. 19, July 4, 1983, p. MP-20.

LaRue, G. T. National, Batelle Study Direct-Cast Strip. Am. Met. Mark., v. 91, No. 131, July 7, 1983, p. 4.

[5]———. Mannesmann Creating System for Making Slab in Mini-Mills. Am. Met. Mark., v. 91, No. 185, Sept. 22, 1983, p. 4.

[6]Iron & Steelmaker. A Rotary Continuous Casting Machine is Now Available From Korf Engineering. V. 10, No. 8, Aug. 1983, p. 11.

[7]Metal Bulletin (London). NKK's Ultra Heavy Plate. No. 6844, Dec. 6, 1983, p. 42.

33 Metal Producing. The Latest Wrinkle in Heavy Plate Production. V. 21, No. 10, Oct. 1983, p. 73.

[8]Sasaki, K., H. Nakashima, M. Nose, Y. Takasaki, and H. Okumura. A Look at Nippon Steel Corp.'s New Optimizing Refining Process. Iron & Steelmaker, v. 10, No. 8, Aug. 1983, pp. 22-27.

[9]Kawaharada, A., S. Ogura, R. Asaho, M. Saigusa, and Y. Kato. New Process for Making Stainless Steel. Paper in Electric Furnace Proc., v. 41 (Detroit, MI, Dec. 6-9, 1983). Iron and Steel Soc. AIME, Warrendale, PA, 1984, pp. 51-56.

McManus, G. J. Allegheny Ludlum and Kawasaki Go Back to Basics in Making Stainless Steel. Iron Age, v. 226, No. 29, Dec. 5, 1983, pp. MP-19-MP-21.

[10]Selines, R. J., and S. K. Mehlman. AOD Refining for Wrought Carbon and Low Alloy Steels. Iron & Steelmaker, v. 10, No. 4, Apr. 1983, pp. 20-25.

[11]Shidemantle, D. R., and V. P. Ardito. Using Air as a Substitute for Nitrogen in the AOD. Paper in Electric Furnace Proc., v. 41 (Detroit, MI, Dec. 6-9, 1983). Iron and Steel Soc. AIME, Warrendale, PA, 1984, pp. 57-60.

[12]Kaltenhauser, R. H., and F. M. Gimbel. Coated Electrodes to Reduce Graphite Consumption. Iron & Steelmaker, v. 11, No. 5, May 1984, pp. 29-33.

[13]Essman, H., and D. Grunberg. Technical and Economical Aspects Regarding the Practical Application of a D.C. Electric Arc Furnace. Paper in Electric Furnace Proc., v. 41 (Detroit, MI, Dec. 6-9, 1983). Iron and Steel Soc. AIME, Warrendale, PA, 1984, pp. 229-237.

[14]Metal Bulletin Monthly. Voest-Alpine's Plasma Plant. No. 150, June 1983, pp. 45-49.

Table 2.—Pig iron produced and shipped in the United States in 1983, 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	2,743	2,754	$512,072	$185.94
Indiana	16,385	16,393	3,275,278	199.80
Michigan	4,443	4,444	849,581	191.17
Ohio	9,291	9,314	2,031,149	218.07
Pennsylvania	6,962	7,110	1,492,330	209.89
California, Texas, Utah	1,634	1,702	360,045	211.54
Alabama, Kentucky, Maryland, New York, West Virginia	7,312	7,364	1,550,488	210.55
Total or average	48,770	49,081	10,070,943	205.19

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	1982[1]	1983[2]
Brazil	197	12
Canada	1,876	2,185
Venezuela	1,171	1,157
Other countries	59	99
Total	[3]3,302	3,453

[1]Excludes 7,931,305 tons used in making agglomerates.
[2]Excludes 8,862,921 tons used in making agglomerates.
[3]Data do not add to total shown because of independent rounding.

Table 4.—Pig iron shipped from blast furnaces in the United States, by grade[1]

Grade	1982			1983		
	Quantity (thousand short tons)	Value		Quantity (thousand short tons)	Value	
		Total (thousands)	Average per ton		Total (thousands)	Average per ton
Foundry	195	$39,839	$204.30	123	$25,969	$211.13
Basic	42,184	8,799,327	208.59	47,915	9,835,227	205.26
Bessemer	572	105,288	184.07	W	W	W
Low phosphorus	W	W	W	W	W	W
Malleable	368	80,700	219.29	W	W	W
All other (not ferroalloys)	130	25,683	197.56	1,043	209,747	201.10
Total or average	43,449	9,050,837	208.31	49,081	10,070,943	205.19

W Withheld to avoid disclosing company proprietary data; included with "All other."
[1]Includes molten iron transferred directly to steel furnaces.

Table 5.—Iron ore and other metalliferous materials, coke, and fluxes consumed in blast furnaces, and pig iron produced in the United States, by State

(Thousand short tons unless otherwise specified)

State	Metalliferous materials consumed in blast furnaces: Iron and manganiferous ores: Domestic	Iron and manganiferous ores: Foreign	Agglomerates	Net ores and agglomerates[1]	Net scrap[2]	Miscellaneous[3]	Net total[4]	Net coke	Fluxes	Pig iron produced	Metalliferous materials consumed per ton of pig iron made (short tons): Net ores and agglomerates[1]	Net scrap[2]	Miscellaneous[3]	Net total[4]	Coke and fluxes consumed per ton of pig iron (short tons): Net coke	Fluxes
1982:																
Alabama	--	W	W	1,516	1	30	1,545	624	122	940	1.613	0.001	0.032	1.644	0.664	0.130
Illinois	W	--	W	3,871	900	112	4,884	1,472	302	2,264	1.710	.398	.049	2.157	.650	.133
Indiana and Michigan	71	29	27,946	27,649	1,086	501	29,235	9,254	686	17,669	1.566	.061	.028	1.655	.524	.039
New York	W	W	W	1,600	45	1	1,646	577	25	1,005	1.592	.045	.001	1.638	.574	.025
Ohio	66	1,628	11,614	13,182	321	814	14,318	4,206	726	7,870	1.675	.041	.103	1.819	.534	.092
Pennsylvania	323	974	7,414	8,610	235	221	9,065	3,083	612	5,448	1.580	.043	.041	1.664	.566	.112
California, Colorado, Utah	1,000	8	2,298	3,269	150	56	3,475	960	297	1,962	1.666	.076	.029	1.771	.489	.151
Kentucky, Maryland, Texas, West Virginia	--	139	9,763	9,738	144	65	9,947	3,114	190	6,184	1.575	.023	.011	1.609	.504	.031
Total[4] or average	1,655	3,302	65,363	69,435	2,882	1,800	74,117	23,290	[5]2,960	43,342	1.602	.066	.042	1.710	.537	.068
1983:																
Illinois	--	--	4,325	4,316	353	123	4,791	1,598	421	2,743	1.573	.129	.045	1.747	.583	.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	[6]2,982	48,770	1.583	.061	.034	1.678	.530	.061

W Withheld to avoid disclosing company proprietary data; included in "Total or average."

[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: 1,340 limestone, 46 burnt lime, 1,553 dolomite, and 122 other fluxes, excluding 1,908 limestone, 21 burnt lime, 1,979 dolomite, and 27 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: 1,362 limestone, 143 tons burnt lime, 1,436 dolomite, and 183 other fluxes, excluding 2,175 limestone, 15 burnt lime, 1,869 dolomite, and 21 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	1982			1983		
	In blast[1]	Out of blast	Total	In blast[1]	Out of blast	Total
Alabama	1	5	6	1	5	6
California	1	3	4	2	2	4
Colorado	--	4	4	--	--	--
Illinois	2	6	8	4	1	5
Indiana	8	14	22	11	7	18
Kentucky	1	1	2	2	--	2
Maryland	1	3	4	1	3	4
Michigan	5	4	9	6	3	9
New York	1	8	9	1	3	4
Ohio	11	10	21	12	6	18
Pennsylvania	7	33	40	9	12	21
Texas	1	1	2	--	2	2
Utah	1	2	3	1	2	3
West Virginia	2	2	4	2	2	4
Total	42	96	138	52	48	100

[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
1979	19,158	83,256	33,927	136,341
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

[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			
1979	73	409	146	74	81,948	1,978	71,715
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	[r]42,395	947	40,379
1983	9	96	75	33	48,300	1,063	45,280

[r]Revised.
[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	1981		1982		1983	
	Thousand short tons	Percent of total	Thousand short tons	Percent of total	Thousand short tons	Percent of total
Basic oxygen converter	62,162	82.8	38,553	86.8	44,330	88.5
Open-hearth	8,867	11.8	3,635	8.2	3,918	7.8
Electric	583	.8	496	1.1	341	.7
Cupola	685	.9	481	1.1	425	.8
Air and other furnaces[1]	254	.3	141	.3	91	.2
Direct castings[2]	2,489	3.3	1,102	2.5	965	1.9
Total[3]	75,040	100.0	44,409	100.0	50,070	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	1982	1983
Arkansas	1	1
Connecticut	6	5
Georgia	2	1
Illinois	2,751	3,285
Indiana	13,600	16,507
Iowa	25	27
Kansas	5	3
Maine	(2)	(2)
Massachusetts	14	13
Michigan	4,212	4,535
Minnesota	18	20
Missouri	6	5
New Jersey	3	2
New York	1,003	886
Ohio	8,142	9,528
Oklahoma	10	10
Pennsylvania	5,537	7,077
Texas	747	65
Virginia	13	16
Wisconsin	50	41
Undistributed[3]	8,261	8,043
Total	[4]44,409	50,070

[1]Includes molten pig iron used for ingot molds and direct castings.
[2]Less than 1/2 unit.
[3]Includes Alabama, California, Colorado, Florida, Kentucky, Maryland, New Hampshire, North Carolina, Oregon, Rhode Island, South Carolina, Tennessee, Utah, Washington, and West Virginia.
[4]Data do not add to total shown because of independent rounding.

Table 11.—U.S. exports of major iron and steel products

Product	1981 Quantity (short tons)	1981 Value (thousands)	1982 Quantity (short tons)	1982 Value (thousands)	1983 Quantity (short tons)	1983 Value (thousands)
Steel mill products:						
Ingots, blooms, billets, slabs, sheet bars	540,600	$154,511	362,299	$82,066	102,756	$27,638
Wire rods	102,688	44,878	25,150	13,374	6,346	7,246
Structural shapes, 3 inches and over	131,384	80,328	56,399	36,992	47,024	30,478
Structural shapes, under 3 inches	16,176	16,065	9,580	11,761	21,801	36,047
Sheet piling	7,607	9,654	5,623	3,406	2,097	11,527
Plates	199,536	126,794	121,930	89,111	101,982	61,875
Rails and track accessories	78,325	51,696	36,490	25,256	18,516	15,833
Wheels and axles	7,390	24,785	2,711	11,501	1,558	9,040
Concrete reinforcing bars	137,317	41,927	114,740	29,705	34,528	9,340
Bars, carbon, hot-rolled	91,041	48,587	31,014	18,083	36,592	17,759
Bars, alloy, hot-rolled	58,518	57,793	48,262	41,303	53,992	41,626
Bars, cold-finished	28,724	36,498	17,400	25,471	21,567	24,954
Hollow drill steel	4,818	9,379	1,447	3,523	1,378	3,279
Pipe and tubing	472,447	841,474	430,630	791,252	257,967	404,319
Wire	37,360	62,470	26,269	49,539	20,349	37,689
Nails, brads, spikes, staples	11,949	34,152	7,089	24,232	6,916	24,326
Blackplate	89,717	25,711	71,888	17,897	60,929	13,704
Tinplate and terneplate	381,089	220,993	240,127	118,870	188,628	83,826
Sheets, hot-rolled	195,294	105,394	62,191	42,744	42,544	32,934
Sheets, cold-rolled	92,485	89,378	50,770	52,198	50,431	47,126
Strip, hot-rolled	36,598	24,258	27,488	18,709	16,428	16,308
Strip, cold-rolled	51,534	73,855	25,421	42,991	26,152	42,255
Plates, sheets, strip, galvanized, coated or clad	131,266	94,686	67,395	51,447	78,142	55,665
Total	2,903,863	[1]2,275,267	1,842,313	1,601,431	1,198,623	1,054,794
Other steel products:						
Plates and sheets, fabricated	40,244	66,404	23,216	52,335	21,990	39,922
Structural shapes, fabricated	172,388	390,526	119,303	268,678	65,803	133,037
Architectural and ornamental work	10,193	23,998	5,578	14,609	3,643	15,178
Sashes and frames	12,804	39,141	10,137	39,514	9,197	38,069
Pipe and tube fittings	50,716	300,810	41,578	293,573	22,831	141,646
Pipe and tubing, coated or lined	19,470	23,806	16,037	21,630	13,025	17,533
Bolts and nuts	70,254	133,442	70,601	114,964	72,913	106,242
Forgings	58,195	144,420	46,139	89,277	33,048	55,132
Cast-steel rolls	5,074	8,811	3,206	10,987	977	2,347
Railway track material	4,458	7,386	6,611	7,544	3,215	4,788
Total	443,796	[1]1,138,745	342,406	913,111	246,642	553,894
Iron products:						
Cast-iron pipes, tubes, fittings	95,386	145,519	113,185	160,091	85,513	128,523
Iron castings	113,521	88,998	69,548	59,522	58,344	45,866
Total	208,907	234,517	182,733	219,613	143,857	174,389
Grand total	3,556,566	[1]3,648,528	2,367,452	2,734,155	1,589,122	1,783,077

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

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

Country	1981 Quantity (short tons)	1981 Value (thousands)	1982 Quantity (short tons)	1982 Value (thousands)	1983 Quantity (short tons)	1983 Value (thousands)
Australia	3,707	$470	8,506	$527	--	--
Belgium-Luxembourg	27	12	1,202	200	915	$129
Brazil	138,951	15,443	146,413	16,313	135,955	14,413
Canada	267,877	46,658	127,337	26,995	94,802	16,004
China	--	--	17,116	1,560	--	--
France	4,833	771	1,624	329	772	101
South Africa, Republic of	45,988	6,972	19,445	2,966	9,650	1,259
Sweden	4,526	430	--	--	--	--
Venezuela	2,204	236	--	--	--	--
Other	12	21	57	49	20	10
Total[1]	468,125	71,013	321,702	48,940	242,114	31,917

[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	1981		1982		1983	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Steel mill products:						
Ingots, blooms, billets, slabs, sheet bars	790,062	$212,449	716,588	$180,612	822,483	$176,621
Wire rods	888,456	388,315	961,768	366,267	1,188,918	392,317
Structural shapes, 3 inches and over	1,976,769	727,669	1,483,486	544,550	1,489,226	425,557
Structural shapes, under 3 inches	105,412	38,027	59,711	21,732	88,288	29,298
Sheet piling	98,718	40,512	114,864	50,810	69,050	26,744
Plates	2,447,687	900,595	1,619,538	565,989	1,393,378	358,945
Rails and track accessories	282,877	109,788	320,353	135,445	168,933	56,528
Wheels and axles	35,702	30,955	19,936	18,682	6,500	7,030
Concrete reinforcing bars	52,647	15,415	51,675	12,700	208,304	39,126
Bars, carbon, hot-rolled	418,006	163,516	297,493	118,733	322,518	109,504
Bars, alloy, hot-rolled	176,571	119,706	164,414	112,848	139,806	87,275
Bars, cold-finished	231,278	219,096	218,317	211,012	204,575	160,887
Hollow drill steel	1,442	1,588	1,462	1,761	--	--
Welded pipe and tubing	2,740,842	1,414,377	2,124,745	1,124,642	1,728,716	595,175
Other pipe and tubing	3,827,736	3,157,481	2,984,566	3,021,885	1,124,266	650,002
Wire	412,802	332,389	346,520	271,039	478,776	316,761
Wire nails	303,471	160,045	264,388	140,491	374,039	188,544
Wire fencing, galvanized	8,446	6,419	8,457	5,825	10,762	6,991
Blackplate	97,836	41,353	119,395	50,482	170,420	66,939
Tinplate and terneplate	288,414	180,390	218,394	134,718	293,819	168,413
Sheets, hot-rolled	1,628,141	526,902	1,355,024	421,498	2,030,684	545,735
Sheets, cold-rolled	1,626,016	720,356	1,706,708	747,464	2,425,167	886,228
Sheets, coated (including galvanized)	1,303,588	604,046	1,227,867	553,108	2,059,275	863,471
Strip, carbon, hot-rolled	24,934	10,719	21,655	9,309	32,530	11,491
Strip, carbon, cold-rolled	50,866	50,218	49,209	45,368	66,090	55,159
Strip, alloy, hot- or cold-rolled (including stainless)	23,087	42,832	22,375	46,156	27,798	47,447
Plates, sheets, strip, electrolytically coated (other than with tin, lead, or zinc)	56,565	32,502	57,384	34,006	110,067	61,448
Total	19,898,371	10,247,660	16,536,292	8,947,132	17,034,388	6,333,636
Other steel products:						
Plates, sheets, strip, fabricated	4,832	5,526	4,016	5,447	5,536	4,430
Structural shapes, fabricated	168,779	179,719	146,596	139,589	206,296	155,308
Pipe fittings	131,829	221,691	112,680	192,912	71,161	92,146
Rigid conduit	1,928	3,952	105	488,282	282	2,187
Bale ties made from strip	1,390	1,190	1,197	1,028	643	546
Nails, brads, spikes, staples, tacks, not of wire	16,123	12,709	12,135	10,013	40,670	46,977
Bolts, nuts, rivets, washers, etc.	445,743	491,230	422,151	471,710	450,707	473,157
Forgings	51,772	38,601	45,910	33,897	28,800	20,730
Total	822,396	954,618	744,790	1,342,878	804,095	795,481
Iron products:						
Cast-iron pipes, tubes, fittings	25,554	27,515	28,565	31,517	30,629	32,155
Iron castings	71,207	56,442	75,817	72,768	94,742	76,693
Total	96,761	83,957	104,382	104,285	125,371	108,848
Grand total	20,817,528	11,286,235	17,385,464	10,394,295	17,963,854	7,237,965

Table 14.—Pig iron: World production, by country[1]

(Thousand short tons)

Country[2]	1979	1980	1981	1982[p]	1983[e]
Algeria	[r]548	[r]737	989	992	1,000
Argentina[3]	2,136	1,976	1,914	2,090	[4]2,062
Australia	8,610	7,672	7,529	6,565	[4]5,561
Austria	4,081	3,842	3,832	3,434	3,362
Belgium	11,878	11,614	10,724	8,638	8,818
Brazil[3]	13,270	14,286	12,150	12,185	14,539
Bulgaria	1,598	1,683	1,667	1,717	1,710
Burma	--	--	4	15	15
Canada	[r]12,022	12,007	10,740	8,818	[4]9,443
Chile	674	[r]714	642	500	600
China	40,488	41,910	37,666	39,171	41,248
Colombia	[r]266	[r]308	[e]287	271	[4]298
Czechoslovakia	10,504	10,824	10,354	9,997	9,921

See footnotes at end of table.

Table 14.—Pig iron: World production, by country[1] —Continued

(Thousand short tons)

Country[2]	1979	1980	1981	1982[p]	1983[e]
Egypt	661	717	717	125	138
Finland	2,247	2,226	2,180	2,157	2,205
France	20,906	20,580	18,697	16,569	[4]14,808
German Democratic Republic[5]	2,630	2,709	2,691	2,369	2,205
Germany, Federal Republic of	38,765	37,339	35,137	30,447	29,321
Greece	362	[r][e]334	[e]330	[e]330	330
Hungary	2,611	2,441	2,417	2,404	[4]2,256
India	9,643	9,362	10,443	10,582	10,472
Iran[e]	900	900	[r]600	[r]700	800
Italy	12,486	13,392	13,513	12,717	[4]11,366
Japan	92,402	95,946	88,239	85,603	79,805
Korea, North[e]	3,200	3,300	3,300	3,300	3,300
Korea, Republic of	5,581	6,148	8,739	9,309	8,845
Luxembourg[5]	4,190	[r]3,933	3,185	2,852	2,557
Mexico[3]	5,541	5,815	6,044	5,625	[4]5,549
Morocco[e]	13	13	13	13	17
Netherlands	5,307	4,771	5,071	3,987	4,090
New Zealand[e 3]	30	[r]148	[r]165	165	165
Norway	717	[r]675	626	532	551
Pakistan	--	--	420	[e]880	880
Peru	283	288	195	[3]226	[4]153
Poland	[r]12,706	[r]13,176	10,308	9,395	9,370
Portugal	403	385	452	237	391
Romania	9,787	9,934	9,763	9,521	9,590
South Africa, Republic of	7,750	8,284	8,119	7,454	5,746
Spain	[r]7,114	7,408	7,080	6,604	[4]5,950
Sweden[3]	3,343	2,685	1,896	2,069	2,094
Switzerland	33	32	33	39	33
Taiwan	1,940	1,857	1,775	2,971	2,976
Thailand	33	20	11	7	8
Tunisia	165	166	176	110	165
Turkey	2,456	2,249	2,154	2,567	3,296
U.S.S.R	[r]120,150	[r]118,259	118,792	117,642	121,805
United Kingdom	14,213	7,068	10,439	9,179	10,472
United States	86,975	68,699	73,755	43,342	48,770
Venezuela[3]	1,468	2,609	2,458	2,598	[4]2,476
Yugoslavia	2,603	[r]2,673	3,105	2,969	[4]3,136
Zimbabwe[e]	660	660	440	[r]390	330
Total[6]	[r]586,300	[r]564,800	551,900	502,400	505,000

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

[1]Table excludes ferroalloy production except where otherwise noted. Table includes data available through May 30, 1984.

[2]In addition to the countries listed, Vietnam and Zaire have facilities to produce pig iron and may have produced limited quantities during 1979-83, 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]Data may not add to totals shown because of independent rounding.

Table 15.—Raw steel:[1] World production, by country[2]

(Thousand short tons)

Country[3]	1979	1980	1981	1982[p]	1983[e]
Algeria	[r]347	[r]423	575	[e]630	660
Angola[e]	11	11	11	11	11
Argentina	3,531	2,978	2,786	3,211	3,230
Australia	8,956	[r]8,371	8,416	7,023	[4]6,177
Austria	5,420	5,097	5,132	4,694	[4]4,862
Bangladesh[5]	139	152	153	120	[4]52
Belgium	[r]14,940	[r]13,585	13,543	[e]10,900	[4]11,194
Brazil	[r]15,315	16,908	14,584	14,319	[4]16,159
Bulgaria	2,736	2,830	2,738	2,848	2,800
Canada	17,723	17,512	16,326	12,965	[4]14,140
Chile	724	[r]776	710	537	680
China	37,953	40,918	39,242	40,960	44,040
Colombia	399	446	435	491	[4]489

See footnotes at end of table.

Table 15.—Raw steel:[1] World production, by country[2] —Continued

(Thousand short tons)

Country[3]	1979	1980	1981	1982[p]	1983[e]
Cuba	[r]362	335	364	332	390
Czechoslovakia	16,333	16,783	16,832	16,526	[4]16,561
Denmark	886	809	675	617	[4]543
Ecuador	9	18	29	31	24
Egypt	882	882	992	529	660
El Salvador[e]	15	15	11	[r]8	6
Finland	2,755	2,766	2,676	2,661	[4]2,663
France	25,750	25,547	23,433	20,300	[4]19,414
German Democratic Republic	7,742	8,056	8,231	7,902	7,700
Germany, Federal Republic of	50,750	48,323	45,867	39,551	[4]39,386
Greece	1,102	1,031	1,002	1,003	1,010
Hong Kong[e]	130	130	130	130	130
Hungary	4,308	4,149	4,018	4,082	[4]3,987
India	11,019	[e]10,384	[r e]11,442	11,811	[4]11,359
Indonesia	336	397	551	[r e]550	550
Iran	[4]1,576	[r]1,300	[r]1,300	1,300	1,500
Iraq[e]	388	287	50	50	50
Ireland	79	2	35	61	60
Israel	118	127	126	[e]100	165
Italy	26,731	29,212	27,312	26,434	[4]23,891
Japan	123,181	122,792	112,078	109,733	[4]107,105
Jordan	[r]89	[r]95	[r]149	154	150
Kenya[e]	11	11	11	11	11
Korea, North[e]	3,700	3,900	[r]3,900	[r]3,900	3,900
Korea, Republic of	8,389	9,434	11,854	12,955	[4]13,134
Luxembourg	5,456	5,092	4,178	3,869	[4]3,632
Malaysia[e]	[4]228	230	230	230	230
Mexico	7,845	7,888	8,383	7,769	[4]7,625
Morocco[e]	7	7	7	7	7
Netherlands	6,400	5,811	6,032	4,799	[4]4,936
New Zealand	[r]244	[r]239	255	278	[4]257
Nigeria[e]	17	17	17	110	150
Norway	1,015	941	935	847	[4]988
Pakistan[e]	33	33	44	44	390
Peru	481	[r]493	401	302	320
Philippines	438	364	386	[e]390	390
Poland	21,184	[r]21,479	17,327	16,309	[4]14,991
Portugal	715	720	607	556	[4]734
Qatar	418	485	499	524	520
Romania	14,230	14,523	14,358	14,391	14,440
Saudi Arabia[e]	50	55	80	110	440
Singapore	327	375	386	[e]385	385
South Africa, Republic of	9,775	9,996	9,925	9,117	[4]7,721
Spain	13,563	13,874	14,233	14,506	[4]14,034
Sweden	5,101	4,665	4,150	4,300	[4]4,641
Switzerland	977	1,024	1,065	1,047	1,050
Syria[e]	[r]120	[r]120	[r]120	[4]109	110
Taiwan	3,512	3,767	3,465	4,495	[4]5,530
Thailand	485	496	331	344	320
Trinidad and Tobago	—	[r]3	58	188	241
Tunisia	194	196	196	121	182
Turkey	2,641	2,795	2,605	3,081	[4]3,904
U.S.S.R	164,353	163,077	163,632	162,221	168,650
United Kingdom	23,631	12,432	17,170	15,106	[4]16,527
United States	136,341	111,835	120,828	74,577	[4]84,615
Uruguay	15	18	15	22	33
Venezuela	1,625	1,967	2,003	2,531	[4]2,476
Vietnam[e]	120	130	120	[r]130	110
Yugoslavia	3,899	4,006	4,383	4,244	[4]4,558
Zimbabwe	816	886	762	582	500
Total	[r]821,091	[r]786,831	776,905	707,081	724,480

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

[1]Steel formed in first solid state after melting, suitable for further processing or sale; for some countries, includes material reported as "liquid steel," presumably measured in the molten state prior to cooling in any specific form.

[2]Table includes data available through May 30, 1984.

[3]In addition to the countries listed, Ghana, Libya, and Mozambique are shown to have steelmaking plants, but available data is 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]

In 1983, brokers, dealers, and other outside sources supplied domestic consumers with 32.8 million tons[2] of all types of ferrous scrap at a delivered value of approximately $2.34 billion, while exporting 7.5 million tons valued at $637 million. In 1982, domestic consumers received 27.5 million tons at a delivered value of approximately $1.8 billion while exports of 6.8 million tons were valued at $610 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 81% 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 0.5%, 6.4%, and 0.2% for the three user industries.

Table 1.—Salient U.S. iron and steel scrap and pig iron statistics

(Thousand short tons and thousand dollars)

	1979	1980	1981	1982	1983
Stocks, Dec. 31:					
Scrap at consumer plants	8,724	8,018	8,118	6,418	5,807
Pig iron at consumer and supplier plants	881	889	859	622	345
Total	9,605	8,907	8,977	7,040	6,152
Consumption:					
Scrap	98,901	83,710	85,097	56,386	61,782
Pig iron	87,458	69,053	75,040	44,409	50,070
Exports:					
Scrap (excludes rerolling material and ships, boats, other vessels for scrapping)	11,054	11,168	6,415	6,804	7,520
Value	$1,142,406	$1,225,941	$638,644	$610,302	$636,723
Imports for consumption:					
Scrap (includes tinplate and terneplate)	760	582	556	r474	641
Value	$70,804	$61,192	$62,126	r$38,020	$48,219

rRevised.

Legislation and Government Programs.—The President in January signed legislation backdated to June 1981 extending the suspension of duty on U.S. imports of all scrap metals without a time limit and permitting U.S. scrap importers to obtain refunds on duties paid. The Interstate Commerce Commission (ICC) in late September ruled that shipments of automobile shredder scrap were eligible for the same railroad freight reductions and refunds, including interest, as nonferrous scrap metal. In addition to immediate rate reductions, the decision meant that an estimated several million dollars would be refunded to scrap shippers because of excessive rates charged since June 1981.

In April 1983, representatives of the National Association of Recycling Industries (NARI) and the Institute of Scrap Iron and

Steel (ISIS) joined in a vigorous request for repeal of the Findley Amendment, Section 7(c), of the Export Administration Act of 1979. The Ferrous Scrap Consumers Coalition was the strongest backer of the Findley amendment with the American Iron and Steel Institute (AISI) maintaining a quieter position. However, the outlook was that the monitoring and control of ferrous scrap exports would remain in the act, although probably more tightly defined. The U.S. House of Representatives on October 27, supported an ISIS amendment strengthening the short supply provision dealing specifically with metallic scrap. The House-passed amendment formalized the hearing process required prior to undertaking monitoring or controls of metallic scrap exports; required a definition of terms such as shortage and inflationary impact; required specific findings by the Secretary of Commerce; and required publications of these findings. The U.S. Senate in December had not started floor debate on its version of the Export Administration Act of 1979, the second extension of which expired on October 14, 1983.

AVAILABLE SUPPLY, CONSUMPTION, AND STOCKS

The ferrous scrap industry and the domestic steel and ferrous casting industry were in a period of rapid transition and major structural changes.

The ferrous scrap industry showed a trend toward fewer small dealers in remote areas because scrap processing had become a capital intensive business requiring large complicated equipment and computerized cost and accounting systems. Many large wholesale processors acted as their own brokers for direct sales to steel mills. The continued existence of processors of obsolete scrap depended on high enough delivered prices to domestic consumers and the continued existence of an export market. A small increase in the number and larger output capability of multiyard processors necessitated capital for additional equipment and parts to produce the higher quality scrap specified by domestic steel and ferrous castings producers and for some grades exported.

The ferrous scrap industry on an average fared somewhat better than in 1982 because of increased shipments to domestic consumers. Manufacturing sectors showing gains in outputs included aircraft, automobiles, coal mining equipment, household appliances, iron castings, materials handling equipment, other consumer goods and materials, and other steel products. Sectors with lower output than in 1982 included capital goods, construction and farm equipment, containers, heavy trucks, nonelectrical machinery, oilfields and gasfields tubular goods, railroad equipment, shipbuilding, and steel castings.

Reportedly, scrap dealers were paying about $22 to $25 per ton total for processing costs and transportation to the consumer. Price weakness and changing patterns in distribution and consumption put financial pressure on some small dealers and processors who dropped out of the competition in this, the second year of a small volume market.

The cost of collecting and processing ferrous scrap increased following the steel industry's changed structure and technology. Fewer people participated in scrap collection because smaller overall demand for scrap had an adverse effect on the scrap industry whose economic survival was governed by the economies of scale. Some U.S. steelmakers moved to the elimination of duplicate handling and inventories by recourse to the "just-in-time" delivery systems. The resulting principal benefit ensured the movement of industrial scrap immediately to steelmaking furnaces that otherwise would have gone to the plants' stockpiles. Consignment sales or deliveries of ferrous scrap at unusually high levels in the U.S. major steelmaking regions involved an estimated 20% of all ferrous scrap to Midwest consumers. Consignments were not favored in the Southeast or Southwest where minimills were the principal consumers. Many domestic steel mills preferred diminished stocks of scrap, with the result that large-tonnage scrap processors held large stocks of processed scrap to ensure short-time-order shipments. Currently, the available general purpose gondola cars sufficed to move scrap and finished steel.

U.S. ferrous scrap exporters encountered increased competition from the surplus scrap available in economically depressed Western European countries; growing exports from the Netherlands, the U.S.S.R., and the United Kingdom to the Far East; and increased shipbreaking in the Far East. The latter was favored by smaller labor costs and ocean freight rates to Japan, the Republic of Korea, and Taiwan, three countries who collectively received a large portion of U.S. scrap exports in the past 3 years.

The quality of ferrous scrap demanded by domestic consumers and some scrap exporters, particularly as affected by the total content of tramp elements, appeared to be related to three trends: the increasingly restrictive quality demands on existing steel grades; a widening of the product spectrum to produce more sophisticated, higher value steels; and the economic necessity of minimizing out-of-specification product.

Such quality-related issues have led to controversy over two key questions regarding scrap consumption—whether a sufficient volume of high-quality scrap will be available to satisfy the indicated need and whether the overall quality of domestic scrap is declining.

Some examples given of trends in progress that could result in an overall buildup in residual tramp elements in scrap include the adoption of continuous casting and other yield-improvement measures, especially in integrated mills, which reduce the availability of low residual revert scrap and place greater dependence on purchased obsolete scrap in the charge; and the increased use of certain alloy and coated steels, especially in the automotive industry, which result in increased residual tramp elements in prompt industrial scrap in the short term and in obsolete scrap in the long term.

The current typical residual content of selected charge materials for electric steelmaking was reported. Combined chromium, copper, molybdenum, and tin residual contents ranged from 0.02% in direct-reduction iron (DRI) to 0.73% in No. 2 heavy melting steel scrap.[3]

The slow but growing interest for both improving and maintaining the quality of top grades of scrap, principally No. 1 bundles and No. 1 busheling, was evidenced by several unrelated developments: Several minimills producing wire rod operated their own purchasing and processing activities to control quality and supply; General Motors Corp.'s Central Foundry Div., in a determined move to boost the quality of its finished products, warned its scrap suppliers in January that rejections, deviations, and poor quality would not be tolerated; and a February substantial purchase at $92 per gross ton delivered to Jones and Laughlin Steel Corp.'s electric arc furnace plants, which specified that 150-pound No. 1 bundles were to be free of zinc and paint and not to exceed 60 inches periphery. Brokers immediately increased the price of No. 1 bundles by $10 per gross ton delivered above the Pittsburgh area price of 2 weeks earlier, resulting in objections by Jones and Laughlin.

The intensive effort by Birmingham, AL, area steelmakers in midyear to upgrade their scrap purchases resulted in price increases of No. 1 bundles and No. 1 railroad heavy melting grades.

A 5,000-ton order by Armco Inc., Houston, TX, in September immediately impacted the normal scrap demand by Southwestern United States minimills who turned to lower-priced bundles, turnings, and shredded scrap. This forced scrap processors to change their traditional processing practices to meet the specified maximum contents of galvanized, cast iron, and dirt in the lower-priced grades.

The Connors Steel Co. minimill in Birmingham, AL, announced its closure in August and canceled its outstanding orders for No. 1 heavy melting, No. 1 bundles, and dealer-processed grades of railroad scrap. In midyear, one ingot-mold producer in Pennsylvania preferred to melt substantial tonnages of scrap-rail, ingot-mold scrap, and heavy plate scrap. Generally, in midyear, consumers were demanding and receiving premium grades of scrap as free as possible from tramp metals and other contamination.

One unusual sale of scrap was made in July by the Grant Oil Country Tubular Corp., Houston, TX, who sold 6,000 tons of alloy steel pipe for about $40 per ton, (about 1% of the original cost), reportedly for tax reasons and inventory reduction. Most of the pipe was to be used as fence posts and cattle guards and only a small tonnage was destined for steelmaking purposes.

Resource Recovery Inc., Dade County, FL, sold 900 tons per week of incinerated ferrous scrap at $20 per ton.

According to ISIS, the U.S. ferrous scrap processing capability was 140 million tons per year based on a two-shift-per-day operation. On a one-shift-per-day basis, the industry could shred, shear, bale, crush, briquet, break, and torch 70 million tons per year. Hammers for medium-size shredders cost $1.17 to $1.35 per automobile hulk shredded, while the maintenance cost excluding hammers was $1.25 to $1.67 per ton of product. The investments for medium-size shredders were approximately $1.7 million for a 5,000- to 6,000-ton-per-month output; $2.0 million for a 10,000- to 15,000-ton-per-month output; and $3.0 million for a 20,000-ton-per-month output.

The distribution of several major grades of scrap supplied by brokers, dealers, and other outside sources was as follows, in thousand tons:

Type	Domestic consumers	Exports	Total
No. 1 heavy melting	7,515	1,895	9,410
No. 2 heavy melting	1,927	720	2,647
No. 1 bundles	5,707	206	5,913
No. 2 bundles	1,058	220	1,278
Borings, shovelings, turnings	898	532	1,430
Shredded	2,493	2,029	4,522
Total	19,598	5,602	25,200
Value millions	$12,973	[1]$403	$13,376

[1]Customs value.

The scrap industry's low-capacity operating rate in 1982 and the first half of 1983 resulted in mergers and consolidations of some processors and brokerage firms. In March, Steelmet Inc. sold its Metals Processing Co. subsidiary to Marc Rich and Co. International for $9 million, with yards capable of processing 400,000 tons of scrap per year at Providence, RI, and Worcester, MA. In February, Steelmet, one of the largest processors and brokers of stainless steel scrap, filed for reorganization under Chapter 11 of the Federal Bankruptcy Code. On August 22, Luria Bros. and Co., Cleveland, OH, the Nation's largest ferrous scrap processor and broker, entered the stainless steel scrap market by a joint venture with the 65-year-old Matlow Co., Syracuse, NY. In June the David J. Joseph Co., Cincinnati, OH, the country's second largest processor-broker, opened a nonferrous metals and stainless steel scrap brokerage office in San Francisco.

The Samuel G. Keywell Co., Detroit, MI, a specialty steel scrap processing firm, moved its facility from Warren, MI, to Midland, PA, because of the closing of the Jones and Laughlin, Warren, MI, melt shop. Albany Alloys and Stainless Inc., a new company engaged in the preparation and processing of stainless steel scrap, began operating in Watervliet, NY, in the former facility of Columbia Iron and Metal Co. Proler International Corp., Houston, TX, bought the scrap facilities of Metal Recovery Inc. (MRI) in Seattle, WA, and Tampa, FL, as well as equipment from an MRI facility in San Francisco, CA, while Vulcan Materials Co., Birmingham, AL, purchased a MRI scrap yard in Elizabeth, NJ. Cozzi Iron and Metal Inc. acquired Snyder Iron and Steel Co., Chicago, IL, thereby increasing the expanded firm's capacity to 50,000 tons per month. Cascade Steel Rolling Mills, McMinnville, OR, contracted with Schnitzer Steel Products Co. for 300,000 tons per year of prepared scrap. Schiavone-Bonomo Corp., Jersey City, NJ, installed a Wang VS 80 computer system to provide on-line data and Bureau of the Census reports. Luria Bros. sold its Brooklyn, NY, yard to the newly formed Newton Steel Co. Metal scrap processors in Virginia maintained their status as manufacturers and continued to be exempt from Virginia's sales tax based on evidence presented to the State Tax Commissioner.

Traders and processors of ferrous scrap who filed for Chapter 7 (liquidation) in Bankruptcy Court included United Stainless & Alloy Inc., Matthews, NC; and those filing for Chapter 11 (reorganization) included Intercontinental Metals Trading Corp., Charlotte, NC, and Amex Co., Corpus Christi, TX.

In June, NARI and ISIS jointly urged the Environmental Protection Agency (EPA) to exempt scrap aluminum, copper, iron and steel, stainless steel, and other metals from a new definition of hazardous metals in EPA's proposed rigid regulations.

Several unrelated substances affecting safety in the processing or use of ferrous scrap made news headlines. At The Auburn Steel Co. minimill in Auburn, NY, on February 21, 60 tons of radioactive scrap was melted containing cobalt 60 that was traced to obsolete hospital equipment in the scrap charged into two electric furnaces. An examination of 60 workers in the plant showed that body exposure was less than the New York State's minimum for radioactivity level. The contaminated billets, 40 tons of baghouse dust, and a substantial amount of slag were moved to a federally approved disposal site and 60 tons of unmelted scrap was sent to an isolated area of the steel plant. A 3-week cleanup period cost the company $1.2 million.

ISIS continued to oppose the installation of air bags in automobiles because the presence of a cannister containing sodium azide as the propellant posed a threat to life and property when processing an automobile hulk.

The EPA sealed off the site of the Brady Iron and Metal Inc. in Newark, NJ, after 1,000 to 5,000 parts per billion of dioxin was found in soil samples taken in the scrap yard in mid-October. New Jersey officials stated that the toxic chemical had been contained in scrapped vessels and piping received from several chemical companies.

Installed capacity and new equipment or processes available to the ferrous scrap industry indicated that the annual U.S. ferrous scrap-processing capacity in late 1983, on a one-shift-per-day operating basis, was as follows, in million tons:

Equipment		Capacity
Type	Number	
Balers	1,200	16.0
Hydraulic guillotine shears	+1,000	17.0
Alligator shears	2,150	4.8
Shredders	200	13.1
Turnings crushers	150	2.2

The Luntz Corp. of Cleveland, OH, installed "the largest shear in the world," reportedly capable of cutting railroad cars, at a total cost of $3 million, including components and train tracks.

New scrap processing equipment made by U.S. manufacturers included heavy-duty balers made by Mac Corp., Grand Prairie, TX, and the Balemaster Div. of East Chicago Machine Tool Corp.; the LS-3400 SL hydraulic scrap crane developed by FMC Corp., Cable Crane and Excavator Div., Cedar Rapids, IA; Models 300 SH, 325 SH, and 350 SH hydraulic scrap handlers by the Bucyrus-Erie Co., Milwaukee, WI; the Ro-Con process by WCS International, Anaheim, CA, for loading scrap for export; a new concept of a locomotive crane by the American Hoist and Derrick Co., St. Paul, MN; a new Bulldog Metals Cleaning System offered by Hammermills Inc., Cedar Rapids, IA; the Model RB-120 Automatic Rail Breaker by Harris Press and Shear Inc., Cordele, GA; the American Model 480 Grab upperworks for locomotive cranes by American Hoist and Derrick Co., St. Paul, MN; the Weigh Mate 82 computerized weighing and billing system, a product of Ameacon Inc., Round Rock, TX; the Triple R Recycle System by Delano D. Van Over and Associates Ltd., Minden, NV; the P- and S-types of Allied-Gator shears by Allied-Gator Inc., Youngstown, OH; a stroke adjustor mechanism for shears by the Enterprise Co., Santa Ana, CA; a new Mosley 330 shear made by Hustler Conveyor Co. and installed by a scrap processor in Toledo, OH; the Newell Double Feed Roll shredder developed by Newell Manufacturing Co., San Antonio, TX; new spectrometers by Bausch and Lomb Optical Co., ARL Div., Sunland, CA; the Clandon Metascop, a portable unit distributed by Jack J. Levand Steel and Supply Corp., Los Angeles, CA; and the EDXRF X-ray spectrometer by Kevex Corp., Foster City, CA.

The world renowned firm, Thyssen Henschel, of Kassel, Federal Republic of Germany, continued to offer proven types of hydraulic guillotine shears, hydraulic baling presses, and scrap grinders, while Officina Metallica S.p.A., Bologna, Italy, offered its Model AL-40 baler to produce small bales of ferrous scrap.

Activities associated with trade associations and other ferrous scrap-related groups included a February meeting of representatives of AISI and the 1,223-member ISIS with officials of the U.S. Department of Defense and the U.S. Department of Commerce to seek support to have U.S. railroads increase the number of gondola cars available to the scrap and steel industries. Also, ISIS expressed extreme disappointment with the U.S. Department of Transportation's study of alternatives to replace the vehicle use tax effective July 1, 1984, enacted by the Surface Transportation Assistance Act of 1982.

Scrap-related publications included an ISIS safety manual advising shredder operations to reject all vehicles with fuel tanks; a study by Arthur D. Little Inc. in collaboration with the Automobile Dismantlers and Recyclers Association on the used parts industry; a report on automobile shredder residue prepared by the Metal Scrap Research and Education Foundation, the research arm of ISIS; and the recovery of nonmagnetic metals from automobile shredder rejects.[4]

Steel mills accounted for 74.3% of all scrap received from brokers, dealers, and other outside sources; steel foundries received 3.2% and iron castings producers received 22.5%.

The apparent consumption of scrap, in million tons, consisted of 34.2 net receipts, 27.3 home scrap, and 0.6 withdrawals from stock for a total of 62.1.

Stocks of ferrous scrap and stainless steel scrap held by domestic consumers were as follows, in thousand short tons:

Consumer	Ferrous		Stainless steel	
	Dec. 31, 1982	Dec. 31, 1983	Dec. 31, 1982	Dec. 31, 1983
Steel manufacturers	5,383	4,849	92	104
Steel castings manufacturers	153	138	6	6
Iron castings manufacturers	783	708	2	2
Total	6,319	5,695	[1]99	112

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

TRANSPORTATION

Gondola cars owned by Class I railroads totaled 129,423 at yearend compared with 134,763 units on December 31, 1982. Class II railroads, switching terminal companies, and private owners had 42,131 gondolas at yearend compared with 42,168 units on December 31, 1982. In the third quarter, Class I railroads scrapped 170 gondolas and added 50 units to their fleet. The relatively low rate of finished steel production and increased shipments of ferrous scrap by trucks and barges precluded a shortage of gondola cars.

ISIS, whose members processed and shipped about 90% to 95% of the ferrous scrap sold domestically or for export, objected to the Waterways Freight Bureau's Proposal No. 7312 whereby shippers would be obligated to pay the same barge rates as those charged for finished iron and steel products. The proposed rates would be increased by 31% to 57%, representing about \$1.56 to \$3.97 per ton.

The Chessie System Railroads Corp. (CSX) filed an application in November with the ICC to assume control of American Commercial Lines Inc., one of the largest transportation companies having 1,600 barges and 61 tugboats on inland waterways.

In July, Consolidated Rail Corp. published a 38-page booklet simplifying numerous tariffs on ferrous scrap. CSX, in December, released an illustrated booklet showing the specifications and chemistry of the ferrous scrap offered for CSX's monthly sales. An ISIS transportation manual cautioned against overloading rail cars with scrap.

By 1985, L. B. Foster Co. expected to recover usable components and scrap from 3,000 miles of abandoned railroads.

In December, the U.S. Department of Transportation allocated \$12.5 million to the Federal Railroad Administration's Local Rail Association Program for fiscal year 1984, primarily to rehabilitate 23,000 miles of branch lines.

Several factors seriously affected rail car builders and their purchases of iron castings and steel products. The continued slump in the domestic mill shipments of almost every product sold to the railroads and to carbuilders dwindled to the lowest level in many years. The market for railcar wheels and axles continued at a low level. In 1982, 71,496 tons of forged wheels and 30,874 tons of axles were shipped from domestic mills, while shipments of wheels through April were 40% less than in the first 4 months of 1982 and shipments of axles were down 63%.

The major problem was a surplus of rail cars owned and stored by Class I railroads that totaled 263,000 on January 1 and 178,000 at yearend. As a result, their few new orders were principally for specialty use cars. For example, new cars on order August 31, 1983, totaled 3,851 compared with 5,175 on August 31, 1982. In the first 8 months of 1982, 14,927 cars were delivered, considerably more than the 3,316 delivered in the first 8 months of 1983. On December 31, 1983, revenue freight cars of all types totaled 1,542,278 compared with 1,587,537 on December 31, 1982.

The Seaboard System ordered 300 coal cars having aluminum bodies from Santee Cooper, the South Carolina Public Service Authority, for which the cars will be built by Portec. The Santa Fe Railroad was converting 350 bulkhead flatcars into single-trailer platforms and the Norfolk Southern Railroad completed the transformation of 500, 50-foot boxcars into 250 articulated single-platform intermodal cars.

PRICES

The calculated weighted delivered price for all types of ferrous scrap received in 1983 by domestic consumers from brokers, dealers, and other outside sources was as follows:

Consumer	Quantity (thousand short tons)	Delivered value (per short ton)	Delivered value (millions)
Steel manufacturers	24,371	$73	$1,785
Steel castings manufacturers	1,052	76	80
Iron castings manufacturers	7,385	64	475
Total or average	32,808	71	2,340

Receipts of all types of scrap accounted for \$25 to \$26 of the \$527 per ton average price of finished steel shipments; for \$114 to \$115 per ton of steel castings shipped; and \$53 to \$54 per ton of iron castings shipped. Total domestic receipts were 14% greater than in 1982. A \$3 per gross ton increase in bids for No. 1 automobile bundles in November reflected the interest by a few steel mills in some areas of the country for prime industrial grades almost to the exclusion of dealer grades. By October, large integrated mills restrained their enthusiasm for scrap as they increased their consumption of iron ore. In November, unexpected purchases by several minimills in the Southeastern States pulled scrap from distant markets and distorted local price relationships.

Pittsburgh area scrap consumers in August lessened their interest in near-term deliveries of No. 1 grades. This caused a \$2 per gross ton decrease in price in that area. In late December, substantial tonnages of ferrous scrap were purchased for delivery to the long-idle electric furnaces of Jones and Laughlin's Pittsburgh works. The firm reportedly paid \$120 per gross ton delivered for both No. 1 busheling and No. 1 dealer bundles.

Because ferrous scrap prices in the first three quarters of 1983 were cheaper than blast furnace iron, steelmakers used more scrap in their furnaces. Steelmakers preferred top grades of scrap for maximum productivity and were willing to pay more for them. The startup of several blast furnaces increased the consumption of iron ore resulting in a smaller demand for mill grades of scrap.

The range of values of the four major grades received by domestic purchasers from brokers, dealers, and other outside sources was as follows:

Grade	Quantity (thousand short tons)	Value (millions)	Monthly values (per short ton) Minimum	Maximum	Average
No. 1 heavy melting	7,515	$491	$61	$87	$74
No. 1 bundles	5,707	456	64	97	80
Shredded	2,493	178	58	84	72
No. 1 busheling	1,716	132	63	92	77
Total	17,431	1,258	XX	XX	XX

XX Not applicable.

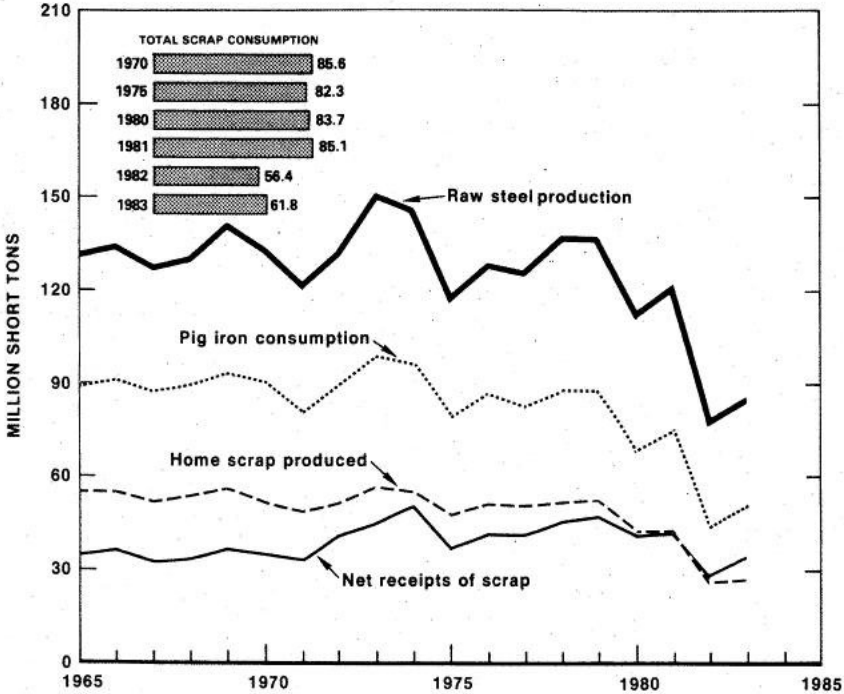

Figure 1.—Raw steel production (AISI), total iron and steel scrap consumption, pig iron consumption, home scrap production, and net scrap receipts.

FOREIGN TRADE

According to the Bureau of the Census, ferrous scrap exports totaled 7.5 million tons, up 11% over those of 1982. Exports, in thousand tons, ranged from 805 in June to 372 in February.

The customs value of total scrap exports from the United States averaged $84.67 per ton compared with $89.70 per ton in 1982. The tonnages and values were as follows:

Type	Quantity (short tons)	Customs value	
		Total (thousands)	Average per short ton
Ferrous	7,352,942	$577,506	$78.54
Stainless steel	80,154	44,071	549.83
Alloy steel (excluding stainless)	86,828	15,146	174.44
Total or average	7,519,924	636,723	84.67

Japan, the Republic of Korea, and Turkey collectively received 4,676,433 tons valued at $347,455,000 of the total scrap exported.

The tonnages and values of total scrap exported from 41 customs districts located in the 5 geographic areas and the leading district in each area were as follows:

Area and leading district	Number of customs districts	Quantity (thousand short tons)	Customs value (thousands)	Average customs value per short ton
East coast	15	2,913	$237,271	$81.43
New York, NY	XX	1,408	111,019	78.85
Great Lakes	5	905	58,914	65.10
Detroit, MI	XX	464	27,688	59.67
Gulf coast	5	641	50,799	79.25
New Orleans, LA	XX	412	31,662	76.85
Inland	9	634	52,019	82.05
Laredo, TX	XX	365	31,589	86.55
West coast	7	2,427	237,720	97.95
Los Angeles, CA	XX	906	96,910	106.96
Total or average all areas	41	7,520	636,723	84.67
Total or average 5 leading districts	XX	3,555	298,868	84.07

XX Not applicable.

The tonnages and values of stainless steel scrap and alloy steel scrap (except stainless) exported from the five geographic areas were as follows:

Area	Quantity (short tons)	Customs value (thousands)	Customs value (average per short ton)
East coast:			
Stainless steel	23,760	$12,775	$537.67
Alloy steel	14,530	4,730	325.53
Great Lakes:			
Stainless steel	5,870	2,624	447.02
Alloy steel	11,310	1,652	146.07
Gulf coast:			
Stainless steel	6,540	3,675	561.93
Alloy steel	7,670	1,434	186.96
Inland:			
Stainless steel	2,580	1,838	712.40
Alloy steel	15,120	1,844	121.96
West coast:			
Stainless steel	41,400	23,668	571.69
Alloy steel	38,200	5,614	146.96
Total or average stainless steel	80,150	44,580	556.21
Total or average alloy steel	86,830	15,274	175.91

Imports of ferrous scrap totaled 640,745 tons valued at $48,218,681. The Detroit customs district handled 326,399 tons; the Seattle customs district handled 145,229 tons; and 29 other customs districts collectively handled 169,117 tons. Canada supplied 589,645 tons valued at $41,754,057; Mexico supplied 32,590 tons valued at $2,061,142; and 18,510 tons valued at $4,403,412 came from 22 other countries.

WORLD REVIEW

Foreign-made processing equipment and additional shipbreaking activities contributed to the worldwide ferrous scrap supply, portending stiff competition as early as 1986 for some grades of scrap exported from the United States to the Far East.

New scrap processing equipment offered by foreign manufacturers in 1983 included the Elden Shear Nibble M-7 by E. Laursen Masinfabrik of Denmark for the mechanical separation of ferrous and nonferrous metals. More than 700 scrap shears manufactured by Lindemann KG GmbH & Co., Dusseldorf, Federal Republic of Germany, were in operation throughout the world. Lindemann's equipment was marketed in the United States by Lindemann of America Inc., Barrington, IL.

Lindemann was manufacturing a new type of baling press for a large East European state organization to compact 85,000 to 113,550 pounds per square inch tensile strength steel turnings. The maximum pressure force of the baler at 1,800 metric tons produces a bale density of 312 pounds per cubic foot. The usual bale weight will range from 110 to 132 pounds depending on bale length, at an output rate between 6 and 7 tons per hour.

Thyssen Henschel, Kassel, Federal Republic of Germany, received an order for four balers from Société Nationale de Siderurgie of Algeria, for delivery at 1-month intervals beginning in September.

J. McIntyre Machinery Ltd. of Nottingham, England, developed a high-speed 5025 metal baler, three of which were purchased by scrap processors in England by midyear. Sheppards Waste Recovery Services Ltd., Rochdale, England, ordered a 250-ton-per-hour shredder scheduled for operation in April 1984. J. A. Williams & Sons Ltd. Industrial Services in 1983 introduced to the United Kingdom a materials-handling crane featuring a counterbalance weight linked to the forward arm. This equilibrium crane was made by Sobemai in Belgium.

Taiwan continued to dominate shipbreaking, although its share was reduced by approximately 30%. The Republic of Korea's shipbreakers achieved a share of 25% during the year, while Bangladesh, India, and Pakistan shipbreakers collectively accounted for about 11%. China and Thailand began to make their presence felt in the market, with China establishing a share of 5%. Most of the increases occurred in the first half of the year, with activity declining in the last quarter, particularly for very large cargo carriers (VLCC).

Prices reversed the trend of 1982, rising steadily throughout the year, by about $40 per long deadweight ton for sales to the Republic of Korea and Taiwan breakers, and by $22 per ton for sales to Pakistan and Spain. In September, following the cessation of the Taiwan shipbreaking cartel, China Dismantled Vessel Trading Corp. (CDVTC), many breakers expected prices to increase considerably as a result of increased competition; however, prices remained fairly stable thereafter.

China's rapidly developing shipbreaking industry by midyear had purchased 11 ships totaling 400,000 deadweight tons at prices ranging from $103 to $109 per long ton. Two new yards in the Shanghai area bid for VLCC on the open market without success. Most of the tonnage of VLCC was outside Far Eastern waters and increasing competition for such vessels among the Republic of Korea, Taiwan, and other breakers increased the prices of such vessels. China invited the Shipbuilders Association of Japan to send a survey team to advise on extending the industry.

Greece's Economic Ministry announced three new shipscrapping ventures costing $23 million. One, by Greece, the Republic of Korea, and Taiwan interests, was a venture in Alexandroúpolis having a 400,000-ton-per-year scrap output; a second activity in Crete would produce 200,000 tons per year of scrap; and a third on an unidentified Aegean island would produce 78,000 tons per year. Greece's state commercial bank reportedly was involved in a project to construct a breaking yard of unknown output in Eleusis near Athens. These ventures would suffice to serve Greece's steel industry and Turkish steelworks near Istanbul and Izmir, although political difficulties could be an obstacle.

The Japanese Government attempted to further induce the country's shipowners to scrap their obsolete vessels to stimulate Japan's shipbreaking industry. Under the old program the response was poor, with only 250,000 tons scrapped out of 3 million tons targeted for demolition by the end of the fiscal year (September 1984). Most Japanese tankers sold for breaking went to Taiwan for approximately $116 per ton.

Inchon Iron & Steel Co. Ltd., a subsidiary of the Hyundai Corp., the world's leading shipbreaker and the Republic of Korea's largest shipbuilder, increased its ship-demolition activities to 1.12 million tons per year in 1982. Inchon, with seven berths, planned to increase its annual breaking activity to 2.24 million tons. Prices paid in 1983 for obsolete ships ranged from $65 to $88 per ton for small tonnage vessels to $107 to $113 per ton for VLCC. Gas and vapor removal from tankers added approximately $1 to $2 per ton to the purchase price.

Shipbreaking activity in India's Gujarat State boomed by midyear with 13 ships already beached and 47 more scheduled for breaking by yearend. Of India's 700,000-ton-per-year target, Gujarat was expected to produce 300,000 tons per year in new yards near Bhavnager and Jamnagar. This upturn was a bonus for local rerollers who obtained suitable scrap from the yards. Plans were made for a new yard costing $2.3 million to handle ships up to 12,000 deadweight tons at the Port of Haldia in West Bengal. This yard will be built either by a private company or by the state-owned Metal Scrap Trade Corp. Ltd. (MSTC) of Calcutta. The Great Eastern Shipping Co. recommended that the Indian Government scrap 200 poor-fuel-efficiency vessels built in the 1970's. Most vessels broken in India were bought from foreign shipowners.

A Pakistani Government committee recommended that the budget decision made in July be reversed to decrease the customs duty on vessels for scrapping from 85% to 50% and the import duty be levied at a fixed rate based on a deadweight ton instead of ad valorem basis. Pakistan's shipbreaking industry supplied 90% of the ferrous metal requirements of the country's rolling mills. The demand for ship scrap was currently about 1 million tons per year representing $21 million in custom duties. The Gadani Beach shipbreaking activity, including beaching facilities, said to be the world's second largest facility, was given a $15 million grant by the Muslim Commercial Bank to expand capacity. Gadani's shipbreaking scrapped 6 vessels in 1973 and 154 in 1982-83.

The number of tankers that eventually could have been laid up or scrapped was reduced by Saudi Arabia's precautionary step in the last 2 months requiring the loading and shipping of an emergency floating stockpile of 50 million barrels of crude oil. Thirty tankers were leased for this purpose at a daily charge of $17,000 for each tanker. Some of the loaded vessels were outside the entrance of the Persian Gulf and others were enroute to Bantrey Bay in Ireland, the Carribean area, and Okinawa, Japan.

A planned Spanish expansion program, involving sites at Barcelona, El Ferral, Gijón, and Santander, could revive the shipbreaking industry and enable the industry to scrap 10 VLCC annually. Ships received for breaking in the first half of the year totaled 195,000 tons compared with 150,000 tons in the same 1982 period.

Far Eastern shipbreaking markets before October were unsettled because of dissatisfaction with Taiwan's CDVTC cartel that was formed September 24, 1982. Finally, in late November, 57 of the 60 total CDVTC members voted to abolish the system of unified purchasing and revert to a free trade system. Four members of CDVTC withdrew from the system and commenced individual purchase negotiations that included four American Oil Co. tankers, one of which was only 4 years old, at $117 per ton. Previously, CDVTC bought obsolete ships for breaking and then auctioned them among its members in the Far East.

The Taiwan Government banned the import of parts of obsolete ships in containers. At midyear, breakers held 55 obsolete ships aggregating 1 million long tons. By mid-August, stocks of 51 vessels totaled 954,000 long tons and purchase prices were leveling off. In February, the CDVTC paid $71 to $82 per ton for large tonnage vessels. Prices paid in India and Pakistan increased from $49 to $70 per ton in January to $60 to $82 in May.

A group of foreign and Thai investors intended to invest $13 million in a 600,000-ton-per-year breaking facility at Prachaub Khiri Khan, Thailand, near a site favored for a planned integrated steelworks. The breakers planned to buy obsolete ships in Hong Kong and Taiwan and sell rerollable plate and scrap steel to domestic and overseas customers. One VLCC was bought for $109 per ton for breaking on the island of Sri Racha.

Vessel demolition practices by Shipbreaking (Queensborough) Ltd. were cited for safety violations during the breaking of the British aircraft carrier *Ark Royal* at Cairnyan, Scotland. Meanwhile, the United Kingdom Ministry of Defense imposed new regulations on the sale of those obsolete ships posing the asbestos hazard.

A new joint Venezuelan-Spanish venture shipbreaking company, Astilleros Navales Venezolanos S.A., planned in November to start breaking vessels up to 60,000 deadweight tons at Los Taques in the Paraguaná Peninsula. A part of the 100,000-ton-per-year scrap output would go to state-owned steelmaker C.V.G. Siderúrgica del Orinoco C.A., whose imports were 30,000 tons per year.

European Communities (EC).—The European Independent Steelworks Association, principally representing minimills, requested the EC to impose a ban on exports of ferrous scrap to nonallied countries. British scrap merchants objected to the request, claiming that exports to nonallied countries have provided the only outlet for the excess of scrap in the United Kingdom. Conversely, the British Steel Corp. (BSC) claimed that exports resulted in periodic shortages of higher grades of scrap. Spain, a non-EC country, was the destination for 70% of scrap exported by British merchants who claimed that exports were the key factor in their return to profitability. Reportedly, the president of Deumu Deutsche Erz-und Metall-Union GmbH, one of the three largest ferrous scrap companies in the Federal Republic of Germany, stated that no steel mill in Europe had suffered from an inadequate scrap supply in 1983 as a result of the rise of exports to nonallied countries. Representatives of Belgium-Luxembourg met November 30 to discuss the availability of scrap in these countries, which are traditionally net importers of scrap.

Scrap purchases, including imports, within the EC totaled 27.9 million tons in 1982 compared with 29.0 million tons in 1981. Italian consumers purchased 11.4 million tons in 1982 and 11.5 million tons in 1981. Stainless steel scrap was in short supply in Northern Europe, but prices in 1983 were not high enough to interest U.S. suppliers. Some scrap dealers increased their exports of ferrous scrap to cope with the sluggish steelmaking rate in Europe, thereby slowing the rise in U.S. steel scrap export prices. In Belgium, steelmakers, aided by Government subsidies, were purchasing ferrous scrap abroad, while the Netherlands exported scrap to the Far East on a large scale.

The International Iron and Steel Institute, Brussels, Belgium, published a report titled "Scrap and the Steel Industry." The report included trends and prospects for scrap and other solid metallics used in the iron and steel industry.

The President of the Bureau International de la Recuperation (BIR), in a European electric steel conference in September at Aachen, Federal Republic of Germany, stated that the current world annual consumption of ferrous scrap was about 386 million tons, 90% of which was used in the steel industry. He further stated that from 1972 to 1981, world consumption of scrap, as a percentage of raw steel produced, fell from 44% to 40% as a result of the decline in open-hearth steelmaking operations that was not matched by a corresponding reduction in blast furnace capacity, growth in the use of DRI, the use of more pig iron in electric furnaces, and a reduction in home scrap production because of the growth of continuous casting. A director of the West German Iron and Steelmakers Association, at the spring convention of BIR in Hamburg, Federal Republic of Germany, stated that the U.S. ferrous scrap reservoir serves as a supply buffer for the rest of the world. U.S. scrap-processing capacity exceeds demand and is a factor that could bring about a drastic reduction in the use of iron ore in steelmaking.

France.—French steelmakers were not interested in increasing electric-furnace capacity, preferring instead the blast-furnace route. The use of the dominant L-D steelmaking process left France with a large surplus of scrap for export in 1982, of which 2.65 million tons went to EC countries and 750,000 tons went to nonallied countries.

Germany, Federal Republic of.—Exports of ferrous scrap in 1982 comprised 2,701,000 tons to EC members and 333,000 tons to nonallied countries, while exports in the first half of the year totaled 1,499,000 tons. Higher price levels abroad attracted ferrous scrap away from the domestic market where Ruhr steelmakers in May and July held to their purchases of grade 0 scrap, at least one-eighth inch thick, at $45 per ton. In October, the steelmakers had to pay $58 per ton for grade 0 scrap.

The Tinplate Information Center tested a mobile, lightweight shredder to increase the iron content of municipal incinerator residue from the normal 50% to a 70% level. The steel industry removed its 250,000-ton-per-year minimum on incinerated scrap that it was obliged to take.

Greece.—The American exporter, Hugo Neu, shipped 22,000 tons of shredded scrap to Greece in September at about $83.50 per ton, f.o.b. U.S. east coast, corresponding with the lowest price quoted by U.S. exporters for No. 1 heavy melting steel scrap.

Hong Kong.—The scrap market was dominated by the minimill of Shui Wing Steel Ltd., which consumed 60% of the colony's 25,000-ton-per-month scrap arisings. This steelmaker in midyear began taking supplies direct from collectors, in a move to bypass local scrap merchants and stabilize supplies.

India.—MSTC predicted that India would import about 772,000 tons of ferrous scrap in the fiscal year starting April 1, and that no stainless steel scrap would be imported because the 65% import duty made it uneconomical. MSTC expected that India's minimills would need, in the same fiscal year, 1,102,000 total tons comprising imported scrap and ships for breaking.

Indonesia.—The electric-furnace steelmaker, Ispat, made its second import purchase for August shipment of 18,000 tons of shredded scrap from U.S. gulf exporter, Southern Scrap, through the trader, Klöckner & Co. of the Federal Republic of Germany, for $104 to $105 c.i.f. per metric ton.

An earlier import purchase was made from Hugo Neu, a U.S. west coast exporter. Ispat estimated its imports at 110,000 tons. Except for stringent Indonesian discharge regulations permitting no vessels other than ferrous scrap carriers, Klöckner might instead have bought a cargo from Hugo Neu. Indonesia's state-run electric-furnace steelmaker, P.T. Krakatau Steel, contracted with Hugo Neu via the Japanese trader, Nissho-Iwai Corp., for a 25,000- to 28,000-ton cargo comprising three-fourths No. 1 heavy melting and one-fourth shredded for $104 to $105 per ton.

Italy.—Italy imported 4.3 million tons of ferrous scrap from EC countries and 1.1 million tons from nonallied countries in 1982. According to Assofermat, the Italian scrap federation, collection of scrap in Italy in 1983 was halved in some areas because of closures of many metalworking companies. Supplies from France were affected by France's industrial recession; scrap from the Federal Republic of Germany was absent from the Italian market, while Austria and other nonallied countries offered higher prices than did Italy. The supply of scrap was small and, because the demand and domestic prices had fallen, Italian steelmakers requested a temporary ban on EC exports of ferrous scrap. The requests were studied by an EC committee, whose 10 members were not expected to remove the ban. Because the prices paid in Italy for French and West German scrap had nearly doubled, any ban on EC exports to nonallied countries would have an immediate effect resulting in India and Spain turning to U.S. dealers for additional scrap requirements. To counter the EC ban on exports, Italian consumers bought 60,000 tons of U.S. scrap for December delivery.

Japan.—Some Japanese steelmakers increasingly depended on imports because of the deterioration in quality of domestically produced scrap. These steelmakers intended to level off the prices of such scrap by continuing sporadic purchases.

Japanese imports of steel scrap totaled 4.3 million tons. Principal suppliers were the United States, 59%; the U.S.S.R., 10%; and the Netherlands, 9%.

Freight rates on 20,000- to 45,000-ton cargoes of ferrous scrap to Japan included the cost of the lay days required during loading and unloading operations at rates of 2,500 to 4,500 tons per day. Export price offers, f.o.b. U.S. east coast ports, were $86 to $88 per ton, with ocean freight costs ranging from $20.80 to $22.40 per ton for shipments in the July 1983 to February 1984 period. In the same time period, export prices offered, f.o.b. U.S. west coast ports, were $89 to $91 to which were added freight rates of $16.40 to $17.40 per ton. Other freight rates, per ton, for ferrous scrap destined for Japan were $22 from Cardiff, Wales; $20 from Liverpool, England; and $16 from Rotterdam, Netherlands.

The Japan Iron and Steel Federation reported in 1983 that in the first 10 months Japan exported 98,700 tons of ferrous scrap including 1,034 tons of alloy steel scrap, of which 447 tons went to Taiwan. The Federation reported total imports of ferrous scrap in the same time period as 3.36 million tons, which included 105,000 tons of alloy steel scrap, of which 52,000 tons came from the United States, 13,000 tons from Taiwan, and 12,000 tons from Hong Kong. Imports in the first 10 months of all types of ferrous scrap from the United States totaled 2,058,034 tons, while 445,800 tons came from the U.S.S.R. at about $95 per ton. The Federation reported that at the end of August, pig iron and ferrous scrap stocks totaled 7.5 million tons after decreasing for 5 consecutive months. Nippon Steel Corp., Kawasaki Steel Corp., and Daido Steel Co. Ltd. paid $576 to $584 per ton for cut-grade 18/8 stainless steel scrap during May through November, while U.S. prices remained at $590 to $617 c.i.f. per ton from U.S. east coast and gulf ports. Nippon Steel intended to reduce the number of trading companies and wholesalers handling its stainless steel scrap purchases from 20 to 3 companies, namely, Nittelsu Shoji, Nissho-Iwai, and Hishisau Shoji, on or after October 1. Other companies were to furnish such scrap to these three companies as subordinate suppliers.

Korea, Republic of.—The delivered price of ferrous scrap for 10,000- to 36,000-ton cargoes received from U.S. east coast ports averaged $110 per ton; U.S. west coast ports, $111; and U.S. gulf ports, $108. Freight rates, including the cost of lay days during loading and unloading, were approximately $21 per ton from east coast ports, $17.50 from west coast ports, $18.50 from Tacoma, WA, and $23.25 from Great Lakes ports. A few shipments of ferrous scrap from Middle and Near East sources were delivered at $93 per ton, and several shipments delivered from England brought $99 per ton. Many cargoes from the United States comprised up to one-third motor blocks, a type of scrap preferred by some Republic of Korea steelmakers who paid about $3 per ton more for it than for No. 1 heavy melting scrap. Consumers of ferrous scrap held up purchases of scrap in midyear because of a change in the country's monetary policy, after which customers paid about $12 more per ton for scrap contracted near yearend compared with midyear contracts.

Mexico.—The Hylsa Steel Group, Monterrey, in January bought 34,500 tons of ferrous scrap from three U.S. companies thereby breaking the freeze in scrap trade prompted by devaluation of the peso in August 1982. The group paid for the first shipment in dollars after obtaining a preferential exchange rate from the Mexican Government. The second shipment was paid for at the regular exchange rate by cash in advance and letters of credit, indicating that the group greatly needed the scrap because of withdrawals from its stocks since August 1982. In April 1983, Hylsa formed Transamerica Trading Co. Inc., a scrap brokerage firm to act as an exclusive broker for its U.S. scrap purchases. Previously, Hylsa had dealt with five or six brokers who objected to the limiting of competition by Hylsa's action. In June, the need for scrap in Mexico was undiminished even though the country's DRI plants and domestic scrap sources essentially met the demand by the steelmakers.

Netherlands.—Exports to Japan and the Republic of Korea were facilitated for large-scale processors such as Heuvelman and Holland-VUY who had yards on deep water. The Pamatex-Thomas-AVI shredder-owner combination took an important part in nonallied countries exports. In the first 6 months, the Netherlands exported 288,000 tons to EC countries and 575,000 metric tons to nonallied countries, including 202,000 tons to India. Rotterdam had excellent transshipment facilities to load large vessels from barges and small vessels arriving from the Federal Republic of Germany and other North European nations. Exports to Japan brought only $4.50 to $9 per ton more than domestic prices in Western Europe, because the Government maintained its policy of total export freedom for ferrous and alloy scrap worldwide. In October, a 47,000-ton cargo of No. 1 scrap left Rotterdam for Japan, reportedly the largest single cargo of scrap ever loaded in Continental Europe. Unloading from barges onto ocean vessels required less than 2 days at a rate of 25,000 tons per day. Exports to the Brescian area of northern Italy remained strong using the 500-mile barge haul to Basel, Switzerland, and subsequent transshipment on railroad cars.

South Africa, Republic of.—In March, the South African Iron and Steel Industrial Corp. Ltd. (Iscor) pulled out of the ferrous scrap buying cartel, Ferrous Scrap Distributors (FSD), taking with it its associated companies Cape Town Iron and Steel Works (Pty.) Ltd. and the Union Steel Corp. (of South Africa) Ltd. FSD, which formerly bought about 95% of the Republic of South Africa's ferrous scrap, was investigated by the country's Competition Board. Iscor's main quarrel with FSD was its low allocation of scrap from the cartel's intake. The Republic of South Africa, normally short of scrap, had several DRI projects underway for Dunswart Iron and Steel Works Ltd. and Scrap Metal that were scheduled for completion in 1985. Iscor, with 1 million tons of ferrous scrap in stock in 1983, was seeking long-term supply agreements with South Africa Transport Services, the state-railway group. In April, two of the country's leading scrap merchants, Jeepe Metals and Rand Scrap, bypassed the cartel to conduct their combined 40,000- to 50,000-ton-per-month trade direct with the steelmakers. By yearend, Scaw Metals Ltd., a steelmaker, bought Rand Scrap and Germiston Scrap, while Davsteel, another steelmaker, bought Jeepe Metals and Hercules, to secure their future scrap supplies. In the past, FSD paid one countrywide price for scrap and then paid the rail freight direct to steelmakers in the Gold Reef area of the Transvaal, at rates ranging from $24 per ton from Durban, $32 from Eastern Cape Province, and $40 from Western Cape Province. Following the collapse of the FSD cartel, Chick's Scrap Metals turned to exports at a 50,000-ton-per-year rate from Port Elizabeth, East London, and Durban.

Spain.—About 70% of Spain's imports of ferrous scrap came from the United Kingdom, whose Government insured exporters against risky payments for cargoes to about 30 privately owned Spanish minimills. Because of Spain's large imports, the EC proposed that a common market in scrap be effective for a 5-year transitional period following Spain's joining the EC. Spain had freedom of supply because most EC scrap exporting regulations had been lifted owing to the weakness of EC internal consumption. In February, the movement of scrap at ports was unsatisfactory, with about 25 vessels incurring demurrage while waiting to unload.

Sweden.—Sweden's ferrous scrap buying agency, Jarnbruksfornadenheter, in December contracted with the U.S.S.R. for first-quarter 1984 delivery of 45,000 tons of scrap at unknown price levels. Sweden's purchase of Soviet scrap increased from 12,624 tons in 1981 to 187,246 tons in 1982.

Taiwan.—In 1983, steelmakers paid approximately \$105.50 per ton for scrap from U.S. east coast ports including \$22.90 for ocean freight plus lay charges for 20,000-ton cargoes; 21,000-ton cargoes from U.S. west coast ports cost \$96 per ton including \$17.45 for ocean rates and lay charges; and 19,500-ton cargoes from U.S. gulf ports cost \$106 per ton including \$25 for ocean rates plus lay charges. In midyear steelmakers paid approximately \$117 to \$119 per ton for steel plate from Taiwanese shipbreakers and \$101 to \$103 per ton for city-generated scrap from other sources. U.S. ferrous scrap exports to Taiwan totaled 499,475 tons.

Trinidad and Tobago.—Trinidad was expected to import 25,000 to 30,000 tons of scrap for the Iron and Steel Co. of Trinidad and Tobago (Iscott) steelmaking shop, principally from the United States. Ferrous materials used in this shop were about 80% DRI and 20% scrap. Trinidad had no indigenous scrap industry, and Iscott was unwilling to set up a shredder for scrap that could be obtained cheaply from other Caricom (Caribbean Common Market) countries, where collection was a problem. Texaco offered Iscott about 25,000 tons of scrap that would have to be collected and processed by Texaco.

Turkey.—The ferrous scrap industry reportedly was totally disorganized. The largest merchants could deliver only 3,000 to 5,000 tons per month, most of which was rated poor quality, while most merchants had smaller outputs. The normal practice was to receive scrap in lorry-load lots with the quality and price determined on an ad hoc basis. Steelmakers sited near the coast relied largely on imported scrap, which accounted for 60% to 85% of their consumption. Inland steelmakers depended entirely on domestic scrap.

Turkish steelmakers imported about 1.1 million tons of ferrous scrap in 1982 of which 78% was purchased by the five largest private sector companies comprising Cukurova Celik, Colakoglu Metalurji AS, Metas Izmir Metalurji Fabrikasi TAS, Asil Celik Sanayi ve Ticaret AS, and Tuben Celik. Smaller tonnage mills, comprising Icdas, Istanbul Metalurgi, Elektro-Metal Sanayii AS, and Electrofer, collectively imported 145,000 tons in 1982. The Turkish import-export company Duru Tezel approached some United Kingdom scrap merchants for 1.0 to 1.5 million tons per year, mostly comprising shredded scrap. Duru Tezel chose the United Kingdom as the main source rather than the United States because of the lower freight costs involved. The company considered buying ships in the United Kingdom for dismantling in Turkey, using such ships to transport the United Kingdom scrap to Turkey. Imports of the United Kingdom's scrap to Turkey in the first half of 1983 were 112,000 tons at approximately \$80 per ton.

U.S.S.R.—Based on scattered information, the U.S.S.R. continued to be a growing competitor in worldwide ferrous scrap exports. Total exports in 1981 were 2.7 million tons. In 1982, exports to Italy were 819,735 tons, representing a moderate portion of the Italian market. Soviet exports to Japan were about 230,000 tons. In the first 10 months of 1983, Soviet exports of ordinary steel scrap to Japan were 445,800 tons, considerably more than the 241,000 tons shipped by Australia to Japan in the same time period. Reportedly, this significant increase was explained by the "supreme quality" of Soviet No. 1 and No. 2 grades of scrap and by the Soviet Government's consistent policy of undercutting U.S. prices to Japan by \$5 to \$10 per ton. The Soviets also gained a sizable share of the scrap imported by Spain.

United Kingdom.—Exports of ferrous scrap in 1982 comprised 514,000 tons to EC countries and 2,717,000 tons to nonallied countries. Of the 882,000-ton production of shredded scrap, 496,000 tons was exported. In the first half of the year, 331,000 tons went to EC countries and 1,814,000 tons went to nonallied countries. Purchases by domestic consumers, who were largely concerned with quality, were at a 3.6-million-ton annual rate. Exports increased after the devaluation of the British pound in January and the termination of the London dock strike in late April that allowed the use of larger vessels. Exports totaled 4.2 million tons valued at \$282 million. The British Scrap Federation (BSF) claimed that the United Kingdom was a net scrap exporter, second only to the United States, and that the Government should support better scrap handling facilities at docks. The BSF, in assessing claims that the United Kingdom's scrap shipments to Spain were short-weight, sent observers to the Basque port of Pasaje to check the weights of 20 cargoes during unloading. In October, the largest scrap cargo ever shipped from the United Kingdom left Liverpool for Japan with 36,500 tons comprising mainly No. 1 and No. 2 grades. The cargo was loaded by Sheppard Waste Recovery and the delivered cost was about $104 per ton c.i.f. A size limit on the United Kingdom's cargoes to Japan was evident because of the general limit of Japanese unloading facilities. Shippers contracted for small vessels to handle scrap to Northern European ports where buyers preferred smaller and less costly cargoes. A midyear decline in freight rates of $3 to $5 per ton encouraged exports to the Far East that brought British shippers $84 to $85 per ton, f.o.b. for No. 1 grade. Turkey was seen as a useful alternative to Spain for the United Kingdom scrap.

Prices of scrap to British consumers were a problem because of their volatility. BSC was no longer a dominant force in the United Kingdom's ferrous scrap market and reacted to market changes rather than leading them as in the past. Some other steelmakers deliberately consumed scrap from their stocks during the summer months to reduce the upward pressure on scrap prices because of the significant demand for exports to Spain. Reportedly, 50% of some steelmakers' home scrap was exported. In April, BSC obtained a $1.50 per ton price reduction for scrap for May delivery, but in August paid $8 to $12 per ton more to expedite deliveries. In September, following a $15 per ton decline in export prices to northern Spain, British steelmakers offered $4 to $8 per ton less for scrap for October delivery.

In mid-March, an increase in the London Metal Exchange (LME) quotations for virgin nickel increased the United Kingdom price of 18/8 stainless steel solids scrap to $476 per ton, an increase over the $454 per ton, f.o.b. Europe, a week earlier. The increase was attributed to merchant speculation because the United Kingdom's steelmakers held adequate stocks. Metal Bulletin prices quoted in May were down to $408 to $435 per ton of 18/8 solids.

The United Kingdom's scrap industry had 46 ferrous scrap shredders rated at 1-million-ton-per-year total capacity based on a one-shift operation.

In May, ELG Metals, Federal Republic of Germany, a stainless and alloy scrap concern, began scrap collection in Manchester, England, and in May, Thos. W. Ward, an affiliate of Rio Tinto Zinc Corp. Ltd. of Chile, sold its scrap operations near Portland, England, to H. Williams and Sons (Hitchin) Ltd. The Portland yard was within BSC's direct-supplier network. In March, seven scrap yards were sold by Thos. W. Ward to the Bird Group comprising yards at Birmingham, Grantham, Ilkeston, London, Peterborough, Scunthorpe, and Sheffield. The Bird Group completed its $3 million restructuring and modernization program after large-capacity scrap-processing equipment started operation in several yards. However, the group's outstanding achievement was a new scrap cleansing process designed to upgrade lower grades of scrap to medium-quality grades. Details of this process were not available. Coopers (Metals) Ltd. and Robinson and Hannon Ltd. amalgamated their dockside interests at Tyne Dock, South Shields, and Sunderland in northeast England. Brasway Ltd. sold its Cardiff dock operations to Hartlepool Steel. Thos. Hill and Co. expanded its export potential by leasing dock facilities at Kings Lynn, Norfolk, England, to permit loading scrap cargoes up to 2,500 tons to serve markets in Western Europe, Italy, and Spain.

The scrap supply-demand situation in the United Kingdom was strongly influenced by the decline in demand by the domestic ferrous industries following violent fluctuations in short-term demand, fluctuations in the quantity of scrap collected in response to price changes, a diminishing difference between BSC and private sector purchasing requirements, and a declining influence by both groups on British prices. Uncollected scrap was accumulated to form a large available supply resource awaiting price increases to make collection attractive. The percentage of British scrap that was exported followed a 21% annual trend in the 1972-82 period.

TECHNOLOGY

The Bureau of Mines and NARI agreed in April 1983 to extend their scrap metals research program for an additional 2 years. A portion of the program will include the recovery of chromium, cobalt, and nickel from stainless steel scrap and superalloy wastes and the recycling of material from scrap automobiles. In the past 2 years about $600,000 was funded by the Bureau for the scrap metals research program.[5]

Bausch and Lomb, Rochester, NY, developed the 3600 Mobile Metal Analyzer permitting nondestructive and automatic composition analysis of alloys in virtually all situations. Hundreds of alloys, including those containing light elements such as aluminum, carbon, magnesium, and silicon, can be identified by the unit. The instrument has four testing modes: Fast Profile, Alloysort, Pass-Fail, and Quantitative. The 3600 Analyzer features an accessory 2-kilowatt motor generator for situations where electricity is not available.[6]

Systems Alternations, Toledo, OH, in midyear, nationally marketed its industrial scrap data base system. The system, developed in cooperation with scrap businesses in California, Michigan, Ohio, and Pennsylvania, was versatile for all recycled materials including operations such as brokering and trading, multiple yard operations, and processing.[7]

Westinghouse Electric Corp. announced in September that it will study its plasma torch technology in a 2.5-ton-per-hour cupola at its Pittsburgh, PA, research center. This demonstration project is intended to increase the use of low-cost iron chips and borings as charge material. The $2 million project, scheduled for operation in late 1984, is being funded by Westinghouse, the Electric Power Research Institute, and General Motors. Reportedly, the improved efficiency of plasma torches may permit as much as 70% chips and borings in the cupola charge.[8]

Plasma technology was tested in 1983 by Voest-Alpine AG at Linz, Austria, in a scrap-consuming pilot plant rated at a total annual raw steel output of 150,000 tons. The electrodeless plasma melting furnace provided an alternative method to produce steels of various qualities.[9]

Aciéries et Laminoirs de Lorraine (Sacilor) was experimenting with a 100% scrap charge in its No. 3 Rombas blast furnace at Moselle, France, in an attempt to reduce production costs to a level comparable to those of electric-furnace shops. Two months of experiments were scheduled to start in September using 70,000 to 100,000 tons of various grades of scrap including low grades.[10] Results of the experiments are unknown.

A process was developed by Melton Mowbray, Leicestershire, England, to reconstitute steel chips into forms without melting. In the process, chips are fragmented into a clean, coarse powder that is compacted into billets, which after heating can be forged or extruded. Reportedly, the energy required for the reconstituted steel is 60% of that for basic wrought steel and the cost is 50% less than for conventional castings.[11]

Wiggin Steel and Alloys, Birmingham, England, offered a metal reclamation process to foundries, forges, and other metal-processing industries in the United Kingdom. The argon-oxygen-decarburization (AOD) process uses a variety of metal sources including grinding dust, foundry scrap, and billet croppings.[12]

Spectro GmbH of the Federal Republic of Germany was marketing a small mobile spectrometer called Spectrotest-L. The small mobile spectrometer was developed primarily for product-mix control and metal sorting identification.[13]

Daido Steel, Nagoya, Japan, designed and installed a commercial-scale scrap preheater to use the sensible heat in the exhaust gas from a 25-metric-ton arc furnace. Tests confirmed that the higher the ratio of light scrap in the charge, the higher the heating efficiency. The full-scale preheater in commercial operations achieved reduction of steelmaking time by 8 minutes per heat, power consumption by 50 kilowatt hours per ton of charge, electrode consumption by 0.7 kilogram per ton of charge, refractory consumption by 17%, and an overall cost reduction of approximately $3 per ton of charge.[14]

Research on ferrous scrap preheating for an electric arc furnace by Toshin Steel Co. Ltd. and Nippon Kokan K.K., Tokyo, Japan, resulted in a process, using gas recycling, to handle scrap without the environmental problems associated with secondary gas emission. The process reduced power consumption by 36 to 45 kilowatt hours per ton, reduced electrode consumption by 0.2 to 0.6 kilogram per ton, and reduced steelmaking time by 8 minutes.[15]

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[1]Physical scientist, Division of Ferrous Metals.

[2]All quantities are in short tons unless otherwise noted.

[3]Brown, J. W., and R. L. Reddy. The Future of Direct Reduced Iron in North America. Iron and Steelmaker, v. 10, No. 12, Dec. 1983, pp. 34-41.

[4]Steele, D. K., and J. W. Sterner. A Water Elutriator System for Recovering Nonmagnetic Metals From Automobile Shredder Rejects. BuMines RI 8771, 1983, 22 pp.

[5]American Metal Market. NARI, Bureau of Mines Extend Joint Research. V. 91, No. 74, Apr. 15, 1983, p. 2.

[6]———. Mobile Analyzer to be Shown. V. 91, No. 13, Jan. 19, 1983, p. 9.

[7]———. New Recycling Systems Offered. V. 91, No. 140, July 20, 1983, p. 9.

[8]———. GM, Westinghouse to Try Foundry Plasma Venture. V. 91, No. 184, Sept. 21, 1983, pp. 1, 7.

[9]Skillings' Mining Review. Voest-Alpine's Steelmaking Complex in Linz. V. 72, No. 47, Nov. 19, 1983, p. 6.

[10]Metal Bulletin (London). Sacilor Tries Scrap to Cut Costs. No. 6805, July 19, 1983, p. 23.

[11]Foundry Management & Technology. Reclaim Chips Without Melting. V. 111, No. 4, Apr. 1983, p. 63.

[12]Steel Times. AOD Refining at the Heart of Scrap Reclamation. V. 211, No. 4, Apr. 1983, pp. 185-186.

[13]American Metal Market. New Mobile Spectrometer Sorts, Identifies Metals. V. 91, No. 121, June 22, 1983, p. 8.

[14]Iron and Steel Engineer. Scrap Preheating by Exhaust Gas From Electric Arc Furnaces. V. 60, No. 11, Nov. 1983, pp. 54-61.

[15]———. Scrap Preheater for Electric Arc Furnace. V. 60, No. 4, Apr. 1983, pp. 45-50.

Table 2.—U.S. consumer receipts, production, consumption, shipments, and stocks of iron and steel scrap and pig iron in 1983, 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	301	(1)	13	1	318	7	21
Cut structural and plate	954	150	331	2	1,433	15	129
No. 1 heavy melting steel	7,380	1,271	8,505	45	15,871	1,329	1,570
No. 2 heavy melting steel	1,833	117	706	4	2,674	21	243
No. 1 and electric-furnace bundles	5,594	229	2,018	6	7,648	154	790
No. 2 and all other bundles	899	35	7	--	1,003	5	104
Electric furnace 1 foot and under (not bundles)	22	3	(1)	--	24	--	4
Railroad rails	102	2	2	6	173	2	39
Turnings and borings	653	17	136	(1)	844	10	70
Slag scrap (Fe content 70%)	730	179	2,670	1	3,072	329	192
Shredded or fragmentized	1,755	554	51	--	2,280	4	224
No. 1 busheling	1,126	50	153	1	1,299	91	105
All other carbon steel scrap	1,296	458	5,871	7	7,245	418	498
Stainless steel scrap	479	18	505	(1)	973	30	104
Alloy steel (except stainless)	146	130	896	32	1,131	142	278
Ingot mold and stool scrap	282	369	617	827	1,603	529	327
Machinery and cupola cast iron	2	--	3	1	3	1	7
Cast iron borings	163	27	50	(1)	178	157	20
Other iron scrap	210	134	243	1	449	167	192
Other mixed scrap	445	134	165	(1)	776	11	37
Total[2]	24,371	3,875	22,941	934	[3]48,996	3,423	4,953
MANUFACTURERS OF STEEL CASTINGS							
Carbon steel:							
Low-phosphorus plate and punchings	351	2	121	--	426	3	34
Cut structural and plate	83	4	6	--	100	(1)	11
No. 1 heavy melting steel	89	(1)	20	--	113	--	3
No. 2 heavy melting steel	45	--	1	--	47	--	6
No. 1 and electric-furnace bundles	12	(1)	2	--	11	--	1
No. 2 and all other bundles	1	--	--	--	1	--	(1)
Electric furnace 1 foot and under (not bundles)	52	(1)	16	--	67	(1)	2
Railroad rails	6	--	--	--	4	--	(1)
Turnings and borings	24	--	13	--	29	4	2
Slag scrap (Fe content 70%)	--	--	(1)	--	--	(1)	(1)
Shredded or fragmentized	19	--	--	--	19	--	5
No. 1 busheling	13	--	--	--	8	(1)	2
All other carbon steel scrap	210	4	134	--	331	1	35
Stainless steel scrap	8	1	17	--	25	(1)	6
Alloy steel (except stainless)	28	(1)	65	(1)	96	(1)	24
Ingot mold and stool scrap	1	--	(1)	--	2	(1)	(1)
Machinery and cupola cast iron	19	--	(1)	--	19	--	(1)
Cast iron borings	62	(1)	19	--	68	--	7
Motor blocks	(1)	--	--	--	(1)	--	(1)
Other iron scrap	28	(1)	17	--	44	2	8
Other mixed scrap	(1)	--	7	--	7	--	(1)
Total[2]	1,052	11	439	(1)	[4]1,415	11	144
IRON FOUNDRIES AND MISCELLANEOUS USERS							
Carbon steel:							
Low-phosphorus plate and punchings	593	34	66	1	691	10	30
Cut structural and plate	881	76	47	1	1,016	1	87
No. 1 heavy melting steel	46	22	64	(1)	99	40	11

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 1983, 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
IRON FOUNDRIES AND MISCELLANEOUS USERS —Continued							
Carbon steel —Continued							
No. 2 heavy melting steel	49	--	9	1	55	1	4
No. 1 and electric-furnace bundles	102	187	27	(1)	340	(1)	8
No. 2 and all other bundles	158	6	--	--	169	--	24
Electric furnace 1 foot and under (not bundles)	128	34	1	--	158	--	5
Railroad rails	151	(1)	7	(1)	163	(1)	9
Turnings and borings	221	2	7	1	235	8	33
Slag scrap (Fe content 70%)	25	--	1	--	25	1	7
Shredded or fragmentized	719	4	--	--	838	--	57
No. 1 busheling	577	29	62	--	668	19	9
All other carbon steel scrap	580	96	59	--	707	11	40
Stainless steel scrap	5	(1)	2	(1)	7	(1)	2
Alloy steel (except stainless)	22	(1)	6	1	25	4	11
Ingot mold and stool scrap	149	--	75	1	232	1	33
Machinery and cupola cast iron	786	4	246	2	971	1	95
Cast iron borings	643	197	98	1	919	29	40
Motor blocks	510	309	364	--	1,096	8	74
Other iron scrap	568	62	1,106	41	1,783	24	84
Other mixed scrap	474	63	632	4	1,173	7	47
Total[2]	7,385	1,125	2,879	54	[5]11,370	166	710
TOTAL—ALL TYPES OF MANUFACTURERS[2]							
Carbon steel:							
Low-phosphorus plate and punchings	1,245	36	200	2	1,434	20	85
Cut structural and plate	1,918	230	385	2	2,549	16	227
No. 1 heavy melting steel	7,515	1,293	8,588	45	16,083	1,369	1,584
No. 2 heavy melting steel	1,927	117	716	5	2,777	22	253
No. 1 and electric-furnace bundles	5,707	416	2,048	6	7,999	154	799
No. 2 and all other bundles	1,058	41	7	--	1,174	5	128
Electric furnace 1 foot and under (not bundles)	202	37	17	--	249	(1)	10
Railroad rails	258	2	9	6	340	3	48
Turnings and borings	898	19	156	1	1,107	22	104
Slag scrap (Fe content 70%)	754	179	2,670	1	3,097	330	199
Shredded or fragmentized	2,493	558	51	--	3,137	4	286
No. 1 busheling	1,716	78	214	1	1,974	109	116
All other carbon steel scrap	2,086	558	6,064	7	8,283	430	572
Stainless steel scrap	492	19	523	(1)	1,005	31	112
Alloy steel (except stainless)	196	130	967	33	1,252	146	313
Ingot mold and stool scrap	432	369	692	828	1,837	530	360
Machinery and cupola cast iron	806	4	249	3	992	2	102
Cast iron borings	869	224	166	1	1,165	187	66
Motor blocks	510	309	364	--	1,097	8	74
Other iron scrap	807	197	1,366	42	2,275	194	284
Other mixed scrap	919	196	805	4	1,957	18	83
Grand total[2]	32,808	5,011	26,259	988	[6]61,782	3,600	5,807

[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 1.9 million short tons.
[4]Internal evaluation indicates that scrap consumption is overstated by approximately 11,000 short tons.
[5]Internal evaluation indicates that scrap consumption is understated by approximately 1.0 million short tons.
[6]Internal evaluation indicates that total scrap consumption is understated by approximately 2.9 million short tons.

Table 3.—U.S. consumer receipts, production, consumption, shipments, and stocks of pig iron and direct-reduced iron in 1983

(Thousand short tons)

	Receipts	Production	Consumption	Shipments	Stocks, Dec. 31
MANUFACTURERS OF PIG IRON AND RAW STEEL AND CASTINGS					
Pig iron	919	48,770	48,991	996	258
MANUFACTURERS OF STEEL CASTINGS					
Pig iron	64	--	63	--	3
IRON FOUNDRIES AND MISCELLANEOUS USERS					
Pig iron	1,086	--	1,016	78	84
TOTAL—ALL TYPES OF MANUFACTURERS					
Pig iron	2,069	48,770	50,070	1,074	345
Direct-reduced or prereduced iron	184	--	258	--	120

Table 4.—Consumption of iron and steel scrap and pig iron in the United States in 1983, 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]	3,125	--	--	--	--	--	3,125	--
Basic oxygen process[3]	16,219	44,330	--	--	--	--	16,219	44,330
Open-hearth furnace	3,275	3,918	W	W	--	(4)	3,275	3,918
Electric furnace	[5]25,786	52	1,319	62	3,514	227	30,619	341
Cupola furnace	6	100	91	--	7,559	325	7,655	425
Other (including air furnace)[6]	585	72	6	1	297	18	888	91
Direct castings[7]	--	519	--	--	--	446	--	965
Total[1]	48,996	48,991	1,415	63	11,370	1,016	61,782	50,070

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]Less than 1/2 unit.
[5]Internal evaluation indicates that scrap consumption in electric furnaces operated by manufacturers of pig iron and raw steel and castings is understated by approximately 1.9 million short tons.
[6]Includes vacuum melting furnaces and miscellaneous uses.
[7]Includes ingot molds and stools.

Table 5.—Proportion of iron and steel scrap and pig iron used in furnaces in the United States in 1983

(Percent)

Type of furnace	Scrap	Pig iron
Basic oxygen process	26.8	73.2
Open-hearth furnace	45.7	54.3
Electric furnace	98.9	1.1
Cupola furnace	94.7	5.3
Other (including air furnace)	90.7	9.3

Table 6.—Iron and steel scrap supply[1] available for consumption in 1983, 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[2]
New England and Middle Atlantic:							
Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island	1,126	96	632	5	1,858	273	1,585
Pennsylvania	4,275	978	4,843	189	10,285	1,196	9,089
Total[2]	5,401	1,073	5,475	194	12,143	1,469	10,674
North Central:							
Illinois	2,935	614	1,770	34	5,354	233	5,121
Indiana	2,666	149	6,593	262	9,671	894	8,777
Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska	5,628	936	2,320	74	8,957	135	8,823
Ohio	4,554	1,198	5,037	230	11,019	330	10,689
Wisconsin	511	21	364	--	896	20	876
Total[2]	16,294	2,918	16,085	600	35,897	1,611	34,286
South Atlantic:							
Delaware, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, West Virginia	3,563	216	1,992	78	5,849	309	5,540
South Central:							
Alabama, Arkansas, Kentucky, Louisiana, Mississippi, Oklahoma, Tennessee, Texas	5,215	557	1,664	48	7,485	175	7,310
Mountain and Pacific:							
Arizona, California, Colorado, Hawaii, Montana, Nevada, Oregon, Utah, Washington	2,334	246	1,043	69	3,690	37	3,654
Grand total[2]	32,808	5,011	26,259	988	65,065	3,600	61,465

[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.—Consumption of iron and steel scrap and pig iron[1] in 1983, by region and State

(Thousand short tons)

Region and State	Pig iron and steel ingots and castings: Scrap	Pig iron and steel ingots and castings: Pig iron	Steel castings: Scrap	Steel castings: Pig iron	Iron foundries and miscellaneous users: Scrap	Iron foundries and miscellaneous users: Pig iron	Total[2]: Scrap	Total[2]: Pig iron
New England and Middle Atlantic:								
Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island	1,029	869	47	4	662	34	1,738	907
Pennsylvania	8,264	6,856	131	4	951	217	9,346	7,077
Total[2]	9,293	7,725	178	8	1,613	251	11,084	7,983
North Central:								
Illinois	4,234	3,036	169	(3)	586	249	4,989	3,285
Indiana	8,132	16,428	106	42	398	37	8,636	16,507
Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska	5,672	4,389	161	1	2,965	200	8,798	4,589
Ohio	8,244	9,400	68	5	2,423	123	10,734	9,528
Wisconsin	--	--	189	1	698	41	887	41
Total[2]	26,281	33,253	694	48	7,070	650	34,045	33,951

See footnotes at end of table.

Table 7.—Consumption of iron and steel scrap and pig iron[1] in 1983, 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 Atlantic:								
Delaware, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, West Virginia	4,998	W	52	3	619	28	5,668	31
South Central:								
Alabama, Arkansas, Kentucky, Louisiana, Mississippi, Oklahoma, Tennessee, Texas	5,173	[4]6,381	316	2	1,717	75	7,206	6,458
Mountain and Pacific:								
Arizona, California, Colorado, Hawaii, Montana, Nevada, Oregon, Utah, Washington	3,252	1,632	176	1	352	12	3,778	1,646
Grand total[2]	48,996	48,991	1,415	63	11,370	1,016	61,782	50,070

W Withheld to avoid disclosing company proprietary data; included in "South Central region."
[1]Includes molten pig iron used for ingot molds and direct castings.
[2]Data may not add to totals shown because of independent rounding.
[3]Less than 1/2 unit.
[4]Includes South Atlantic region.

Table 8.—Consumer stocks of iron and steel scrap and pig iron, December 31, 1983, 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	136	19	17	42	2	217	83
Pennsylvania	871	67	177	198	3	1,316	69
Total[1]	1,007	86	194	239	5	1,532	152
North Central:							
Illinois	537	W	6	43	W	588	15
Indiana	532	4	26	169	1	731	17
Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska	480	1	([2])	82	11	574	34
Ohio	469	8	47	86	9	618	87
Wisconsin	11	W	([2])	7	W	19	3
Total[1]	2,028	14	79	387	22	2,530	157
South Atlantic:							
Delaware, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, West Virginia	435	[3]12	11	76	[3]32	566	8
South Central:							
Alabama, Arkansas, Kentucky, Louisiana, Mississippi, Oklahoma, Tennessee, Texas	654	W	16	133	W	803	20
Mountain and Pacific:							
Arizona, California, Colorado, Hawaii, Montana, Nevada, Oregon, Utah, Washington	288	2	12	50	22	374	7
Grand total[1]	4,413	112	313	886	83	5,807	345

W Withheld to avoid disclosing company proprietary data; included in "South Atlantic region."
[1]Data may not add to totals shown because of independent rounding.
[2]Less than 1/2 unit.
[3]Includes South Central region.

Table 9.—U.S. average monthly price and composite price for No. 1 heavy melting scrap in 1983

(Per long ton)

Month	Chicago	Pittsburgh	Philadelphia	Composite price[1]
January	$56.14	$61.86	$59.76	$59.25
February	67.00	70.39	61.89	66.43
March	77.70	77.70	68.00	74.47
April	70.33	74.00	68.00	70.78
May	65.00	69.12	66.19	66.77
June	70.52	72.50	66.00	69.67
July	70.08	74.50	66.00	70.19
August	74.00	81.20	69.35	74.85
September	78.00	82.38	73.00	77.79
October	78.00	82.95	73.00	77.98
November	78.30	85.98	74.80	79.69
December	84.00	91.26	85.71	86.99
Average 1983	72.42	76.99	69.31	72.91
Average 1982	57.78	66.47	66.94	63.73

[1]Composite price, Chicago, Pittsburgh, and Philadelphia. American Metal Market, Mar. 8, 1984.

Table 10.—U.S. exports[1] of iron and steel scrap, by country

(Thousand short tons and thousand dollars)

Country	1979		1980		1981		1982		1983	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Canada	861	60,275	790	57,507	737	52,463	307	21,006	539	39,717
Greece	500	52,395	545	57,484	271	25,452	208	16,517	112	8,215
Italy	1,186	124,361	892	101,865	34	2,407	12	2,972	65	4,395
Japan	2,922	305,509	2,838	308,784	1,191	117,724	1,530	145,083	2,600	218,337
Korea, Republic of	1,418	152,483	1,736	192,745	1,241	114,736	1,522	115,515	1,476	111,051
Mexico	814	85,098	1,134	137,273	896	102,329	380	33,822	419	36,017
Spain	1,400	127,592	1,163	114,837	434	34,570	868	61,616	356	22,734
Taiwan	634	70,004	990	125,716	374	59,874	352	57,213	499	75,638
Turkey	242	23,482	318	31,363	364	31,814	639	48,286	700	50,851
Other	1,077	141,207	762	98,367	874	97,274	987	108,273	754	69,767
Total[2]	11,054	1,142,406	11,168	1,225,941	6,415	638,644	6,804	610,302	7,520	636,723

[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	1979[1]		1980[1]		1981[1]		1982[1]		1983	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Exports:										
No. 1 heavy melting scrap	2,697	269,845	2,907	297,666	1,606	141,205	1,883	138,973	1,895	139,935
No. 2 heavy melting scrap	1,117	104,017	1,067	102,137	618	51,630	626	44,032	720	50,081
No. 1 bundles	145	14,455	119	11,542	41	3,476	115	8,619	206	16,486
No. 2 bundles	652	46,889	314	24,852	273	18,993	181	11,310	220	13,727
Stainless steel scrap	112	66,118	125	78,034	63	40,307	131	74,052	80	44,671
Shredded steel scrap	2,980	308,383	3,323	345,946	1,923	179,626	2,023	160,169	2,029	154,753
Borings, shovelings, turnings	889	59,467	769	50,381	486	24,757	577	28,923	532	28,277
Other steel scrap[2]	1,828	211,352	1,762	240,886	903	127,937	878	112,130	1,532	164,101
Iron scrap	632	61,879	783	74,497	501	50,714	389	32,096	306	24,692
Total[3]	11,054	1,142,406	11,168	1,225,941	6,415	638,644	6,804	610,302	7,520	636,723
Ships, boats, other vessels (for scrapping)	73	5,436	169	18,340	52	3,643	69	4,440	198	9,623
Rerolling material	70	10,222	86	12,768	57	10,831	53	7,969	34	4,194
Grand total[3]	11,197	1,158,064	11,423	1,257,049	6,524	653,118	6,925	622,711	7,752	650,540
Imports for consumption:										
Iron and steel scrap	760	70,804	582	61,192	556	62,126	[r]474	[r]38,020	641	48,219

[r]Revised.
[1]Starting in 1978, exports of rerolling material are not comparable with those of previous years because of a change of classification by the Bureau of the Census.
[2]Includes terneplate and tinplate.
[3]Data may not add to totals shown because of independent rounding.

Table 12.—U.S. exports of rerolling material (scrap), by country[1]

(Thousand short tons and thousand dollars)

Country	1979		1980		1981		1982		1983	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Korea, Republic of	2	172	4	538	--	--	--	--	5	462
Mexico	57	8,614	65	10,848	55	10,267	33	5,290	28	3,579
Pakistan	--	--	2	185	--	--	--	--	--	--
Other	11	1,436	14	1,197	2	564	20	2,679	1	153
Total	70	10,222	[2]86	12,768	57	10,831	53	7,969	34	4,194

[1]Starting in 1978, exports of rerolling material are not comparable with those of previous years because of a change of classification by the Bureau of the Census.
[2]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	1982		1983	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Austria	25	$118	116	$253
Belgium-Luxembourg	36	2	422	11
Canada	[r]389,661	[r]32,211	589,645	41,754
Germany, Federal Republic of	[r]1,171	[r]249	2,027	94
Japan	[r]248	[r]193	1,346	2,634
Mexico	[r]65,805	[r]3,904	32,590	2,061
Netherlands	1	10	([2])	([2])
Panama	6,002	61	--	--
Sweden	325	9	251	101
United Kingdom	3,967	235	2,236	396
Other	[r]6,798	[r]1,029	12,113	913
Total[3]	[r]474,038	[r]38,020	640,745	48,219

[r]Revised.
[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	1978	1979	1980	1981	1982
North America:					
Canada[2 3 4 5]	8,622	9,145	9,395	8,233	6,261
United States[2 5 6]	99,223	98,901	83,710	85,097	56,386
Latin America:[7]					
Argentina	1,523	[r]1,621	[8]1,320	[r e]1,230	[e]1,420
Brazil	5,800	6,497	[r e]7,170	[r e]6,190	[e]6,080
Chile	177	204	[8]209	[r e]220	[e]140
Colombia	183	261	[8]211	[r e]205	[e]210
Mexico	3,097	2,705	[8]2,345	[r e]2,490	[e]2,310
Peru	150	230	[8]173	[r e]130	[e]90
Uruguay	57	55	[8]24	[e]20	[e]30
Venezuela	602	1,052	[8]1,068	[r e]1,090	[e]1,500
Central America, not further detailed	61	[8]128	[8]54	[r e]50	[e]50
Europe:					
European Economic Community:					
Belgium[2]	4,182	4,467	4,065	4,133	4,566
Denmark[9]	[3]1,068	[3]998	[3]894	758	690
France	9,018	8,941	8,748	8,040	7,076
Germany, Federal Republic of[5]	23,359	23,993	22,401	21,632	19,342
Greece[e]	300	330	310	300	300
Ireland	87	[10]93	[10]3	[10]41	[10]76
Italy	17,897	17,928	[10]19,825	17,799	16,944
Luxembourg	1,942	1,968	1,738	1,458	1,450
Netherlands	2,030	2,166	2,025	1,961	1,594
United Kingdom	16,902	16,761	10,248	11,424	[e]11,409
European Free Trade Association:					
Austria	1,926	2,013	[r]1,910	[r]1,910	1,807
Finland	832	819	848	807	758
Norway	[e]490	607	526	[10]551	537
Portugal	491	[e]520	[r]564	[e]450	[e]440
Sweden	2,872	3,045	[5]2,835	2,924	[e]3,030
Switzerland	[e]770	[e]870	[e]909	[10]948	[10]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	1978	1979	1980	1981	1982
Europe —Continued					
Council for Mutual Economic Assistance:					
Bulgaria[e]	720	805	860	830	830
Czechoslovakia[2 3 5]	8,173	8,438	8,884	8,244	8,186
German Democratic Republic	5,040	5,545	5,833	5,816	5,649
Hungary	2,566	2,595	2,528	2,425	2,446
Poland	12,518	11,597	11,817	9,598	[11]9,093
Romania[e]	4,080	4,190	4,300	4,250	4,240
U.S.S.R.[e]	54,450	53,020	[r]56,690	[r]56,900	56,500
Other:					
Spain	8,726	7,961	[10]9,195	9,933	[e]10,150
Yugoslavia	2,249	2,272	2,287	2,324	2,245
Africa: South Africa, Republic of[2 12]	[r]3,656	[r]3,062	[r]3,974	[r]3,333	[e]3,060
Asia:					
China[e]	8,000	[r]8,700	[r]9,400	[r]9,000	9,400
India[e]	4,400	4,400	4,080	4,100	4,200
Japan[5]	43,445	50,292	48,291	44,616	42,832
Korea, Republic of[e]	1,860	1,800	2,200	2,700	3,300
Taiwan[e 13]	600	800	1,200	[r]1,100	1,400
Turkey	[10]1,017	[r e]1,500	[r e]1,900	[10]1,764	[e]1,900
Oceania:					
Australia	[10]2,448	[10]2,639	[e]2,470	[e]2,480	[e]2,070
New Zealand	[e]182	[10]160	[r e]160	[r e]155	[e]160
Total	[r]367,791	[r]376,094	[r]359,597	[r]349,659	313,072

[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, v. 10, 1982, New York, 1983, 87 pp., which is the source of all 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 data.

[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 Steelmaking and Iron Ore Mining in Latin America, 1981. Santiago, 1982, 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]Iron and Steel Statistics Bureau (United Kingdom). International Steel Statistics, Selected Central and South American countries, 1981. London, 1981, 76 pp.

[9]Includes scrap used in production of steel casting at shipyards, but excludes scrap, if any, used in the production of pig iron.

[10]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.

[11]Includes 8,983,000 short tons reported for use in production of pig iron and crude steel, and an estimated 110,000 short tons for use in foundries.

[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	1978	1979	1980	1981	1982
North America:					
Canada	963	1,139	865	632	[2]689
United States[2 3]	9,089	11,124	[r]11,254	[r]6,472	6,857
Latin America:					
Mexico[2]	([4])	1	4	2	22
Europe:					
European Economic Community:					
Belgium-Luxembourg	585	606	592	637	549
Denmark	89	100	110	204	[2]121
France	4,038	3,887	3,651	3,510	3,397
Germany, Federal Republic of	3,048	3,305	3,392	3,756	3,160
Greece	([4])	([4])	([4])	1	[2]1
Ireland	60	79	93	80	65
Italy	8	14	9	25	19
Netherlands	1,311	1,259	1,316	1,380	1,300
United Kingdom	1,725	1,475	3,092	3,712	3,387
European Free Trade Association:					
Austria	9	17	14	14	10
Finland	1	3	([4])	([4])	([4])
Norway	40	46	42	35	35
Portugal	11	6	6	6	[2]10
Sweden	86	19	15	15	20
Switzerland	97	110	71	141	116
Council for Mutual Economic Assistance:					
Bulgaria	184	143	171	[r]87	63
Czechoslovakia[5]	126	137	109	113	[e]100
German Democratic Republic[5]	15	57	54	21	[e]20
Hungary	46	41	34	35	58
Poland[5]	15	12	16	52	[e]50
Romania[5]	3	1	([4])	([4])	([4])
U.S.S.R.[2]	1,849	2,190	2,756	[r]2,681	2,859
Other:					
Iceland	--	5	3	3	4
Spain	1	([4])	1	[r]1	[2]1
Yugoslavia	87	52	50	[2]65	[e]60
Africa:					
Morocco[2]	50	98	38	53	[e]50
South Africa, Republic of[5]	8	1	7	2	[e]2
Asia:					
China[5]	([4])	([4])	11	10	[e]10
Hong Kong[2]	315	412	302	371	300
India[2]	31	12	2	[e]10	[e]10
Indonesia[2]	7	--	1	--	([4])
Japan	181	166	175	206	193
Korea, Republic of[2]	9	14	10	28	155
Malaysia[2]	15	15	12	13	7
Philippines	3	3	2	2	[e]2
Singapore[2]	4	2	6	2	9
Taiwan[2]	172	79	14	141	443
Thailand[2]	--	--	1	2	9
Oceania:					
Australia[2]	755	63	[r e]600	708	[e]700
New Zealand[2]	2	5	49	3	[e]3
Total	25,038	26,698	[r]28,950	[r]25,231	24,866

[e]Estimated. [r]Revised.

[1]Unless otherwise specified, source is United Nations Economic Commission for Europe. Annual Bulletin of Steel Statistics for Europe 1982, v. 10, New York, 1983, 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	1978	1979	1980	1981	1982
North America:					
Canada	1,052	1,156	1,119	924	[2]500
United States[2]	794	761	582	556	468
Latin America:					
Argentina[2]	18	7	2	2	[e]1
Brazil[2]	([3])	([3])	24	8	8
Chile	[2]8	[e]10	[e]10	[e]10	[e]10
Colombia[2]	23	25	14	33	[e]30
Cuba	[4]92	[4]80	[4]95	[e]100	[e]100
Mexico[2]	531	393	257	235	96
Peru	--	--	[2]36	[e]35	[2]18
Venezuela[2]	5	50	36	55	[e]50
Europe:					
European Economic Community:					
Belgium-Luxembourg	1,079	1,069	947	1,054	978
Denmark	290	313	239	198	[2]96
France	434	465	503	383	304
Germany, Federal Republic of	1,705	1,769	1,658	1,473	1,421
Greece	218	254	263	317	[2]478
Ireland	10	6	9	4	2
Italy	7,238	7,596	8,168	6,107	6,141
Netherlands	182	136	170	262	244
United Kingdom	47	49	28	23	41
European Free Trade Association:					
Austria	127	149	158	187	420
Finland	24	98	117	68	56
Norway	11	8	58	26	4
Portugal	731	161	164	94	[2]187
Sweden	130	143	84	272	588
Switzerland	96	197	151	125	118
Council for Mutual Economic Assistance:					
Bulgaria	--	[4]1	([3 4])	--	--
Czechoslovakia[4]	54	47	62	59	[e]50
German Democratic Republic	602	780	1,001	764	502
Hungary	3	7	4	159	15
Poland	10	7	250	58	6
Romania	9	11	62	--	--
U.S.S.R.	[5]21	[5]22	[6]23	[6]24	[e]20
Other:					
Spain	2,811	3,805	4,835	[r]4,479	[2]5,000
Yugoslavia	443	292	437	[2]528	[e]500
Africa:					
Egypt[2]	46	18	41	15	14
Morocco	1	([3])	([3])	[2]2	[e]1
South Africa, Republic of[2]	19	9	31	14	30
Asia:					
China[4]	19	6	2	2	[e]2
Hong Kong[2]	139	116	103	104	71
India	[2]119	[2]160	[e]130	[e]100	[e]100
Indonesia	89	33	43	69	250
Japan	3,559	3,688	3,291	1,974	2,232
Korea, Republic of[2]	1,867	1,742	2,130	2,546	1,994
Malaysia	8	7	5	60	28
Pakistan	187	139	368	[2]534	[e]500
Philippines[2]	87	105	10	10	[e]10
Singapore[2]	103	120	190	86	103
Taiwan[2]	686	839	1,358	971	718
Thailand[2]	884	678	373	460	429
Turkey	356	399	381	579	[e]500
Oceania:					
Australia[2]	1	1	1	1	[e]1
New Zealand[2]	19	1	69	5	[e]5
Total	[r]26,987	27,928	30,092	[r]26,154	25,385

[e]Estimated. [r]Revised.

[1]Unless otherwise specified, source is United Nations Economic Commission for Europe. Annual Bulletin of Steel Statistics for Europe 1982, v. 10, New York, 1983, 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, $Al_2O_3 \cdot SiO_2$. 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 are incomplete, the United States, the Republic of South Africa, and India appear to be the leading world producers of kyanite-group minerals. The U.S.S.R. and perhaps a few other industrialized nations are also presumed to produce significant quantities of these materials.

U.S. kyanite output in 1983 was estimated to be approximately the same as in 1982. 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. An estimate of total production was made by the Bureau of Mines using prior year 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 6% of the total production data shown in table 1. The percentage of production that was estimated, 94%, was arrived at by using prior year 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 1983, 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.

The tonnage of domestic kyanite was estimated to be approximately 100,000 tons, the same as in 1982.[2]

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 1983 was 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.—Synthetic mullite production in the United States

Year	Quantity (short tons)	Value (thousands)
1979	40,660	$6,675
1980	40,540	8,012
1981	42,000	9,050
1982	27,000	5,950
1983[e]	23,000	4,700

[e]Estimated.

CONSUMPTION AND USES

Kyanite and related materials were consumed mostly in the manufacture of high-alumina or mullite-class refractories and in lesser quantities as ingredients in ceramic compositions. U.S. kyanite, already ground to minus 35 mesh as required by the flotation process used in its separation and recovery, was marketed either in this raw form or, after heat treatment, as mullite, sometimes further reduced in particle size before use. In the 35- to 48-mesh range, kyanite was used mostly in monolithic refractory applications such as for 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 1983, listed prices for kyanite, f.o.b. Georgia, ranging from $85 to $137 per short ton for bulk shipments and $9 more per ton for bagged material.

The December 1983 issue of Industrial Minerals (London) quoted kyanite-group prices approximately equivalent to the following:[3]

	Per short ton
Andalusite, Transvaal, 52% to 54% Al_2O_3, bulk, c.i.f. main European port	$95
Andalusite, Transvaal, 60% Al_2O_3, c.i.f. main European port	122
Sillimanite, South African, 70% Al_2O_3, bags, c.i.f. main European port	259
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	$122- 211
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 shipped overseas, primarily to the Federal Republic of Germany. Imports were estimated to be insignificant.

WORLD REVIEW

India.—Sillimanite minerals described in a journal article included producing companies; 1980 and 1981 production tonnages and values for kyanite and sillimanite, by State; and exports for 1979 to 1981.[4]

The Indian Rare Earths Ltd. sands project at Orissa required the installation of a dredge and wet concentration unit with a capacity of 500 tons per hour. Heavy mineral content of the sand was 20% with the remainder consisting of quartz. The second stage of the project will require a heavy mineral sand separation plant and was expected to yield 33,000 tons per year of sillimanite and various other heavy minerals.[5]

The Lapso Buru kyanite operation of Hindustan Copper Ltd., located in the Singhbhum District of Bihar State, was described in a journal article. Output was about 20,000 tons per year. Project history, geology, mining methods, and washing were described.[6]

Japan.—Consumption of sillimanite, andalusite, and/or kyanite was approximately 17,600 tons per year from 1980 to 1982. Consumption of synthetic mullite was approximately 38,000 tons per year in 1980 and 1981 and 29,000 tons in 1982.[7]

South Africa, Republic of.—Total andalusite production decreased an estimated 31% compared with that of 1982.

A journal article described the andalusite operation of Rand London Andalusite Ltd. in the State of Lebowa. Information was included on history, geology, reserves, mining, processing, and sales.[8]

United Kingdom.—Imports of kyanite-group minerals in 1981 were approximately 42,000 tons. Principal countries of origin and the share supplied were the Republic of South Africa, 40%; France, 34%; and the United States, 7%. In 1982, imports of kyanite-group minerals were 38,700 tons. Principal countries of origin and the share supplied were the Republic of South Africa, 53%; France, 29%; and the United States, 10%.[9]

Colin Stewart Minerals Ltd. was appointed official distributor for the United Kingdom of andalusite produced by Rand London Andalusite Ltd. The Al_2O_3 content of the product was guaranteed at a minimum of 59%, and the Fe_2O_3 content at a maximum of 0.9%.[10]

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[1]Physical scientist, Division of Industrial Minerals.

[2]Dickson, T. Sillimanite Minerals. Min. Annu. Rev. (London), 1983, p. 114.

[3]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$1.50.

[4]Clark, G. M. The Industrial Minerals of India. Ind. Miner. (London), No. 191, Aug. 1983, pp. 42-43, 51.

[5]Industrial Minerals (London). Don't Forget Orissa for 1984. No. 189, June 1983, pp. 11, 13.

[6]Mining Magazine (London). Lapso Buru Kyanite. V. 149, No. 5, Nov. 1983, pp. 378-379, 381.

[7]Industrial Minerals (London). Refractories in '82. No. 189, June 1983, p. 13.

[8]Holz, P. Rand London Andalusite Is Mining Again. Ind. Miner. (London), No. 187, Apr. 1983, pp. 45-47.

[9]Industrial Minerals (London). United Kingdom Industrial Mineral Statistics. No. 187, Apr. 1983, p. 60.

[10]———. Company News & Mineral Notes. No. 186, Mar. 1983, p. 61.

Table 2.—Kyanite: World production, by country[1]

(Short tons)

Country[2] and commodity	1979	1980	1981	1982[p]	1983[e]
Australia: Sillimanite[3]	626	729	365	863	880
Brazil: Kyanite[4]	1,929	[r]4,707	1,753	[e]2,000	1,650
France: Kyanite-andalusite[e]	33,100	33,100	33,100	33,100	33,100
India:					
Kyanite	44,874	51,282	42,200	37,245	38,600
Sillimanite	17,752	14,315	11,303	14,403	15,400
Korea, Republic of: Andalusite	66	90	99	36	55
South Africa, Republic of:					
Andalusite	147,905	216,622	199,818	[e]175,700	121,300
Sillimanite	21,577	17,851	17,090	[e]12,500	4,400
Spain: Andalusite	5,903	7,133	6,780	5,627	5,500
United States:					
Kyanite	W	W	W	W	W
Synthetic mullite	40,660	40,540	42,000	27,000	23,000

[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 Mar. 28, 1984.

[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: 1979—9,031; 1980—20,168; 1981—2,618; 1982—20,000 (estimated); and 1983—3,300 (estimated).

Lead

By William D. Woodbury[1]

Domestic mine output of recoverable lead declined by over 60,000 metric tons in 1983 and was the lowest production in a nonstrike year since the mines in southeast Missouri reached significant production levels in 1969. The decline was attributed to the closure for economic reasons of the Nation's second-largest lead mine at Sweetwater, MO, in March. Total primary refinery output from domestic and foreign raw materials, however, was about the same as that of 1982. Production from scrap materials declined significantly for the fourth consecutive year, owing to a continued shortage of scrap at acceptable prices. Secondary production declined to less than two-thirds that of 1979, and during 1983, virtually all plants curtailed production, operated intermittently, or temporarily closed for long periods. Secondary refined production was the lowest since 1968. Consumption of lead for storage batteries, the major end use, increased by over 100,000 tons.

Table 1.—Salient lead statistics

(Metric tons unless otherwise specified)

	1979	1980	1981	1982	1983
United States:					
Production:					
Domestic ores, recoverable lead content	525,569	550,366	445,535	r512,516	449,038
Value thousands	$609,929	$515,189	$358,821	r$288,579	$214,623
Primary lead (refined):					
From domestic ores and base bullion	529,970	508,163	440,238	459,865	459,328
From foreign ores and base bullion	45,641	39,427	55,085	52,295	55,227
Antimonial lead (primary lead content)	2,596	851	3,008	4,622	W
Secondary lead (lead content)	801,368	675,578	641,105	571,276	503,501
Exports (lead content):					
Lead ore and concentrates	32,902	27,615	33,043	29,104	20,119
Lead materials excluding scrap	10,646	164,458	23,320	55,629	20,449
Imports, general:					
Lead in ore and matte	39,998	44,095	58,545	35,807	47,516
Lead in base bullion	1,681	296	449	19	53
Lead in pigs, bars,[1] reclaimed scrap	198,344	88,995	107,185	99,587	179,485
Stocks, Dec. 31 (lead content):					
At primary smelters and refineries	89,322	125,994	140,207	125,537	106,661
At consumers and secondary smelters	153,195	126,214	123,216	97,209	100,771
Consumption of metal, primary and secondary	1,358,335	1,070,303	1,167,101	1,075,408	1,148,487
Price: Common lead, average, cents per pound[2]	52.64	42.46	36.53	25.54	21.68
World:					
Production:					
Mine thousand metric tons	r3,450.6	r3,448.2	3,349.4	p3,408.0	e3,324.4
Refinery[3] do	r3,297.5	r3,172.9	3,124.0	p3,149.8	e3,204.6
Secondary refinery do	r2,414.6	r2,257.0	2,211.5	p2,077.6	e2,024.7
Price: London Metal Exchange, pure lead, average, cents per pound	54.52	41.21	33.30	24.66	19.27

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. Average transactions on a delivered basis.
[3]Primary metal production only. Includes secondary metal production where inseparably included in country total.

The U.S. producer prices gradually declined during the first half of 1983, bottomed in July at the lowest level since January and February 1976, but recovered in the last quarter to about 3 cents per pound above the beginning of the year. The average U.S. transactions price for the year was the lowest since 1975 and the second lowest of the century in 1972 constant dollars. London Metal Exchange (LME) cash quotations for lead averaged 2.4 cents per pound less than U.S. prices for the year and about 6.5 cents per pound less in the fourth quarter, which triggered record-high imports of pig lead from the LME during November and December.

During the year, the final phase of the in-plant worker blood-lead-level standard for medical removal protection (MRP), which affected all plants of the lead-producing and consuming sectors, went into effect. For the second consecutive year, a major technologic innovation was introduced in the domestic automotive replacement battery market, reportedly the first truly "maintenance-free" lead-acid system.

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 smelter and consumer surveys. Of the 324 consumer plants to which a survey request was sent, 90% responded, representing 96% of the primary and secondary lead consumption shown in tables 1, 13, 14, 15, and 16. Of the 78 secondary producer plants to which a survey request was sent, 60% responded, representing 83% of the total secondary lead production shown in tables 1, 11, and 12. Production and consumption for the nonrespondents were estimated using reported prior year production levels adjusted by general industry trends.

Legislation and Government Programs.—Four significant actions by U.S. Government agencies during 1983 had immediate and/or potentially severe long-term consequences to the domestic lead industry. On March 1, the final phase of the worker blood-lead-level MRP standard of the Occupational Safety and Health Administration's (OSHA) 1979 Lead Standard became effective. In some plants the standard reportedly could temporarily idle up to 30% of the work force with pay, according to industry, but for most plants, the impact will be significantly less. The standard was applied to all producers and consumers of lead regulated by OSHA. Also affecting the industry was the decision by OSHA to retain the in-plant air-lead permissible exposure limit (PEL), but not to enforce ultimate compliance solely by engineering controls as originally scheduled. Compliance plans with the PEL based on variable mixtures of engineering controls with supplemental work practice and administrative controls, including worker self-protection devices, were to be negotiated on a plant-by-plant basis with organized labor input, a significantly less costly approach at most plants.

On February 17, the Environmental Protection Agency (EPA) published proposed specific point source effluent limitations, pretreatment standards, and new source performance standards for nonferrous metals manufacturers for compliance with the 1977 Clean Water Act requirements. Compliance with these standards, together with similar proposed guidelines for battery manufacturers published on November 10, 1982, utilizing best available technology standards, was expected to be required by mid-1984. On April 4, 1983, EPA also published proposed rules for hazardous waste management affecting secondary lead smelters and the lead-acid battery recycling sector in general, to implement applicable sections of the 1976 Resource Conservation and Recovery Act. Compliance was also expected to be mandated in 1984 and reportedly was the most troublesome to the secondary lead and battery recycling industries of the pending rulemakings at yearend.

The National Defense Stockpile during 1983 remained at 545,000 tons, about 55% of the current authorized goal.

DOMESTIC PRODUCTION

MINE PRODUCTION

The decline in U.S. mine production of recoverable lead reflected the low worldwide demand for lead. Unfavorable economic conditions forced the closing in early March of the Nation's second-largest lead mine, Ozark Lead Co.'s Milliken Mine, at Sweetwater, MO. Eight lead mines in Missouri, including St. Joe Lead Co.'s new Viburnum No. 35 Mine at Bixby, MO, which yielded development ore in the second half of the year, produced 91% of the domestic total. Lead-producing mines in Idaho and Missouri together accounted for 97% of the total U.S. mine output.

According to AMAX Lead Co. of Missouri's annual report, the Buick Mine in Iron County, MO, equally owned by AMAX, the operator, and Homestake Mining Co., continued to be the Nation's largest single lead-producing unit, milling 1.93 million tons of ore at an average grade of 7.9% lead, down 6% in volume but upgraded 0.3% in metal content over that of 1982. Estimated reserves of the mine at yearend were reported to be 34.5 million tons of ore at an average grade of 5.7% lead. Contained metal production at 147,000 tons of lead in concentrates was only down 2% from that of 1982 owing to the slightly higher average grade of the ore hoisted.

St. Joe Lead, the largest integrated producer of lead in the United States, operated three lead mine and milling complexes in southeastern Missouri, producing 196,000 tons of lead in concentrates during its fiscal year ending October 31, 1983, according to parent Fluor Corp.'s annual report, an increase of 4% over that of 1982. The three mills treated 4.17 million tons of ore from five captive mines averaging about 4.8% lead during the year. Total estimated mill capacity was 20,000 tons of ore per day. St. Joe Lead had proven domestic reserves of 56.3 million tons of ore containing 5.0% lead at fiscal yearend. The Fletcher Mine in Reynolds County, MO, was the Nation's second-largest producing lead mine during the year.

The third-largest producing lead mine was Cominco American Incorporated and Dresser Industries Inc.'s equally owned Magmont Mine in Iron County, MO, which milled 1.04 million tons of ore at an average grade of 7.2% lead, according to Cominco's annual report. Lead concentrate production increased 17% to 94,600 tons owing to the significantly higher average grade of the ore mined compared with that of 1982. Production began late in 1983 from the new, higher grade West area after completion of a 2-mile haulage drift from the main shaft. As a result, the published measured and indicated yearend reserves increased nearly 20% to 6,200,000 tons, with an average grade of 8.0% lead. On November 1, Cominco, the operator, signed a toll agreement with the ASARCO Incorporated smelter-refinery at Glover, MO, to replace the expired contract with the adjacent AMAX plant at Boss, MO.

At Ozark Lead's Milliken Mine in Reynolds County, MO, normally the Nation's second-largest lead-producing mine with 82,000 tons capacity, production was indefinitely suspended in the first week of March owing to unfavorable economic conditions. According to Standard Oil Co. of Ohio's (Sohio) annual report, the mine produced 10,250 tons of lead in concentrates. Ozark Lead is wholly owned by Kennecott, which is a subsidiary of Sohio. Milliken's concentrates were purchased on contract by Asarco for processing at its Glover, MO, smelter-refinery.

Hecla Mining Co. reported that its Lucky Friday unit in Shoshone County, ID, produced 233,375 tons of silver ore with a grade of 11.3% lead. That was the highest ore production in the mine's history and represented 26,000 tons of contained lead and 5.08 million troy ounces of recovered silver. The new record was attributed to the first-stage completion of the new deep shaft to 6,205 feet on April 27. Development of the 4,900-foot and 5,100-foot levels began at midyear, and the first ore was hoisted on October 10. The shaft was designed so that it could be extended to an ultimate depth of 7,500 feet, permit a 35% increase in mine capacity, and also enhance further exploration and future development of large company holdings surrounding Lucky Friday. Ore reserves at the end of 1983 were 470,000 tons at an average grade of 12.2% lead, up 3% from that of 1982. An extensive exploration program from the new shaft levels was to be started in 1984 as, for the first time in the history of the mine, adequate hoisting capacity to allow exploration waste to be hoisted was available. According to Hecla, this program promised to be the greatest opportunity for discovery of new high-grade silver-lead veins ever to be presented to the company. Exploration was also to continue during 1984 on seven additional projects in Colorado, Montana, Washington, and Quebec, Canada. Hecla's Leadville unit, known as the Sherman Mine, or Sherman Tunnel, which was operated on a 60%-equity basis for Leadville Corp. in Lake County, CO, and which had ceased production in January 1982, resumed production in June 1983 at a rate of 120 tons of ore per day grading 0.5% lead as a byproduct of silver ore grading over 15 troy ounces per short ton. This level of production was expected to be maintained through 1984.

Asarco, which had suspended underground development at its new, large West Fork Mine in southeast Missouri in October 1982, placed the project on standby status in June 1983 after completion of the mill and other surface facilities. In October, however, Asarco started dewatering operations and was to continue with construction of permanent underground facilities through 1984. The mine reportedly could be on-stream by late 1985 at a capacity of 46,000 tons of lead in concentrates per year. The reserves were estimated at 13.6 million tons grading 5.5% lead and 1.2% zinc, according to Asarco. Mill capacity was estimated at 3,450 tons of ore per day. Output at the Leadville Mine in Colorado, formerly known as the Resurrection Mine, which Asarco operated under a 50%-owned joint venture, produced near its capacity of 6,000 tons of lead in concentrates in 1983.

SMELTER AND REFINERY PRODUCTION

Primary.—During 1983, the St. Joe Lead smelter-refinery at Herculaneum, MO, the Nation's largest, with a rated capacity of 204,000 tons per year, produced 206,600 tons of lead metal according to the company's October 31 fiscal yearend 10K Report filed with the Securities and Exchange Commission. At Boss, MO, the AMAX-Homestake smelter-refinery produced 129,700 tons of lead metal, also slightly over plant capacity, which was rated at 127,000 tons, and about 12% over that of 1982. At the smelter, a new elemental sodium drossing process was introduced that materially increased recovery and eliminated a drossing process step, which also reduced costs, according to Homestake's annual report. Total production at the plant broke the record-high achieved in 1975 by over 6,000 tons. In mid-November, the plant's long-term commitment to Cominco-Dresser to set aside one-half of its capacity for toll of lead concentrates from the adjacent Magmont Mine expired, and from that point, the smelter-refinery became totally committed to processing concentrates from AMAX-Homestake's own Buick Mine.

Asarco reported that its three smelters, one each at East Helena, MT, El Paso, TX, and Glover, MO, produced 188,000 tons of lead bullion in 1983. The El Paso and East Helena operations, which custom toll concentrates from domestic and foreign sources, shipped the bullion to Asarco's Omaha refinery where 90,000 tons of lead metal was produced. Foreign concentrates came from Peru, Australia, Honduras, and Canada, in order of significance, but those imported for domestic consumption were virtually all from Asarco's direct Peruvian interests or long-term relationships. The Glover smelter-refinery complex produced 91,000 tons of lead metal, and the company's total refined production was down 13% or 26,850 tons compared with that of 1982. This was directly attributed to the closure of Ozark Lead's Milliken Mine on March 1, 1983, which had been Glover's prime purchased feed source. The Glover plant was immediately forced to curtail operations, and temporarily suspended operations from August 15 until September 19. A toll contract was signed on November 1 with Cominco-Dresser to smelt and refine concentrates from the Magmont Mine, whose current contract had expired with AMAX-Homestake's Boss smelter-refinery. Although the Magmont Mine and the Milliken Mine are about equal in capacity, the net result of this switch was that Asarco could have as much as 80,000 tons less of its own lead to market annually. Asarco's total refined lead production was 70% of estimated capacity.

Secondary.—During the year, permanent closure was announced for two plants with a combined capacity of 31,000 tons, but at yearend, total refined secondary metal capacity was still estimated to be over 1.2 million tons. At yearend, there were 27 "major" producers who owned and/or operated 42 plants ranging from 5,000 to 68,000 tons in annual capacity, averaging just under 30,000 tons, and who accounted for about 99% of U.S. secondary lead production. On December 1, Bergsoe Metal Corp. of Portland, OR, assumed ownership and operation of RSR Corp.'s 33,000-ton-per-year Seattle, WA, smelter-refinery under a Federal Trade Commission divestiture order. At that time, Bergsoe became the only large secondary lead producer in the Pacific Northwest and had a total capacity of 60,000 tons per year in that area.

CONSUMPTION AND USES

The increase in domestic consumption of lead was attributed to a 15% increase in demand for use in all types of lead-acid storage batteries. According to Battery Council International, shipments of replacement automotive batteries, the largest single end use of lead, increased 3.5% during the year to 56.1 million units, and shipments of original equipment automotive batteries increased 29% to 10.8 million units. Those increases, together with considerably increased demand for wrought lead products in construction and pigments for paints and glass or ceramic products, were partially offset by a decline of 30,000 tons in consumption of lead in gasoline additives. Use of lead in casting metals also declined significantly, but all other end uses remained about level compared with those of 1982.

Although consumption of lead for the manufacture of all types of storage batteries represented 70% of total demand in 1983 compared with 65% in 1982, the gain was attributed primarily to rebuilding of starting-lighting-ignition (SLI) battery grid and oxide inventories, which was reflected by the record-high fourth quarter consumption by the battery manufacturers. The use of lead in each SLI unit was estimated to have actually declined slightly owing to continuing technologic improvements. Lead in industrial and traction batteries represented 10.3% of the total used for batteries, and consumption of lead increased 22.6% in 1983 compared with that of 1982 for that sector of the battery industry.

STOCKS

Refined soft lead stocks at primary refineries decreased 21%, but increased at secondary and consumer plants because of favorable prices and anticipated increased demand. Stocks declined in all other categories except bullion at primary refineries. World stocks of lead and antimonial lead metal in countries reporting to the International Lead and Zinc Study Group (ILZSG) were approximately 540,000 tons at yearend, about 10% of total world demand, and 20,000 tons less than that at yearend 1982.[2]

PRICES

The U.S. producer price for lead opened the year in a quoted range of 20.5 to 23 cents per pound, according to Metals Week, and fluctuated from that range to 1/2 cent to 1 cent higher through February, when a continuous, gradual, steady decline commenced. This decline bottomed out at 19 to 20 cents per pound from July 12 through August 2, when a gradual increase began in response to early buying from battery manufacturers, whose raw materials and retail stocks were reportedly low. This range represented the bottom of a 2-year down cycle from just under an average of 44 cents per pound in August 1981. The high quoted range for 1983 of 25 to 27 cents per pound was sustained from October 19 until December 12, when it dropped 1 cent and closed the year at 24 to 26 cents. The average transactions price for the year was 21.7 cents per pound as most sales were at or near the low end of the quoted ranges, and several forms of discounts were offered by major producers.

Published price quotations for U.S. secondary lead during 1983 were generally 3 to 3.5 cents per pound above the average price for primary soft lead, and most secondary producers were not competitive in that market. However, secondary producers were able to realize premiums for alloyed metals, and the sector maintained its share of the market for antimonial lead and other alloys.

The LME average cash prices during 1983 were about 1/2 cent per pound below average U.S. producer prices from the beginning of the year through mid-June. From that point, the spread began to increase, reaching an average of 3.4 cents during the start of the U.S. high-demand period in September, and averaged over 6 cents per pound in the fourth quarter. The LME average for the year was 2.4 cents per pound less than the average U.S. price. 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 shipping, duty, and insurance accounting for 3 to 3.5 cents. Since LME prices were depressed and stayed relatively close to U.S. prices in the first half of 1983, LME inventories built from 126,000 tons of refined lead metal at 1982 yearend to a record-high of 218,000 tons in the first week of October, then declined to 172,000 tons at yearend 1983 as U.S. prices rose.

The quoted domestic prices for lead oxides were based on the selling prices 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, were estimated to be 9.8 cents per pound above the average pig lead price for litharge and 13.8 cents above for red lead.

FOREIGN TRADE

Exports of lead in concentrates were at the lowest level since lead concentrates were classified separately from mixed ores in 1978. Over 80% went to Canada, which in turn supplied over one-half of the non-LME U.S. imports for consumption of refined pig lead. Lead content of exported scrap, which was recorded by gross weight, was estimated to be 60% metal. The United States had net imports for consumption of nearly 130,000 tons of lead, including that contained in concentrates and scrap, compared with 3,000 tons in 1982. The significant increase in imports was necessary because of relatively low U.S. mine output and secondary production. An unusual trade situation was the importation of 42,000 tons of U.S. brand pig lead from LME warehouses during November and December that had been exported during 1982. Imports of concentrates for consumption in 1983 were virtually all from Honduras and Peru, traditional suppliers under long-term contracts to domestic producers. Imports from Peru increased significantly to offset the considerable decline of Honduran concentrates. Canada, Mexico, and Peru supplied over 75% of imported lead in all forms, and Australia continued to be an increasingly important supplier of refined metal.

There was a general increase in imports of lead chemicals and compounds. The most significant was a 40% increase in imports of chrome yellow, used primarily for highway markings. Mexico accounted for all but 200 tons of U.S. imports of litharge and red lead, while Canada supplied 47% of all other categories, including nearly 80% of the chrome yellow. Peru supplied virtually all of the lead arsenate imported; the Republic of South Africa, 60% of the lead nitrate; the Federal Republic of Germany, 84% of the lead acetate; and the United Kingdom, 60% of the total carbonate and sulfate white lead.

Table 2.—U.S. import duties for lead materials, January 1, 1983

(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	3.0% ad valorem[2]	Current MFN rate only	10.0% ad valorem.
Waste and scrap	624.04	do	Free[1] or 2.3% ad valorem.	11.5% ad valorem.

[1]Free if eligible under General System of Preferences.
[2]Temporary reduction until July 1, 1983, but the minimum duty shall not be less than 1.0625 cents per pound of contained lead.

WORLD REVIEW

According to ILZSG statistics, reported consumption of refined lead and antimonial lead metal in the market economy countries during both 1982 and 1983 was just under 3.8 million tons, compared with just under 3.9 million tons in 1981.[3] Estimated total world consumption of lead during 1983 decreased marginally to 5.22 million tons from 5.24 million tons in 1982, compared with 5.34 million tons estimated for 1981. Estimated total world refined lead production, excluding remelt scrap, and world mine production, excluding the United States, were also about the same as that of 1982.

ILZSG, at its 28th annual session in Geneva in October 1983, forecast a worldwide growth in lead consumption by market economy countries of about 3% for 1984, with a corresponding increase in refined metal production of nearly 4%. Mine production and net metal exports to centrally planned economy countries of about 100,000 tons were expected to remain at 1983 levels. Total metal production by the market economy countries was expected to exceed demand by about 100,000 tons in 1984; therefore, no significant change in stocks was anticipated.

Australia.—Early in the year, EZ Industries Ltd. started production at its new zinc-lead-silver Elura Mine in New South Wales.

The mine and mill were designed for a yearly throughput of 1.1 million tons of ore yielding 65,000 tons of zinc and 40,000 tons of lead. As a result, the lead mining industry set a new production record for the second year in a row, and for the first time since 1968 exceeded U.S. lead mine production, usually the first in the world. Production in the main two producing areas, Mount Isa, Queensland, and Broken Hill, New South Wales, also increased substantially. Minor increases in production were recorded at the west coast mines of Tasmania and near Cobar, New South Wales, and slight declines were recorded in all other regions. Exports of lead concentrates were at the same gross tonnage level as those of 1982, but owing to an estimated 22% upgrading, increased from the equivalent of 8% to over 9% of the contained lead in total mine production.

Production at The Broken Hill Associated Smelters Pty. Ltd. (BHAS), Australia's only producer of primary refined lead, decreased in 1983 because of a breakdown at the Port Pirie complex in the last quarter. Consequently, refined metal production and exports decreased about 10%, but with over 180,000 tons of refined metal exported, Australia continued to be the world's leading lead metal exporter.

Significant lead-zinc-silver mineralization was delineated at Conjuboy in northwest Queensland and at the Hellyer Prospect just north of the Que River Mine in western Tasmania. Drilling at the Currawong Prospect, Benambra, Victoria, continued along strike. Following extensive exploration and development in 1982, a full feasibility study began in 1983 to evaluate the economic viability of the zinc-lead-copper deposit at Thalanga, Queensland. The project is a joint venture between Peñarroya of France, EZ Industries, and The Broken Hill Pty. Co. Ltd. with production slated after 1986. Possible startup of production in 1984 was announced by the consortium for the Woodcutters zinc-lead-silver prospect near Darwin, in the Northern Territory. At Plenty River Mining Pty. Ltd.'s Attutra open pit mine, in the Jervois Range, Northern Territory, the 250,000-ton-per-year mill remained closed during 1983 as the mine continued to stockpile ore.

BHAS developed a chloride leaching process for copper-lead sulfide mattes at its Port Pirie, South Australia, lead smelter-refinery, and in midyear, Mount Isa Mines Ltd. (MIM) and the Commonwealth Scientific and Industrial Research Organization (CSIRO) signed a licensing agreement for the commercial application of CSIRO's direct smelting process (Sirosmelt), to be known as Isasmelt.

Canada.—The decline in lead mine production was attributed to the continued suspension of operations at Cyprus Anvil Mining Corp.'s Faro Mine in the Yukon; Heath Steele Mines Ltd. and Asarco's suspension of operations in May at the Little River Mine joint venture, Newcastle, New Brunswick; and the shutdown from January 2 to June 15 of Cominco Ltd.'s subsidiary Pine Point Mines Ltd.'s mine in the Northwest Territories. There was no production from the copper-lead-zinc MacLean Mine at Buchans, Newfoundland (Abitibi-Price Inc., 51%, and Asarco, 49%) during the first half of 1983, but it reopened in June after an 18-month shutdown. An 8-day strike at Cominco Ltd.'s Sullivan Mine and mill in British Columbia ended when employees represented by the United Steelworkers of America approved a 2-year contract retroactive to May 1.

Westmin Resources Ltd. continued to work toward a 1984 startup for its new mill to process ore from its new HW Mine and the Myra Creek and Lynx Mines at Buttle Lake, British Columbia. A 760-meter-deep shaft at the HW Mine was completed in the second quarter of 1983, and an extension to the Lynx Mine ore body was discovered. In May, Cyprus Anvil began a 2-year overburden stripping program at its Faro Mine. In September, an agreement was reached between the Yukon Territorial government and Cyprus Anvil's parent, Dome Petroleum Ltd., on financial assistance from existing Federal programs in the Territory.

Cominco Ltd.'s smelter-refinery at Trail, British Columbia, represented about 36% of total Canadian lead refinery capacity, including secondary, but accounted for 50% of total refinery production.

Greece.—The Government announced plans to reopen in 1984 the Laurium lead smelter and refinery at Attica, which closed in early 1982. The plant, formerly owned by Companie Française des Mines du Laurium S.A.F., a subsidiary of Peñarroya of France, was nationalized in 1982. The plant, originally constructed in 1875, had a capacity of 30,000 tons per year but was expected to undergo modernization and reopen at 15,000 tons capacity. The expansion of the Olympias Mine in northern Greece continued in 1983 and was expected to be onstream in 1984. The mine was one of three of the Kassandra Mines Group in the eastern Chalkidiki area and would expand production of the group, owned by Hellenic Chemical Products and Fertilizers Co., from 20,000 to 40,000 tons per year of contained lead. Eventually, this group was to become the prime feedstock for a planned new 40,000-ton-per-year, Government-owned smelter-refinery to be built at nearby Amphipolis on the Strymon River Estuary.

India.—Hindustan Zinc Ltd. (HZL) began production at mines in Rajpura-Dariba, Rajasthan, capacity of 10,000 tons per year contained lead, and Sargipalli, Orissa, capacity of 6,000 tons per year contained lead. HZL was expected to increase capacity at its Vishakhapatnam smelter in Andhra Pradesh to 34,000 tons per year from the present 22,000 tons per year by 1987 to accommodate the additional production. Refined lead production in 1983 was almost evenly split between HZL's plants at Tundoo in Bihar, 8,000 tons per year capacity, and Vishakhapatnam. HZL's announced long-range plans called for building a new 35,000-ton-per-year smelter in Chittorgarh based on the recently established Rampura-Agucha zinc-lead deposits in Rajasthan, with open pit ore reserves of 61 million tons; however, the Government deferred this project beyond 1987.

Iran.—The Government announced the construction of a new secondary lead plant, capacity of 15,000 tons per year, to be operational in 1984 at Sorbabad near Tehran. During 1983, the National Iranian Lead and Zinc Co. proceeded with preliminary investigations leading to a possible 1987 startup of the country's first primary lead and zinc smelter-refinery. The proposed plant, at Zanjan, in northern Iran, is in the same area as Iran's largest lead-zinc mine at Angouran, and would have a lead capacity of 40,000 tons per year.

Ireland.—Bula Ltd. received Government permission after 6 years of negotiation to bring its new zinc-lead mine at Navan, County Meath, into production in 1985. The mine, near the existing operations of Tara Mines Ltd., was expected to have a capacity of 15,000 tons per year of lead in concentrates.

Italy.—During 1983, the state-owned nonferrous metals producer, Società per Azioni Minero-Metallurgiche (SAMIM), was involved in numerous projects in the lead industry. A new mine and expansion of an old mine, with an additional 13,000 tons per year lead capacity, were under development at Monteponi, Sardinia, for startup in 1986. A new mine was opened in Tuscany, and planning for a new 20,000-ton-per-year secondary smelter at Sán Gavino, Sardinia, continued. SAMIM also awarded design and construction contracts for its new 84,000-ton-per-year Kivcet primary lead smelter at Porto Vesme, Sardinia, expected to start up in 1986 and be fully operational by 1987. SAMIM currently operates a 32,000-ton-per-year Imperial Smelting Furnace plant at Porto Vesme, built in 1972. A new electrolytic refinery of 80,000 tons per year capacity, to replace the existing plant built in 1932, was also expected to be operational by 1987, at Sán Gavino.

Morocco.—Société des Fonderies de Plomb de Zellidja planned to expand the capacity of its smelter-refinery at Oued el Heimer by 35,000 tons per year to 100,000 tons per year by the end of 1984 to accommodate expected increased domestic mine production. The Government mining agency, Bureau de Recherches et de Participations Minières, apparently abandoned plans to build a smelter-refinery in the Meknes area.

TECHNOLOGY

Research in hydrometallurgical technology by the Bureau of Mines, in cooperation with the four U.S. primary lead producers, resulted in the development of a technically feasible experimental process to produce 99.999% lead, at about 98% recovery, from typical southeast Missouri concentrates. The process involved ferric chloride leaching of galena to produce lead chloride, followed by molten-salt electrolysis to yield lead metal plus chlorine, which was used to regenerate the leaching solution. Problems related to impurity buildup, essentially copper and silver, were investigated. Testing was performed over 28 months in an experimental unit with a capacity of 500 pounds of lead metal per day, and air-lead levels and blood-lead levels of operating personnel were monitored. Commercial viability, however, could not be determined at that scale.[4]

Scale-up of a previously developed bench-scale electrolytic method for recovery of lead from scrap batteries from 1- to 2-liter cells to 20-liter cells was reported by the

Bureau of Mines. The objective of the scale-up was to identify possible problems with impurity buildup in the electrolyte, generation of wastes, lead levels in the workplace, and worker health hazards. The metallic fraction of crushed batteries was melted and cast as anodes for electrorefining in waste fluosilicic acid electrolyte. Cathode deposits assaying 99.99% lead were obtained. The sludge fraction of the batteries was leached with ammonium carbonate and ammonium bisulfite to convert the lead sulfate and lead dioxide into lead carbonate, which is acid soluble, and then filtered. Leaching of the carbonate sludge with the spent electrolyte produced 99.995% to 99.999% lead by electrowinning using lead dioxide-coated titanium anodes and pure lead cathodes. The repeatedly recycled electrolyte exhibited no impurity buildup, and emissions of lead in air were less than 10 micrograms per cubic meter.[5]

A significant commercial technologic development in the United States was the introduction to the marketplace of the first truly maintenance-free automotive lead-acid storage battery by Chloride Inc. The new battery operates on the "starved electrolyte-gas recombination" principal utilizing highly absorptive microporous spun-glass separators and produces no hydrogen in operation. The oxygen produced passes directly from the positive plates to the negative plates through the separators where it is recombined back into water in the electrolyte. The quantity of the water in the electrolyte, none of which is present as free acid, remains constant. This reportedly means less weight, no spillage, no damage if tipped or overturned, and no terminal corrosion, because all of the sulfuric acid is stored in the separators at optimum absorption. The battery is manufactured in a single size, which reportedly fits 92% of all cars on the road in the United States today. The concept was test marketed in Australia in 1981 and the Republic of South Africa in 1982 after 3 years of field trials and refinements. The cushioning effect of the compressed separator units reportedly made the battery especially resistant to malfunction caused by vibration in heavy-duty use. Chloride Inc. introduced a recombination principal miner's cap lamp in the Republic of South Africa in 1981.[6]

A comprehensive coverage of lead-related investigations and an extensive review of current world literature on the extraction and uses of lead and its products were published in quarterly issues of Lead Abstracts, Lead Development Association, London, United Kingdom. A program report of the 1983 projects supported by the International Lead and Zinc Research Organization Inc. (New York) was published in Lead Research Digest (No. 40, 1984).

[1]Physical scientist, Division of Nonferrous Metals.
[2]International Lead and Zinc Study Group (London). Lead and Zinc Statistics. Monthly Bull., v. 24, No. 7, July 1983, pp. 16-18.
[3]Work cited in footnote 2.
[4]Wong, M. M., R. G. Sandberg, C. H. Elges, and D. C. Fleck. Integrated Operation of Ferric Chloride Leaching, Molten-Salt Electrolysis Process for Production of Lead. BuMines RI 8770, 1983, 21 pp.
[5]Lee, A. Y., E. R. Cole, Jr., and D. L. Paulson. Electrolytic Method for Recovery of Lead From Scrap Batteries. Scale-Up Study Using 20-Liter Multielectrode Cell. BuMines RI 8857, 1984, 20 pp.
[6]Batteries Today. Chloride's Torque Starter Battery. V. 3, No. 3, Summer 1983, pp. 20-23.

Table 3.—Mine production of recoverable lead in the United States, by State

(Metric tons)

State	1979	1980	1981	1982	1983
Alaska	--	31	W	W	W
Arizona	354	162	993	359	144
California	W	W	W	W	W
Colorado	7,554	10,272	11,431	W	W
Idaho	42,636	38,607	38,397	W	25,726
Illinois	W	W	W	W	W
Missouri	472,054	497,170	389,721	474,460	409,280
Montana	258	295	194	661	1,163
Nevada	24	26	W	W	14
New Mexico	W	--	W	W	258
New York	458	876	968	r1,065	1,299
Oregon	(1)	--	W	--	W
Tennessee	(1)	--	--	--	--
Utah	W	W	1,662	W	--
Virginia	1,596	1,563	1,607	--	--
Washington	(1)	W	--	W	--
Wisconsin	W	--	--	--	--
Total	525,569	550,366	445,535	r512,516	449,038

rRevised. W Withheld to avoid disclosing company proprietary data; included in "Total."
1Less than 1/2 unit.

Table 4.—Production of lead and zinc, in terms of recoverable metal, in the United States in 1983, by State

(Metric tons unless otherwise specified)

State	Lead ore			Zinc ore			Lead-zinc ore		
	Gross weight (dry basis)	Lead	Zinc	Gross weight (dry basis)	Lead	Zinc	Gross weight (dry basis)	Lead	Zinc
Alaska	--	--	--	--	--	--	--	--	--
Arizona	--	--	--	--	--	--	--	--	--
California	--	--	--	--	--	--	--	--	--
Colorado	--	--	--	--	--	--	W	W	W
Idaho	1	1	--	--	--	--	--	--	--
Illinois	--	--	--	--	--	--	--	--	--
Kentucky	--	--	--	W	--	W	--	--	--
Missouri	7,303,066	409,280	57,044	--	--	--	--	--	--
Montana	--	--	--	--	--	--	--	--	--
Nevada	--	--	--	--	--	--	--	--	--
New Jersey	--	--	--	87,761	--	16,475	--	--	--
New Mexico	--	--	--	--	--	--	--	--	--
New York	--	--	--	683,150	1,299	56,748	--	--	--
Oregon	--	--	--	--	--	--	--	--	--
Pennsylvania	--	--	--	338,531	--	16,792	--	--	--
Tennessee	--	--	--	4,019,432	--	108,352	--	--	--
Total	7,303,067	409,281	57,044	[1]5,128,874	1,299	[1]198,367	([2])	([2])	([2])
Percent of total lead or zinc	XX	91	21	XX	([3])	72	XX	([2])	([2])
	Copper-lead, copper-zinc, copper-lead-zinc ores			All other sources[4]			Total		
	Gross weight (dry basis)	Lead	Zinc	Gross weight (dry basis)	Lead	Zinc	Gross weight (dry basis)	Lead	Zinc
Alaska	--	--	--	W	W	--	W	W	--
Arizona	--	--	--	7,264,776	144	--	7,264,776	144	--
California	--	--	--	W	W	--	W	W	--
Colorado	--	--	--	W	W	W	W	W	W
Idaho	--	--	--	601,597	25,725	W	601,598	25,726	W
Illinois	--	--	--	([5])	W	W	([5])	W	W
Kentucky	--	--	--	--	--	--	W	--	W
Missouri	--	--	--	--	--	--	7,303,066	409,280	57,044
Montana	--	--	--	9,473,890	1,163	--	9,473,890	1,163	--
Nevada	--	--	--	7,014	14	--	7,014	14	--
New Jersey	--	--	--	--	--	--	87,761	--	16,475
New Mexico	--	--	--	89,581	258	--	89,581	258	--
New York	--	--	--	--	--	--	683,150	1,299	56,748
Oregon	--	--	--	W	W	--	W	W	--
Pennsylvania	--	--	--	--	--	--	338,531	--	16,792
Tennessee	1,822,270	--	1,605	--	--	--	5,841,702	--	[6]109,958
Total	1,822,270	--	1,605	17,948,423	38,458	18,277	32,202,634	449,038	[6]275,294
Percent of total lead or zinc	XX	--	1	XX	9	7	XX	100	100

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

[1]Zinc ore and zinc recovered from zinc ore in Kentucky included with "All other sources" to avoid disclosing company proprietary data.

[2]Included with "All other sources" to avoid disclosing company proprietary data.

[3]Less than 1/2 unit.

[4]Includes zinc recovered from zinc ore in Kentucky and lead and zinc recovered from lead-zinc ore in Colorado 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.

[5]Excludes tonnages of fluorspar from which lead and zinc were recovered as byproducts.

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

Table 5.—Mine production of recoverable lead in the United States, by month

(Metric tons)

Month	1982[r]	1983
January	40,261	44,897
February	43,214	39,575
March	48,374	37,313
April	44,056	36,728
May	41,814	35,879
June	42,351	28,367
July	36,782	35,271
August	42,654	43,242
September	41,440	37,362
October	44,663	37,125
November	41,816	38,332
December	45,091	34,947
Total	512,516	449,038

[r]Revised.

Table 6.—Twenty-five leading lead-producing mines in the United States in 1983, 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	Fletcher	Reynolds, MO	St. Joe Lead Co.	Do.
3	Magmont	Iron, MO	Cominco American Incorporated	Do.
4	Viburnum No. 29	Washington, MO	St. Joe Lead Co.	Do.
5	Viburnum No. 28	Iron, MO	do	Do.
6	Brushy Creek	Reynolds, MO	do	Do.
7	Lucky Friday	Shoshone, ID	Hecla Mining Co.	Silver ore.
8	Milliken	Reynolds, MO	Ozark Lead Co	Lead ore.
9	Leadville unit	Lake, CO	ASARCO Incorporated	Lead-zinc ore.
10	Sunnyside	San Juan, CO	Standard Metals Corp	Gold ore.
11	Viburnum No. 35	Iron, MO	St. Joe Lead Co.	Lead ore.
12	Balmat	St. Lawrence, NY	do	Zinc ore.
13	Bulldog Mountain	Mineral, CO	Homestake Mining Co	Silver ore.
14	Troy unit	Lincoln, MT	ASARCO Incorporated	Do.
15	Black Pine	Granite, MT	Black Pine Mining Co.	Do.
16	Clayton	Custer, ID	Clayton Silver Mines	Do.
17	St. Cloud	Sierra, NM	St. Cloud Mining Co.	Do.
18	Rosiclare	Hardin and Pope, IL	Ozark-Mahoning Co.	Fluorspar.
19	Berkeley Pit	Silver Bow, MT	The Anaconda Company	Copper ore.
20	Sherman Tunnel (Leadville unit)	Lake, CO	Hecla Mining Co.	Silver ore.
21	Hyatt	St. Lawrence, NY	St. Joe Resources Co	Zinc ore.
22	Tiger	Pinal, AZ	McFarland & Hullinger	Gold-silver tailings.
23	Sunshine	Shoshone, ID	Sunshine Mining Co	Silver ore.
24	Comet	Jefferson, MT	Concorde Mines Ltd.	Gold-silver ore.
25	Pierrepont	St. Lawrence, NY	St. Joe Resources Co	Zinc ore.

Table 7.—Refined lead produced at primary refineries in the United States, by source material

(Metric tons unless otherwise specified)

Source material	1979	1980	1981	1982	1983
Refined lead:					
From primary sources:					
Domestic ores and base bullion	529,970	508,163	440,238	459,865	459,328
Foreign ores and base bullion	45,641	39,427	55,085	52,295	55,227
Total	575,611	547,590	495,323	512,160	514,555
From secondary sources	2,862	2,117	1,745	657	648
Grand total	578,473	549,707	497,068	512,817	515,203
Calculated value of primary refined lead[1] thousands	\$668,004	\$512,590	\$398,908	\$288,377	\$245,938

[1]Value based on average quoted price and excludes value of refined lead produced from scrap at primary refineries.

Table 8.—Antimonial lead produced at primary lead refineries in the United States

Year	Production (metric tons)	Antimony content		Lead content by difference (metric tons)			
		Metric tons	Percent	From domestic ore	From foreign ore	From scrap	Total
1979	3,402	271	8.0	2,491	105	535	3,131
1980	881	27	3.1	711	140	3	854
1981	3,557	503	14.1	1,989	1,019	46	3,054
1982	W	W	W	1,895	2,727	34	4,656
1983	W	W	W	W	W	W	W

W Withheld to avoid disclosing company proprietary data.

Table 9.—Stocks and consumption of new and old lead scrap in the United States in 1983, by type of scrap

(Metric tons, gross weight)

Type of scrap	Stocks, Jan. 1	Receipts	Consumption			Stocks, Dec. 31
			New scrap	Old scrap	Total	
Smelters, refiners, others:						
Soft lead[1]	1,554	27,238	--	27,315	27,315	1,477
Hard lead	1,146	20,379	--	19,521	19,521	2,004
Cable lead	2,767	3,636	--	4,479	4,479	1,924
Battery-lead plates	27,874	578,965	--	564,428	564,428	42,411
Mixed common babbitt	135	2,725	--	2,730	2,730	130
Solder and tinny lead	233	17,356	--	16,592	16,592	997
Type metals	1,230	4,693	--	5,332	5,332	591
Drosses and residues	11,700	63,965	69,959	--	69,959	5,706
Total	46,639	718,957	69,959	640,397	710,356	55,240

[1]Includes remelt lead from cable sheathing plus other soft lead scrap processing.

Table 10.—Secondary metal recovered[1] from lead and tin scrap in the United States in 1983

(Metric tons)

	Lead	Tin	Antimony	Other	Total
Refined pig lead	177,813	--	--	--	177,813
Remelt lead	11,789	--	--	--	11,789
Total	189,602	--	--	--	189,602
Refined pig tin	--	1,171	--	--	1,171
Remelt tin	--	10	--	--	10
Total	--	1,181	--	--	1,181
Lead and tin alloys:					
Antimonial lead	271,638	803	11,488	955	284,884
Common babbitt	3,150	151	415	19	3,735
Genuine babbitt	--	34	2	--	36
Solder	17,812	3,072	317	7	21,208
Type metals	4,750	172	634	11	5,567
Cable lead	840	--	15	--	855
Miscellaneous alloys	902	94	15	1	1,012
Total	299,092	4,326	12,886	993	317,297
Tin content of chemical products	--	182	--	--	182
Grand total	488,694	5,689	12,886	993	508,262

[1]Most of the figures herein represent actual reported recovery of metal from scrap.

Table 11.—Secondary lead recovered in the United States

(Metric tons unless otherwise specified)

	1979	1980	1981	1982	1983
As metal:					
At primary plants	2,862	2,117	1,745	657	648
At other plants	349,359	313,061	280,409	239,819	188,954
Total	352,221	315,178	282,154	240,476	189,602
In antimonial lead:					
At primary plants	535	3	46	34	--
At other plants	378,295	306,683	304,330	284,333	271,638
Total	378,830	306,686	304,376	284,367	271,638
In other alloys	70,317	53,714	54,575	46,433	42,261
Grand total:					
Quantity	801,368	675,578	641,105	571,276	503,501
Value[1] thousands	\$930,019	\$632,397	\$516,313	\$321,663	\$240,655

[1]Value based on average quoted price of common lead.

Table 12.—Lead recovered from scrap processed in the United States, by kind of scrap and form of recovery

(Metric tons)

	1982	1983
KIND OF SCRAP		
New scrap:		
Lead-base	46,449	48,534
Copper-base	3,541	2,981
Tin-base	14	8
Total	50,004	51,523
Old scrap:		
Battery-lead plates	437,197	371,540
All other lead-base	72,550	69,469
Copper-base	11,524	10,969
Tin-base	1	--
Total	521,272	451,978
Grand total	571,276	503,501
FORM OF RECOVERY		
As soft lead:		
At primary plants	657	648
At other plants	239,819	188,954
Total	240,476	189,602
In antimonial lead[1]	284,367	271,638
In other lead alloys	30,741	27,178
In copper-base alloys	15,683	15,075
In tin-base alloys	9	8
Total	330,800	313,899
Grand total	571,276	503,501

[1]Includes 34 metric tons of lead recovered in antimonial lead from secondary sources at primary plants in 1982 and none in 1983.

Table 13.—Lead consumption in the United States, by product

(Metric tons)

SIC code	Product	1982	1983
	Metal products:		
3482	Ammunition: Shot and bullets	44,237	43,697
	Bearing metals:		
35	Machinery except electrical	1,216	1,283
36	Electrical and electronic equipment	96	141
371	Motor vehicles and equipment	2,020	2,808
37	Other transportation equipment	2,801	1,612
	Total bearing metals	6,133	5,844
3351	Brass and bronze: Billets and ingots	11,352	10,980
36	Cable covering: Power and communication	15,181	10,505
15	Calking lead: Building construction	4,056	3,572
	Casting metals:		
36	Electrical machinery and equipment	802	1,277
371	Motor vehicles and equipment	657	690
37	Other transportation and equipment	23,603	5,638
3443	Nuclear radiation shielding	([1])	8,640
	Total casting metals	25,062	16,245
	Pipes, traps, other extruded products:		
15	Building construction	8,255	12,771
3443	Storage tanks, process vessels, etc.	424	245
	Total pipes, traps, other extruded products	8,679	13,016
	Sheet lead:		
15	Building construction	9,989	10,939
3443	Storage tanks, process vessels, etc.	125	130
3693	Medical radiation shielding	5,045	3,176
	Total sheet lead	15,159	14,245
	Solder:		
15	Building construction	6,740	7,554
341	Metal cans and shipping containers	7,459	5,141
367	Electronic components and accessories	5,967	5,674
36	Other electrical machinery and equipment	2,702	2,433
371	Motor vehicles and equipment	5,632	7,688
	Total solder	28,500	28,490
	Storage batteries:		
3691	Storage battery grids, post, etc.	312,582	382,336
3691	Storage battery oxides	391,741	424,563
	Total storage batteries	704,323	806,899
371	Terne metal: Motor vehicles and equipment	3,288	5,057
27	Type metal: Printing and allied industries	2,766	2,540
34	Other metal products[2]	7,094	7,869
	Total metal products	875,830	968,959
	Pigments:		
285	Paint	13,375	15,441
32	Glass and ceramic products	34,526	39,671
28	Other pigments[3]	12,965	13,582
	Total pigments	60,866	68,694
2911	Chemicals: Petroleum refining	119,234	89,118
	Miscellaneous uses	19,478	21,716
	Grand total	1,075,408	1,148,487

[1]Included with "Other transportation and equipment" to avoid disclosing company proprietary data.
[2]Includes lead consumed in foil, collapsible tubes, annealing, galvanizing, plating, and fishing weights.
[3]Includes color, lead content of leaded zinc oxide, and other pigments.

Table 14.—Lead consumption in the United States, by month[1]

(Metric tons)

Month	1982	1983
January	98,691	91,521
February	87,923	73,950
March	97,168	83,139
April	94,522	85,852
May	84,678	83,778
June	88,432	96,251
July	72,418	79,266
August	96,674	102,620
September	88,321	115,663
October	98,252	112,266
November	81,539	102,747
December	86,790	121,434
Total[2]	1,075,408	1,148,487

[1]Monthly totals include monthly reported consumption plus the 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 15.—Lead consumption[1] in the United States in 1983, by State

(Metric tons)

State	Refined soft lead	Lead in antimonial lead	Lead in alloys	Lead in copper-base scrap	Total
California	51,427	36,408	5,571	363	93,769
Colorado	536	153	19	--	708
Connecticut	8,849	9,631	--	458	18,938
District of Columbia	15	--	--	--	15
Florida	12,167	9,052	1,766	--	22,985
Georgia	29,227	7,140	4,026	--	40,393
Illinois	21,485	31,806	5,456	1,075	59,822
Indiana	177,278	26,973	8,989	636	213,876
Kansas	10,378	7,471	3,298	--	21,147
Kentucky	7,251	11,046	3,847	--	22,144
Maryland	89	472	--	4	565
Massachusetts	1,169	160	86	181	1,596
Michigan	9,175	10,561	352	--	20,088
Missouri	11,864	11,213	445	34	23,556
Nebraska	81	5	1,053	279	1,418
New Jersey	64,329	1,272	3,707	412	69,720
New York	14,471	3,648	4,047	187	22,353
Ohio	9,023	9,908	3,640	264	22,835
Pennsylvania	99,319	53,948	15,983	1,755	171,005
Rhode Island	2,590	21	9	--	2,620
Tennessee	767	1,265	957	146	3,135
Virginia and West Virginia	616	381	944	--	1,941
Washington	5,008	185	--	--	5,193
Wisconsin	655	6,742	16	36	7,449
Alabama and Mississippi	5,981	2,751	1,363	1,495	11,590
Arkansas and Oklahoma	2,876	1,392	--	--	4,268
Hawaii and Oregon	8,633	8,443	397	--	17,473
Iowa and Minnesota	14,903	9,863	7,274	--	32,040
Louisiana and Texas	115,047	25,033	3,148	--	143,228
Montana and Idaho	220	--	--	--	220
New Hampshire, Maine, Vermont, Delaware	10,043	13,513	--	18	23,574
North Carolina and South Carolina	39,067	25,454	2,941	--	67,462
Utah, Nevada, Arizona	--	--	1,361	--	1,361
Total	734,539	325,910	80,695	7,343	1,148,487

[1]Includes lead that went directly from scrap to fabricated products and lead contained in leaded zinc oxide.

Table 16.—Lead consumption in the United States in 1983, by class of product

(Metric tons)

Class of product	Refined soft lead	Lead in antimonial lead	Lead in alloys	Lead in copper-base scrap	Total
Metal products	79,642	48,134	26,941	7,343	162,060
Storage batteries	481,100	275,581	50,218	--	806,899
Pigments	68,693	--	1	--	68,694
Chemicals	89,118	--	--	--	89,118
Miscellaneous	15,986	2,195	3,535	--	21,716
Total	734,539	325,910	80,695	7,343	[1]1,148,487

[1]Includes lead that went directly from scrap to fabricated products and lead contained in leaded zinc oxide.

Table 17.—Production and shipments of lead pigments[1] and oxides in the United States

Product	1982			1983		
	Production (metric tons)	Shipments		Production (metric tons)	Shipments	
		Metric tons	Value[2]		Metric tons	Value[2]
White lead	1,331	1,186	$1,624,947	1,051	1,129	$1,407,994
Red lead	13,324	13,669	11,084,454	15,042	15,015	11,829,368
Litharge	52,112	51,402	45,724,111	79,139	78,719	58,398,026
Leady oxide	413,139	--	--	458,541	--	--

[1]Excludes basic lead sulfate; withheld to avoid disclosing company proprietary data.
[2]At plant, exclusive of container.

Table 18.—Lead content of lead pigments[1] and oxides produced by domestic manufacturers

(Metric tons)

Product	Lead in pigments from pig lead	
	1982	1983
White lead	1,174	841
Red lead	12,125	13,688
Litharge	48,465	73,599
Leady oxide	390,493	424,319
Total	452,257	512,447

[1]Excludes basic lead sulfate; withheld to avoid disclosing company proprietary data.

Table 19.—Distribution of red lead shipments in the United States, by industry

(Metric tons)

Industry	1979	1980	1981	1982	1983
Paint	5,300	3,241	3,172	2,395	2,542
Ceramics	--	2,597	2,307	W	W
Storage batteries	W	6,068	7,573	W	W
Other	12,846	995	2,025	11,274	12,473
Total	18,146	12,901	15,077	13,669	15,015

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

Table 20.—Distribution of litharge shipments in the United States, by industry

(Metric tons)

Industry	1979	1980	1981	1982	1983
Ceramics	37,620	36,560	34,732	30,980	37,143
Chrome pigments	--	3,015	4,247	6,591	6,214
Oil refining	W	170	227	W	W
Paint	3,038	3,362	3,765	3,052	3,256
Rubber	1,520	943	1,107	787	933
Other	58,792	784	3,063	10,267	11,394
Total	100,970	44,834	47,141	51,677	58,940

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

Table 21.—U.S. imports for consumption of lead pigments and compounds, by kind

Kind	1982		1983	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
White lead	83	$174	332	$300
Red lead	686	466	843	461
Litharge	9,931	5,695	11,528	5,149
Chrome yellow	1,255	2,610	1,754	3,275
Other lead pigments	94	413	215	1,059
Other lead compounds	855	1,255	995	1,200
Total	12,904	10,613	15,667	11,444

Table 22.—Stocks of lead at primary smelters and refineries in the United States, December 31

(Metric tons)

Stocks	1979	1980	1981	1982	1983
Refined soft lead	45,448	54,728	78,836	73,455	58,267
Lead in antimonial lead	646	122	666	W	W
Lead-base bullion	5,683	5,398	4,872	4,252	5,557
Lead in ore and matte	37,545	65,746	55,833	47,830	42,837
Total	89,322	125,994	140,207	125,537	106,661

W Withheld to avoid disclosing company proprietary data.

Table 23.—Stocks of lead at consumers and secondary smelters in the United States, December 31

(Metric tons)

Year	Refined soft lead	Lead in antimonial lead	Lead in alloys	Lead in copper-base scrap	Total
1979	95,655	49,188	7,346	1,006	153,195
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

Table 24.—Average monthly and annual quoted prices of lead[1]

(Cents per pound)

Month	1982 U.S. producer	1982 London Metal Exchange	1983 U.S. producer	1983 London Metal Exchange
January	29.67	29.37	22.03	21.54
February	28.70	28.01	21.12	20.61
March	27.64	27.75	20.71	20.09
April	26.06	26.05	21.17	20.74
May	26.09	26.05	20.22	19.63
June	24.76	23.59	19.41	18.49
July	27.18	25.03	19.32	18.27
August	25.82	23.70	19.46	18.04
September	25.32	23.35	21.69	18.34
October	23.19	22.54	25.38	19.00
November	21.61	20.96	25.15	18.34
December	20.47	20.30	24.46	18.23
Average	25.54	24.66	21.68	19.27

[1]Metals Week. Quotations for United States on a nationwide, delivered basis.

Table 25.—U.S. exports of lead, by country

Country	1982 Quantity (metric tons)	1982 Value (thousands)	1983 Quantity (metric tons)	1983 Value (thousands)
Ore and concentrates (lead content):				
Belgium-Luxembourg	4,056	$948	--	--
Brazil	--	--	896	$202
Canada	16,778	6,885	16,298	5,382
India	3,555	743	--	--
Italy	245	60	--	--
Mexico	641	324	119	36
Spain	3,711	1,122	2,699	1,810
Other	r118	r53	107	72
Total	29,104	10,135	20,119	7,502
Unwrought lead and lead alloys (lead content):				
Australia	3	22	16	34
Austria	16	74	9	3
Belgium-Luxembourg	17,403	11,370	4,581	3,487
Brazil	--	--	292	64
Canada	1,963	1,051	2,537	1,576
Chile	6	12	--	--
Colombia	24	82	1	1
Dominican Republic	49	39	75	71
Egypt	1,136	1,172	194	351
France	3	7	8	12
Germany, Federal Republic of	292	112	42	44
Ghana	--	--	92	78
Greece	3,066	1,473	552	147
Haiti	27	21	46	47
Honduras	83	77	10	10
Israel	18	17	--	--
Italy	908	676	3	4
Jamaica	54	56	21	29
Japan	99	280	64	259
Korea, Republic of	111	89	137	127
Kuwait	21	45	--	--
Mexico	125	211	252	342
Netherlands	21,980	18,530	8,227	3,414
Netherlands Antilles	--	--	18	12
Panama	40	110	4	8
Peru	24	52	3	5
Philippines	172	152	62	43
Saudi Arabia	80	95	79	401
Singapore	43	39	42	54
Spain	21	22	--	--
Switzerland	10	17	2	12
Taiwan	1,816	808	33	98
Thailand	320	265	13	9
Trinidad and Tobago	22	29	32	28
United Kingdom	208	481	130	137
Venezuela	742	919	34	136
Other	r104	r544	73	261
Total	50,989	38,949	17,684	11,304

See footnotes at end of table.

Table 25.—U.S. exports of lead, by country —Continued

Country	1982 Quantity (metric tons)	1982 Value (thousands)	1983 Quantity (metric tons)	1983 Value (thousands)
Wrought lead and lead alloys (lead content):				
Australia	1	$7	11	$32
Belgium-Luxembourg	186	51	(1)	5
Canada	1,407	1,280	1,005	1,087
Ecuador	3	7	25	42
France	7	84	4	17
Germany, Federal Republic of	120	1,002	32	297
Honduras	6	17	10	26
India	30	145	2	6
Israel	2	6	5	7
Italy	96	88	70	128
Japan	238	402	68	359
Mexico	1,421	4,985	1,059	4,253
Netherlands	549	400	17	23
Panama	5	14	6	10
Philippines	38	36	13	27
Saudi Arabia	269	420	86	280
Singapore	2	41	11	60
Spain	147	472	43	148
Taiwan	14	96	11	48
United Kingdom	12	29	180	584
Venezuela	34	88	28	25
Other	r53	r199	79	322
Total	4,640	9,869	2,765	7,786
Scrap (gross weight):				
Argentina	--	--	131	39
Belgium-Luxembourg	657	247	347	400
Brazil	481	28	4,844	1,153
Canada	18,343	4,658	15,708	3,472
Colombia	--	--	2,899	324
Denmark	353	270	235	329
Ecuador	--	--	101	95
Egypt	200	120	--	--
Germany, Federal Republic of	2,724	1,342	1,517	622
India	231	99	34	19
Italy	194	162	376	57
Japan	766	355	265	77
Korea, Republic of	3,754	877	4,277	972
Mexico	7,011	2,393	886	275
Netherlands	437	440	492	526
Philippines	142	29	255	48
South Africa, Republic of	8,298	2,796	--	--
Spain	91	52	1,992	395
Taiwan	7,200	1,947	14,193	2,901
Thailand	--	--	520	94
Trinidad	--	--	1,045	103
United Kingdom	769	1,344	785	1,217
Other	r101	r95	16	21
Total	51,752	17,254	50,918	13,139
Grand total	136,485	76,207	91,486	39,731

rRevised.
1Less than 1/2 unit.

Table 26.—U.S. exports of lead

(Lead content unless otherwise specified)

Year	Blocks, pigs, anodes, etc.				Wrought lead and lead alloys				Scrap (gross weight)	
	Unwrought		Unwrought alloys		Sheets, plates, rods, other forms		Foil, powder, flakes			
	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)
1981	14,484	$12,591	2,320	$2,936	5,966	$9,719	550	$750	59,419	$22,388
1982	47,250	35,917	3,739	3,032	4,078	9,056	562	813	51,752	17,254
1983	13,244	8,895	4,440	2,409	2,406	6,866	359	920	50,918	13,139

Table 27.—U.S. imports[1] of lead, by country

(Lead content)

Country	1981 Quantity (metric tons)	1981 Value (thousands)	1982 Quantity (metric tons)	1982 Value (thousands)	1983 Quantity (metric tons)	1983 Value (thousands)
Ore, flue dust, residues, n.s.p.f.:						
Argentina	3,932	$3,023	--	--	--	--
Australia	2,160	1,228	7,694	$2,875	10,002	$2,865
Canada	23,500	17,149	4,780	2,259	6,143	1,234
Chile	2,084	1,719	--	--	--	--
Colombia	122	64	105	32	--	--
Honduras	11,617	9,271	8,677	4,850	8,663	3,945
Mexico	961	864	--	--	4	1
Peru	14,149	8,397	14,549	5,481	22,702	7,041
Other	20	14	2	1	2	1
Total	58,545	41,729	35,807	15,498	47,516	15,087
Base bullion:						
Canada	59	58	19	25	28	12
Mexico	--	--	--	--	25	10
Peru	390	278	--	--	--	--
Other	(2)	4	(2)	3	(2)	1
Total	449	340	19	28	53	23
Pigs and bars:						
Argentina	300	220	--	--	--	--
Australia	10,893	8,023	7,256	3,786	10,883	3,825
Belgium-Luxembourg	286	1,666	146	783	322	2,273
Canada	50,849	39,298	49,834	27,701	72,655	31,578
Denmark	354	341	449	351	--	--
Germany, Federal Republic of	1,433	8,899	927	5,836	1,022	7,020
Mexico	33,723	25,183	23,473	12,422	34,861	14,071
Netherlands	--	--	--	--	11	84
Peru	2,907	2,146	8,296	3,816	10,096	3,526
United Kingdom	989	2,269	748	1,902	716	898
Other	186	499	r60	r125	166	171
Total	101,920	88,544	91,189	56,722	130,732	63,446
Reclaimed scrap, etc.:						
Australia	2,605	1,611	3,992	1,301	2,272	347
Bahamas	83	12	37	8	90	6
Barbados	22	5	--	--	--	--
Canada	1,792	1,394	3,481	1,205	2,718	861
Chile	87	28	18	4	--	--
Guatemala	77	29	--	--	14	6
Mexico	456	344	852	398	1,551	371
Spain	92	380	--	--	--	--
United Kingdom	--	--	--	--	93	20
Other	51	28	18	8	15	100
Total	5,265	3,831	8,398	2,924	6,753	1,711
Pigs and bars:						
London Metal Exchange (return of U.S. brands)	--	--	--	--	[3]42,000	[3]16,945
Grand total	166,179	134,444	135,413	75,172	227,054	97,212

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]Bureau of Mines estimate.

Table 28.—U.S. imports for consumption of lead, by country

Country	1981 Quantity (metric tons)	1981 Value (thousands)	1982 Quantity (metric tons)	1982 Value (thousands)	1983 Quantity (metric tons)	1983 Value (thousands)
Ore, flue dust, residues, n.s.p.f. (lead content):						
Argentina	3,932	$3,023	--	--	--	--
Australia	648	457	--	--	--	--
Canada	1,913	1,353	29	$10	483	$112
Chile	2,084	1,719	--	--	--	--
Colombia	122	64	106	32	--	--
Honduras	11,617	9,271	8,677	4,850	1,522	674
Mexico	961	864	--	--	4	1
Peru	5,909	3,431	10,131	3,891	17,742	4,924
Other	20	14	2	1	2	1
Total	27,206	20,196	18,945	8,784	19,753	5,712
Base bullion (lead content):						
Canada	59	58	19	25	28	12
Mexico	--	--	--	--	25	10
Peru	390	278	--	--	--	--
Other	(1)	4	(1)	3	(1)	1
Total	449	340	19	28	53	23
Pigs and bars (lead content):						
Argentina	300	220	--	--	--	--
Australia	9,080	6,505	10,882	5,674	14,508	4,604
Belgium-Luxembourg	286	1,666	146	783	322	2,273
Canada	50,849	39,298	49,834	27,701	72,655	31,578
Denmark	354	341	449	351	--	--
Germany, Federal Republic of	1,433	8,899	927	5,836	1,022	7,020
Mexico	33,723	25,183	23,513	12,444	34,861	14,071
Netherlands	--	--	--	--	11	84
Peru	2,907	2,146	8,296	3,816	10,096	3,526
United Kingdom	989	2,269	748	1,903	716	898
Other	187	499	[r]60	[r]125	166	171
Total	100,108	87,026	94,855	58,633	134,357	64,225
Reclaimed scrap, etc. (lead content):						
Australia	--	--	428	132	6	6
Bahamas	83	12	37	8	90	6
Canada	1,792	1,394	3,481	1,205	2,443	831
Chile	87	28	18	4	--	--
Guatemala	77	29	--	--	14	6
Mexico	456	344	852	398	1,551	371
Spain	92	380	--	--	--	--
United Kingdom	--	--	--	--	93	20
Other	74	33	18	8	15	100
Total	2,661	2,220	4,834	1,755	4,212	1,340
Sheets, pipe, shot, other forms:						
Canada	203	343	313	335	228	238
Germany, Federal Republic of	51	85	40	111	216	1,189
Italy	20	33	24	52	--	--
Mexico	177	164	45	73	10	64
United Kingdom	4	17	3	12	3	14
Other	19	84	42	111	39	127
Total	474	726	467	694	496	1,632
Pigs and bars (lead content):						
London Metal Exchange (return of U.S. brands)	--	--	--	--	[2]42,000	[2]16,945
Grand total	130,898	110,508	119,120	69,894	200,871	89,877

[r]Revised.
[1]Less than 1/2 unit.
[2]Bureau of Mines estimate.

Table 29.—U.S. imports for consumption of lead

(Thousand metric tons and thousand dollars)

Year	Ore (lead content)		Base bullion (lead content)		Pigs and bars (lead content)		Sheets, plates, strip, other forms	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	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
	Waste and scrap (lead content)		Dross, skimmings, residues, n.s.p.f. (lead content)		Powder and flakes		Total value	
	Quantity	Value	Quantity	Value	Quantity	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

[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 30.—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

[1]Babbitt metal, solder, white metal, and other lead-containing combinations.

Table 31.—Lead: World mine production, by country[1]

(Thousand metric tons)

Country[2]	1979	1980	1981	1982[p]	1983[e]
Algeria	2.2	1.8	5.1	4.9	6.0
Argentina	31.8	32.6	32.7	30.1	[3]28.8
Australia[4]	421.6	[r]397.5	388.1	455.3	477.0
Austria	4.5	4.3	4.3	4.1	4.3
Bolivia	15.4	17.7	16.8	12.4	12.4
Brazil	27.9	27.8	28.4	[e]18.0	18.0
Bulgaria[e]	[r]108.0	[r]100.0	[r]96.0	[r]96.0	96.0
Burma[e]	[r]15.0	14.2	[r]16.1	[r]16.1	16.3
Canada	[r]341.8	[r]296.6	332.0	341.2	[3]251.5
Chile	.3	.3	.2	1.6	1.5
China[e]	155.0	[r]160.0	[r]160.0	[r]160.0	160.0
Colombia	.2	.2	.2	.4	.4
Congo (Brazzaville)	[r]7.0	[r]7.0	7.7	8.0	8.0
Czechoslovakia	4.0	3.3	3.4	3.5	3.4
Ecuador	.2	.2	.2	[e].2	.2
Finland	1.0	1.1	1.9	1.9	1.9
France	[r]29.3	[r]28.4	17.2	5.9	[3]1.5
Germany, Federal Republic of	25.2	23.1	21.6	23.5	[3]23.5
Greece	21.7	20.5	[e]21.0	[e]21.0	22.0
Greenland	31.9	[r]31.1	27.4	28.0	28.0
Guatemala[e]	.1	.1	([5])	([5])	--
Honduras	16.4	13.3	12.6	15.1	19.3
Hungary[e]	1.0	1.1	1.0	1.0	1.0
India	16.0	12.7	15.3	[r][e]16.6	25.7
Iran	[e]15.0	[r]12.0	20.0	25.0	[3]26.0
Ireland	71.0	59.0	28.8	38.8	36.0
Italy	28.1	22.9	21.6	16.2	15.0
Japan[6]	46.9	44.7	46.9	45.9	[3]47.1
Korea, North[e]	[r]120.0	[r]125.0	100.0	[r]95.0	95.0

See footnotes at end of table.

Table 31.—Lead: World mine production, by country[1] —Continued

(Thousand metric tons)

Country[2]	1979	1980	1981	1982[p]	1983[e]
Korea, Republic of	11.1	11.4	13.6	12.2	10.6
Mexico[7]	173.5	145.5	157.4	145.8	150.0
Morocco	115.7	[r]114.8	116.0	103.6	101.5
Namibia	[r]44.2	[r]50.2	46.9	32.9	[3]33.2
Nigeria[e]	.1	[r].4	.2	[r].3	.3
Norway	3.6	2.6	3.6	3.7	3.7
Peru	174.0	[r]189.1	192.7	175.8	[3]205.6
Philippines	1.9	1.8	1.1	--	--
Poland	61.9	60.0	50.4	57.5	58.6
Romania	33.3	33.5	[e]33.5	[e]33.5	34.0
South Africa, Republic of	--	86.1	98.9	90.3	[4]80.2
Spain	72.3	87.1	80.2	73.3	75.0
Sweden	81.6	72.2	84.1	80.8	80.0
Thailand	8.7	10.6	17.3	18.6	[3]21.0
Tunisia	10.0	8.3	5.7	5.0	4.7
Turkey	7.5	[r]6.7	8.0	6.4	6.3
U.S.S.R.[e]	415.0	420.0	425.0	430.0	435.0
United Kingdom	4.7	[r]3.6	7.0	4.0	4.0
United States[8]	525.6	550.4	445.5	512.5	449.0
Yugoslavia	129.8	[r]121.5	118.6	[e]115.0	120.0
Zambia	17.6	[r e]13.9	17.2	21.1	[3]25.9
Total	[r]3,450.6	[r]3,448.2	3,349.4	3,408.0	3,324.4

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through June 13, 1984.
[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]Content by analysis.
[5]Revised to zero.
[6]Content of concentrates.
[7]Recoverable metal content of lead in concentrates for export plus lead content of domestic smelter products (refined lead, antimonial lead, mixed bars, and other unspecified items).
[8]Recoverable.

Table 32.—Lead: World smelter production, by country[1]

(Thousand metric tons)

Country	1979	1980	1981	1982[p]	1983[e]
Argentina:					
Primary (refined)	32.0	23.2	19.0	[e]17.0	16.0
Secondary (refined)	18.0	18.5	15.6	14.6	14.0
Total	50.0	41.7	34.6	[e]31.6	30.0
Australia:					
Primary:					
Bullion for export	169.5	160.2	161.6	170.0	[2]160.4
Refined	215.6	200.5	207.7	218.8	[2]196.3
Secondary (refined)	42.0	32.6	31.5	28.3	[2]28.0
Total	427.1	393.3	400.8	417.1	[2]384.7
Austria:					
Primary (refined)	6.0	5.4	3.3	3.4	[2]3.1
Secondary (refined)	10.8	11.5	12.8	14.5	[2]14.4
Total	16.8	16.9	16.1	17.9	[2]17.5
Belgium:					
Primary[e 3]	33.7	53.9	60.2	52.9	53.0
Secondary[4]	27.0	30.0	28.0	28.0	28.0
Total	60.7	83.9	88.2	80.9	81.0
Brazil:					
Primary (refined)	55.1	44.5	34.7	[e]21.9	22.0
Secondary (refined)	43.0	40.4	31.1	[e]26.3	26.0
Total	98.1	84.9	65.8	[e]48.2	48.0

See footnotes at end of table.

Table 32.—Lead: World smelter production, by country[1] —Continued

(Thousand metric tons)

Country	1979	1980	1981	1982[p]	1983[e]
Bulgaria:[e]					
Primary	115.0	115.0	115.0	115.0	115.0
Secondary[4]	4.0	4.0	4.0	4.0	4.0
Total	119.0	119.0	119.0	119.0	119.0
Burma: Primary[e]	6.2	6.0	4.1	7.8	[2]7.6
Canada:					
Primary (refined)	[r]183.9	162.5	168.5	174.3	[2]178.1
Secondary (refined)	[r]68.5	72.1	69.7	64.6	[2]63.9
Total	252.4	234.6	238.2	238.9	[2]242.0
China:[e]					
Primary (refined)	150.0	[r]145.0	150.0	[r]155.0	155.0
Secondary (refined)	20.0	[r]30.0	[r]25.0	20.0	20.0
Total	170.0	[r]175.0	[r]175.0	[r]175.0	175.0
Colombia: Secondary (refined)[e]	2.5	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)	19.0	20.0	21.0	21.0	21.0
Denmark: Secondary (refined)	29.8	24.5	26.5	20.0	20.0
Finland: Secondary (refined)	3.0	3.2	4.5	4.4	4.0
France:					
Primary (refined)	129.1	[r]126.8	128.6	122.7	115.0
Secondary	30.8	35.7	38.9	40.7	37.6
Total	159.9	[r]162.5	167.5	163.4	152.6
German Democratic Republic: Secondary (refined)[e 4]	42.0	42.0	[r]48.0	[r]50.0	50.0
Germany, Federal Republic of:					
Primary	103.4	111.9	107.5	110.7	110.0
Secondary	213.2	189.5	254.8	239.7	239.2
Total	316.6	301.4	362.3	350.4	349.2
Greece:					
Primary (refined)	[r]22.1	[r]15.6	21.0	[r e]3.0	18.0
Secondary (refined)	6.0	4.0	4.0	[e]1.0	4.0
Total	[r]28.1	[r]19.6	25.0	[e]4.0	22.0
Guatemala: Secondary (refined)	.1	.1	.1	.1	.1
Hungary: Secondary (refined)	.1	.1	.1	[e].1	.1
India:					
Primary (refined)	9.8	[r]14.9	14.3	[e]14.4	23.0
Secondary (refined)	10.8	10.7	11.1	[e]8.8	8.8
Total	20.6	25.6	25.4	[e]23.2	31.8
Italy:					
Primary (refined)	[r]25.2	42.1	35.6	36.4	40.0
Secondary (refined)	101.0	91.6	97.4	97.3	90.0
Total	[r]126.2	133.7	133.0	133.7	130.0
Japan:					
Primary	187.8	185.8	190.7	192.8	250.0
Secondary (refined)	[r]106.5	129.8	141.6	119.1	114.0
Total	[r]294.3	315.6	332.3	311.9	364.0
Korea, North: Primary (refined)[e]	70.0	[r]65.0	[r]65.0	[r]60.0	60.0
Korea, Republic of:					
Primary (refined)[e]	[r]7.1	[r]8.6	[r]7.2	[r]9.5	10.5
Secondary (refined)[e]	.5	1.8	7.5	6.6	7.3
Total	[r]7.6	[r]10.4	14.7	16.1	[2]17.8
Malaysia: Secondary (refined)[e]	2.1	5.2	3.5	[2]3.0	3.0
Mexico:					
Primary	173.0	145.0	156.7	137.4	140.0
Secondary (refined)	50.0	[r]44.0	38.0	34.0	35.0
Total	223.0	[r]189.0	194.7	171.4	175.0

See footnotes at end of table.

Table 32.—Lead: World smelter production, by country[1] —Continued

(Thousand metric tons)

Country	1979	1980	1981	1982[p]	1983[e]
Morocco:					
Primary (refined)	35.3	40.3	50.1	56.5	56.0
Secondary (refined)[e]	1.5	2.1	2.1	2.0	2.0
Total	36.8	42.4	52.2	58.5	58.0
Namibia: Primary (refined)	41.7	42.7	41.7	40.6	[2]35.4
Netherlands:					
Primary[e]	[r]6.8	[r]6.0	[r]2.5	[r]2.5	2.5
Secondary	18.6	18.1	17.0	22.2	24.1
Total	25.4	24.1	19.5	24.7	26.6
New Zealand: Secondary (refined)[e]	9.0	7.0	7.0	7.0	6.5
Peru:					
Primary (refined)	[r]85.7	[r]79.9	79.2	77.0	[2]67.7
Secondary (refined)	5.0	5.0	5.0	5.0	5.0
Total	90.7	84.9	84.2	82.0	72.7
Philippines: Secondary (refined)	1.9	4.8	4.0	6.0	6.0
Poland:					
Primary (refined)[e]	59.2	[r]58.0	[r]47.0	55.0	56.5
Secondary (refined)[e 4]	25.0	[r]24.0	[r]22.0	23.8	24.5
Total	84.2	82.0	69.0	78.8	81.0
Portugal: Secondary (refined)	4.5	5.6	5.3	4.0	3.0
Romania:					
Primary (refined)	[r]30.9	[r]34.9	35.0	36.0	36.0
Secondary (refined)	10.0	6.0	6.0	9.6	10.0
Total	40.9	40.9	41.0	45.6	46.0
South Africa, Republic of: Secondary	23.3	35.4	26.9	30.4	[2]29.6
Spain:					
Primary (refined)[3]	87.2	[r]83.3	83.1	99.5	100.0
Secondary (refined)	39.8	[r]37.4	34.1	32.1	30.0
Total	127.0	[r]120.7	117.2	131.6	130.0
Sweden:					
Primary (refined)	[r]22.7	20.3	7.0	29.6	[2]35.2
Secondary (refined)	24.0	22.0	22.0	19.9	[2]16.6
Total	46.7	42.3	29.0	49.5	[2]51.8
Taiwan: Secondary (refined)[e]	20.0	16.8	30.0	35.0	35.0
Thailand: Secondary (refined)	.8	1.7	1.8	.9	[2]2.5
Trinidad and Tobago: Secondary (refined)[e]	2.0	2.0	2.0	2.0	2.0
Tunisia:					
Primary (refined)	16.2	[r]19.2	17.5	15.3	[2]10.4
Secondary (refined)[e]	.6	.6	.5	.5	.4
Total	16.8	19.8	18.0	15.8	[2]10.8
Turkey:					
Primary (refined)	[r]4.9	6.5	4.8	2.5	1.5
Secondary (refined)	1.0	1.2	1.2	.6	.5
Total	5.9	7.7	6.0	3.1	2.0
U.S.S.R.:[e]					
Primary (refined)	[r]475.0	[r]475.0	[r]480.0	[r]485.0	490.0
Secondary (refined)	215.0	[r]225.0	[r]235.0	[r]245.0	255.0
Total	[r]690.0	[r]700.0	[r]715.0	[r]730.0	745.0
United Kingdom:					
Primary[5]	32.3	30.0	26.5	34.1	[2]40.7
Secondary (refined)	244.2	211.4	198.0	179.2	[2]185.3
Total	276.5	241.4	224.5	213.3	[2]226.0

See footnotes at end of table.

Table 32.—Lead: World smelter production, by country[1] —Continued

(Thousand metric tons)

Country	1979	1980	1981	1982[p]	1983[e]
United States:					
Primary (refined)	578.2	548.4	498.3	516.8	[2]514.6
Secondary (refined)	801.4	675.6	641.1	571.3	[2]503.5
Total	1,379.6	1,224.0	1,139.4	1,088.1	[2]1,018.1
Venezuela: Secondary (refined)[e]	10.0	10.0	10.0	10.0	10.0
Yugoslavia:					
Primary	92.0	85.0	74.0	74.0	75.0
Secondary	41.6	[r]39.7	46.5	35.0	35.0
Total	133.6	[r]124.7	120.5	109.0	110.0
Zambia: Primary (refined)	12.8	10.0	9.9	14.6	[2]14.6
Grand Total	[r]5,627.8	[r]5,369.6	5,345.0	5,255.1	5,233.5
Of which:					
Primary	[r]3,275.4	[r]3,171.4	3,107.3	3,162.0	3,209.1
Secondary	[r]2,352.4	[r]2,198.2	2,237.7	2,093.1	2,024.4

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

[1]Table includes data available through June 13, 1984. 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]Production from Imperial Smelting Furnace at Avonmouth only.

Table 33.—Lead: World refined production, by country[1]

(Thousand metric tons)

Country	1979	1980	1981	1982[p]	1983[e]
Argentina:					
Primary	32.0	23.2	19.0	[e]17.0	16.0
Secondary	18.0	18.5	15.6	14.6	14.0
Total	50.0	41.7	34.6	[e]31.6	30.0
Australia:					
Primary	215.6	200.5	207.7	218.8	[2]196.3
Secondary	42.0	32.6	31.5	28.3	[2]28.0
Total	257.6	233.1	239.2	247.1	[2]224.3
Austria:					
Primary	6.0	5.4	3.3	3.4	[2]3.1
Secondary	10.8	11.5	12.8	14.5	[2]14.4
Total	16.8	16.9	16.1	17.9	[2]17.5
Belgium:					
Primary	65.2	75.9	73.9	66.0	65.0
Secondary	48.2	52.0	36.0	33.7	30.0
Total	113.4	127.9	109.9	99.7	95.0
Brazil:					
Primary	55.1	44.5	34.7	[e]21.9	22.0
Secondary	43.0	40.4	31.1	[e]26.3	26.0
Total	98.1	84.9	65.8	[e]48.2	48.0

See footnotes at end of table.

Table 33.—Lead: World refined production, by country[1] —Continued

(Thousand metric tons)

Country	1979	1980	1981	1982[p]	1983[e]
Bulgaria:[e]					
Primary	[r]105.0	[r]105.0	[r]110.0	[r]100.0	100.0
Secondary	[r]20.0	[r]13.0	[r]13.0	[r]18.0	18.0
Total	[r]125.0	[r]118.0	[r]123.0	[r]118.0	118.0
Burma:					
Primary[e]	6.0	[r]5.8	[r]3.9	[r]7.6	7.4
Secondary[e]	.2	.2	.2	.2	.2
Total	6.2	[r]6.0	4.1	7.8	[2]7.6
Canada:					
Primary	183.9	162.5	168.5	174.3	[2]178.1
Secondary	68.5	72.1	69.7	64.6	[2]63.9
Total	252.4	234.6	238.2	238.9	[2]242.0
China:[e]					
Primary	150.0	[r]145.0	150.0	[r]155.0	155.0
Secondary	20.0	[r]30.0	[r]25.0	20.0	20.0
Total	170.0	[r]175.0	[r]175.0	[r]175.0	175.0
Colombia: Secondary[e]	2.5	3.0	3.0	3.0	3.0
Cyprus: Secondary[e]	2.5	2.5	2.5	2.5	2.5
Czechoslovakia: Secondary	19.0	20.0	21.0	21.0	21.0
Denmark: Secondary	29.8	24.5	26.5	20.0	20.0
Finland: Secondary	3.0	3.2	4.5	4.4	4.0
France:					
Primary	[r]129.1	[r]126.8	128.6	122.7	115.0
Secondary	90.6	92.0	99.4	85.9	91.0
Total	[r]219.7	[r]218.8	228.0	208.6	206.0
German Democratic Republic: Secondary[e]	42.0	42.0	[r]48.0	[r]50.0	50.0
Germany, Federal Republic of:					
Primary	194.8	191.1	189.5	190.3	192.5
Secondary	178.5	159.2	158.8	158.0	160.0
Total	373.3	350.3	348.3	348.3	[2]352.5
Greece:					
Primary	[r]22.1	[r]15.6	21.0	[r][e]3.0	18.0
Secondary	6.0	4.0	4.0	[r][e]1.0	4.0
Total	[r]28.1	[r]19.6	25.0	[r][e]4.0	22.0
Hungary: Secondary	.1	.1	.1	[e].1	.1
India:					
Primary	9.8	14.9	14.3	[e]14.4	23.0
Secondary	10.8	10.7	11.1	[e]8.8	8.8
Total	20.6	25.6	25.4	[e]23.2	31.8
Ireland: Secondary[e]	[r]7.0	7.0	[r]10.0	[r]10.0	10.0
Italy:					
Primary	[r]25.2	[r]42.1	35.6	36.4	40.0
Secondary	101.0	91.6	97.4	97.3	90.0
Total	[r]126.2	[r]133.7	133.0	133.7	130.0
Jamaica: Secondary[e]	2.0	2.0	1.0	1.0	1.0
Japan:					
Primary	[r]176.2	[r]175.2	175.4	183.1	[2]241.3
Secondary	[r]106.5	129.8	141.6	119.1	[2]114.0
Total	282.7	[r]305.0	317.0	302.2	[2]355.3
Korea, North:[e]					
Primary	65.0	[r]60.0	[r]60.0	[r]55.0	55.0
Secondary	5.0	5.0	5.0	5.0	5.0
Total	70.0	[r]65.0	[r]65.0	[r]60.0	60.0

See footnotes at end of table.

Table 33.—Lead: World refined production, by country[1] —Continued

(Thousand metric tons)

Country	1979	1980	1981	1982[p]	1983[e]
Korea, Republic of:					
Primary[e]	[r]7.1	[r]8.6	[r]7.2	[r]9.5	10.5
Secondary[e]	[r].5	[r]1.8	[r]7.5	[r]6.6	7.3
Total	[r]7.6	[r]10.4	14.7	16.1	[2]17.8
Malaysia: Secondary[e]	2.1	5.2	3.5	[2]3.0	3.0
Mexico:					
Primary	167.1	140.3	150.5	129.2	130.0
Secondary	50.0	[r]44.0	38.0	34.0	35.0
Total	217.1	[r]184.3	188.5	163.2	165.0
Morocco:					
Primary	[r]35.3	40.3	50.1	56.5	56.0
Secondary[e]	1.5	2.1	2.1	2.0	2.0
Total[e]	[r]36.8	42.4	[r]52.2	[r]58.5	58.0
Namibia: Primary	41.7	42.7	41.7	40.6	[2]35.4
Netherlands:					
Primary	16.4	13.9	7.0	10.8	10.9
Secondary	[r]18.6	[r]18.1	17.0	22.2	24.1
Total	[r]35.0	[r]32.0	24.0	33.0	35.0
New Zealand: Secondary[e]	9.0	7.0	7.0	7.0	6.5
Nigeria: Secondary[e]	1.5	2.0	2.0	2.0	2.0
Norway: Secondary	.4	.4	--	--	--
Pakistan: Secondary[e]	1.5	1.0	1.0	1.0	1.0
Peru:					
Primary	85.7	79.9	79.2	77.0	[2]67.7
Secondary[e]	5.0	5.0	5.0	5.0	5.0
Total[e]	90.7	84.9	84.2	[r]82.0	72.7
Philippines: Secondary	1.9	4.8	4.0	6.0	6.0
Poland:					
Primary[e]	59.2	58.0	47.0	55.0	56.5
Secondary[e]	25.0	24.0	22.0	23.8	24.5
Total	84.2	82.0	69.0	78.8	81.0
Portugal:					
Primary	--	--	1.0	--	--
Secondary	[r]4.5	[r]5.6	5.3	4.0	3.0
Total	[r]4.5	[r]5.6	6.3	4.0	3.0
Romania:[e]					
Primary	30.9	34.9	35.0	[r]36.0	36.0
Secondary	10.0	6.0	6.0	[r]9.6	10.0
Total	40.9	40.9	41.0	[r]45.6	46.0
South Africa, Republic of: Secondary	23.3	35.4	26.9	30.4	[2]29.6
Spain:					
Primary	87.2	83.3	83.1	99.5	100.0
Secondary	39.8	37.4	34.1	32.1	30.0
Total	127.0	120.7	117.2	131.6	130.0
Sweden:					
Primary	22.7	20.3	7.0	29.6	[2]35.2
Secondary	[r]24.0	22.0	22.0	19.9	[2]16.6
Total	[r]46.7	42.3	29.0	49.5	[2]51.8
Switzerland: Secondary[e]	5.0	7.0	7.2	7.0	6.0
Taiwan: Secondary[e]	20.0	16.8	[r]30.0	[r]35.0	35.0
Thailand: Secondary	.8	1.7	1.8	.9	[2]2.5
Trinidad and Tobago: Secondary[e]	2.0	2.0	2.0	2.0	2.0
Tunisia:					
Primary	16.2	19.2	17.5	15.3	[2]10.4
Secondary[e]	.6	.6	.5	.5	.4
Total[e]	16.8	19.8	18.0	15.8	10.8

See footnotes at end of table.

Table 33.—Lead: World refined production, by country[1] —Continued

(Thousand metric tons)

Country	1979	1980	1981	1982[p]	1983[e]
Turkey:					
Primary	4.9	6.5	4.8	2.5	1.5
Secondary	1.0	1.2	1.2	.6	.5
Total	5.9	7.7	6.0	3.1	2.0
U.S.S.R.:[e]					
Primary	[r]475.0	[r]475.0	[r]480.0	[r]485.0	490.0
Secondary	215.0	[r]225.0	[r]235.0	[r]245.0	255.0
Total	[r]690.0	[r]700.0	[r]715.0	[r]730.0	745.0
United Kingdom:					
Primary	124.1	113.4	135.4	131.0	[2]130.1
Secondary	244.2	211.4	198.0	179.2	[2]185.3
Total	368.3	324.8	333.4	310.2	[2]315.4
United States:					
Primary	578.2	548.4	498.3	516.8	[2]514.6
Secondary	801.4	675.6	641.1	571.3	[2]503.5
Total	1,379.6	1,224.0	1,139.4	1,088.1	[2]1,018.1
Venezuela: Secondary[e]	10.0	10.0	10.0	10.0	10.0
Yugoslavia:					
Primary	92.0	84.7	73.9	72.0	77.5
Secondary	19.0	17.0	12.5	10.2	20.0
Total	111.0	101.7	86.4	82.2	[2]97.5
Zambia: Primary	12.8	10.0	9.9	14.6	[2]14.6
Grand total	[r]5,712.1	[r]5,429.9	5,335.5	5,227.4	5,229.3
Of which:					
Primary	[r]3,297.5	[r]3,172.9	3,124.0	3,149.8	3,204.6
Secondary	[r]2,414.6	[r]2,257.0	2,211.5	2,077.6	2,024.7

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

[1]Table includes data available through June 14, 1984. 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.

Lime

By J. W. Pressler[1]

Lime output, including that for Puerto Rico, was 14.9 million short tons, an increase of 6% compared with that of 1982. Total value increased 9% to $761 million.

Output of agricultural lime increased 30%, refractory lime increased 24%, and construction as well as chemical and industrial lime increased 5% each.

Domestic Data Coverage.—Domestic production data for lime were 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 140 operations to which an annual survey request was sent, 100% 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)

	1979	1980	1981	1982	1983
Number of plants	154	153	150	147	139
Sold or used by producers:					
Quicklime	17,553	15,972	16,142	11,701	12,383
Hydrated lime	2,599	2,544	2,279	2,037	2,066
Dead-burned dolomite	793	494	435	337	418
Total	20,945	19,010	18,856	14,075	14,867
Value[2] thousands	$862,459	$842,922	$884,197	$696,207	$757,611
Average value per ton	$41.18	$44.34	$46.89	$49.46	$50.96
Lime sold	15,423	13,809	14,271	10,856	12,083
Lime used	5,522	5,201	4,585	3,219	2,784
Exports[3]	45	42	28	23	28
Imports for consumption[3]	640	480	504	348	283

[1]Excludes regenerated lime. Excludes Puerto Rico.
[2]Selling value, f.o.b. plant, excluding cost of containers.
[3]Bureau of the Census.

DOMESTIC PRODUCTION

Lime sold or used by producers increased 6% to 14.9 million tons. Commercial sales increased 11% to 12.1 million tons. Captive lime used by producers continued its long decline with a 14% reduction to 2.8 million tons. This was a 62% decrease from the record high in 1971.

Production of quicklime increased 6% to 12.8 million tons. Production of hydrated lime remained virtually the same at 2.1 million tons. Production of dead-burned dolomite increased 24%, but was still 83% below the 1956 record level of 2.4 million tons.

Five States—Ohio, Pennsylvania, Missouri, Kentucky, and Texas—accounted for 50% of total lime output. Production increased 16% in Pennsylvania, 14% in Ohio, 10% in Missouri, and 6% in Kentucky, but decreased 5% in Texas.

Table 2.—Lime sold or used by producers in the United States, by State[1]

State	1982 Plants	1982 Hydrated (thousand short tons)	1982 Quicklime (thousand short tons)	1982 Total[2] (thousand short tons)	1982 Value (thousand dollars)	1983 Plants	1983 Hydrated (thousand short tons)	1983 Quicklime (thousand short tons)	1983 Total[2] (thousand short tons)	1983 Value (thousand dollars)
Alabama	5	109	799	907	42,380	5	125	856	981	41,149
Arizona	5	--	326	326	17,080	3	--	340	340	16,700
Arkansas, Louisiana, Oklahoma	7	125	238	363	22,481	5	119	213	332	19,751
California	12	W	W	364	23,000	11	W	W	358	22,994
Colorado, Nevada, Wyoming	12	53	258	311	15,761	11	W	W	242	14,287
Connecticut	1	2	6	8	568	1	--	5	5	400
Florida	3	W	W	103	5,828	3	W	W	W	13,881
Hawaii, Oregon, Washington	5	24	286	311	21,239	5	27	277	306	20,115
Idaho	3	W	W	W	W	3	--	85	85	7,686
Illinois, Indiana, Missouri	8	401	2,223	2,623	116,619	8	391	2,582	2,974	144,049
Iowa, Kansas, Nebraska, South Dakota	7	41	160	202	13,221	7	W	W	208	10,165
Kentucky, New York, Tennessee, West Virginia	7	64	2,067	2,130	102,898	6	79	2,141	2,220	105,753
Maryland	1	4	3	7	396	1	4	3	7	383
Massachusetts	2	15	120	135	9,414	2	16	140	156	10,671
Michigan	8	W	W	571	26,823	9	W	W	503	23,142
Minnesota	4	--	133	133	4,694	4	--	W	W	W
Montana	3	--	45	45	2,331	3	--	86	86	W
New Mexico	1	W	W	W	W	1	--	17	17	W
North Dakota	3	W	W	W	W	3	--	57	57	6,798
Ohio	14	98	1,568	1,666	76,370	14	W	W	1,906	84,928
Pennsylvania	10	297	1,000	1,297	70,902	10	308	1,199	1,507	81,682
Puerto Rico	1	35	2	37	1,906	1	35	--	35	3,885
Texas	10	532	592	1,125	62,277	9	485	582	1,067	60,193
Utah	4	W	W	286	15,121	4	W	W	315	16,771
Virginia	7	113	529	641	29,118	6	103	454	557	24,637
Wisconsin	5	85	227	312	17,685	5	97	222	319	17,624
Other[3]	(4)	75	1,459	210	6,262	(4)	311	3,542	322	13,852
Total[2]	148	2,072	12,039	14,112	698,112	140	2,100	12,801	14,902	761,496

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 and exports.
[4]Included with data for each individual State.

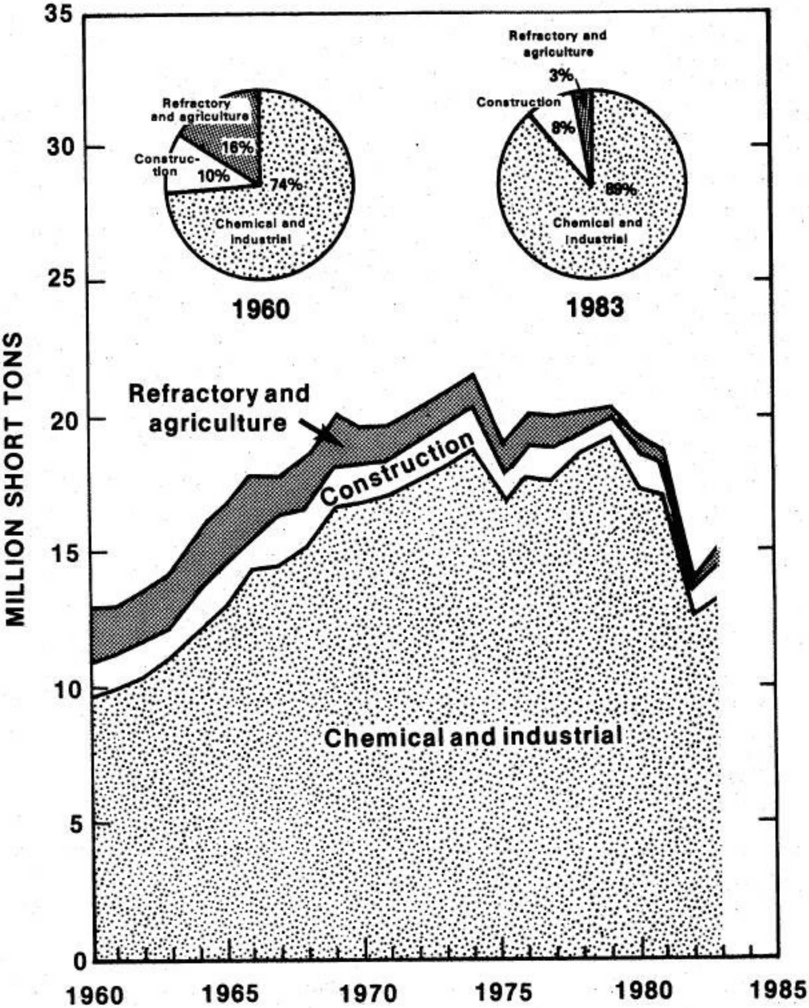

Figure 1.—Trends in major uses of lime.

Leading producing companies were Dravo Lime Co. with one plant each in Alabama, Kentucky, Louisiana, and Texas; Marblehead Lime Co. with two each in Illinois and Michigan, and one each in Indiana, Pennsylvania, and Utah; Mississippi Lime Co. in Missouri; Martin Marietta Corp., Chemical Div. in Alabama and two plants in Ohio; Allied Chemical Corp. in New York; Black River Lime Co. in Kentucky; Genstar Lime Co. with two plants each in California and Nevada, and one each in Arizona, Utah, and Virginia; Bethlehem Steel Corp. with two plants in Pennsylvania; Rangaire Corp. with one plant each in Arkansas, Pennsylvania, Texas, and Virginia; and Warner Co. with two plants in Pennsylvania. These 10 companies, operating 32 plants, accounted for 52% of total lime production.

The six largest lime plants, each producing more than 400,000 tons, accounted for 28% of total lime output. Thirteen plants produced 100,000 to 200,000 tons each and accounted for 23% of the total.

Leading individual plants were Mississippi Lime's Ste. Genevieve plant in Missouri, Dravo Lime's Maysville plant in Kentucky, Allied Chemical's Syracuse plant in New York, Black River Lime's Carntown plant in Kentucky, and Martin Marietta Chemical Div.'s Woodville No. 1 plant in Ohio.

A total of 356 lime kilns were operated during the year. Eleven sugar companies operated 35 plants with 54 shaft kilns and 1 rotary kiln, and produced 513,000 tons of lime valued at $35.6 million. The remainder of the lime industry, not including the paper and pulp industry, operated 301 kilns during the year: 112 vertical kilns, 149 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 138; 121 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 8 to 140, and the average production per plant, excluding the sugar industry average of 14,650 tons per year, was 125,300 tons per year.

New Plants, Expansions, and Changes.— The number of kilns in the lime industry increased by one. The Maerz-Warwick vertical shaft, parallel-flow kiln went on-stream in July at Chemical Lime Co.'s Marble Falls, TX, plant. Its capacity was 600 tons per day of dolomitic lime, principally for use in the production of magnesium from seawater.

The Bellefonte lime plant of Domtar Industries Inc. in Centre County, PA, had ceased operations in June 1982. In April 1983, Domtar sold the plant to Con Lime Inc., which reopened the plant and operated one of its three kilns. Quicklime and hydrated lime produced at the plant were sold principally to the steel industry.

Genstar Stone Products Co. sold its Stephens City lime plant in Frederick County, VA, to Shen Valley Lime Corp. in September. Shen Valley did not operate the vertical lime kiln, but planned to operate the batch hydrator using purchased quicklime. North American Refractories Co. sold its Bonne Terre dolomitic lime and refractory dead-burned dolomite plant in St. Francois County, MO, to Resco Products of Missouri Inc. in June. Martin Marietta sold its Roberta lime plant in Shelby County, AL, to Blue Circle Inc. in May.

Reflecting continued depressed markets for lime, several plants were closed, or remained closed. Amstar Corp.'s plant in Chandler, AZ, remained idle, and its Spreckles, CA, plant was dismantled. Kennecott-Ray Mines Div.'s plant near Hayden, AZ, and Phelps Dodge Corp.'s plant in Morenci, AZ, were idle. Aluminum Co. of America's plant in Bauxite, AR, was permanently closed in August. CF&I Steel Corp.'s plant in Pueblo, CO, had ceased operations in August 1982 and was permanently closed in 1983. S. I. Lime Co.'s Morgan City, LA, plant had shut down its two kilns in July 1982 and operated only two continuous hydrators on quicklime from Kentucky during 1983. Chino Mines Co.'s plant near Hurley, NM, was dormant during the year. Cuyahoga Lime Co. permanently closed its Cleveland, OH, lime plant. C-E Basic Inc. permanently closed its Maple Grove, OH, plant at yearend. Pfizer Inc. shut down its Gibsonburg, OH, dolomitic lime plant in July. Armco Inc.'s Azbe vertical lime kiln in Houston, TX, had been shut down in late 1982 and remained dormant during 1983. Greer Lime Co.'s Saltville, VA, plant had ceased operations in July 1982 and remained dormant during 1983. Riverton Corp.'s Martinsburg, WV, plant, which had been closed in July 1982, remained dormant.

As reported by the National Lime Association, direct fuel sources for the commercial lime industry through 1983 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.

Table 3.—Lime sold or used by producers in the United States,[1] by size of plant

Size of plant	1982 Plants	1982 Quantity (thousand short tons)	1982 Percent of total	1983 Plants	1983 Quantity (thousand short tons)	1983 Percent of total
Less than 10,000 tons	21	116	1	23	133	1
10,000 to 25,000 tons	30	495	4	29	501	3
25,000 to 50,000 tons	24	867	6	18	667	5
50,000 to 100,000 tons	26	1,920	14	24	1,861	12
100,000 to 200,000 tons	31	4,523	32	27	4,131	28
200,000 to 400,000 tons	12	3,156	22	13	3,383	23
More than 400,000 tons	4	3,035	22	6	4,226	28
Total	148	14,112	[2]100	140	14,902	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 were Pennsylvania, Ohio, Indiana, Texas, and Michigan, each of which consumed more than 1 million tons. These five States accounted for 46% of the total lime consumed. Twenty-eight plants in thirteen States produced dolomitic quicklime or dead-burned dolomite, and represented about 20% of the lime industry.

Lime consumption in the steel industry increased 13% to 5.4 million tons, and equaled 36% 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, 3% and 16%, respectively. Environmental uses of lime continued to increase. Lime consumption in flue gas desulfurization processes and effluent water cleanup increased 4%.

Leading quicklime-consuming States were Ohio, Pennsylvania, and Indiana, each of which consumed more than 1 million tons. These three States accounted for 35% of the total quicklime consumed.

Leading hydrate-consuming States were Texas, Pennsylvania, Ohio, and Illinois, each of which consumed more than 100,000 tons. These four States accounted for 44% of the total hydrate consumed.

Lime sold or used by producers was for chemical and industrial uses, 89%; construction, 8%; and refractories and agriculture, 3%. Captive lime used by producers remained at 23% of the total. Captive lime was used mainly in the production of basic oxygen furnace (BOF) steel, 30%; alkalies, 20%; and sugar, 19%.

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, 23%; and Pennsylvania, 11%. Lime for water purification was produced mainly in Missouri, 30%; Texas, 9%; and Pennsylvania and Alabama, 8% each. Lime for sulfur removal from stack gases was principally produced in the Eastern United States. Lime used for paper and pulp, excluding regenerated lime, was produced mainly in Alabama, 24%; Tennessee and Virginia, 16% each; and Wisconsin, 13%. Lime for electric steel was produced principally in Pennsylvania, 28%; Texas, 13%; Ohio, 10%; and Missouri, 8%.

Mason's lime was produced at 26 plants in 14 States, including Puerto Rico. Leading States were Pennsylvania, 25%, with three plants; Wisconsin, 23%, with four plants; and Virginia, 16%, with three plants. Finishing lime was produced in 12 plants in 8 States; the leading State was California with 3 plants.

The use of lime in agriculture increased 30%, from its long-term decline, to about 61,000 tons. Compared with its high of 252,000 tons per year in 1956, it has become of small significance. Conversely, the use of less-reactive pulverized limestone and dolomite in agriculture was 18.7 million tons.

Table 4.—Destination of shipments of lime sold or used by producers in the United States, by State[1]

(Thousand short tons)

State	1982			1983		
	Quicklime	Hydrated lime	Total[2]	Quicklime	Hydrated lime	Total[2]
Alabama	369	47	416	367	57	424
Alaska	W	W	23	W	W	8
Arizona	206	17	223	210	25	235
Arkansas	94	30	124	98	36	134
California	448	62	511	436	72	508
Colorado	135	13	148	81	20	101
Connecticut	25	11	36	33	13	46
Delaware	30	5	35	40	5	45
District of Columbia	W	W	10	W	W	13
Florida	287	37	324	333	18	351
Georgia	193	36	229	215	74	289
Hawaii	1	5	5	1	5	6
Idaho	116	2	118	95	3	97
Illinois	483	103	586	560	103	664
Indiana	1,272	42	1,314	1,512	41	1,553
Iowa	70	16	86	62	17	79
Kansas	65	15	79	64	15	79
Kentucky	387	16	403	457	22	479
Louisiana	144	101	245	166	100	265
Maine	15	(3)	15	11	1	13
Maryland	316	17	333	262	18	280
Massachusetts	50	13	63	65	12	77
Michigan	980	28	1,008	993	29	1,022
Minnesota	219	12	231	181	16	198
Mississippi	111	55	166	96	32	129
Missouri	123	33	156	148	35	183
Montana	67	6	73	62	10	72
Nebraska	56	5	61	51	6	57
Nevada	73	5	79	50	6	56
New Hampshire	W	W	3	W	W	3
New Jersey	82	41	124	106	40	147
New Mexico	68	30	98	62	19	81
New York	597	44	641	607	40	647
North Carolina	163	23	186	170	23	193
North Dakota	100	5	105	81	8	88
Ohio	1,296	102	1,398	1,470	110	1,580
Oklahoma	79	15	94	88	15	103
Oregon	85	8	93	87	8	95
Pennsylvania	1,315	195	1,509	1,469	195	1,664
Rhode Island	4	2	7	5	2	7
South Carolina	79	15	95	88	15	103
South Dakota	11	10	21	61	16	77
Tennessee	147	66	213	122	53	174
Texas	614	551	1,165	586	515	1,101
Utah	172	9	181	240	11	251
Vermont	W	W	1	W	W	W
Virginia	121	82	202	110	74	183
Washington	226	13	240	222	16	238
West Virginia	328	26	355	386	29	415
Wisconsin	109	45	155	109	45	154
Wyoming	62	9	71	51	18	69
Other[4]	35	30	28	13	36	25
Total United States[2]	12,028	2,055	14,083	12,782	2,079	14,861
Exports:						
Canada	7	6	13	16	7	23
Mexico	2	--	2	(3)	--	(3)
Other countries	2	12	14	3	14	17
Total exports	11	18	29	19	21	40
Grand total[2]	12,039	2,072	14,112	12,801	2,100	14,902

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	1982				1983			
	Sold	Used	Total[2]	Value	Sold	Used	Total[2]	Value
Agriculture	47	--	47	2,541	61	--	61	3,246
Construction:								
Road stabilization	532	--	532	27,364	592	--	592	33,384
Mason's lime	179	33	212	13,432	W	W	218	14,166
Soil stabilization	220	--	220	13,666	215	--	215	12,660
Finishing lime	138	--	138	10,863	160	--	160	13,243
Other	21	17	38	2,199	17	--	17	1,216
Total[2]	1,090	49	1,140	67,523	W	W	1,201	74,668
Chemical and industrial:								
Steel, BOF	2,838	800	3,638	165,870	3,461	832	4,293	193,552
Water purification	1,318	12	1,331	65,435	W	W	1,488	76,932
Sulfur removal from stack gases	996	--	996	48,787	1,019	--	1,019	50,817
Paper and pulp	990	105	1,096	55,644	W	W	916	44,619
Steel, electric	714	61	775	38,814	W	W	808	38,937
Sewage treatment	586	6	592	30,983	W	W	578	31,847
Sugar refining	50	719	769	38,267	43	523	566	38,320
Alkalies	14	647	661	33,051	W	W	560	26,852
Magnesia from seawater or brine	W	W	417	19,610	W	W	557	27,084
Copper ore concentration	240	122	363	18,866	W	W	390	19,529
Steel, open hearth	338	21	359	16,799	W	W	292	13,265
Acid water, mine or plant	237	--	237	12,567	W	W	268	14,365
Calcium carbide	158	51	209	8,738	W	W	209	9,416
Aluminum and bauxite	97	87	184	10,217	W	W	203	11,423
Magnesium metal	10	147	156	2,833	W	W	171	10,707
Glass	140	--	140	6,375	156	--	156	6,947
Precipitated calcium carbonate	74	30	104	5,233	W	W	128	9,046
Ore concentration, other	45	--	45	1,910	80	--	80	3,963
Oil and grease	47	--	47	2,525	52	--	52	3,166
Petrochemicals	56	--	56	3,816	W	--	W	W
Food products, animal or human	31	--	31	1,709	35	--	35	2,255
Oil-well drilling	31	--	31	2,075	30	--	30	2,113
Petroleum refining	21	--	21	1,154	26	--	26	1,308
Tanning	19	--	19	1,126	20	--	20	1,246
Citric acid	--	21	21	1,455	--	20	20	1,337
Metallurgy, other	26	(3)	26	1,213	11	--	11	492
Fertilizer	6	--	6	434	5	--	5	456
Gelatin	5	--	5	348	5	--	5	311
Calcium silicate	7	--	7	346	W	--	W	W
Brick, sand-lime	4	--	4	235	4	--	4	220
Paint	2	--	2	109	2	--	2	161
Other[4]	r359	299	r241	12,367	5,569	1,328	329	18,442
Total[2]	9,460	3,128	12,589	608,911	10,518	2,703	13,221	659,128
Refractory dolomite	296	41	337	19,136	W	W	418	24,454
Grand total[2]	10,893	3,219	14,112	698,112	12,118	2,784	14,902	761,496

rRevised. W Withheld to avoid disclosing company proprietary data.
[1]Excludes regenerated lime. Includes Puerto Rico.
[2]Data may not add to totals shown because of independent rounding.
[3]Less than 1/2 unit.
[4]Includes asphalt fillers, briquetting, brokers, chrome, coke and gas, commercial hydrators (1983), desiccants, explosives, ferroalloys, fiberglass, glue, insecticides, ladle desulfurizing, manganese (1983), 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 increased 3% to $51.10 per ton, an increase of 193% over the 1973 price. Values ranged from $49.85 for chemical and industrial lime to $62.17 for construction lime, $58.46 for refractory dolomite, and $53.36 for lime used in agriculture.

Values for quicklime sold ranged from $46.44 for chemical lime to $51.83 for construction lime, $31.31 for lime used in agriculture, and $59.31 for refractory dead-burned dolomite, and averaged $47.05, a decrease of 2%.

Values for hydrated lime sold ranged

from $66.24 for construction lime to $66.54 for chemical lime and $60.71 for lime used in agriculture, and averaged $66.28, an increase of 14%.

FOREIGN TRADE

Exports of lime increased 25% to 28,154 tons, but was still 59% below the 1968 record. Of the total exports, Canada received 63%; Sudan, 11%; Guyana, 9%; and Panama, 4%. The remaining 13% went to 29 countries as follows, in descending order of volume: The Bahamas, Jordan, Mexico, the Philippines, Bermuda, the Republic of Korea, Brazil, Saudi Arabia, the Republic of South Africa, Singapore, Colombia, Belgium-Luxembourg, Venezuela, the Netherlands Antilles, the United Kingdom, New Zealand, Trust Pacific Islands, France, Peru, Liberia, Argentina, Japan, Barbados, China, India, the Netherlands, Hong Kong, the United Arab Emirates, and the Federal Republic of Germany.

Imports, principally from Canada, 80%, and Mexico, 20%, were 282,563 tons, a decrease of 19%. Import reliance, expressed as a percentage of apparent consumption, was 2%.

Table 6.—U.S. exports of lime

	Quantity (short tons)	Value (thousands)
1980	41,843	$3,990
1981	28,429	3,996
1982	22,541	3,199
1983	28,154	4,815

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)
1980	62,423	$3,129	417,792	$16,044	480,215	$19,173
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

WORLD REVIEW

Canada.—Canadian production of lime decreased 3% to 2.3 million tons valued at $110 million. In 1982, 18 companies operated 21 lime plants in Canada, 1 in New Brunswick, 4 in Quebec, 9 in Ontario, 2 in Manitoba, 3 in Alberta, and 2 in British Columbia. Of these, six were captive plants, of which three were in the sugar industry, one was in the iron and steel industry, one was in the soda ash industry, and one produced dolomitic lime for use in production of magnesium, calcium, and strontium metal. Eight plants produced hydrated lime for road stabilization, water and sewage treatment, and agricultural use. In 1982, principal lime uses were iron and steel, 48%; pulp and paper, 11%; and nonferrous smelters, 5%. Consumption by cyanide, flotation, and uranium processing plants was substantial, but company data were proprietary. Average energy consumption in the Canadian lime industry was 5.0 million British thermal units (Btu) per ton of production.[2]

There were four high-calcium lime producers in Quebec, with an annual capacity of 770,000 tons. Shipments amounted to 350,000 tons in 1983. Markets were mostly to the pulp and paper industry and to iron foundries in eastern Canada.

Jolichaux Inc., formerly Domtar Inc., with three rotary kilns near Joliette, and Domlin Inc., with six vertical kilns at Lime Ridge, were the principal producers in Quebec. At Saint-Hilaire, near Montreal, La Raffinerie de Sucre du Quebec operated a lime kiln for sugar refining, and, at Shawinigan, Le Carbure Shawinigan Inc. marketed a hydrated lime reclaimed from acetylene production from the calcium carbide process.

The major lime producer in Manitoba was Steel Bros. Canada Ltd. Its 350-ton-per-day plant with a 140-foot-long rotary kiln was located at Faulkner, near Steep Rock. Both high-calcium and high-purity dolomite were used in the production of lime for use in the chemical, metallurgical, and pulp and paper industries.

In Ontario, nine companies produced an estimated 1.5 million tons of lime from high-calcium and dolomitic limestone valued at $90 million. Principal uses were chemical and metallurgical, with minor amounts for construction, agriculture, and road stabilization.

Two lime producers in British Columbia, Texada Lime of Selco Inc. and Pavilion Lake of Steel Bros. Canada, operated at reduced capacity. Pulp and paper plants operated their own lime kilns, and purchased limestone from the Texada Quarry and other smaller quarries.[3]

Libya.—The Libyan Cement Co. added a third lime kiln to its plant facilities at Benghazi. The shaft kiln had an output of 138 tons per day of quicklime. Fired by heavy fuel oil, the 52-foot-high vertical shaft operated on the induced draft principle, waste heat recuperation, and a multiple firing system, which can use either solid, liquid, or gaseous fuel. The soft, porous coral limestone was crushed and screened to provide a minus 3-inch, plus 1-inch feed for the kiln. A continuous hydrating plant with a capacity of 15 tons per hour produced pulverized hydrated lime for bulk or bagging facilities.[4]

South Africa, Republic of.—Three of the Republic of South Africa's largest lime producers—Pretoria Portland Cement Co. Ltd. (PPC), Union Lime Co. Ltd., and Cape Lime Holdings Ltd.—dominated national production with annual shipments of 1.9 million tons. The Republic of South Africa was the world's third largest user of lime in road and soil stabilization, behind the United States and France. However, two-thirds of the production was consumed in the gold, uranium, and steel industries. Road and soil application only accounted for 10%, but it was expected that increased use would effectively reduce the high cost of road construction and maintenance. The capacity at PPC's plant was increased to 7,400 tons per day with the installation of the world's largest single lime kiln, which came onstream near yearend.[5]

Sweden.—Sales of lime had increased 2% in 1982 to 720,000 tons and maintained that level in 1983. End uses were in the metallurgical, paper and pulp, and building materials industries.

A new lime system for dry scrubbing of dust and sulfur from flue gas was installed in the Sysav project in Malmo. A reduction of 95% to 98% of the particulates and sulfur dioxide was achieved. This system was to be installed on a new coal-fired power station outside of Stockholm.[6]

Turkey.—Turkey's estimated lime production was 1.1 million tons. The major producers, 11 companies in 10 locations, operated 20 different kilns—9 Maerz, 8 Nikex, 2 vertical shaft, and 1 rotary. Together they produced about 450,000 tons of lime. The balance of Turkey's production was attributed to many small primitive hand-fired kilns, producing lime principally for housing construction use as mortar and plaster. The total end-use pattern consisted of housing and building construction, 42%; steel refining, 16%; iron blast furnaces, 13%; sugar refining, 10%; fertilizer, 6%; soda ash and paint, 5% each; glass, 1%; and other, 2%.[7]

United Kingdom.—Ready Mixed Concrete Ltd. (RMC) acquired Peakstone Ltd., in late 1982, and reorganized the Lime Div. to form RMC Industrial Minerals Ltd., which operated one limestone quarry at Dove Holes and a calcining plant at Hindlow in Derbyshire. The market for RMC's lime was to private steelworks and specialized chemical and industrial uses, including the sugar beet refining industry. However, the largest outlet continued to be building products such as aerated concrete blocks, calcium silicate bricks, and calcium silicate boards.[8]

Table 8.—Quicklime and hydrated lime, including dead-burned dolomite: World production, by country[1]

(Thousand short tons)

Country[2]	1979	1980	1981	1982[p]	1983[e]
Algeria[e]	[r]40	[r]45	[r]45	[r]45	45
Australia[3]	963	992	1,433	1,350	1,430
Austria	[r]1,027	[r]1,108	1,140	1,132	[4]1,257

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]	1979	1980	1981	1982[p]	1983[e]
Belgium	[r]3,503	[r]3,346	3,021	2,244	2,200
Brazil[e]	5,200	5,300	5,500	5,500	5,500
Bulgaria	2,059	[r]2,061	1,938	1,958	1,870
Canada	2,050	2,815	2,816	2,422	[4]2,344
Chile	870	858	714	711	720
Colombia[e]	1,430	1,430	1,430	1,430	1,430
Costa Rica[e]	10	8	[r]8	[r]13	10
Cuba	200	161	154	160	160
Cyprus	[e]20	15	12	11	[4]9
Czechoslovakia	3,272	3,327	3,565	3,404	3,420
Denmark	195	187	215	[e]215	220
Dominican Republic	42	44	[e]44	[e]44	44
Egypt	[e]100	97	101	[e]105	100
Fiji Islands	1	2	3	4	3
Finland	484	432	422	290	285
France	4,266	3,979	3,710	3,300	3,300
German Democratic Republic	3,825	3,749	3,793	3,869	3,860
Germany, Federal Republic of	10,183	[r]9,453	8,726	7,604	7,720
Guatemala	45	39	27	[r e]27	27
Hungary	787	769	834	931	[4]884
India[e]	[4]450	440	440	440	440
Iran[e]	550	550	550	600	700
Ireland	[r]80	35	51	51	50
Israel[e]	137	137	[4]88	[r]55	55
Italy	2,405	2,606	2,543	2,389	2,430
Jamaica	225	175	146	126	120
Japan	10,613	10,307	8,848	8,573	[4]8,197
Jordan	4	[e]4	22	56	[4]294
Kenya	30	29	[e]30	24	30
Korea, Republic of[e]	66	[4]232	220	220	220
Kuwait	6	[r]20	24	11	15
Lebanon	132	132	67	[r e]55	20
Libya	248	254	259	[e]250	220
Malta	33	34	[e]35	[e]35	36
Martinique	--	--	6	[e]6	6
Mauritius[e]	9	[4]8	8	8	8
Mexico	5,048	4,795	4,960	[e]4,400	4,000
Mongolia[e]	51	55	55	[r]65	70
Mozambique[e]	11	11	11	11	11
New Zealand[e]	190	190	190	[r]190	180
Nicaragua[e]	40	44	33	[r]17	33
Norway[e]	145	145	145	145	145
Paraguay	36	61	63	67	65
Peru	([5])	([5])	37	[r e]40	40
Philippines	59	96	94	73	80
Poland	[r]5,271	[r]5,324	4,607	4,476	4,409
Portugal	288	298	287	276	250
Romania	4,221	4,203	4,125	4,180	4,190
Saudi Arabia[e]	165	165	190	220	230
South Africa, Republic of (sales)	1,897	2,407	2,380	2,232	[4]2,085
Spain	773	1,047	1,158	[e]1,200	1,100
Sweden	[r]855	820	708	[r e]720	720
Switzerland	77	71	63	51	50
Taiwan	195	219	158	120	[4]115
Tanzania[e]	7	7	7	8	8
Tunisia	474	583	514	[e]520	[4]640
Turkey	NA	1,100	1,000	1,000	1,100
Uganda[e]	31	17	17	17	17
U.S.S.R.[e]	26,500	27,000	27,600	27,600	28,100
United Arab Emirates[e]	NA	[4]49	45	45	50
United Kingdom	3,649	3,285	[e]3,310	[e]3,310	3,310
United States including Puerto Rico (sold or used by producers)	20,983	19,037	18,890	14,112	[4]14,902
Uruguay	89	22	[e]55	15	18
Venezuela	NA	NA	2	2	2
Yugoslavia	2,647	2,628	2,826	2,984	3,220
Zaire	127	125	136	114	115
Zambia	276	201	221	204	[4]213
Total	[r]129,665	[r]129,185	126,875	118,082	119,147

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available.
[1]Table includes data available through June 13, 1984.
[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

A recently patented lime-slaking system, which converted 100% of its pebble quicklime feed into hydrated lime, was successfully tested. It required lower capital investment than current systems, was more energy efficient, and more responsible to slaking requirements. Key to the process was an attrition scrubber that eliminates the pulverization of quicklime prior to processing and allows a wide variation in particle size.[9]

The South African Transvaal Roads Department collaborated with the principal South African lime producers in the use of quicklime instead of hydrated lime for road and highway soil stabilization. Carried out on the Piet Retief Mahamba Road, it proved that unslaked lime could readily be slaked in situ, with significant cost savings and improved engineering properties. Significant transportation savings up to 25% were realized. The Roads Department authorized the use of quicklime for future road stabilization use.[10]

Several benefits were associated with lime kiln optimization based on oxygen and carbon monoxide control. Energy savings was the most visible benefit. Oxygen control was shown to increase refractory life by stabilizing flame temperature, thus moderating temperature cycles that fracture refractories. Shift-to-shift differences in operating procedures were also reduced. Thus, accurate and reliable oxygen and carbon monoxide measurements, using an analyzer coupled with a distributed control capability to provide quick responses to changing process conditions, were found to yield the highest possible product quality with minimum operating and maintenance costs.[11]

A catalyst that increased by as much as 50% the rate at which lime is calcined from limestone had been developed by the Southeast Research Institute of San Antonio, TX. The catalyst improved the heat transfer during calcining by providing a vehicle for the disassociation of calcium carbonate at the carbon-oxygen bond.[12]

Polysius Corp. developed a system for calcining soft crumbly limestones, dolomites, magnesites, or other calcium carbonate fines, to produce quicklime. The Polcal system consisted of three preheater cyclones, a calciner with a separator cyclone, and a single or multistage cyclone cooler in which the pulverized material, or fines, was distributed in the airstream and suspended in the gaseous combustion calciners using a counter-current cyclone system. Energy consumption for pure lime qualities averaged 4.2 million Btu per ton of product. Advantages were homogeneous firing for all particle size ranges, direct use of moist powder feeds, low environmental impact from NO_x emissions, and no unusable particle sizes from the grinding systems.[13]

In 1983, 116 flue gas desulfurization units were operating at electrical utility, coal-fired generating stations. Of these, 53 were limestone-based systems, 45 were lime-based, and 18 used other processes. In terms of the electrical energy generated by these units, 53% used limestone, 36% used lime, and 11% used other materials to absorb the sulfur dioxide in the flue gas.[14]

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[1]Physical scientist, Division of Industrial Minerals.

[2]Stonehouse, D. H. 1982 Preprint Chapter on Lime. Mineral Policy Sector, Energy, Mines, and Resources, Canada, p. 5.

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

[4]Ironman, R. Third Kiln Adds to Lime Output. Rock Prod., v. 86, No. 11, Nov. 1983, pp. 43-47.

[5]Industrial Minerals (London). South Africa. Development In Lime With USA. No. 189, June 1983, p. 14.

[6]Anderson, L. Lime in Sweden in 1981. Steering Committee Report. Fifth International Lime Congress, Paris, France, June 30-July 2, 1982.

[7]Buyuran, M. S. Burnt Lime Industry In Turkey. Ind. Miner. (London), No. 193, Oct. 1983, pp. 81-83.

[8]Industrial Minerals (London). RMC Lime Incorporated As New Company. No. 198, Mar. 1984, p. 14.

[9]Quarry Management and Products. Lime-Slaking System. V. 9, No. 8, Aug. 1983, p. 545.

[10]Industrial Minerals (London). Company News & Mineral Notes. No. 192, Sept. 1983, p. 79.

[11]Pit & Quarry. Optimizing Lime Kiln Control. V. 76, No. 5, Nov. 1983, pp. 51-54.

[12]Chemical Week. SRI's New Catalyst Boosts Lime Production. V. 132, No. 26, June 29, 1983, p. 29.

[13]Pit & Quarry. Polysius Develops New Pyroprocessing System to Manufacture Quicklime. V. 76, No. 11, May 1984, pp. 36-44.

[14]Ozol, M. A. Lime. Pit & Quarry, v. 76, No. 11, May 1984, pp. 64-93.

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 and profits, reflecting increased demand for lithium carbonate by the aluminum industry.[2] Imports were insignificant during the year, whereas exports increased about 13% and estimated apparent consumption rose 10%.

The aluminum industry continued to account for about one-third of the lithium consumed in the United States. In Western Europe and Japan, the glass industry was probably the largest consumer of lithium.

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, because of the small survey size, production and stock data were withheld from publication to avoid disclosing individual company proprietary data.

Table 1.—Salient lithium statistics

(Short tons of contained lithium)

	1979	1980	1981	1982	1983
United States:					
Production[1]	W	W	W	W	W
Yearend producers' stocks[1]	W	W	W	W	W
Imports[1]	50	90	150	30	35
Shipments of Government stockpile surplus[2]	--	--	--	r2	1
Supply[1 3]	6,300	6,200	6,700	5,000	5,820
Supply[e 2 4]	5,600	5,500	5,800	4,300	4,800
Exports[e 2]	2,400	2,500	2,600	2,300	2,600
Apparent consumption[e 2]	3,200	3,000	3,200	2,000	2,200
Rest of world: Production[e 1]	2,250	2,250	2,250	2,000	2,100

[e]Estimated. [r]Revised. W Withheld to avoid disclosing company proprietary data.
[1]Mineral concentrate.
[2]Chemicals.
[3]Production plus inventory decrease.
[4]A 15% loss was assumed in converting supply from mineral concentrate to the chemical form. Changes in producers' inventories of lithium chemicals were unknown and were assumed to be zero. An estimated 50 short tons of imported chemicals are included.

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 7 short tons of material depleted of lithium 6, at a price of $1.43 per pound. GSA reported stocks were 15,390 pounds of virgin material and 39,979 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., 87.9% 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 and Chemical Corp., produced lithium from pegmatite dikes in North Carolina.[3]

Foote Mineral reported total production of 11,860 tons of lithium carbonate (Li_2CO_3) equivalent (2,230 tons of contained lithium), an increase of 23% over the recession-induced production level of 1982. Foote Mineral's lithium operations had increased profits during 1983 as sales increased 10%, reflecting increased demand by the aluminum industry.[4] 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.

Lithco reported production of 14,258 tons of Li_2CO_3 equivalent (2,680 tons of contained lithium), up 33% over that of 1982.[5] Contributions to earnings from lithium operations rose more than 40%. Lithco's enhanced financial performance was made possible chiefly by improvements in the economic health of the aluminum and construction industries, as well as the continuation of growth of high-technology specialty products. 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

Estimated domestic consumption of lithium increased 10% owing to a recovery experienced by the principal users—the aluminum, grease, ceramics and glass, and synthetic rubber industries. These markets were closely aligned with the construction and automobile industries.

Most of the mineral concentrate was converted to lithium compounds and metal. The most widely used compound, Li_2CO_3, was added to aluminum potlines to reduce electricity consumption and fluorine emissions. It was also used to produce both ground-coat and cover-coat frits for vitreous enameling of steel. The lithium constituent functioned as a flux to lower firing temperatures and reduce thermal expansion to extend the life of the enamel coating.

The second most widely used lithium compound, $LiOH \cdot H_2O$, was used to manufacture lithium grease, which withstands temperature extremes better than most other greases. Less widely consumed lithium compounds included lithium bromide, which was used in absorption refrigeration air conditioning systems; lithium chloride, which was valued as a dehumidifying agent; and lithium hypochlorite, which served as a sanitizer for swimming pools. Alkyllithium compounds, principally n-butyllithium, were used in synthetic rubber manufacturing.

Lithium metal for lithium batteries continued as a relatively small, but growing market. Disk film cameras contained a lithium battery as an integral part of the camera to provide twice the service life of typical alkaline cells and higher energy density and greater resistance to extremes of heat and cold. Disposable lithium batteries, which offer high energy density and long life, found application in calculators, flashlights, pacemakers, and memory circuits.

The growth in use of the lithium batteries has been bolstered by their military applications. The U.S. Air Force's Minuteman Intercontinental Ballistic Missile Program added a lithium-thionyl-chloride primary battery system to the Minuteman silos as a backup power supply should commercially available power fail. An Air Force representative estimated that 27 tons of lithium metal was required for these batteries. The new Peacekeeper missile system planned by the Air Force was designed to use an identical battery system.

Some mineral concentrate, possibly as much as 10% of total production, was used directly by the glass and ceramics industry. In this application, lithium acts as a powerful fluxing agent. In addition, use of lithium instead of soda or potash imparts a greater chemical durability and thermal shock resistance to the finished material. Because of these intrinsic qualities, lithium mineral concentrate was preferred as a significant ingredient in glass material for the manufacture of cathode ray tubes and sealed-beam headlights and in ceramic material for heat-resistant cookware.

PRICES

With the exception of the battery-grade lithium metal price, which increased 21% during the year, most lithium material prices increased moderately or were unchanged.

Table 2.—Domestic yearend producers' prices of lithium and lithium compounds

(Dollars per pound)

	1982	1983
Lithium bromide, 54% brine: 2,268-pound lots, delivered in drums	3.68	3.79
Lithium carbonate, technical: Truck load lots, delivered	1.41	1.48
Lithium chloride, anhydrous, technical: Truck load lots, delivered	[r]3.15	3.15
Lithium fluoride	4.50	4.72
Lithium hydroxide monohydrate: Truck load lots, delivered	1.84	1.93
Lithium metal ingot, battery-grade: 1,000-pound lots, f.o.b	28.70	34.65
Lithium metal ingot, standard-grade: 1,000-pound lots, f.o.b	20.65	21.70
Lithium sulfate, anhydrous	2.64	3.64
N-butyllithium in n-hexane (15%): 3,000-pound lots, delivered	12.75	13.39

[r] Revised.

FOREIGN TRADE

Lithium carbonate exports increased 63% in response to an economic turnaround in the aluminum, glass, and ceramics industries. Lithium hydroxide exports increased 9%.

China continued as the leading exporter of lithium compounds to the United States, although total U.S. imports were relatively minor compared with exports. Small shipments of spodumene concentrate from Australia had been reported since Greenbushes Tin Ltd. opened its quarry in the spodumene belt in 1982.

Table 3.—U.S. exports of lithium chemicals, by compound and country

Compound and country	1982 Gross weight (pounds)	1982 Value	1983 Gross weight (pounds)	1983 Value
Lithium carbonate:[1]				
Argentina	247,480	$352,402	262,587	$377,817
Brazil	55,050	73,463	686,852	1,113,583
Canada	602,715	859,831	1,890,333	2,889,872
Germany, Federal Republic of	6,181,611	7,064,153	6,204,129	7,429,436
Japan	2,343,220	3,019,904	4,510,594	6,064,719
Mexico	84,675	121,977	297,602	483,095
Netherlands	119,600	165,088	950,738	1,199,088
South Africa, Republic of	39,623	58,435	81,125	109,121
United Kingdom	132,208	148,424	88,609	204,159
Venezuela	1,083,445	1,608,957	2,066,068	3,008,491
Other	20,007	33,470	740,497	1,073,539
Total	10,909,634	13,506,104	17,779,134	23,952,920
Lithium hydroxide:				
Argentina	107,247	206,877	143,085	256,062
Australia	89,600	166,660	--	--
Belgium	15,400	25,564	--	--
Brazil	439,699	834,632	693,930	1,226,102
Canada	108,423	151,442	24,000	45,540
Chile	16,520	28,051	211,179	395,980
Colombia	39,950	72,096	72,955	133,091
France	261,334	395,224	122,720	227,786
Germany, Federal Republic of	854,688	1,344,064	597,592	1,044,745
India	118,607	203,297	120,028	196,941

See footnote at end of table.

Table 3.—U.S. exports of lithium chemicals, by compound and country —Continued

Compound and country	1982 Gross weight (pounds)	1982 Value	1983 Gross weight (pounds)	1983 Value
Lithium hydroxide —Continued				
Indonesia	100,000	$206,456	60,000	$126,985
Israel	60,391	100,266	24,918	44,084
Italy	220	3,240	95,700	169,180
Japan	807,610	1,404,672	1,053,928	1,873,493
Kenya	33,000	58,276	--	--
Korea, Republic of	61,823	104,675	81,877	148,847
Mexico	356,972	631,626	106,368	188,842
Netherlands	316,729	525,030	544,017	916,608
Peru	61,600	109,032	--	--
Philippines	81,200	143,918	197,800	349,001
Singapore	103,241	175,253	57,283	101,298
South Africa, Republic of	234,471	384,813	115,145	199,918
Spain	149,600	230,536	79,600	125,136
Sweden	--	--	26,729	71,820
United Kingdom	644,873	1,090,531	996,927	1,731,709
Venezuela	44,000	68,903	88,300	155,879
Other	142,888	266,309	205,310	429,756
Total	5,250,086	8,931,443	5,719,391	10,158,803
Other:				
Argentina	52,950	80,918	5,327	8,630
Australia	511,706	147,069	127,818	182,380
Belgium	12,214	48,229	5,071	13,845
Brazil	266,594	599,360	625,280	1,465,696
Canada	1,192,440	1,900,647	611,419	1,297,285
China	--	--	147	1,089
Colombia	12,835	39,188	19,871	65,207
France	54,459	148,996	12,008	31,990
Germany, Federal Republic of	1,669,517	1,894,869	118,908	184,246
India	204,884	367,627	5,665	21,226
Israel	3,967	40,998	15,644	103,002
Italy	33,805	155,622	23,252	47,884
Japan	2,769,895	3,924,604	793,757	1,167,463
Korea, Republic of	--	--	8,818	12,200
Mexico	366,685	806,083	93,543	239,046
Netherlands	44,000	53,240	69,473	98,991
Pakistan	49,116	48,515	31,250	44,095
Saudi Arabia	29,372	61,855	4,030	7,819
South Africa, Republic of	15,969	25,818	44,822	47,250
Spain	45,191	57,224	15	660
Switzerland	43,319	99,097	16,797	200,321
Taiwan	66,282	96,134	168,663	283,951
Turkey	40,311	53,173	7,576	7,939
United Kingdom	1,039,563	1,784,818	1,098,433	2,020,004
Venezuela	125,964	197,977	283,104	411,809
Other	86,999	158,902	87,064	218,582
Total	8,738,037	12,790,963	4,277,755	8,182,610

[1]Before 1982, lithium carbonate exports were included with "Other lithium compounds."

Source: U.S. Department of Commerce, Bureau of the Census.

Table 4.—U.S. imports for consumption of lithium-bearing materials, by commodity and country

Commodity and country	1982 Gross weight (pounds)	1982 Value (thousands) Customs	1982 Value (thousands) C.i.f.	1983 Gross weight (pounds)	1983 Value (thousands) Customs	1983 Value (thousands) C.i.f.
Lithium ores:						
Australia	12,181	(1)	$2	16,424	$1	$4
Canada	12,423	(1)	(1)	--	--	--
Peru	4,409	$2	2	--	--	--
Total[2]	29,013	3	5	16,424	1	4
Lithium compounds:						
Algeria	350	1	1	--	--	--
Austria	3,175	9	9	--	--	--

See footnotes at end of table.

Table 4.—U.S. imports for consumption of lithium-bearing materials, by commodity and country —Continued

Commodity and country	1982 Gross weight (pounds)	1982 Value (thousands) Customs	1982 Value (thousands) C.i.f.	1983 Gross weight (pounds)	1983 Value (thousands) Customs	1983 Value (thousands) C.i.f.
Lithium compounds —Continued						
Canada	3,015	$3	$3	3,005	$5	$5
China	238,043	306	334	328,485	458	502
Denmark	61	4	4	18	1	1
France	257	12	12	6,972	1,228	1,233
Germany, Federal Republic of	19,190	156	165	36,455	164	170
Japan	161	23	24	321	19	20
Netherlands	73	6	6	2	1	1
Switzerland	551	1	1	571	1	1
United Kingdom	630	8	9	1,759	44	46
Total[2]	265,506	529	568	377,588	1,920	1,978
Lithium salts:						
Germany, Federal Republic of	67	8	8	2,354	5	5
United Kingdom	191	2	2	2	([1])	([1])
Total[2]	258	10	10	2,356	6	6
Lithium metal:						
Germany, Federal Republic of	11	2	2	1,228	9	9
Japan	--	--	--	1,281	24	24
Total	11	2	2	2,509	33	33

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

Source: U.S. Department of Commerce, Bureau of the Census.

WORLD REVIEW

The U.S.S.R. was the world's second largest producer of lithium minerals, although published production data were scant. The United States continued to supply about three-fourths of lithium demand in nonproducing countries; the remainder was supplied by the U.S.S.R. and China in the form of lithium chemicals and by Zimbabwe and Australia as mineral concentrate. Brazil, Portugal, and Argentina produced primarily for internal consumption. The Federal Republic of Germany and Japan were large importers of lithium chemicals, primarily Li_2CO_3, which they used domestically or converted to downstream chemicals for resale to their export markets.

Australia.—In 1982, Greenbushes opened a lithium quarry in the spodumene zone within the main pegmatite ore body and mined approximately 55,000 tons of primary spodumene ore.[6] The first 2,200 tons of spodumene concentrate, assaying 7.2% lithia (Li_2O), was shipped to Europe in August 1983. The production facilities were being upgraded to a spodumene concentrate capacity of 16,500 tons per year. Greenbushes reported proven lithium ore reserves of 25.7 million tons with an average grade of 2.5% Li_2O and probable reserves of 11.2 million tons containing 2.6% Li_2O.

Chile.—At yearend, the Sociedad Chilena de Litio Ltda. (SCL) completed construction of its 14-million-pound-per-year lithium carbonate plant near the Salar de Atacama. Foote Mineral Co. anticipated that 6 million pounds of lithium carbonate would be produced in 1984 and 14 million pounds in 1985. The estimated capital cost of the project had been reduced from the initial estimate of $61 million to $48 million, primarily because of devaluation of the Chilean peso. Total Salar de Atacama reserves were estimated at 1.3 million tons of lithium equivalent. SCL was a limited partnership owned 55% by Foote Mineral and 45% by the Chilean Government's development company, Corporación de Fomento de la Producción.[7]

Table 5.—Lithium minerals: World production, by country[1]

(Short tons)

Country[2]	1979	1980	1981	1982[p]	1983[e]
Argentina (minerals not specified)	117	88	28	125	130
Australia, spodumene[e]	--	--	--	90	2,200
Brazil:					
Amblygonite	206	201	305	[e]220	220
Lepidolite	64	56	2	[e]55	55
Petalite	1,655	2,741	2,298	[e]2,760	2,760
Spodumene	--	108	268	[e]220	220
China (minerals not specified)[e 3]	11,000	[r]15,400	[r]15,400	[r]15,400	15,400
Namibia (minerals not specified)	NA	NA	1,392	1,091	1,100
Portugal, lepidolite[e]	1,100	1,100	990	880	770
Rwanda, amblygonite[e]	31	33	28	([4])	--
U.S.S.R. (minerals not specified)[e 3]	55,000	[r]60,600	[r]60,600	[r]60,600	60,600
United States, spodumene	W	W	W	W	W
Zimbabwe (minerals not specified)	14,547	21,982	18,126	10,788	5,500

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available. W Withheld to avoid disclosing company proprietary data.
[1]Table includes data available through May 2, 1984.
[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]These estimates denote only an approximate order of magnitude; no basis for more exacting estimates is available. Output by China and the U.S.S.R. have never been reported.
[4]Revised to zero.

TECHNOLOGY

Aluminum-lithium alloys under development for the aircraft industry were expected to become available in commercial quantities. In the short term, these alloys, which contain 2% to 3% lithium, could be expected to develop into a significant lithium end use. The Aluminum Co. of America (Alcoa), which developed three of these alloys, called Alithalite, estimated that costs could exceed $50 million for developing the alloys and their manufacturing processes and building casting facilities. Alcoa reported that the alloys were expected to reduce conventional airframe weight by 10% to 15%, saving up to 6 metric tons for a large commercial aircraft.[8]

Martin Marietta Corp. was planning to begin casting in 1984 aluminum-lithium structural components for Boeing Commercial Aircraft Co. and other commercial aircraft companies. Annual production capacity of these components was to be 2 million pounds.[9]

British Alcan Corp. was preparing to supply annually between 2,000 and 4,000 metric tons of aluminum-lithium alloys from a new pilot plant that was expected to start producing larger castings and slabs in the spring of 1985.[10]

[1]Physical scientist, Division of Industrial Minerals.
[2]See 1983 10-K reports for Gulf Resources and 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]Greenbushes Tin Ltd. 1983 Annual Report. P. 4.
[7]Work cited in footnote 2.
[8]Aluminum Co. of America. 1983 Annual Report. Pp. 10-11.
[9]American Metal Market. Metalworking News. Aerospace Metals and Machines Today. Mar. 19, 1984, p. 13A.
[10]Page 14A of work cited in footnote 9.

Magnesium

By Langtry E. Lynd[1]

An increase in domestic primary magnesium metal production and consumption resulted mainly from an increase in demand for aluminum alloys, its major use.

Domestic Data Coverage.—Domestic consumption data for magnesium metal are developed by the Bureau of Mines from a voluntary domestic survey. Of the 172 operations to which a survey request was sent, 62% responded, representing an estimated 68% of the total consumption shown in tables 1 and 3. Consumption by the 63 nonrespondents was estimated using reported prior year consumption levels.

Table 1.—Salient magnesium statistics

(Short tons unless otherwise specified)

	1979	1980	1981	1982	1983
United States:					
Production:					
Primary magnesium	[1]162,464	[1]169,477	[r]153,782	[r]102,197	115,431
Secondary magnesium	37,222	40,461	46,256	43,232	46,329
Exports	54,280	56,761	34,855	39,613	46,690
Imports for consumption	4,754	3,757	6,897	4,784	6,350
Consumption	108,844	95,788	91,461	74,599	81,976
Price per pound	\$1.01-\$1.09	\$1.07-\$1.25	\$1.25-\$1.34	\$1.34	\$1.38
World: Primary production	[r]338,850	[r]348,440	336,454	[p]272,660	[e]291,323

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

[1]Derived figure; United States production is not officially reported by the Bureau of Mines for 1979-80 in order to avoid disclosing company proprietary data; figures reported for those years represent the differences between total North American production reported by the International Magnesium Association and Canadian production reported by Energy, Mines and Resources Canada.

DOMESTIC PRODUCTION

The decline in production that began in 1981 was reversed in 1983 as recovery in the U.S. economy got underway. Production was about 60% of domestic installed production capacity. Three companies produced 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. The first two companies processed natural brines to magnesium chloride to provide feed material for electrolysis to pure magnesium metal. Northwest Alloys produced metal from dolomite using the silicothermic technique. The producers were operating at 50% to 67% of capacity during the first half of the year, increasing their operating rates to 65% to 90% by yearend as demand improved.

Chicago White Metal Castings Inc., Bensenville, IL, and Spartan Aluminum Products Inc., Sparta, IL, were each planning to install two additional 300-ton hot-chamber magnesium diecasting machines in 1983.

In February, Reactive Metals & Alloys Corp. (REMACOR) purchased Reade Manufacturing Co. Inc., Lakehurst, NJ, a major producer of magnesium granules, chips, and powders. REMACOR was involved in steel desulfurization. Magnesium demand for steel desulfurization was estimated to be 6,000 short tons, with a potential of about 30,000 tons per year.

Table 2.—Magnesium recovered from scrap processed in the United States, by kind of scrap and form of recovery

(Short tons)

	1979	1980	1981	1982	1983
KIND OF SCRAP					
New scrap:					
Magnesium-base	5,025	5,929	2,833	2,455	2,873
Aluminum-base	18,315	16,978	19,240	17,346	18,718
Total	23,340	22,907	22,073	19,801	21,591
Old scrap:					
Magnesium-base	4,778	5,275	5,593	5,314	5,311
Aluminum-base	9,104	12,279	18,590	18,117	19,427
Total	13,882	17,554	24,183	23,431	24,738
Grand total	37,222	40,461	46,256	43,232	46,329
FORM OF RECOVERY					
Magnesium alloy ingot[1]	3,739	4,205	4,230	4,228	4,232
Magnesium alloy castings (gross weight)	790	836	806	746	952
Magnesium alloy shapes	2,176	3,144	13	--	--
Aluminum alloys	28,857	29,612	38,755	36,587	39,451
Zinc and other alloys	13	13	9	11	20
Chemical and other dissipative uses	47	9	55	3	4
Cathodic protection	1,600	2,642	2,388	1,657	1,670
Total	37,222	40,461	46,256	43,232	46,329

[1]Includes secondary magnesium content of both secondary and primary alloy ingot.

CONSUMPTION AND USES

The upturn in magnesium metal consumption was attributed mainly to increased use in aluminum alloys, but steel desulfurization was probably the fastest growing use. Demand for magnesium diecastings was expected to increase in 1984 because of their expanded use in automobiles and other applications, as a result of a narrowing of the magnesium-aluminum price ratio to about 1.5, considered to be a critical point for magnesium to become a cost-effective substitute for aluminum.

Table 3.—Consumption of primary magnesium in the United States, by use

(Short tons)

Use	1979	1980	1981	1982	1983
For structural products:					
Castings:					
Die	5,182	3,190	2,812	1,600	1,937
Permanent mold	1,069	922	917	663	16
Sand	1,209	1,735	1,222	1,337	1,388
Wrought products:					
Extrusions	6,420	6,855	5,786	7,059	7,093
Sheet and plate	4,925	4,704	4,547	2,981	4,313
Other (includes forgings)	217	61	43	88	29
Total	19,022	17,467	15,327	13,728	14,776
For distributive or sacrificial purposes:					
Alloys:					
Aluminum	60,549	54,490	50,518	39,878	46,026
Copper	9	6	5	7	4
Zinc	15	11	9	3	3
Other	8	7	7	3	--
Cathodic protection (anodes)	6,769	3,930	6,449	5,964	5,686
Chemicals	9,044	6,278	5,315	4,823	5,664
Nodular iron	4,335	4,176	3,755	2,541	2,200
Reducing agent for titanium, zirconium, hafnium, uranium, beryllium	7,435	7,957	9,071	5,901	4,711
Other[1]	1,658	1,466	1,005	1,751	2,906
Total	89,822	78,321	76,134	60,871	67,200
Grand total	108,844	95,788	91,461	74,599	81,976

[1]Includes scavenger, deoxidizer, and powder.

STOCKS

Consumer stocks of primary magnesium ingot increased from 10,268 tons at yearend 1982 to 11,329 tons at yearend 1983; magnesium alloy ingot stocks declined from 705 tons at the beginning of the year to 551 tons at yearend.

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
1982:						
Cast scrap	1,459	6,336	376	5,846	6,222	1,573
Solid wrought scrap[1]	28	764	769	--	769	23
Total	1,487	7,100	1,145	5,846	6,991	1,596
1983:						
Cast scrap	1,573	6,065	412	5,836	6,248	1,390
Solid wrought scrap[1]	23	846	824	--	824	45
Total	1,596	6,911	1,236	5,836	7,072	1,435

[1]Includes borings, turnings, drosses, etc.

PRICES

The quoted prices of magnesium metal and magnesium diecasting alloy began the year at $1.34 and $1.21 per pound, respectively. The price of magnesium metal was increased to $1.38 in the second quarter, and that of diecasting alloy to $1.23 per pound in the third quarter. In December, Dow and AMAX Inc. announced increases in their primary metal price to $1.43 per pound, effective in mid-December for spot customers and on January 3, 1984, for contract customers. Dow increased its price for diecasting alloy to $1.28 per pound, effective on the same dates.

FOREIGN TRADE

All categories of exports, except semifabricated forms, increased significantly in quantity and value. Large quantities of metal were exported to industrialized nations, especially those producing aluminum.

All categories of imports of magnesium increased, particularly alloys, imports of which were more than double those of 1982.

Table 5.—U.S. exports and imports for consumption of magnesium

Year	EXPORTS: Waste and scrap: Quantity (short tons)	Waste and scrap: Value (thousands)	Metals and alloys in crude form: Quantity (short tons)	Metals and alloys in crude form: Value (thousands)	Semifabricated forms, n.e.c.: Quantity (short tons)	Semifabricated forms, n.e.c.: Value (thousands)
1981	261	$689	32,910	$81,116	1,684	$9,048
1982	149	349	37,281	92,554	2,183	11,942
1983	638	1,681	43,992	111,988	2,060	11,045

Year	IMPORTS: Waste and scrap: Quantity (short tons)	Waste and scrap: Value (thousands)	Metal: Quantity (short tons)	Metal: Value (thousands)	Alloys (magnesium content): Quantity (short tons)	Alloys (magnesium content): Value (thousands)	Powder, sheets, tubing, ribbons, wire, other forms (magnesium content): Quantity (short tons)	Powder, sheets, tubing, ribbons, wire, other forms (magnesium content): Value (thousands)
1981	3,225	$3,338	2,897	$6,844	625	$2,652	150	$4,804
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

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)
1982						
Argentina	--	--	215	$456	321	$731
Australia	--	--	1,686	3,862	276	1,141
Austria	--	--	26	72	9	100
Belgium-Luxembourg	--	--	1	10	8	125
Brazil	--	--	2,976	6,955	39	107
Canada	144	$337	2,543	6,034	226	927
Colombia	--	--	29	63	10	40
France	--	--	58	152	23	468
Germany, Federal Republic of	--	--	681	1,617	44	495
India	--	--	177	437	7	21
Israel	--	--	--	--	204	1,191
Italy	--	--	37	378	175	1,206
Japan	--	--	10,787	21,546	97	734
Korea, Republic of	--	--	165	459	31	48
Mexico	--	--	2,423	5,824	186	1,105
Netherlands	--	--	12,996	39,893	23	182
New Zealand	--	--	142	239	2	38
Norway	--	--	47	144	3	43
Saudi Arabia	--	--	883	954	95	345
Singapore	--	--	40	85	45	293
South Africa, Republic of	--	--	394	929	76	294
Spain	--	--	81	231	28	119
Sweden	--	--	--	--	3	29
Taiwan	--	--	101	248	5	78
United Kingdom	--	--	279	775	120	1,200
Venezuela	--	--	44	109	13	50
Other	5	12	470	1,082	114	832
Total	149	349	37,281	92,554	2,183	11,942
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
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

[1]Less than 1/2 unit.

WORLD REVIEW

Primary world production of magnesium increased in 1983 as a result of the improvement in world economic conditions.

Canada.—The Mineral Processing Licensing Corp. (MPLC), which purchased the assets of the former American Magnesium Co., announced that it was close to reaching an agreement to build a 110,000-ton-per-year magnesium plant in the Province of Alberta. MPLC developed technology for the conversion of coarsely ground magnesite in one step to magnesium chloride for electrolytic cell feed material that is then converted to metal. Implementation of this project would raise North American metal production capacity to about 300,000 tons when completed.

Alcan Aluminum Ltd. announced it purchased a 20.5% share of Haley Industries Ltd., a maker of magnesium and aluminum castings for the aerospace industry, for about $5.3 million. The purchase makes Alcan Haley's largest stockholder.

India.—India's first magnesium metal plant was being set up by the state-owned Tamil Nadu Industrial Development Corp. at Valinokkam in the Ramanathapuram district. The $6 million, 660-ton-per-year plant was expected to be operating by yearend 1985.

In 1983, Duncans Agro Industries Ltd. was granted Government of India clearance to proceed with plans to build a $50 million plant to produce magnesium and chemicals from seawater. The plant was to be located at Srikakulam in Andhra Pradesh, with a production capacity of 75,000 tons per year.

Norway.—Norsk Hydro AS carried out a modernization program at its Heroya, Norway, plant including rebuilding of electrolysis facilities. Completion of the program will facilitate future capacity expansion but prevented full utilization of Norsk's 50,000-ton-per-year capacity in 1983. Norsk also entered into an agreement with Elf Aquitaine Norway and AS Kongsberg Vaapenfabrikk to develop casting technology for magnesium alloy automotive wheels. This use of the metal could add as much as 40 pounds of magnesium per automobile.

[1]Physical scientist, Division of Nonferrous Metals.

Table 7.—Magnesium: World primary production, by country[1]

(Short tons)

Country	1979	1980	1981	1982[p]	1983[e]
Canada	9,937	10,199	9,370	[r] [e]5,600	8,600
China[e]	6,600	7,700	7,700	7,700	7,700
France	9,968	10,282	8,006	10,593	10,470
India	(2)	(2)	(2)	(2)	--
Italy	9,653	8,693	8,623	8,466	8,490
Japan	12,531	10,199	6,247	6,123	[3]6,652
Norway	48,697	48,890	52,472	38,581	38,580
U.S.S.R.[e]	79,000	83,000	86,000	89,000	91,000
United States	[4]162,464	[4]169,477	153,782	102,197	[3]115,431
Yugoslavia	--	--	4,254	[e]4,400	4,400
Total	[r]338,850	[r]348,440	336,454	272,660	291,323

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through May 23, 1984.
[2]Revised to zero.
[3]Reported figure.
[4]Derived figure; U.S. production is not officially reported by the Bureau of Mines for 1979-80 in order to avoid disclosing company proprietary data; figures reported for those years represent the difference between total North American production reported by the International Magnesium Association and Canadian production reported by Energy, Mines and Resources Canada.

Table 8.—Magnesium: World secondary production, by country[1]

(Short tons)

Country	1979	1980	1981	1982[p]	1983[e]
Germany, Federal Republic of	(2)	(2)	(2)	(2)	--
Japan	18,058	[r]26,314	31,345	[e]24,000	13,890
U.S.S.R.[e]	8,000	8,000	9,000	9,000	9,000
United Kingdom	[e]3,000	[e]3,000	2,094	1,938	1,980
United States	37,222	40,461	46,256	43,232	[3]46,329
Total	66,280	77,775	88,695	78,170	71,199

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through May 23, 1984.
[2]Revised to zero.
[3]Reported figure.

Magnesium Compounds

By W. Timothy Adams[1]

Magnesium compounds shipped and used in the United States increased from those of 1982. Magnesium oxide and other compounds were produced from seawater by seven companies in California, Delaware, Florida, New Jersey, 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 by two companies in North Carolina and Washington. Three companies accounted for almost 80% of the magnesia production. Three-fourths of the consumption of magnesium compounds was for the production of basic refractories used in high temperature metallurgical furnaces for making products such as iron and steel. The remainder was used to prepare caustic-calcined and specified magnesias and other magnesium compounds.

Domestic Data Coverage.—Domestic data for magnesium compounds shipped and used were developed by the Bureau of Mines from a voluntary survey of U.S. operations entitled "Magnesium Compounds." Of the 19 operations to which a survey request was sent, 42% responded, representing an estimated 53% of the total magnesium compounds shipped and used shown in table 3. Data for the 11 nonrespondents was estimated using prior year production levels adjusted by trends in employment and other factors.

Table 1.—Salient magnesium compound statistics

(Thousand short tons and thousand dollars)

	1979	1980	1981	1982	1983
United States:					
Caustic-calcined and specified magnesias:[1]					
Shipments by producers:					
Quantity	164	157	160	148	160
Value	$50,047	$51,282	$58,420	$56,363	$57,882
Exports: Value[2]	$16,433	$17,692	$14,559	$10,925	$8,426
Imports for consumption: Value[2]	$1,169	$2,122	$2,177	$2,055	$5,476
Refractory magnesia:					
Sold and used by producers:					
Quantity	847	731	616	453	466
Value	$125,289	$162,697	$146,903	$112,101	$99,782
Exports: Value	$8,183	$13,279	$4,727	$2,721	$1,955
Imports for consumption: Value	$13,546	$16,672	$22,990	$14,162	$11,495
Dead-burned dolomite:					
Sold and used by producers:					
Quantity	793	494	435	NA	NA
Value	$41,676	$28,308	$23,789	NA	NA
World: Production (magnesite)	r12,054	r12,762	12,277	p12,119	e12,103

eEstimated. pPreliminary. rRevised. NA Not available.

[1]Excludes caustic-calcined magnesia used in production of refractory magnesia.

[2]Caustic-calcined magnesia only.

DOMESTIC PRODUCTION

The major source of domestic magnesia refractory compounds continued to be synthetic magnesia that was derived from natural brine solutions found in seawater, lake brines, and well brines. The Harbison-Walker Refractories Co. seawater plant, located in New Jersey, with a capacity of 100,000 short tons was closed in October 1983. Magnesium compounds were also produced from natural magnesite mined in Nevada. Olivine was produced from deposits in North Carolina and Washington. Olivine was ground to various grades for consumption by the foundry, steel, and refractory industries.

Table 2.—Current 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

The major portion of U.S. magnesium compound production was converted to refractory products such as refractory brick. The chemical processing and pharmaceutical industries provided a strong market for caustic-calcined and specified magnesias. These products were also used to prepare animal feeds, fertilizers, construction materials, chemicals, electrical heating rods, fluxes, petroleum additives, and rayon. A report reviewed the use of minerals in the refractory industry. Current applications of refractories in various industries were described in detail and probable trends were examined.[2]

Table 3.—Magnesium compounds shipped and used in the United States

	1982		1983	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Caustic-calcined[1] and specified (USP and technical) magnesias	147,525	$56,363	160,389	$57,882
Refractory magnesia	453,163	112,101	466,206	99,782
Magnesium hydroxide (100% $Mg(OH)_2$)[1]	357,060	41,597	359,773	47,231
Magnesium sulfate (anhydrous and hydrous)	46,524	11,326	38,424	10,769
Precipitated magnesium carbonate[1]	4,000	900	6,003	1,101

[1]Excludes material produced as an intermediate step in the manufacture of other magnesium compounds.

Table 4.—Domestic shipments of caustic-calcined and specified magnesias, by use

(Short tons)

Use	1981	1982	1983
Agriculture, nutrition, pharmaceuticals:			
Animal feed	W	W	W
Fertilizer	W	W	W
Medicinals and pharmaceuticals	W	W	W
Sugar and candy	W	W	W
Winemaking	W	W	W
Total	W	W	W
Construction materials:			
Insulation and wallboard	W	W	W
Oxychloride and oxysulfate cement	W	W	W
Total	W	W	W
Chemical processing, manufacturing, metallurgical:			
Chemical	19,330	17,591	12,971
Electrical heating rods		W	W
Flux		W	W
Petroleum additive	57,581	9,482	W
Pulp and paper		W	W
Cosmetics		W	W
Rayon		W	W
Rubber		13,819	12,425
Stack-gas scrubbing	W	W	W
Uranium processing		W	W
Water treatment		W	W
Total	76,911	40,892	25,396
Unspecified	83,156	106,633	134,993
Grand total	160,067	147,525	160,389

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

PRICES

The Chemical Marketing Reporter published the following prices at yearend: magnesia, natural, technical, heavy, 85% and 90% (f.o.b. Nevada), $222 and $255 per short ton, respectively; magnesium chloride, hydrous, 99%, flake, $290 per ton; magnesium carbonate, light, technical (freight equalized), $0.73 to $0.78 per pound; magnesium hydroxide, NF, powder (freight equalized), $0.78 per pound; and magnesium sulfate, technical, $0.115 per pound.

FOREIGN TRADE

U.S. exports of crude and processed compounds, such as dead-burned magnesia and magnesite and crude caustic-calcined lump or ground magnesite, declined significantly from those of 1981 and 1982 in both quantity and value. Total imports of crude and processed magnesite were significantly more than those of 1982 in quantity and value. Additional magnesium compounds valued at $10 million were also imported.

Table 5.—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			
	1982		1983		1982		1983	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Argentina	--	--	--	--	1,221	$546	804	$344
Australia	58	$8	2,556	$551	2,690	709	132	187
Belgium-Luxembourg	--	--	--	--	1,066	737	369	453
Brazil	--	--	1	--	172	137	141	89
Canada	10,054	2,269	4,665	1,028	12,434	4,761	7,369	2,744
Colombia	1,030	131	1,190	159	156	165	148	117
France	23	17	--	--	188	184	134	100
Germany, Federal Republic of	--	--	--	--	687	612	824	609
Italy	--	--	--	--	574	525	343	291
Japan	650	51	197	26	2	5	1	3
Mexico	721	163	81	12	515	376	75	81
Netherlands	--	--	--	--	288	274	286	313
New Zealand	--	--	--	--	102	129	1	2
Spain	--	--	--	--	437	279	341	212
Sweden	--	--	--	--	161	192	118	133
United Kingdom	--	--	--	--	130	158	75	111
Venezuela	46	10	--	--	2,015	874	1,950	966
Other	287	72	2,165	179	287	262	3,510	1,671
Total	12,869	2,721	10,855	1,955	23,125	10,925	16,621	8,426

Table 6.—U.S. imports for consumption of crude and processed magnesite, by country

Country	1982		1983	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Lump or ground caustic-calcined magnesia:[1]				
Australia	220	$55	--	--
Canada	1,559	323	13,166	$3,086
China	4,701	214	2,907	386
Greece	4,023	927	3,837	740
Japan	--	--	220	14
Netherlands	2,447	311	751	123
Spain	--	--	2,083	366
Turkey	669	143	2,175	670
United Kingdom	312	76	113	40
Other	28	6	205	51
Total	13,959	2,055	25,457	5,476
Dead-burned and grain magnesia and periclase:				
Not containing lime or not over 4% lime:				
Brazil	2,746	474	6,652	996
China	12,528	1,222	4,827	458
Greece	8,277	1,285	6,889	938
Ireland	33,868	10,500	24,230	7,535
Japan	391	624	454	588
Mexico	--	--	1,474	337
South Africa, Republic of	--	--	1,222	567
Other	142	57	150	76
Total	57,952	14,162	45,898	11,495

See footnotes at end of table.

Table 6.—U.S. imports for consumption of crude and processed magnesite, by country —Continued

Country	1982 Quantity (short tons)	1982 Value (thousands)	1983 Quantity (short tons)	1983 Value (thousands)
Dead-burned and grain magnesia and periclase —Continued				
Containing over 4% lime:				
Austria	544	$229	1,241	$302
Canada	292	22	15,346	618
China	23	4	--	--
Germany, Federal Republic of	294	90	241	46
Greece	379	74	17,433	1,864
Guinea	5	(2)	--	--
Japan	17	5	--	--
United Kingdom	13	2	222	8
Other	--	--	48	7
Total	1,567	426	34,531	2,845
Total dead-burned and grain magnesia and periclase	59,519	14,588	80,429	14,340

[1]In addition, crude magnesite was imported as follows, in short tons and thousand dollars: 1982—Canada, 83 ($5); Greece, 3,133 ($293); India, 60 ($1); Japan, 1 ($1); and the United Kingdom, 28 ($6). 1983—Canada, 19 ($4); the Federal Republic of Germany, 15 ($11); and Spain, 20 ($10).
[2]Less than 1/2 unit.

Table 7.—U.S. imports for consumption of magnesium compounds

Year	Oxide or calcined magnesia		Magnesium carbonate[1] (precipitated)		Magnesium chloride (anhydrous)		Magnesium chloride (other)		Magnesium sulfate (epsom salts and kieserite)		Magnesium salts and compounds, n.s.p.f.[2]	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1981	1,537	$2,419	212	$362	40	$20	592	$161	30,233	$1,852	2,768	$1,427
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

[1]In addition, magnesium carbonate, not precipitated, was imported as follows, in short tons and thousand dollars: 1981—119 ($97); 1982—125 ($69); and 1983—21 ($28).
[2]Includes magnesium silicofluoride or fluosilicate and calcined magnesium.

WORLD REVIEW

World production of magnesite and synthetic magnesia met world demand for the manufacture of refractory, and caustic-calcined and specified magnesias. Most producing nations derived magnesia from magnesite, but countries such as Ireland, Israel, and the United States used natural brines.

A report reviewed the current state of the world's magnesite and magnesia industry. Changes in operating practices in the steel industry were reported to be directly responsible for reduced consumption.[3]

Norsk Hydro AS's modernization of the Porsgrunn, Norway, magnesium smelter proceeded on schedule. Modernization involved the production of anhydrous magnesium chloride from a magnesium chloride brine mixture rather than from the more traditional dolomite seawater mix.[4]

Table 8.—Magnesite: World production, by country[1]

(Short tons)

Country	1979	1980	1981	1982[p]	1983[e]
Australia	32,299	35,492	29,638	[e]28,900	31,000
Austria	1,216,563	1,453,017	1,277,414	[e]1,268,000	1,200,000
Brazil[2]	[r]292,852	348,166	315,031	248,607	220,000
Canada[e 3]	58,000	69,000	76,000	75,000	74,000
China[e]	2,200,000	2,200,000	2,200,000	2,200,000	2,200,000
Colombia	1,744	1,744	[e]1,800	[e]1,800	1,800
Czechoslovakia	720,911	734,139	732,000	[e]728,000	740,000
Greece	1,166,477	1,286,394	909,674	[e]882,000	770,000
India	[r]436,747	[r]419,002	499,798	[e]408,000	520,000
Iran[e 4]	5,500	4,400	4,400	5,500	5,500
Kenya	[e]4,400	1	10	[e]10	--
Korea, North[e]	2,010,000	2,040,000	2,040,000	2,040,000	2,040,000
Mexico[5]	[r]19,842	[r]17,488	13,357	24,793	22,000
New Zealand	--	--	340	[e]330	--
Pakistan	3,029	[r]1,681	1,710	1,861	1,900
Poland	22,046	21,605	12,500	[e]13,000	12,000
South Africa, Republic of	72,021	86,871	62,343	35,193	23,500
Spain	420,936	557,253	[e]550,000	[e]500,000	595,000
Turkey	804,071	910,451	864,174	[e]860,000	840,000
U.S.S.R.[e]	2,150,000	2,200,000	2,290,000	2,370,000	2,400,000
United States	W	W	W	W	W
Yugoslavia	323,313	288,630	330,336	361,558	340,000
Zimbabwe	93,140	86,219	66,352	[e]66,000	66,000
Total	[r]12,053,891	[r]12,761,553	12,276,877	12,118,552	12,102,700

[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. 25, 1984.

[2]Series reflects output of marketable concentrates. Production of crude ore was as follows, in short tons: 1979—650,627 (revised); 1980—869,023 (revised); 1981—681,504 (revised); 1982—557,091; and 1983—496,000 (estimated).

[3]Magnesitic dolomite and brucite. Figures are estimated on the basis of reported tonnage dollar value.

[4]Year beginning Mar. 21 of that stated.

[5]Mexico's figure for the years 1977 and 1978 erroneously referred to production of magnesium from brine. The mine output of magnesite for 1977 and 1978 was 3,528 short tons and 23,085 short tons, respectively.

TECHNOLOGY

A product, designed for use in electric, open-hearth, and basic oxygen furnaces, composed of 98% magnesium oxide high-density periclase with a new nontoxic bonding system, was developed. The bonding system was intended to replace the chromic acid binder previously used.[5]

Planning and preparation for increased production of high-magnesium limestone near Maysville, KY, was completed. A product from this operation known as thiosorbic lime, was shown to be capable of absorbing high quantities of SO_2 from stack gases of high-sulfur coal-burning powerplants while virtually eliminating buildup of scale in the equipment.[6]

The use of magnesium oxide for deep-bed filtration of water was developed. Magnesium oxide was shown to be unique because it has a positive surface charge in water, whereas most suspended materials are negatively charged. The attraction of these negatively charged suspended particles to the magnesium oxide enhances filtering performance.[7]

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[1]Physical scientist, Division of Nonferrous Metals.

[2]Dickson, E. M., and Harben, P. W. (ed.). Minerals in the Refractories Industry Assessing the Decade Ahead. Ind. Miner., No. 187, Refractories Suppl., Apr. 1983, 110 pp.

[3]Coope, B. M. Magnesia Markets—Refractory Contraction and Caustic Stagnation. Ind. Miner., No. 191, Aug. 1983, pp. 57-87.

[4]Donauher, D. Bright Magnesium Prospects—Norsk. Met. Bull., No. 6833, Oct. 28, 1983, p. 13.

[5]Chemical Week. Technology Newsletter. V. 132, No. 25, June 22, 1983, p. 42.

[6]Mining Journal. Dravo Makes Life Easier for Scrubbers. V. 300, No. 7714, June 24, 1983, p. 425.

[7]Skillings' Mining Review. Magnesium Oxide Used as Deep Bed Filter Medium. V. 72, No. 43, Oct. 22, 1983, p. 21.

Manganese

By Thomas S. Jones[1]

Manganese oversupply in both mineral and processed form was evidenced by price decreases of 13% or more for imported metallurgical ore and imports of principal manganese ferroalloys. Ore production declined for the majority of the chief market economy producers, most notably by 45% for the Republic of South Africa. Rate of recovery of manganese consumption in the United States was slowed by a further significant decline in unit consumption of manganese ferroalloys in steelmaking. Changes in steelmaking technology and production mix contributed to use of smaller amounts of manganese per ton of steel produced.

Domestic ore production continued to consist of only a small quantity of manganiferous materials. Domestic production of ferromanganese and silicomanganese was below even those abnormally small amounts produced in 1982. Two governmental actions supportive of the domestic ferroalloy industry were reduction in preferential tariff treatment for imports of manganese ferroalloys and contracting for a domestic plant to upgrade a portion of the metallurgical manganese ore in the National Defense Stockpile into high-carbon ferromanganese. Record imports of silicomanganese and suspension of electrolytic metal production by one of three domestic producers signified the continuing international competitive pressure upon domestic processors of ore.

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, 100% responded, representing 100% of the total production shown in table 3.

Table 1.—Salient manganese statistics

(Thousand short tons)

	1979	1980	1981	1982	1983
United States:					
Manganese ore (35% or more Mn):					
Imports for consumption	500	698	639	238	368
Consumption	1,372	1,071	1,077	609	531
Manganiferous ore (5% to 35% Mn):					
Production (shipments)	241	174	175	32	34
Ferromanganese:					
Production	317	189	193	119	86
Exports	25	12	15	10	8
Imports for consumption	821	606	671	493	342
Consumption	976	789	821	439	446
World: Production of manganese ore	r28,950	r29,089	25,894	p26,607	e24,739

eEstimated. pPreliminary. rRevised.

Legislation and Government Programs.—On February 7, the General Services Administration (GSA) announced the offering for sale of approximately 155,700 tons[2] of natural battery-grade manganese dioxide (ore) under Solicitation of Offers for Manganese Dioxide, Natural Battery, Grades A and B, ORES-259. Sales under ORES-259 were limited to 78,782 tons through September 30, and could be to any party for consumption anywhere. The majority of the material being offered for sale under ORES-259 was of Greek or domestic origin.

Material	Sales (short tons)	Change in yearend inventory (short tons)
Natural battery ore:		
Stockpile grade	3,731	-12,578
Nonstockpile grade	200	-200
Chemical ore: Stockpile grade	29,391	-12,726
Metallurgical ore:		
Stockpile grade	--	-45,102
Nonstockpile grade	3,000	-3,000

Table 2.—U.S. Government stockpile goals and yearend inventories for manganese materials in 1983

(Short tons)

Material	Stockpile goals	Physical inventory				
		Uncommitted				
		Stockpile grade	Nonstockpile grade	Total	Sold, pending shipment	Grand total
Natural battery ore	62,000	181,633	33,561	215,194	4,441	219,635
Synthetic manganese dioxide	25,000	3,011	--	3,011	--	3,011
Chemical ore	170,000	191,564	89	191,653	16,666	208,319
Metallurgical ore	2,700,000	2,409,160	957,943	3,367,103	236,426	3,603,529
High-carbon ferromanganese	439,000	599,978	--	599,978	--	599,978
Medium-carbon ferromanganese	--	28,920	--	28,920	--	28,920
Silicomanganese	--	23,574	--	23,574	--	23,574
Electrolytic metal	--	14,172	--	14,172	--	14,172

At yearend 1983, GSA awarded a $9.8 million contract to Elkem Metals Co. for converting about 48,000 tons of metallurgical manganese ore in the National Defense Stockpile into high-carbon ferromanganese. This was the first contract awarded for the manganese portion of a 10-year stockpile upgrading program announced in 1982 under which 577,000 tons of high-carbon ferromanganese ultimately was to be produced. The award to Elkem Metals proceeded from a request for bids by GSA in June for the upgrading of 100,000 tons of manganese ore, to be done domestically and paid for with excess stockpile materials. Accompanying GSA's contract activity, the U.S. Department of Commerce twice revised the National Stockpile Purchase Specification for Standard High-Carbon Ferromanganese, primarily to specify manganese content as 76% to 78% and to address sizing requirements. The second revision, P-30a-R4, was effective July 25.

Through the Trade and Development Program of its International Development Cooperation Agency, the U.S. Department of State outlined opportunities for U.S. mining firms to become involved in expanding manganese and/or ferroalloy production from deposits in the Molango area of Mexico belonging to Cía. Minera Autlán S.A. de C.V.

DOMESTIC PRODUCTION

Ore and Concentrate.—No manganese ore, concentrate, or nodules containing 35% or more manganese were produced or shipped in the United States. Ferruginous manganese ores or concentrates containing 10% to 35% manganese were not produced, only shipped on a still-much-reduced basis from the Cuyana Range of Minnesota. 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. This latter material ranged in manganese content from 5% to 15% but averaged less than 10%.

Haber Inc., of Towaco, NJ, and Houston Mining & Resources Inc., of Houston, TX, formed the joint venture company, Silver

Tech Mines Inc., to test coextraction of manganese and silver from manganiferous silver ores of the Tombstone, AZ, region. Manganese was to be recovered as manganese carbonate from ores containing 15% to 25% manganese by means of Haber's hydrometallurgical "Alpha Process" technology.[3]

Table 3.—Manganiferous ore shipped[1] in the United States, by type and State

(Short tons unless otherwise specified)

Type and State	1982 Gross weight	1982 Manganese content	1983 Gross weight	1983 Manganese content
Ferruginous manganese ore (10% to 35% Mn, natural):				
Minnesota	16,307	2,659	11,314	1,689
Manganiferous iron ore (5% to 10% Mn, natural):				
South Carolina[2]	15,202	1,325	22,209	1,987
Total	31,509	3,984	33,523	3,676
Value	$293,214	XX	$215,693	XX

XX Not applicable.
[1]Shipments are used as the measure of manganiferous ore production for compiling U.S. mineral production value. They are taken at the point at which the material is considered to be in marketable form for the consumer. In addition to direct-shipping ore, they include, without duplication, concentrate and nodules made from domestic ores.
[2]Miscellaneous ore.

Ferroalloys and Metal.—Output of ferromanganese and silicomanganese by a struggling domestic industry was even less than in 1982. Those plants that functioned operated well below capacity. The plants of Autlan Manganese Corp. at Theodore (Mobile), AL, and Roane Alloys Div. of Samancor Metals and Minerals Ltd. at Rockwood, TN, were effectively shut down for the entire year, although the Roane plant operated briefly in January. The plant of SKW Alloys Inc. at Calvert City, KY, was closed by a strike the last 4 months of the year. Chemetals Corp. underwent a name change to Chemetals Inc. early in the year, at which time ferromanganese operations at Kingwood, WV, were organized into a Metals Div.

Production quantities tabulated for the 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.

Ferromanganese.—Domestic production was by four companies at four locations. Submerged-arc electric furnaces were used by Elkem Metals at Marietta, OH; Roane Alloys at Rockwood, TN; and SKW Alloys at Calvert City, KY. Fused-salt electrolysis was used by Chemetals at Kingwood, WV, to make low- and medium-carbon ferromanganese sold under the trade name of Massive Manganese.

Silicomanganese.—Domestic production, all by submerged-arc furnace, was by three companies at three locations: Elkem Metals, Marietta, OH; Globe Metallurgical Div., Interlake Inc., Beverly, OH; and SKW Alloys, Calvert City, KY. Production of silicomanganese was so concentrated in 1983 that data were not publishable.

Electrolytic Manganese Metal.—The quantity produced was company proprietary data and not publishable. In the first part of the year, production was by three companies at three locations: Elkem Metals, Marietta, OH; Foote Mineral Co., New Johnsonville, TN; and Kerr-McGee Chemical Corp., Hamilton, MS. Foote Mineral suspended production as of the end of May, however, and mothballed its capability for producing over 10,000 tons per year. Foote Mineral entered into an agreement with Delta Manganese (Pty) Ltd. of the Republic of South Africa whereby Delta would supply electrolytic manganese metal partly to be distributed in the United States by Foote Mineral and partly to be processed by Foote Mineral into traditional products such as manganese-aluminum briquettes.

Table 4.—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			Silicomanganese		Manganese ore[1] consumed[2]	
	Production						
	Gross weight	Manganese content (average percent)	Shipments	Production	Shipments	Total quantity	Per ton of ferromanganese and silicomanganese made
1979	317	80	330	165	167	911	1.8
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

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.—Consumption of manganese as manganese ore in making pig iron or equivalent hot metal was approximately 1.1 pounds per ton of raw steel, compared with 1.0 pound per ton in 1980-82. The average for 1983 was calculated from a reported consumption in iron blast furnaces of 105,000 tons of manganese ore containing more than 35% manganese, all of foreign origin. This ore was consumed in the production of 85,300,000 tons of raw steel as ingots, continuous- or pressure-cast blooms, billets, slabs, etc., and steel castings. Iron blast furnaces consumed an additional 142,000 tons of domestic manganiferous iron ore containing 5% to 10% manganese.

Unit consumption of manganese ferroalloys and metal in steelmaking totaled 9.2 pounds of manganese per ton of raw steel produced, also on the basis of reported consumption of the various materials. In pounds of manganese per ton, makeup of the 9.2-pound total was ferromanganese, 7.8; silicomanganese, 1.2; and metal, 0.2. For the 75,600,000 tons of raw steel produced in 1982, total unit consumption was 10.6 pounds per ton, of which ferromanganese accounted for 8.7; silicomanganese, 1.7; and metal, 0.2. Consumption in steelmaking of direct-charged manganese ore containing 35% or more manganese was negligible in both 1982 and 1983.

Table 5.—U.S. consumption and industry stocks of manganese ore,[1] by use

(Short tons)

Use	Consumption		Stocks, Dec. 31	
	1982	1983	1982	1983
Manganese alloys and metal	412,280	274,280	367,119	270,933
Pig iron and steel	83,906	105,505	104,610	101,971
Dry cells, chemicals, miscellaneous[2]	112,555	150,874	279,707	244,584
Total	608,741	530,659	751,436	617,488

[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 6.—U.S. consumption, by end use, and industry stocks of manganese ferroalloys and metal in 1983

(Short tons, gross weight)

End use	Ferromanganese: High carbon	Ferromanganese: Medium and low carbon	Ferromanganese: Total	Silico-manganese	Manganese metal
Steel:					
Carbon	273,800	61,629	335,429	50,199	5,646
Stainless and heat-resisting	13,855	773	14,628	4,418	1,699
Full alloy	30,643	7,589	38,232	13,303	1,103
High-strength low-alloy	29,012	8,037	37,049	5,441	806
Electric	41	76	117	319	53
Tool	242	41	283	74	53
Unspecified	304	31	335	201	--
Total steel	347,897	78,176	426,073	73,955	9,360
Cast irons	14,736	309	15,045	7,993	11
Superalloys	220	W	220	W	262
Alloys (excluding alloy steels and superalloys)	986	137	1,123	1,245	8,071
Miscellaneous and unspecified	3,115	724	3,839	200	547
Total consumption	366,954	79,346	446,300	83,393	18,251
Total manganese content[1]	286,224	63,477	349,701	55,039	18,251
Stocks, Dec. 31:					
Consumer	137,526	11,094	148,620	6,257	W
Producer	26,236	20,450	46,686	14,457	W
Total stocks	163,762	31,544	195,306	20,714	3,882

W Withheld to avoid disclosing company proprietary data; included with "Miscellaneous and unspecified" where applicable.
[1]Estimated based on typical percent manganese content.

Average unit consumption of ferromanganese and silicomanganese in 1982-83 was significantly below the levels of prior years, when a ferroalloys and metal total unit consumption of about 12 pounds per ton had been typical. Unit consumption of manganese ferroalloys had declined progressively in much of 1982, whereas in 1983, no month-to-month trends were evident. Changes in steelmaking technology and production mix were among the factors causing lower manganese usage rates. End-use consumption of silicomanganese fell back to 19% of ferromanganese consumption, after this ratio had risen to 24% in 1982.

Some low- or medium-carbon ferromanganese, such as the domestically produced Massive Manganese or the imported Gimel Metal, and some manganese-aluminum additives may have been erroneously reported by consumers as manganese metal. This introduced uncertainties into consumption statistics for the respective materials, but was of little consequence for overall consumption.

Battery and Miscellaneous Industries.—Electrolytic manganese dioxide (EMD) was in regular commercial production by the ESB Materials Co., a subsidiary of RAYOVAC Corp. at Covington, TN; Kerr-McGee at Henderson, NV; and Union Carbide Corp. at Marietta, OH. Foote Mineral began evaluating possible production of EMD at its New Johnsonville, TN, plant, where it completed a pilot plant test program. Chemetals continued test production of chemical manganese dioxide at the Baltimore, MD, plant of its Chemicals Div. Some synthetic dioxide was used for chemical purposes, but most was used in manufacturing dry cell batteries, particularly the alkaline-manganese dioxide type. Synthetic dioxide was also used as a blend with natural ore in carbon-zinc dry cells, mainly in the heavy-duty type.

Increased international activities in dry cell battery manufacture were reported by the major producers. The Duracell Inc. subsidiary of Dart & Kraft Inc. began making alkaline batteries in Australia and Japan, RAYOVAC acquired a button cell plant in the United Kingdom, and the Battery Products Div. of Union Carbide brought a new battery facility into production in Singapore.

PRICES

Manganese Ore.—All manganese ore prices are negotiated. 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 editor's evaluation of the market.

High inventories continued to have a depressing effect on ore prices; in Japan, the quantity of ore contracted for was nearly 40% less than in 1982. Contract prices for metallurgical ore delivered to the United States appeared to drop by about the same percentage as for the price of similar ore delivered to consumers in Japan and Western Europe. The average price for metallurgical ore containing 48% manganese was \$1.38 per long ton unit, c.i.f. U.S. ports, compared with \$1.58 in 1982; per metric ton unit, these prices were \$1.36 and \$1.56, respectively.

Manganese Alloys.—Price levels for manganese ferroalloys were generally below those in 1982, by 15% or more. A current published list price for domestically produced high-carbon ferromanganese was not available, only a nominal value that dated back to January 1982. This was \$490 per long ton of alloy, f.o.b. shipping point, for standard high-carbon ferromanganese with a minimum manganese content of 78%. The price of comparable imported high-carbon ferromanganese began the year at \$365 to \$380 per long ton of alloy, f.o.b. Pittsburgh or Chicago warehouse, but promptly dropped and then fluctuated in the range of \$310 to \$340 for the rest of 1983. The price of imported silicomanganese, which had progressively declined in 1982 to end that year at 16.5 to 18 cents per pound of alloy, f.o.b. warehouse, went even lower in the first 2 months of 1983, to 15.5 to 17 cents. The price then rose, finally reaching 18 to 18.5 cents as of the end of July and thereafter. The price of domestic silicomanganese began the year unchanged at 24.5 cents per pound of alloy, f.o.b. producer, but was lowered 14% to 21 cents in mid-April by Elkem Metals and SKW Alloys and did not change thereafter.

Manganese Metal.—The list price of 70 cents per pound for bulk shipments, f.o.b. domestic producer plant, which continued from 1982 into 1983, eroded as of the second quarter. A range of 66 to 70 cents developed along with reports of discounting. This trend was reversed at the end of November when, for the remainder of the year, the price firmed to 70 cents for all domestic suppliers, and discounting was reportedly eliminated.

FOREIGN TRADE

Exports of silicomanganese and manganese metal (including alloys and waste and scrap) both increased to more than twice those in 1982, whereas exports decreased for ferromanganese and for ore and concentrate. Ore and concentrate exports again appeared to consist of 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.

In 1983, imports of manganese as ore and dioxide were slightly more than one-half the imports as ferroalloys and metal. Ore imports from Gabon rose sharply to nearly one-half of total ore imports, whereas those from the Republic of South Africa greatly decreased, exceeding only those from Morocco. The average grade of imported manganese ore increased to over 48%. Imports of manganiferous ore were only 42 tons, all from Mexico, with an average manganese content of 30%.

Imports of ferromanganese were down for the second consecutive year and fell to the lowest level since 1971. Much of the decrease was due to a large reduction in imports from the Republic of South Africa, which was displaced by France as the leading import source. The average manganese content of all ferromanganese imports remained at 78%. In returning to a growing trend, imports of silicomanganese more than doubled to a record total. Large increases in silicomanganese imports from the Republic of South Africa and Brazil, the leading sources, were responsible for most of the advance. All imports of unwrought manganese metal were from the Republic of South Africa.

Imports for consumption of spiegeleisen were reported as 157 tons, of which about two-thirds was from the Federal Republic of Germany at relatively high unit value; Canada and Mexico supplied about equal amounts of the balance.

All but 7 tons of 1983 imports for consumption of manganese dioxide were apparently battery-grade synthetic dioxide, although not necessarily from the original source country. Manganese sulfate imports for consumption of variable unit value totaled 97 tons, of which the principal amounts were 57 tons from China, 20 tons from the Federal Republic of Germany, and 18 tons from Belgium-Luxembourg. Imports for consumption of potassium permanganate rose markedly to 1,468 tons; receipts consisted mostly of 600 tons from China, 524 tons from Spain, and other quantities apparently transshipped from Western Europe.

Tariffs.—Public Law 97-446 was approved on January 12 whereby duty on imports of manganese waste and scrap was suspended permanently retroactive to July 1, 1981.

Under Executive Order 12413, duty-free treatment under the Generalized System of Preferences was ended as of March 31 for imports of high-carbon ferromanganese from developing countries and of silicomanganese from Brazil.

The International Trade Administration (ITA) of the U.S. Department of Commerce published results of a final administrative review of countervailing duties on ferroalloys from Spain on July 29. Effective immediately with this notice, a cash deposit of estimated countervailing duties of 1.53% was required on imports for consumption of medium- and high-carbon ferromanganese and silicomanganese. Higher countervailing duties ranging from 2.14% to 3.09% were assessed against 1980 and 1981 imports. These percentages equaled Spanish Government subsidies to Spain's domestic ferroalloy industry in those years, as determined by ITA.

Near yearend, ITA and the International Trade Commission separately determined that potassium permanganate from both China and Spain was being sold in the United States at less than fair value, and that such sales were materially injuring a U.S. industry. The injury was specifically to Carus Chemical Co. of La Salle, IL, the sole domestic producer. In its investigations, ITA found that the overall weighted average margin by which the foreign market value exceeded the U.S. price was 39.63% for permanganate from China and 5.49% for permanganate from Spain.

Table 7.—U.S. exports of manganese ore, ferroalloys, and metal, by country

(Gross weight)

Country	1982		1983	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Ore and concentrates containing 5% or more manganese:				
Brazil	--	--	4,509	$605
Canada	17,203	$1,403	12,625	1,030
Mexico	8,804	626	357	25
Other	2,553	481	1,823	312
Total	28,560	2,510	19,314	1,972
Ferromanganese:				
Canada	7,441	5,820	8,061	5,509
Mexico	772	681	83	71
Trinidad and Tobago	1,762	784	198	117
Other	336	232	91	68
Total	10,311	7,517	8,433	5,765
Silicomanganese:				
Canada	250	159	175	105
Japan	274	144	3,549	593
Trinidad and Tobago	2,318	1,156	2,697	1,042
Other	110	73	5	6
Total	2,952	1,532	6,426	1,746
Metal including alloys and waste and scrap:				
Belgium-Luxembourg	90	126	1,002	1,518
Brazil	162	225	154	206
Canada	487	757	374	603
Germany, Federal Republic of	185	189	--	--
India	118	161	1,685	1,576
Japan	118	145	805	908
Netherlands	574	708	1,008	1,519
Sweden	578	698	903	1,552
Other	636	852	460	649
Total	2,948	3,861	6,391	8,531

Table 8.—U.S. imports for consumption of manganese ore, ferroalloys, metal, and dioxide, by country

Country	1982			1983		
	Gross weight (short tons)	Manganese content (short tons)	Value (thousands)	Gross weight (short tons)	Manganese content (short tons)	Value (thousands)
ORE AND CONCENTRATES						
35% or more manganese:						
Australia	[1]36,884	[1]18,842	[1]$2,667	29,319	15,118	$1,740
Brazil	6,167	2,962	344	78,928	39,112	3,742
Canada	4,242	1,734	153	--	--	--
Gabon	46,059	23,156	3,514	171,018	85,509	9,628
Mexico	3,278	1,492	345	63,588	25,598	3,575
Morocco	[1]9,345	[1,2]4,996	[1]968	39	[2]20	12
South Africa, Republic of	131,782	57,873	8,169	25,406	12,703	1,170
Total[3]	237,759	111,054	16,160	368,297	178,060	19,867
Of which, more than 35% but less than 47% manganese:						
Canada	4,242	1,734	153	--	--	--
Mexico	1,900	813	165	59,053	23,428	2,815
South Africa, Republic of	78,305	32,414	5,352	--	--	--
Total[3]	84,448	34,961	5,670	59,053	23,428	2,815
FERROMANGANESE						
All grades:						
Australia	6,063	4,759	1,980	--	--	--
Belgium-Luxembourg	--	--	--	2,522	2,053	1,248
Brazil	30,864	23,607	8,853	28,550	22,022	5,971
Canada	18,360	14,241	5,669	2,366	1,761	600
France	102,854	80,729	35,710	117,142	91,611	32,494
Germany, Federal Republic of	1,252	1,031	691	5,696	4,552	2,688
India	9,645	7,204	2,646	--	--	--
Japan	5,627	4,564	3,334	2,757	2,231	1,638
Mexico	34,422	27,400	13,866	36,302	28,519	10,899
Norway	1,056	907	965	26,207	20,621	7,070
Portugal	19,538	14,966	5,201	17,637	13,565	3,212
South Africa, Republic of	242,414	188,711	70,269	87,664	67,988	22,841
Spain	--	--	--	4,404	3,523	1,923
United Kingdom	16,756	12,585	4,245	--	--	--
Yugoslavia	3,858	2,998	1,063	10,362	7,914	2,498
Total[3]	492,708	383,702	154,490	341,608	266,360	93,083
Of which, 1% or less carbon:						
France	2,900	2,562	2,860	3,668	3,291	3,426
Germany, Federal Republic of	11	10	9	2,218	1,730	1,062
Norway	946	821	938	1,081	935	922
Total[3]	3,858	3,393	3,808	6,967	5,957	5,410
More than 1% to 4% or less carbon:						
Belgium-Luxembourg	--	--	--	2,522	2,053	1,248
Canada	--	--	--	568	457	282
France	3,421	2,830	2,221	--	--	--
Germany, Federal Republic of	1,240	1,021	682	3,478	2,822	1,626
Japan	5,627	4,564	3,334	2,757	2,231	1,638
Mexico	9,395	7,688	5,710	10,578	8,542	4,889
South Africa, Republic of	6,222	5,020	3,212	5,136	4,108	2,345
Spain	--	--	--	4,404	3,523	1,923
Total[3]	25,907	21,124	15,159	29,442	23,735	13,952
SILICOMANGANESE						
Australia	11,883	7,806	3,617	16,227	10,654	4,286
Brazil	12,897	8,715	4,496	30,803	20,269	8,582
Canada	1,980	1,209	361	815	525	242
France	1,605	1,020	1,098	--	--	--
Mexico	5,209	3,524	1,854	5,731	3,839	1,695
Norway	3,441	2,261	1,302	6,628	4,219	2,926
Portugal	--	--	--	10,472	6,820	2,667
South Africa, Republic of	12,347	8,245	4,467	52,196	34,704	14,564
Spain	--	--	--	1,221	780	747
Taiwan	221	138	88	--	--	--

See footnotes at end of table.

Table 8.—U.S. imports for consumption of manganese ore, ferroalloys, metal, and dioxide, by country —Continued

Country	1982 Gross weight (short tons)	1982 Manganese content (short tons)	1982 Value (thousands)	1983 Gross weight (short tons)	1983 Manganese content (short tons)	1983 Value (thousands)
SILICOMANGANESE —Continued						
Yugoslavia	12,511	8,203	$4,189	15,563	10,182	$4,408
Total[3]	62,095	41,121	21,471	139,657	91,992	40,117
METAL						
Unwrought:						
Australia[4]	60	XX	23	--	XX	--
Canada[4]	71	XX	82	--	XX	--
South Africa, Republic of	5,063	XX	5,099	5,295	XX	5,034
Total[3]	5,194	XX	5,203	5,295	XX	5,034
Waste and scrap: Canada	32	XX	10	655	XX	289
Total metal	5,226	XX	5,213	5,950	XX	5,323
DIOXIDE						
Belgium-Luxembourg	1,473	XX	1,341	495	XX	555
Greece	2,060	XX	2,389	1,852	XX	2,082
Ireland	219	XX	309	118	XX	170
Japan	15,913	XX	21,407	18,174	XX	23,283
Other	81	XX	73	174	XX	220
Total	19,746	XX	25,519	20,813	XX	26,310

XX Not applicable.
[1]After adjustment of data for shipment originally declared from Australia but subsequently identified as having been from Morocco.
[2]Includes Bureau of Mines conversion of part of reported data (from apparent MnO_2 content to Mn content).
[3]Data may not add to totals shown because of independent rounding.
[4]Country of transshipment rather than original source.

Table 9.—U.S. import duties on manganese materials

Item	TSUS No.	Most favored nation (MFN) Jan. 1, 1983	Most favored nation (MFN) Jan. 1, 1987	Non-MFN Jan. 1, 1983
Ore and concentrate	601.27	Free	Free	1 cent per pound Mn.
Ferromanganese:				
Low-carbon	606.26	2.6% 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]	1.5% ad valorem	10.5% ad valorem.
Silicomanganese	606.44	5.0% 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 (GSP); as of Mar. 31, 1983, GSP treatment ended for high-carbon ferromanganese from all source countries and for silicomanganese from Brazil.

WORLD REVIEW

Australia.—Nearly all manganese ore production was by Groote Eylandt Mining Co. Pty. Ltd. (GEMCO). GEMCO's output increased, but was only about one-half of its capacity of approximately 2.5 million tons. Shipments by GEMCO totaled 1,380,000 tons, a 4% increase. Shipments for domestic consumption again fell, but those for export rose to about 1,100,000 tons.[4] The rise in exports was partly due to shipments of about 110,000 tons to the U.S.S.R., the third largest export destination for GEMCO in 1983.

Brazil.—Exports of manganese ore products from the Serra do Navio, Amapá Territory, operations of Indústria e Comércio de Minérios S.A. (ICOMI) were 740,000 tons, a 7% decrease. The largest portion of these shipments, 522,000 tons, was exported to Europe via Porto de Santana on the Amazon River. Other destinations included the United States, 159,000 tons; Argentina, 38,000 tons; and Japan, 17,000 tons. ICOMI also shipped 193,000 tons to Brazilian customers for a total of 933,000 tons.[5] Production of high-grade pellets from fine-sized mill fractions was suspended because of market conditions.

Production of manganese ferroalloys receded slightly from the 1982 record total. Silicomanganese output was up again, by a small amount to 197,000 tons, whereas ferromanganese production fell to 115,000 tons.

Cutbacks in Government support for mineral resource projects caused state-controlled Cia. Vale do Rio Doce (CVRD) to defer large-scale development of the Igarapé Azul deposits in the Carajás region of Pará State for metallurgical ore. In the interim, CVRD restricted its manganese production in that region to about 4,000 tons of battery ore. CVRD supplied battery ore to domestic consumers and shipped sample lots to potential foreign users.

France.—Blast furnace production of high-carbon ferromanganese plus a small amount of spiegeleisen declined by about one-sixth to 304,000 tons in 1983, according to preliminary data.

Gabon.—The Moanda Mine of Compagnie Minière de l'Ogooué S.A. (COMILOG) recorded significant increases in manganese ore production and shipments, especially the latter. Production of over 2 million tons of ore included 105,000 tons of battery ore plus a small amount of chemical ore. Exports through the Port of Pointe Noire in the Congo were 2,236,000 tons.[6] Exports included 130,000 tons of battery ore along with a small amount of chemical ore, and 110,000 tons of metallurgical ore shipped to the U.S.S.R. In 1982, the contribution of manganese ore to Gabon's total export earnings was 5%, or about the same percentage as in 1980-81.

The shareholding of United States Steel Corp. in COMILOG decreased in 1983 from 39% to 36%, still the largest interest. Elkem AS of Norway and its U.S. subsidiary, Elkem Metals, increased their combined shareholding in COMILOG to 6%. COMILOG made a long-term commitment to supply ore to Elkem's plants in Norway and the United States.

India.—Manganese ore production declined for the fourth successive year, partly because demand from the domestic ferroalloy industry was lowered by power shortages. Sandur Manganese & Iron Ore Ltd. of Karnataka State slightly worsened an already existing condition of overcapacity for ferromanganese in India by switching one of its electric furnaces from ferrosilicon to ferromanganese. This action was taken at midyear to help absorb output from Sandur's manganese mines.

Japan.—Average grade of a minimally decreased production of manganese concentrates was 27% manganese. Production of manganese ferroalloys dropped 28% to 429,000 tons for ferromanganese and 18% to 245,000 tons for silicomanganese. The rounded total for manganese metal production was unchanged at 4,300 tons. Exports of ferroalloys declined again, to 24,500 tons for ferromanganese and to only about 120 tons for silicomanganese. Imports rose, however, by about one-third to approximately 17,500 tons for ferromanganese and by over one-half to more than 127,000 tons for silicomanganese. A small but unusual component of these imports was high-carbon ferromanganese and silicomanganese from Mexico in exchange for car parts from a Japanese automobile manufacturer. Silicomanganese imports also included receipts in June of 10,000 tons from the U.S.S.R. To help the domestic ferroalloy industry adjust to the effects of imports and other economic changes, the Government included the ferroalloys industry in the Specific Industries Restructure Law made effective as of the second half of the year.

Production of synthetic manganese dioxide increased 3% to 52,000 tons; exports of the dioxide showed another healthy gain of 13% to 38,900 tons.

Mexico.—Autlán, the leading Mexican producer of both manganese ore and manganese ferroalloys, announced successful pilot production of electrolytic manganese dioxide, and was reportedly planning a commercial dioxide plant with an annual capacity of 6,600 tons. Autlán also researched production of such other chemicals as manganese sulfate, manganese chloride, and chemical manganese dioxide.

Autlán's shipments of oxide nodules from its mining and calcining operations in the Molango District of Hidalgo State totaled 353,000 tons, of which about 235,000 tons was for domestic consumption and about 119,000 tons was exported through the Port of Tampico.[7] Shipments in 1982 had been about one-sixth greater, totaling 415,000 tons, of which 275,000 tons was for domestic consumption and 140,000 tons was exported.[8] Production quantities reported by Autlán for 1982 were nearly 780,000 tons of carbonate ore, approximately 460,000 tons of nodules, and 33,000 tons of battery ore. The proportion of carbonate ore produced in 1982 by underground mining rose to exceed by about one-third that produced by open pit mining.

Norway.—Elkem AS and its U.S. subsidiary, Elkem Metals, increased to 6% their combined shareholding in COMILOG, Gabon's manganese ore mining company. Elkem and COMILOG also made a long-term agreement whereby COMILOG will continue to supply the largest part of the manganese ore needs of Elkem's Norwegian and U.S. ferroalloy smelters.

South Africa, Republic of.—Some manganese mines were temporarily closed, and at others, production was cut back to levels well below capacity. According to preliminary data, production fell by nearly one-half for both metallurgical ore and manganese ore overall. Total ore production of 3,181,000 tons was the lowest in over a decade. Production of highest grade metallurgical ore containing over 48% manganese continued a rising trend, however, increasing by more than one-half. Approximate 1983 production of metallurgical ore was 2,895,000 tons, of which 1,400,000 tons contained 30% to 40% manganese, 458,000 tons contained 40% to 45% manganese, 295,000 tons contained 45% to 48% manganese, and 742,000 tons contained over 48% manganese. Production of chemical ore was 286,000 tons, of which 178,000 tons contained less than 35% manganese dioxide and 108,000 tons contained 35% to 65% manganese dioxide; no production of ore containing 65% to 75% manganese dioxide was reported.

About midyear, control of South African Manganese Amcor Ltd. (Samancor) effectively passed to General Mining Union Corp. Ltd. (Gencor) as a consequence of property and equity transactions between Gencor and state-owned South African Iron and Steel Industrial Corp. Ltd. (Iscor). In one of the transactions, Gencor acquired 50.25% of African Metals Ltd. from Iscor. Because of African Metals' 39.6% shareholding in Samancor, this acquisition plus Gencor's 7% direct and previous 1.4% indirect shareholding in Samancor gave Gencor 48% control of Samancor. Anglo American Corp. of South Africa Ltd. remained the second largest stockholder in Samancor with about a 30% interest.

Samancor began operating an 8-megawatt plasma arc furnace at its Meyerton ferroalloy plant in Transvaal Province. This new furnace was being used to melt ore and plant fines, including those containing manganese, and to test ferroalloy production by the plasma arc process.

U.S.S.R.—Ore production capacity was being expanded or developed in the Ukraine at the Ordzhonikidze, Marganets, and Tavricheskiy (Bol'she-Tokmak) complexes and in Georgia at the Chiatura complex. Estimated mine output in 1983 surpassed the previous record high total of 11.3 million tons in 1979. Even so, high-grade concentrates were imported, 110,000 tons each from Australia and Gabon, according to trade journal reports. Press articles indicated these imports would augment domestic material in the mixture being fed to an increased electric-furnace capacity for ferromanganese and/or silicomanganese. Installation of the last six 75 megavolt ampere closed submerged-arc furnaces contracted for in 1976 with Japan's Tanabe Kakoki was completed in the fall. Four were located at the Nikopol steel plant and two at the Zestafoni plant in Georgia near the Chiatura Mine operations. Each furnace was rated at about 130,000 tons per year of ferromanganese.

According to official statistics, average grade of ore and concentrates in 1982 was 30% manganese, the same as in 1981. Although mine production recovered in 1982, ore exports fell slightly to 1,261,000 tons. Principal destinations accounting for over 90% of the export total were, in tons, Poland, 590,000; Czechoslovakia, 381,000; the German Democratic Republic, 143,000; and Bulgaria, 85,000.

United Kingdom.—Early in the year, the Government had begun establishing a small stockpile of strategic materials. Manganese as both ore and ferroalloys was reported to be one of the main items being acquired. Trade journals identified the Republic of South Africa as a principal source of both these forms in which manganese was being stockpiled.

Table 10.—Manganese ore: World production, by country[1]

(Thousand short tons, gross weight, unless otherwise specified)

Country[2]	Percent Mn[e]	1979	1980	1981	1982[p]	1983[e]
Australia[3]	37-53	1,871	2,204	1,555	1,248	[4]1,491
Bolivia[5 6]	28-54	12	1	1	([7])	([7])
Brazil[8]	38-50	2,490	2,515	2,251	[9]2,580	2,300
Bulgaria	30-	46	54	50	50	50
Chile	32-35	28	31	28	18	18
China[e 10]	20+	1,650	[r]1,760	1,760	1,760	1,760
Gabon	50-53	2,535	2,366	1,640	1,667	[4]2,047
Ghana	30-50	300	278	246	176	210
Greece	48-50	6	6	6	[e]6	6
Hungary[11]	30-33	91	91	78	91	94
India[12]	10-54	[r]1,952	[r]1,865	1,682	1,596	[4]1,455
Indonesia	47-56	7	5	3	20	19
Iran[13]	33+	[e]22	--	--	--	--
Italy[14]	30	11	10	10	10	10
Japan	24-27	97	88	96	86	[4]85
Korea, Republic of	23-40	([7])	([7])	--	--	--
Mexico[5]	27+	543	493	637	561	386
Morocco	50-53	150	145	121	106	81
Pakistan	35-	([7])	([7])	([7])	([7])	([7])
Philippines	30+	4	3	3	2	2
South Africa, Republic of	30-48+	5,713	6,278	5,555	5,750	[4]3,181
Sudan	48	([7])	([7])	([7])	[e]([7])	([7])
Thailand	46-50	39	60	12	9	[4]7
Turkey	27-46	46	46	16	8	[4]4
U.S.S.R.[15]	30-31	11,292	10,750	10,090	10,830	11,500
Vanuatu	40-44	12	--	--	--	--
Yugoslavia	30+	33	33	34	[e]33	33
Zaire	30-57	--	[r]7	20	--	--
Total	XX	[r]28,950	[r]29,089	25,894	26,607	24,739

[e]Estimated. [p]Preliminary. [r]Revised. XX Not applicable.

[1]Table includes data available through June 13, 1984.

[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: Argentina (19% to 32% Mn), 1979—11, 1980—7, 1981—3, 1982—4, and 1983—5; Czechoslovakia (about 17% Mn), an estimated 1 in each year; Malaysia (grade unspecified but apparently a ferruginous manganese ore), 1979—35, 1980—4, and 1981-83—zero; and Romania (about 22% Mn), an estimated 90 in each year.

[3]Metallurgical ore.

[4]Reported figure.

[5]Estimated on the basis of reported contained manganese.

[6]Exports.

[7]Less than 1/2 unit.

[8]Figures are the sum of (1) sales of direct-shipping manganese ore and (2) production of beneficiated ore, both as reported in Annuario Mineral Brasileiro.

[9]Only about two-thirds of this quantity was marketed.

[10]Includes manganiferous ore.

[11]Concentrate.

[12]Much of India's production grades below 35% Mn; average content was reported as about 37% Mn in 1979-80.

[13]Reported as if data are for calendar years, but may actually represent output for Iranian calendar years beginning Mar. 21 of the year stated.

[14]From wastes.

[15]Reported in Soviet sources. Grade represents the annual averages obtained from reported metal contents of the gross weights shown.

TECHNOLOGY

Thermodynamic data on manganese sulfate were developed by the Bureau of Mines to better the understanding of reactions occurring when mineral concentrates are roasted or sintered. These data were derived from measurements of equilibrium oxygen pressure in the Mn-S-O system at 896° to 1,227° Kelvin. The experiments involved use of a high-temperature solid-state electrochemical cell employing a zirconia electrolyte.[9]

To aid silver conservation and reduction of cadmium emissions, the Bureau explored the potential of manganese-bearing copper-base alloys as substitutes for commercial silver brazing alloys. Results for copper-manganese-tin alloys containing 10% to 15% manganese suggested further development in this system could be worthwhile.[10]

The Bureau, in updating the 1977 Dames & Moore report on manganese nodule processing, presented detailed flowsheets and descriptions for the five most probable schemes for extracting metal values from ocean nodules. Manganese recovery was inherent in two processes and optional in three.[11] The Bureau also outlined methods of characterizing nodule feed materials and wastes from their processing according to the five likely schemes.[12]

The Bureau also analyzed hypothetically the economics of metal recovery from deep sea nodules. The analysis was for recovery from three of the most promising sites in the Clarion-Clipperton fracture zone south and east of Hawaii. Conceptually, nodules from these sites were hydraulically mined and transported to the west coast of the United States, where cobalt, copper, and nickel were recovered by the Cuprion (Kennecott) process. As an option, manganese was recovered as ferromanganese by smelting feed material obtained from tailings in an electric furnace. Production at each ocean mining site was estimated as roughly 3 million dry tons annually at an estimated capital cost of nearly $2 billion in January 1981 dollars. Each operation was projected to supply at least 10% of annual U.S. manganese demand. Discounted cash flow rates of return were projected to be only 6% at most and even less when manganese was also recovered.[13]

The possibility that on-going geological investigation of ocean floors could aid onshore minerals exploration was pointed out in a review of the associations of mineral accumulations with submerged boundaries between segments of the Earth's surface. These studies showed layered oxides of manganese and iron to be found in sediments associated with divergent and transform plate boundaries, such as those of the Mid-Atlantic Ridge.[14]

The possible existence in North America of undiscovered large, high-grade sedimentary manganese deposits formed by precipitation from shallow-water marine transgressive environments was discussed. Areas where such deposits might be found were identified as a mid-continent region of the United States and Canada northwest from east-central South Dakota and portions of the Atlantic and Gulf Coastal Plains of Mexico and the United States.[15]

Leaching manganese dioxide with dilute aqueous solutions of sulfur dioxide is a potentially useful process for extracting manganese from low-grade oxide ores. Further insight into the kinetics of this leaching reaction was obtained by experiments on samples of pyrolusite and electrolytic manganese dioxide. Rate of reduction of manganese dioxide to a compound with manganese in a lower valence state was found to be controlled by an electrochemical reaction at the manganese surface.[16]

Chemical analysis reference samples of two important manganese ores from the Republic of South Africa were prepared and certified. One of the samples, SARM 16, was of ore from the Wessels Mine and the other, SARM 17, was of ore from the Mamatwan Mine.[17]

Also reported from the Republic of South Africa were results of radiotracer and mineralogical investigations of conditions inside large submerged-arc furnaces smelting high-carbon ferromanganese. Findings supported those of a dig-out previously conducted on one of the furnaces.[18]

In contrast to established smelting of ferromanganese from lumpy ores by submerged-arc and blast furnace processes, plasma and other furnace technologies were under development for better utilizing both metallic and mineral fines. If proved commercial, these newer technologies would increase overall recovery of manganese in extraction. Work with plasmas was reported from both Western and Eastern Europe.[19] In Japan, Kawasaki Steel Corp. claimed favorable results from pilot testing a combined prereduction and smelting arrangement in which low-grade coke was the principal reductant.[20]

In recent years, several steelmaking practices that have come into use for improving product quality or melt shop operations have also increased manganese yield, thereby decreasing ferromanganese requirements. This trend was exemplified in use of the lance bubbling equilibrium or LBE version of combined blowing, for which manganese recovery was slightly improved in some instances.[21]

Liquid and solid phase equilibria in ternary systems of iron and manganese with each of six other transition metals—chromium, cobalt, copper, nickel, titanium, and vanadium—were reviewed in 1983. Liquidus surfaces and various constant temperature sections were graphed for the ternaries, and phase diagrams were presented for the 12 underlying binaries.[22]

Values for electrical resistivity of manganese at temperatures between 1° and 700° Kelvin were recommended in a review of the electrical resistivity of aluminum and manganese.[23]

A mathematical model of a diaphragm cell for production of electrolytic manganese metal was developed and programed for use on a digital computer. Optimum commercial operating conditions were predicted using the model.[24]

Technical feasibility of a chloride route to manganese metal more than 99.9% pure was investigated in laboratory studies. Pure manganese carbonate and Ghanaian ore were tested as feed material. Process steps were (1) production of gaseous manganese chloride by reacting manganese feed material at about 950° C with liquid calcium chloride to which silica had been added to suppress calcium chloride vaporization, (2) condensation of manganese chloride in a magnesium-potassium-sodium chloride fused-salt melt at 500° C, and (3) electrolysis of this melt, also at 500° C. A brief economic evaluation indicated the process to be both energy and capital intensive.[25]

Advances in technology of dry cell battery systems with manganese included development of a chemical manganese dioxide, trade named Faradiser WS, suitable for use in alkaline and lithium-manganese dioxide batteries. The processing route to Faradiser WS was devised to give particles with internal porosity and surface area lower than those of the conventional chemical manganese dioxide, Faradiser M, already in use in carbon-zinc cells.[26] Technology and commercialization of lithium-manganese dioxide batteries and present and future applications of these cells in computer equipment and consumer electronics such as calculators, watches, and cameras were reviewed.[27] Performance of a hermetically sealed lithium-manganese dioxide cell being tested for temperature stability and ruggedness was described. High reliability of the cell signified its suitability for use in telecommunications devices.[28]

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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]Chemical Week. V. 133, No. 24, Dec. 14, 1983, pp. 30, 32.

[4]Skillings' Mining Review. V. 73, No. 8, Feb. 25, 1984, p. 10.

[5]———. V. 73, No. 9, Mar. 3, 1984, p. 20.

[6]———. V. 73, No. 11, Mar. 17, 1984, p. 15.

[7]———. V. 73, No. 15, Apr. 14, 1984, p. 14.

[8]———. V. 72, No. 30, July 23, 1983, p. 10.

[9]Schaefer, S. C. Electrochemical Determination of Thermodynamic Properties of Manganese Sulfate and Cadmium Oxysulfate. BuMines RI 8809, 1983, 20 pp.

[10]Miller, V. R., and W. L. Falke. Copper-Manganese-Base Silverless Brazing Systems. BuMines RI 8783, 1983, 16 pp.

[11]Haynes, B. W., S. L. Law, and R. Maeda. Updated Process Flowsheets for Manganese Nodule Processing. BuMines IC 8924, 1983, 100 pp.

[12]Haynes, B. W., D. C. Barron, G. W. Kramer, and S. L. Law. Methods for Characterizing Manganese Nodules and Processing Wastes. BuMines IC 8953, 1983, 10 pp.

[13]Hillman, C. T. Manganese Nodule Resources of Three Areas in the Northeast Pacific Ocean: With Proposed Mining-Beneficiation Systems and Costs. BuMines IC 8933, 1983, 60 pp.

[14]Rona, P. A. Potential Mineral and Energy Resources at Submerged Plate Boundaries. Nat. Resour. Forum, v. 7, No. 4, 1983, pp. 329-338.

[15]Cannon, W. F., and E. R. Force. Potential for High-Grade Shallow-Marine Manganese Deposits in North America. Paper in Unconventional Mineral Deposits, ed. by W. C. Shanks III (Cameron Symp., SME-AIME Annu. Meeting, Dallas, TX, Feb. 14-18, 1982). Soc. Min. Eng., AIME, Littleton, CO, 1983, pp. 175-189.

[16]Miller, J. D., and R-Y Wan. Reaction Kinetics for the Leaching of MnO_2 by Sulfur Dioxide. Hydrometall., v. 10, No. 2, May 1983, pp. 219-242.

[17]Hansen, R. G., E. J. Ring, and T. W. Steele. The Preparation and Certification of Two Reference Materials of South African Manganese Ore. Coun. Miner. Technol., Republic of South Africa, MINTEK Rep. M70, Feb. 25, 1983, 44 pp.

[18]Smith, D. J., and A. Wedepohl. Tracer Tests on Furnaces at Metalloys Limited. Coun. Miner. Technol., Republic of South Africa, MINTEK Rep. M48, Jan. 14, 1983, 57 pp.

[19]Metal Bulletin Monthly. Voest-Alpine's Plasma Plant. No. 150, June 1983, pp. 45, 47, 49.

Berry, B. H. SKF Steel Fires Up Its Plasma Technologies. Iron Age, v. 226, Aug. 1, 1983, pp. MP-22, MP-24-MP-25.

[20]Iron and Steel Engineer. New Ironmaking/Ferroalloy Reduction Process. V. 60, May 1983, p. 68.

Iron and Steelmaker. New Ironmaking/Ferroalloy Manufacturing Process. V. 10, Nov. 1983, p. 17.

[21]Mastey, A. D. The LBE Experience: Four Users Share Their Results. 33 Met. Producing, v. 21, July 1983, pp. 42-45.

[22]Rivlin, V. G., and G. V. Raynor. Critical Review of Constitution of Ternary Systems Fe-Mn-X (X = Ti, V, Cr, Co, Ni, Cu). Int. Met. Rev., v. 28, No. 1, 1983, pp. 23-64.

[23]Desai, P. D., H. M. James, and C. Y. Ho. Electrical Resistivity of Aluminum and Manganese. Purdue Univ., CINDAS Rep. 65, Mar. 1983, pp. 39-49; available from National Technical Information Service, Springfield, VA 22161, No. AD-A129 158/2.

[24]Bryson, A. W., and J. C. P. Rodrigues. Modelling the Performance of Manganese Electrowinning Cells. Paper in Proc. 3d. International Symposium on Hydrometallurgy (Atlanta, GA, Mar. 6-10, 1983). AIME, Warrendale, PA, 1983, pp. 773-787.

[25]Louis, P., A. Fontana, and R. Winand. Recovering Manganese From a Carbonate Ore by Chloride Volatilization and Subsequent Electrowinning. Paper in Proc. First International Conf. on Molten Salt Chemistry and Technology (Kyoto, Japan, Apr. 20-22, 1983). Electrochemical Soc. of Japan, Kyoto, Japan, 1983, pp. 167-171.

[26]Picquet, P. C., and J. Y. Welsh. A Broader Application of Chemical Manganese Dioxide in the Battery Industry. New Mater. & New Processes, v. 2, 1983, pp. 12-18.

[27]Ikeda, H. Lithium-Manganese Dioxide Cells. Ch. in Lithium Batteries, ed. by J.-P. Gabano. Academic Press, New York, NY, 1983, pp. 169-210.

[28]Reddy, T. B., J. R. Sullivan, and A. Shakked. Performance and Safety Characteristics of the MDX-200A, an Hermetically Sealed Li/MnO_2 Primary Cell. Pres. at Fall Meeting of the Electrochem. Soc., Washington, DC, Oct. 9-14, 1983, 11 pp.; available from J. R. Sullivan, Power Conversion Inc., Elmwood Park, NJ.

Mercury

By Linda C. Carrico[1]

Domestic mercury mine production, reported by three mines in Nevada, decreased for the third consecutive year. Secondary output increased more than threefold. Although consumption remained essentially the same, the U.S. dealers' price declined by about $49 per flask[2] in response to an oversupply of secondary mercury.

World mine production declined in response to a world surplus of secondary mercury and depressed European prices.

Table 1.—Salient mercury statistics

	1979	1980	1981	1982	1983
United States:					
Producing mines	3	4	3	3	3
Mine production .... flasks	29,519	30,657	27,904	25,760	25,070
Value .... thousands	$8,299	$11,939	$11,549	W	W
Secondary production:					
Industry .... flasks	4,287	6,793	4,244	4,473	13,474
Government[1] .... do	11,300	10,013	7,000	--	--
Industry stocks, yearend[2] .... do	27,582	33,069	27,339	29,327	31,518
Shipments from the National Defense Stockpile do	196	--	--	[3]7,088	6,000
Imports for consumption .... do	26,448	9,416	12,408	8,916	12,786
Exports .... do	NA	NA	NA	NA	NA
Consumption, reported .... do	62,205	58,983	59,244	48,943	49,138
Consumption, apparent[4] .... do	82,721	51,392	57,286	44,249	55,252
Price: New York, average per flask	$281.10	$389.45	$413.89	$370.93	$322.44
Employment, mine and mill, average	41	46	48	45	45
World:					
Mine production .... flasks	174,436	[r]197,426	210,897	[p]197,696	[e]188,493
Price: London, average per flask	$291.73	$398.07	$417.52	$376.96	$313.33

[e]Estimated. [p]Preliminary. [r]Revised. 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]Includes 1,000 pounds of mercuric oxide, equivalent to 12 flasks of mercury metal, at a nominal 91%.

[4]Mine production plus secondary production plus imports for consumption minus exports, plus Government stockpile shipments, and plus or minus changes in industry stocks.

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 390 firms to which this survey request was sent, 81% responded, representing an estimated 80% of the total U.S. consumption shown in tables 1 and 4. Consumption for the 74 nonrespondents was estimated using prior years' consumption levels.

Legislation and Government Programs.—The Omnibus Budget Reconciliation Act of 1981, Public Law 97-35, authorized the disposal of 50,000 flasks of primary mercury and 710,253 pounds of mercuric oxide from the National Defense Stockpile (NDS). During 1983, the General Services Administration (GSA) continued to auction primary mercury from NDS, offering 1,500 flasks on the third Tuesday of each month. GSA thereby sold and shipped 6,000 flasks during the year, leaving 36,924 flasks authorized for disposal. The stockpile goal remained at 10,500 flasks.

Scheduled monthly auctions of mercuric oxide from NDS remained canceled in 1983 because the containers holding the material failed to meet U.S. Department of Transportation regulations. The stockpile goal for mercuric oxide was zero.

Auctions of surplus secondary mercury, managed by the U.S. Department of Energy (DOE) in Oak Ridge, TN, also remained suspended during the year.

The Environmental Protection Agency, under Section 112 of the Clean Air Act, proposed changes to the existing test method (Method 105) used in determining the content of mercury in waste water treatment plant sewage sludges. The proposed changes were not intended to impose any additional emission measurement requirements on any facility but would simply change the existing testing method to improve the precision and accuracy.[3]

DOE released a report on May 17, 1983, entitled "Mercury Inventory at the Y-12 Plant, 1950 through 1977." The report indicated that about 8,553 flasks of mercury was spilled and lost to the environment between 1950 and 1963 and that almost 26,316 flasks remained unaccounted for. The mercury was used to produce lithium deuteride fuel, which was used to produce thermonuclear weapons.[4] In 1983, an interagency task force, including Federal, State, and local governments continued to investigate the extent of mercury contamination and to devise possible solutions to the problem. A construction project was underway for a central pollution control facility designed to treat liquid waste at the Y-12 plant.

DOMESTIC PRODUCTION

For the second consecutive year, Nevada was the only mercury producing State, with producers operating at about 72% of capacity. Total mine production, including byproduct mercury, was 25,070 flasks. Three mines were in operation during the year: the Carlin gold mine, the Pinson gold mine, and the McDermitt mercury mine. Mercury was produced as a byproduct at the Carlin and Pinson gold mines. The McDermitt Mine, operated by Placer U.S. Inc. (formerly Placer Amex Inc.), remained the principal mercury producer in the United States.

Table 2.—Mercury ore treated and mercury produced in the United States[1]

Year	Ore treated (short tons)	Mercury produced	
		Flasks	Pounds per ton of ore
1979	242,564	29,499	9.2
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

[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
1979	4,287	11,300	15,587
1980	6,793	10,013	16,806
1981	4,244	7,000	11,244
1982	4,473	--	4,473
1983	13,474	--	13,474

Exploration work by Placer continued at its mine in Nevada and at other mercury prospects in the Western States. The McDermitt Mine has about 5 years of proven reserves based on an annual production rate of about 25,000 flasks.

During 1983, four companies specialized in processing primary and/or scrap mercury. The companies were 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 more than tripled, probably as a result of the temporary closure of two mercury-cell chlor-alkali plants. A portion of the mercury in these plants was thus available to be recovered, processed, rebottled, and shipped either to warehouses or consumers. Production from scrap was equivalent to 27% of the reported consumption. Major sources of secondary mercury were amalgams, sludges, obsolete industrial and control instruments, and metal retrieved from chlorine and caustic soda plants.

CONSUMPTION AND USES

Mercury was consumed in about 410 plants, of which more than one-half are located east of the Mississippi River. Primary mercury accounted for 66% of the total reported consumption; redistilled mercury, 27%; and secondary mercury, 7%.

The mercury-cell chlor-alkali plants of LCP Chemicals at Linden, NJ, and Olin Corp. at McIntosh, AL, were inactive because of economic problems. Although these two plants were idle, the consumption of mercury in the production of chlorine and caustic soda increased by 29%.

Table 4.—Mercury consumed in the United States, by use

(Flasks)

SIC code	Use	1979	1980	1981	1982	1983
28	Chemical and allied products:					
2812	Chlorine and caustic soda manufacture	12,180	9,470	7,328	6,243	8,054
2816	Pigments	W	W	W	W	W
2819	Catalysts, miscellaneous	1,257	765	815	499	484
2821	Catalysts for plastics	W	W	W	W	W
2819	Laboratory uses	410	363	328	281	280
2851	Paints	9,979	8,621	7,049	6,794	6,047
2879	Agricultural chemicals	W	W	79	36	--
--	Other chemicals and allied products	82	W	W	W	W
36	Electrical and electronic uses:					
3641	Electric lighting	511	1,036	1,043	826	1,273
3643	Wiring devices and switches	3,213	3,062	2,641	2,004	2,316
3692	Batteries	25,299	27,829	29,441	24,880	23,350
--	Other electrical and electronic uses	106	144	W	W	W
38	Instruments and related products:					
382	Measuring and control instruments	3,603	3,049	5,671	3,064	2,465
3843	Dental equipment and supplies	1,422	1,779	1,613	1,019	1,597
--	Other instruments and related products	192	190	253	194	W
--	Other	556	790	242	984	1,356
	Total	62,205	58,983	59,244	48,943	49,138

W Withheld to avoid disclosing company proprietary data; included in "Total."

STOCKS

NDS, as of December 31, 1983, contained 178,315 flasks of primary mercury and 712,202 pounds of mercuric oxide. DOE held 35,305 flasks of secondary mercury in Oak Ridge, TN.

Table 5.—Stocks of mercury, December 31

(Flasks)

Year	Producer (mine)	Consumer and dealer	Total
1979	9,181	18,401	27,582
1980	11,095	21,974	33,069
1981	11,783	15,556	27,339
1982	14,098	15,229	29,327
1983	18,823	12,695	31,518

PRICES

In 1983, mercury prices declined in response to an oversupply of secondary material and relatively steady demand.

Table 6.—Average prices of mercury at New York and London

(Per flask)

Period	New York	London
1979	$281.10	$291.73
1980	389.45	398.07
1981	413.89	417.52
1982	370.93	376.96
1983:		
January	375.71	346.88
February	347.37	340.12
March	341.65	330.44
April	331.76	317.50
May	309.76	300.56
June	291.50	296.12
July	275.95	288.44
August	281.57	285.89
September	305.43	298.28
October	340.75	324.31
November	342.05	320.28
December	325.81	311.11
1983 average	322.44	313.33

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, increased significantly. Spain was the leading supplier, followed by the United Kingdom, Algeria, and Mexico. The average unit value of imports during 1983 was $298.22 per flask, compared with $336.81 per flask in 1982.

The U.S. rate of duty on imported mercury metal, TSUS 632.34, as of January 1, 1983, from countries with most-favored-nation status, was 10 cents per pound. A duty of 25 cents per pound applied to other countries.

Presidential Proclamation 5140, December 19, 1983,[5] changed the rate of duty on imported mercury metal from countries with most-favored-nation status, in cents per pound, as follows, effective January 1 of year indicated: 1984—6.6; 1985—6.2; 1986—6.3; and 1987—6.4.

Table 7.—U.S. imports for consumption of mercury, by country

Country	1981 Flasks	1981 Value (thousands)	1982 Flasks	1982 Value (thousands)	1983 Flasks	1983 Value (thousands)
Algeria	--	--	--	--	1,795	$560
Canada	112	$78	5	$14	4	19
China	801	308	100	42	--	--
Denmark	500	201	390	161	--	--
Dominican Republic	129	54	--	--	100	23
France	(1)	(1)	--	--	--	--
Germany, Federal Republic of	--	--	2	1	13	20
Italy	--	--	--	--	500	122
Japan	2,372	925	4,345	1,444	511	179
Mexico	104	29	182	59	1,590	426
Netherlands	--	--	200	62	1,501	359
Philippines	--	--	881	293	--	--
Spain	4,989	2,021	1,404	484	3,408	1,063
Turkey	500	197	900	286	1,333	385
United Kingdom	--	--	507	157	2,031	657
Yugoslavia	2,901	1,192	--	--	--	--
Total	12,408	5,005	8,916	3,003	12,786	3,813

[1]Less than 1/2 unit.

WORLD REVIEW

The decrease in world mine production was attributed largely to an excess of world secondary mercury supplies and depressed European prices.

Canada.—In late 1982, to comply with environmental standards, Cominco Ltd. opened a $15 million plant to remove mercury vapors released in the roasting of concentrates at its operations at Trail, British Columbia. Mercury was expected to be recovered in the form of mercurous chloride. Cominco's Pinchi Lake Mine remained closed in 1983.

Czechoslovakia.—Plans to mine up to 50,000 metric tons of mercury ore per year, beginning in 1985, continued. The new mine will be located near Presov, Czechoslovakia. A concentrator was under construction at the minesite. The concentrates will then be transported to a processing plant of the Rudne Bane Banska Bystrica National Corp.

Italy.—The Monte Amiata mercury mine remained closed during the year because of insufficient demand, large inventories, and low prices. Italy's 1982 production was adequate to meet its goal of self-sufficiency in 1982 and 1983.

Japan.—The Japanese Ministry of International Trade and Industry (MITI) ordered the remaining 22 Japanese mercury-cell chlor-alkali processors to convert to the diaphragm-cell or membrane-cell process by June 30, 1986. As the conversions continue, secondary mercury production and inventories were expected to rise. MITI also ordered secondary processors to sell the reclaimed mercury to domestic thermometer and battery manufacturers.

Spain.—The Almadén region remained the only producer of mercury and was the second largest world producer in 1983. Three mines, the Almadén, El Entredicho, and Las Cuevas, comprised the Almadén region and were operated by Minas de Almadén y Arrayanes S.A., a mining company owned by the Spanish Government. It was reported that the Government had agreed to buy Almadén's excess prime virgin mercury for its newly created mercury stockpile. This was in response to low European prices and a surplus of reclaimed mercury worldwide.

U.S.S.R.—Mine production in the U.S.S.R. comprised an estimated 34% of total world mine production. Ore was mined from Khaydarkan in southern Kirgiziya, Nikitovskiy in the Ukraine, and Zakarpatskiy in Zakarpatskaya Oblast. A new mercury-antimony operation, the Dzhidzhikrutskiy complex, was under construction in the Tadzhik S.S.R. Increased development in recent years has enabled the U.S.S.R. to become self-sufficient in mercury.

Yugoslavia.—In September 1983, the Idria mercury mine in Slovenia (northwestern Yugoslavia) resumed operation after closing in early 1977 because of low prices and declining grade of ore. The discovery of a new ore body was the major factor in reopening the mine. Production was about 1,500 flasks in 1983. The mine was scheduled to produce about 8,700 flasks in 1988. Most of the mercury produced at the mine was expected to be consumed domestically.

Table 8.—Mercury: World mine production, by country[1]

(Flasks)

Country	1979	1980	1981	1982[p]	1983[e]
Algeria	14,719	24,403	25,000	11,000	10,000
China[e]	20,000	20,000	20,000	20,000	20,000
Czechoslovakia	4,960	[r]4,612	4,438	4,380	4,380
Dominican Republic	281	159	77	49	40
Finland	1,348	2,170	1,949	1,848	1,848
Germany, Federal Republic of	2,639	1,624	2,205	1,537	[2]2,005
Italy	--	96	7,427	4,612	--
Mexico	1,973	4,206	6,962	8,558	8,000
Spain	33,275	[r]43,038	46,008	48,808	48,000
Turkey	4,722	4,461	5,927	7,144	3,650
U.S.S.R.[e]	61,000	62,000	63,000	64,000	64,000
United States	29,519	30,657	27,904	25,760	[2]25,070
Yugoslavia	--	--	--	--	1,500
Total	174,436	[r]197,426	210,897	197,696	188,493

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through Apr. 11, 1984.
[2]Reported figure.

TECHNOLOGY

The Bureau of Mines, in cooperation with the operators of the McDermitt Mine, investigated a method for recovering mercury metal from mercury sulfide concentrates using hydrometallurgical techniques. The preliminary report demonstrates the feasibility of leaching mercury with a cupric chloride solution and electrowinning mercury from the resultant solution.[6]

The Bureau of Mines evaluated various methods for identifying sources of mercury vapor in excess of the threshold limit value of 0.05 milligram per cubic meter of air in mines and mineral processing plants. The best method appeared to be a spot test that used a commercially available test paper sensitive only to mercuric ions.[7]

A patent was issued on a container that prevents contamination and leakage of metallic mercury during transportation and storage.[8]

[1]Mineral specialist, Division of Nonferrous Metals.

[2]Flask, as used throughout this chapter, refers to the 76-pound flask.

[3]Federal Register. National Emission Standards for Hazardous Air Pollutants. V. 48, No. 215, Nov. 4, 1983, pp. 51064-51066.

[4]U.S. House of Representatives. The Extent and Impact of Mercury Releases and Other Pollutants at the Department of Energy's Oak Ridge Complex at Oak Ridge, Tennessee. Committee on Science and Technology. 98th Congr., 1st sess., House Rep. No. 98-558, Nov. 17, 1983, 42 pp.

———. The Impact of Mercury Releases at the Oak Ridge Complex. Committee on Science and Technology, Subcommittee on Investigations and Oversight, and Subcommittee on Energy Research and Production. 98th Congr., 1st sess., Committee Print 44, July 11, 1983, 951 pp.

[5]Federal Register. Proclamation of Trade Agreements With Japan and Spain Providing Compensatory Concessions. V. 48, No. 247, Dec. 22, 1983, pp. 56553-56559.

[6]Atkinson, G. B., J. E. Murphy, and J. A. Eisele. Recovering Mercury From a Flotation Concentrate by Continuous Leaching-Electrolysis. BuMines RI 8769, 1983, 9 pp.

[7]Neylan, D. L., H. C. Triantafillou, and S. L. Law. Methods for Determining Sources of Mercury Vapor in the Workplace. BuMines IC 8921, 1983, 15 pp.

[8]Lawrence, J. B., and B. J. Lawrence (assigned to Bethlehem Apparatus Co. Inc., PA). Mercury Containers. U.S. Pat. 4,416,382, Nov. 22, 1983.

Mica

By Lawrence L. Davis[1]

In 1983, a total of 140,000 short tons of scrap and flake mica was reported produced in the United States, a 32% increase from 1982 production.

Nearly all sheet mica supply continued to be imported. Consumption of mica block decreased by 13% to 83,000 pounds. Consumption of mica splittings declined 20% to 2.1 million pounds. The value of sheet mica exports decreased 29% to $4.1 million. Imports of sheet mica decreased 32% to 2.6 million pounds.

Domestic Data Coverage.—Domestic production and consumption data for mica were 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, 54 operations, or 98% responded, representing more than 99% of the total mica production and consumption shown in table 1. Production and consumption for the nonrespondent was estimated by adjusting reported prior year production levels using the percentage decrease for respondent data for 1983 compared with that for 1982.

Table 1.—Salient mica statistics

	1979	1980	1981	1982	1983
United States:					
Production (sold or used by producers):					
Sheet mica ... thousand pounds	1	NA	NA	NA	NA
Value ... thousands	(1)	NA	NA	NA	NA
Scrap and flake mica ... thousand short tons	134	116	133	106	140
Value ... thousands	$7,708	$6,262	$8,212	r$6,398	$6,479
Ground mica ... thousand short tons	122	111	117	96	130
Value ... thousands	$15,169	$14,870	$17,440	$16,106	$18,702
Consumption:					
Block ... thousand pounds	277	156	166	95	83
Value ... thousands	$1,841	$1,886	$1,533	$1,366	$993
Film ... thousand pounds	5	4	3	3	3
Value ... thousands	$25	$18	$13	$15	$16
Splittings ... thousand pounds	4,877	4,383	4,386	2,639	2,120
Value ... thousands	$3,248	$3,101	$3,064	$2,032	$1,394
Exports ... thousand short tons	12	r15	r12	r12	11
Imports ... do	10	12	13	10	8
World: Production ... thousand pounds	r514,351	r501,356	525,968	p474,867	e534,831

eEstimated. pPreliminary. rRevised. NA Not available.
1Less than 1/2 unit.

Legislation and Government Programs.—The Government inventory of stockpile-grade natural sheet mica was reduced by 2% to 25.5 million pounds by yearend. Sales of sheet mica by the General Services Administration were 58,000 pounds of muscovite film, 578,000 pounds of muscovite splittings, and 8,000 pounds of phlogopite splittings. No stockpiled block mica was sold.

Table 2.—Stockpile goals and Government inventories for mica, December 31, 1983

(Thousand pounds)

Material	Goal	Inventory: Stockpile grade	Inventory: Non-stockpile grade	Available for disposal	1983 sales
Block:					
Muscovite, Stained and better	6,200	5,006	207	--	--
Phlogopite	210	17	114	--	--
Film: Muscovite, 1st and 2d qualities	90	1,221	1	77	58
Splittings:					
Muscovite	12,630	17,587	--	4,542	578
Phlogopite	930	1,673	--	738	8

DOMESTIC PRODUCTION

Scrap and Flake Mica.—U.S. production of scrap (flake) mica[2] was 140,000 tons valued at $6.5 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, and South Dakota. 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; Lithium Corp. of America Inc., Gastonia, NC; Feldspar Corp., Spruce Pine, NC; and Kings Mountain Mica Co., Kings Mountain, NC.

Ground Mica.—Production (sold or used) of ground mica, from scrap and flake mica, increased 35% to 130,000 tons, valued at $18.7 million. Dry-ground mica, 91% of the total, increased by 39%, whereas wet-ground mica increased by 9%. Twelve companies operated 16 grinding plants; of these, 12 produced dry-ground and 4 produced wet-ground mica. Leading ground mica producers were, in order of output, Pacer, Custer, SD; United States Gypsum Co., Chicago, IL; M.I.C.A., Santa Fe, NM; Harris Mining Co., Spruce Pine, NC; and Kings Mountain Mica, Kings Mountain, NC.

Production of low-quality sericite, primarily for use in brick manufacturing, was 39,000 tons valued at $122,000; from this was produced approximately 41,500 tons of ground sericite valued at $263,200. 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
1979	134	7,708
1980	116	6,262
1981	133	8,212
1982	106	[r]6,398
1983:		
North Carolina	69	4,266
Other States[2]	71	2,213
Total	140	6,479

[r]Revised.

[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, and South Dakota.

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
1979	108	10,840	14	4,329	122	15,169
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

[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 73,600 pounds, a decrease of 14% from that of 1982. Of the total muscovite block fabricated, 78% went into electronic uses; of this, about three-fourths was used in vacuum tubes. Of the muscovite block fabricated for nonelectronic uses, 16% went into gauge glass and diaphragms. Most of the decrease in consumption was in Stained quality, although it remained in greatest demand, accounting for 74% of consumption. Consumption of grade No. 6 increased by 76% while consumption of other grades 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 83% of the total.

Phlogopite block fabrication totaled 9,800 pounds, an increase of 4% from that of 1982. The block was consumed by four companies in four States.

Consumption of mica splittings decreased 20% to 2.1 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 decreased 25% from that of 1982. Molding plate and segment plate continued to be the major end products, accounting for 29% and 27% of the total, respectively.

Reconstituted Mica (Mica Paper).—Five companies consumed 5.0 million pounds of scrap mica to produce 3.6 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, in order of output, were General Electric Co., Schenectady, NY; Proctor-Silex Div., SCM Corp., Mount Airy, NC; Kirkwood-Acim Corp., Hempstead, NY; U.S. Samica Corp., Rutland, VT; and Corona Film Inc., West Townsend, MA.

Ground Mica.—The major end uses continued to be joint cement, 47%, and paint, 14%. Other end uses included oil well drilling mud, roofing, and rubber.

Table 5.—Fabrication of muscovite ruby and nonruby block and film mica and phlogopite block mica in the United States in 1983, 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
Muscovite:								
Block:								
Good Stained or better	600	200	100	900	2,100	1,000	3,100	4,000
Stained	--	40,800	10,800	51,600	400	2,200	2,600	54,200
Lower than Stained[2]	--	2,700	2,200	5,000	100	10,400	10,400	15,400
Total[1]	600	43,700	13,100	57,500	2,500	13,600	16,100	73,600
Film:								
1st-quality	1,400	--	--	1,400	--	--	--	1,400
2d-quality	1,700	--	--	1,700	--	--	--	1,700
Total	3,100	--	--	3,100	--	--	--	3,100
Block and film:								
Good Stained or better[3]	3,700	200	100	4,000	2,100	1,000	3,100	7,100
Stained[4]	--	40,800	10,800	51,600	400	2,200	2,600	54,200
Lower than Stained	--	2,700	2,200	5,000	100	10,400	10,400	15,400
Total[1]	3,700	43,700	13,100	60,600	2,500	13,600	16,100	76,700
Phlogopite: Block (all qualities)	--	--	200	200	--	9,600	9,600	9,800

[1]Data may not add to totals shown because of independent rounding.
[2]Includes punch mica.
[3]Includes 1st- and 2d-quality film.
[4]Includes other-quality film.

Table 6.—Fabrication of muscovite ruby and nonruby block and film mica in the United States in 1983, 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	3,400	200	100	200	--	3,900
Stained	5,800	18,900	18,500	7,100	2,600	52,800
Lower than Stained	4,400	500	800	1,400	6,800	13,900
Total[2]	13,600	19,600	19,300	8,800	9,400	70,600
Nonruby:						
Good Stained or better	100	--	--	--	--	100
Stained	800	--	400	300	--	1,400
Lower than Stained	1,000	--	--	400	--	1,500
Total	1,900	--	400	700	--	3,000
Total block (ruby and nonruby)[2]	15,400	19,600	19,700	9,500	9,400	73,600
Film:						
Ruby:						
1st-quality	--	400	300	200	--	900
2d-quality	--	500	400	300	--	1,300
Total[2]	--	900	700	600	--	2,200
Nonruby:						
1st-quality	--	--	200	300	--	500
2d-quality	--	--	400	--	--	400
Total	--	--	600	300	--	900
Total film (ruby and nonruby)[2]	--	900	1,200	900	--	3,100

[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.

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:						
1979	4,714	2,745	163	503	4,877	3,248
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
Stocks on Dec. 31:						
1979	2,331	NA	110	NA	2,441	NA
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

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	1982		1983	
	Quantity	Value	Quantity	Value
Molding plate	1,018	3,119	634	1,803
Segment plate	947	3,115	593	1,960
Heater plate	72	201	101	370
Flexible (cold)	222	1,033	192	842
Tape	387	2,211	289	2,065
Other	241	1,239	356	1,935
Total[2]	2,886	10,919	2,164	8,975

[1]Consists of alternate layers of binder and irregularly arranged and partly overlapped splittings.
[2]Data may not add to totals 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	1982		1983	
	Quantity	Value	Quantity	Value
Roofing	W	W	W	W
Well-drilling mud	W	W	13	1,364
Paint	15	2,852	18	2,897
Joint cement	49	6,947	61	8,955
Other[1]	32	6,306	39	5,486
Total[2]	96	16,106	130	18,702

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 may not add to totals shown because of independent rounding.

STOCKS

Reported yearend consumer stocks of sheet mica were 1.6 million pounds; of this, mica splittings represented 84% and mica block represented 16%.

PRICES

Average reported values of consumed muscovite sheet mica decreased as follows: block, 16% to $13.06 per pound; film, 3% to $5.18 per pound; and splittings, 13% to $0.60 per pound. The average value of phlogopite block decreased 24% to $3.29 per pound while the value of phlogopite splittings decreased 17% to $3.35 per pound.

The average value of crude scrap (flake) mica, including high-quality sericite, was $46.31 per ton. The average value per ton for North Carolina scrap (flake) mica, predominantly a flotation product, was $61.96.

Table 10.—Average reported price for dry- and wet-ground mica sold or used by U.S. producers in 1983

(Dollars per short ton)

Kind	Price
Wet-ground	397
Dry-ground	118
End uses:	
Roofing	W
Well-drilling mud	109
Paint	164
Joint cement	146
Other[1]	142

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 remained a net exporter of ground mica, exporting 16.4 million pounds valued at \$2.1 million, while importing 10.3 million pounds valued at \$1.9 million. Ground mica was exported to 41 countries. The leading countries of destination were Canada, 29%, Mexico and Spain, 13% each, and France, 11%. Canada supplied more than 99% of ground mica imports.

Imports of unmanufactured block, film, and splittings decreased by 40% to 1.9 million pounds. India remained the primary source, accounting for 70% of the imports.

The total value of exported cut, stamped, and built-up mica was \$4.0 million, a decrease of 27%. Canada continued to be the leading country of destination, accounting for 38% of the total. The United Kingdom received 10%, Mexico and Spain received 7% each, and the remainder went to 43 countries. The total value of imports of these materials decreased by 12% to \$2.6 million. Of this, 51% by volume came from Belgium, 23% from India, and 18% from Japan.

The combined value of all mica exports was \$6.8 million, a decrease of 22%. The total imported mica value was \$5.8 million, a 12% decrease.

Table 11.—U.S. exports of mica and manufactures of mica in 1983, 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
Australia	58	9	--	--	--	--	129
Brazil	--	--	12	2	--	--	239
Canada	4,780	492	938	127	--	--	1,506
France	1,732	249	--	--	--	--	--
Germany, Federal Republic of	568	73	--	--	--	--	56
India	--	--	4	1	--	--	229
Indonesia	152	15	--	--	36	28	--
Italy	410	49	168	21	--	--	262
Jamaica	8	3	--	--	8	3	--
Japan	1,052	166	922	131	10	39	134
Korea, Republic of	324	98	68	10	--	--	74
Kuwait	700	147	42	7	--	--	3
Mexico	2,208	229	26	4	--	--	283

See footnotes at end of table.

Table 11.—U.S. exports of mica and manufactures of mica in 1983, by country —Continued

(Thousand pounds and thousand dollars)

Country	Scrap and flake mica: Ground or pulverized: Quantity	Scrap and flake mica: Ground or pulverized: Value	Scrap and flake mica: Waste and scrap[1]: Quantity	Scrap and flake mica: Waste and scrap[1]: Value	Sheet mica: Unmanufactured block, film, and splittings: Quantity	Sheet mica: Unmanufactured block, film, and splittings: Value	Sheet mica: Manufactured, cut or stamped, built-up: Value
Netherlands	630	125	80	10	--	--	9
Spain	2,112	213	190	27	--	--	286
United Kingdom	254	28	718	102	6	35	393
Venezuela	684	80	366	42	10	4	3
Other[2]	758	138	452	64	--	--	397
Total[3]	16,430	2,112	3,986	545	70	109	4,001

[1]Some shipments of ground mica are included in this category.
[2]Includes Algeria, Argentina, Austria, The Bahamas, Bahrain, Belgium, Bermuda, the Cayman Islands, Chile, China, Colombia, Costa Rica, Ecuador, Egypt, El Salvador, the French Pacific Islands, Hong Kong, Hungary, Ireland, Israel, the Leeward and Windward Islands, Malaysia, Morocco, New Zealand, Nigeria, Pakistan, Panama, Peru, the Philippines, Saudi Arabia, Singapore, the Republic of South Africa, Sweden, Switzerland, Taiwan, Trinidad and Tobago, the Turks and Caicos Islands, the United Arab Emirates, and Uruguay.
[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: Quantity	Waste and scrap: Value	Ground or pulverized: Quantity	Ground or pulverized: Value
1981	r8,075	r915	13,369	r1,390
1982	r5,030	r427	r10,824	1,724
1983:				
Brazil	1,102	53	--	--
Canada	89	5	10,288	1,863
India	2,555	252	--	--
Italy	40	6	--	--
Japan	--	--	13	9
Switzerland	--	--	1	1
Total[1]	3,787	316	10,304	1,873

rRevised.
[1]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: Quantity	Block: Value	Splittings: Quantity	Splittings: Value	Not cut or stamped, not over 0.006 inch in thickness[1]: Quantity	Not cut or stamped, not over 0.006 inch in thickness[1]: Value
1981r	40	308	3,439	1,531	5	15
1982r	89	244	3,084	1,181	(2)	24
1983:						
Brazil	11	44	9	2	--	--
Canada	9	20	148	94	--	--
France	3	12	134	72	--	--
India	21	85	1,199	392	116	79
Italy	--	--	--	--	124	93
Japan	--	--	1	(2)	38	37
Morocco	--	--	86	35	--	--
Other	1	7	2	13	--	--
Total[3]	44	169	1,577	608	278	209

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

Table 14.—U.S. imports for consumption of manufactured sheet mica, by country

(Thousand pounds and thousand dollars)

	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
1981	75	[r]981	[r]177	[r]1,044	395	917	41	[r]435
1982	67	730	157	798	468	1,042	32	366
1983:								
Belgium	1	4	--	--	377	665	(1)	(1)
Hong Kong	--	--	--	--	--	--	2	3
India	46	599	91	338	29	88	3	73
Japan	(1)	3	92	354	33	135	10	47
Netherlands	--	--	--	--	17	30	4	28
Taiwan	(1)	8	(1)	1	--	--	4	16
United Kingdom	(1)	10	1	9	--	--	13	80
Other	(1)	9	3	30	4	8	5	44
Total[2]	48	633	186	731	460	927	41	292

[r]Revised.
[1]Less than 1/2 unit.
[2]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)

	EXPORTS							
	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	Quantity	Value
1979	11,692	[r]1,378	11,644	1,669	10	4	NA	[r]5,225
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	[r]7,001
1982	16,746	[r]2,144	5,254	742	294	296	NA	5,499
1983	16,430	2,112	3,986	545	70	109	NA	4,001
	IMPORTS FOR CONSUMPTION							
	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	Quantity	Value
1979	[r]9,063	[r]742	5,840	484	4,925	2,671	776	2,929
1980	11,345	1,065	6,936	663	5,013	2,648	831	3,487
1981	13,369	[r]1,390	8,075	915	3,484	1,854	[r]688	[r]3,377
1982	[r]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

[r]Revised. NA Not available.
[1]Some shipments of ground mica are included in this category.

WORLD REVIEW

World production of all forms of mica increased 13% to 535 million pounds, primarily because of increased U.S. production of scrap and flake mica. India continued to lead the world in production of sheet mica. The United States remained the leader in production of scrap (flake) mica.

In total mica production, the United States and the U.S.S.R. remained first and second, respectively. India's mica production fell 12%, moving India from third to fourth, behind the Republic of Korea. China increased its production and continued to increase its exports of scrap mica and might have equaled or surpassed India in total mica production.[3] Reliable figures for China are not available.

India.—The Government's Mica Trading Corp. (MITCO) continued with its plans to develop new plants for ground mica and fabricated mica products. A new plant, capable of producing 3,000 tons per year of micronized mica, began trial production early in the year. MITCO and a Japanese firm collaborated on a plant for manufacturing mica paper. The Japanese firm agreed to purchase one-half of the production from the 900-ton-per-year plant. Efforts were also underway to establish a wet-ground mica plant.[4]

The U.S.S.R. continued to be India's largest customer. MITCO also signed agreements to supply mica to Czechoslovakia, the German Democratic Republic, and Poland.[5] Exports to countries with centrally planned economies accounted for 70% of the value of India's mica exports.[6]

Sri Lanka.—The State Mining and Mineral Development Corp. was examining the Balulla and Haputale districts in hope of locating good-quality sheet mica. Low-quality scrap mica had been produced in these districts for many years, and sheet mica was believed to be available at depth.[7]

U.S.S.R.—The Ust-Kamenogoesk titanium and magnesium combine tested a synthetic mica and found that it possessed resistance to heat and chemical attack. The combine planned to double production to meet demand for the material.[8]

[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]Industrial Minerals (London). No. 189, June 1983, p. 27.
[4]Mining Magazine (London). V. 149, No. 5, Nov. 1983, p. 301.
[5]Industrial Minerals (London). No. 188, May 1983, p. 61.
[6]U.S. Embassy, New Delhi, India. Indian Non-Fuel Minerals Resources and Mineral Based Industries: Industrial Outlook-1983. State Dep. Airgram A-11, Mar. 5, 1984.
[7]Industrial Minerals (London). No. 193, Oct. 1983, p. 71.
[8]Page 91 of work cited in footnote 3.

Table 16.—Mica: World production, by country[1]

(Thousand pounds)

Country[2]	1979	1980	1981	1982[p]	1983[e]
Argentina:					
Sheet	794	481	97	53	70
Waste, scrap, etc	2,513	1,358	1,012	657	660
Brazil (exports)	8,982	10,620	4,297	9,920	4,400
Canada[e]	24,200	22,000	24,000	22,000	23,000
France[e]	15,400	15,400	15,000	14,300	13,200
India:					
Exports:					
Block	2,476	1,737	[e]2,200	[e]2,400	2,400
Film and disk	582	724	[e]220	[e]440	400
Splittings	9,160	3,606	[e]7,900	[e]8,800	7,000
Scrap	17,177	15,603	[e]31,000	[e]17,600	15,500
Powder	9,685	30,876	[e]15,400	[e]11,000	9,000
Manufactured	860	3,861	[e]660	[e]660	1,100
Domestic consumption, all forms[e]	6,600	6,600	6,600	6,600	6,600
Total	46,540	63,007	[e]63,980	[e]47,500	42,000
Korea, Republic of (all grades)	22,057	22,773	[e]22,000	44,875	44,100
Madagascar (phlogopite):					
Block	134	185	736	661	600
Sheet and splittings	2,438	3,631	--	--	--
Scrap	NA	NA	108	110	110
Mexico	536	[r]7,937	4,579	265	440
Mozambique (including scrap)[e]	[3]553	440	440	440	440
Peru	35	110	1,265	[e]1,200	1,200
South Africa, Republic of:					
Sheet	([4])	([4])	--	--	--
Scrap	3,792	5,573	5,280	3,871	5,700
Spain	11,395	10,650	7,769	7,557	7,500
Sri Lanka (scrap)	814	320	401	642	600

See footnotes at end of table.

Table 16.—Mica: World production, by country[1] —Continued

(Thousand pounds)

Country[2]	1979	1980	1981	1982[p]	1983[e]
Sudan	4,409	[e]3,300	4,409	2,205	2,200
Tanzania (sheet)	13	22	11	11	11
U.S.S.R. (all grades)[e]	101,000	101,000	104,000	106,000	108,000
United States:[5]					
Sheet[e]	1	NA	NA	NA	NA
Scrap and flake[6]	268,000	232,000	266,000	212,000	280,000
Yugoslavia	745	549	584	[e]600	600
Grand total	[r]514,351	[r]501,356	525,968	474,867	534,831

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available.
[1]Table includes data available through May 9, 1984.
[2]In addition to the countries listed, China, Namibia, Norway, Pakistan, Romania, Sweden, and Zimbabwe are known to produce mica, but available information is inadequate to make reliable estimates of output levels.
[3]Reported figure.
[4]Less than 1/2 unit.
[5]Ground mica production was deleted because it was production from, not in addition to, scrap and flake mica production.
[6]Excludes U.S. production of low-quality sericite.

Molybdenum

By John W. Blossom[1]

Domestic and foreign molybdenum markets were imbalanced in 1983. Worldwide mine production exceeded demand, while consumer stocks were kept at a minimum. U.S. mine output of molybdenum decreased 60% compared with that of 1982 and represented 25% of the world production. Reported end-use consumption of molybdenum in raw materials and apparent domestic demand declined compared with that of 1982. World demand for molybdenum fell, resulting in smaller quantities of molybdenum exported from the United States. Domestic producer stocks of molybdenum concentrate and products decreased by 53%, but confronted with large stock inventories, domestic producers' prices were weak during the year. World market prices were below those of most U.S. producer price listings for most of the year.

Domestic Data Coverage.—Domestic production data for molybdenum are developed by the Bureau of Mines by means of three separate, voluntary surveys. These surveys are the Molybdenum Ore and Concentrate, Molybdenum Concentrate and Molybdenum Products, and Molybdenum Concentrates. Out of the 55 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)

	1979	1980	1981	1982	1983
United States:					
Concentrate:					
Production	143,967	150,686	139,900	r84,381	33,951
Shipments	143,504	149,311	118,916	r76,135	49,163
Value	1$871,068	$1,344,181	$945,540	r$504,089	$167,164
Consumption	103,152	108,206	80,725	49,444	27,014
Imports for consumption	2,329	1,825	1,988	3,115	1,121
Stocks, Dec. 31: Mine and plant	9,520	18,101	35,043	r38,510	11,637
Primary products:					
Production	101,753	106,284	105,824	65,381	37,533
Shipments	109,419	95,391	64,368	47,884	49,587
Consumption	60,388	53,265	50,189	27,665	27,225
Stocks, Dec. 31: Producers	8,502	27,007	44,961	r49,402	28,323
World: Mine production	229,350	r241,734	241,125	p207,344	e137,861

eEstimated. pPreliminary. rRevised.

1For 1979, value is based on the average domestic price of molybdenum in technical-grade molybdic oxide ($6.07 per pound) sold by the major domestic producer.

DOMESTIC PRODUCTION

Domestic mine production of molybdenum decreased for the third consecutive year to a total of 34 million pounds of contained molybdenum. The country's three largest producers in 1983 were The Anaconda Minerals Company, Duval Corp., and Kennecott Minerals Co., which together produced 77% of the year's total production.

Molybdenum produced in association with domestic copper mining accounted for over 89% of total U.S. output compared with 38% in 1982. Anaconda, Duval, and

Kennecott are the leading producers of molybdenum from copper-mining operations. Other domestic mining companies that recovered molybdenum from copper ore were Anamax Mining Co., ASARCO Incorporated, Cyprus Mines Corp., Inspiration Consolidated Copper Co., Magma Copper Co., and Phelps Dodge Corp.

Domestic producers attempted to correct oversupply conditions by reducing production, and canceling or extending new project development.

The Anaconda mine at Tonopah, NV, Molycorp Inc. mine at Questa, NM, and Amoco Minerals Co.'s Thompson Creek Mine, Challis, ID, started operating during the fourth quarter of the year. AMAX Inc. kept its two mines in Colorado closed.

Despite the worldwide surplus of molybdenum stocks in 1983, U.S. Borax & Chemical Corp. continued 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)

	1982	1983	1982	1983	1982	1983
	Molybdic oxides[1]		Metal powder		Ammonium molybdate	
Received from other producers	4,912	13,818	324	263	852	1,089
Gross production during year	52,176	27,705	3,842	4,587	2,195	2,731
Used to make other products listed here	16,822	16,558	539	921	1,282	1,676
Net production	35,354	11,148	3,304	3,667	913	1,055
Shipments	37,143	37,667	3,693	3,874	1,696	2,058
Producer stocks, Dec. 31	r41,855	22,981	443	503	1,072	1,038
	Sodium molybdate		Other[2]		Total	
Received from other producers	14	49	76	1,511	6,178	16,730
Gross production during year	121	191	7,047	2,319	65,381	37,533
Used to make other products listed here	(3)	---	15	91	18,658	19,246
Net production	121	191	7,035	2,227	46,727	18,288
Shipments	115	204	5,237	5,784	47,884	49,587
Producer stocks, Dec. 31	48	79	5,984	3,722	r49,402	28,323

rRevised.

[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]Less than 1/2 unit.

CONSUMPTION AND USES

The quantity of molybdenum in concentrate roasted domestically to produce technical-grade molybdic oxide decreased to 27 million pounds, about 45% below that of 1982. The remainder of the mine production of concentrate, containing about 7 million pounds of molybdenum, was either exported for conversion, or purified to lubrication-grade molybdenum disulfide. 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 demand (calculated from mine production, imports minus exports, and change in industry stocks) decreased by about 71% from that of 1982 to 16.7 million pounds of molybdenum. The decline in apparent demand was the fourth since 1979 and reflected the depressed economic conditions existing in 1983. Likewise, total reported end-use consumption of molybdenum in raw materials decreased about 1.6% from that of 1982. Molybdenum consumed in oxide form (technical-grade, purified, and briquets) accounted for about 64% of total reported consumption; in ferromolybdenum and calcium molybdate, 13%; and in other forms, 23%.

Molybdenum reported as consumed in the production of steel accounted for 60% of total consumption in 1983. Approximately 27% 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 a decline in molybdenum consumption when compared with those of 1982.

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
1982					
Steel:					
Carbon	766	125	--	12	903
Stainless and heat resisting	2,729	456	--	133	3,318
Full alloy	9,571	1,105	--	33	10,709
High-strength, low-alloy	678	344	--	2	1,024
Tool	736	209	--	5	950
Cast irons	368	1,032	--	6	1,406
Superalloys	595	152	--	857	1,604
Alloys (excludes steels and superalloys):					
Welding and alloy hard-facing rods and materials	--	185	--	12	197
Other alloys[3]	243	93	--	95	431
Mill products made from metal powder	--	--	--	2,980	2,980
Chemicals and ceramics:					
Pigments	W	--	327	--	327
Catalysts	1,735	--	W	98	1,833
Other	3	--	--	892	895
Miscellaneous and unspecified	366	48	571	103	1,088
Total	17,790	3,749	898	5,228	27,665
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

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 producers and consumers, decreased by almost 53% to 43.6 million pounds of contained molybdenum. Inventories of molybdenum in concentrate at mine locations registered a decline from 38.5 to 11.6 million pounds. Producers' stocks of molybdenum in consumer products, such as oxide, ferromolybdenum, molybdate, metal powders, and other types, decreased from 49.4 million pounds at the beginning of the year to 28.3 million pounds by yearend. Compared with monthly molybdenum shipments, yearend producers' stocks of these materials totaled almost a 5-month supply. Domestic consumers held inventories of about 4 million pounds throughout most of the year, representing approximately a 2-month supply when compared with average monthly reported consumption.

Table 4.—Industry stocks of molybdenum materials, December 31

(Thousand pounds of contained molybdenum)

Material	1979	1980	1981	1982	1983
Concentrate: Mine and plant	9,520	18,101	35,043	r38,510	11,637
Producers:					
Molybdic oxides[1]	6,172	22,825	38,999	r41,855	22,981
Metal powder	270	560	507	443	503
Ammonium molybdate	381	944	1,075	1,072	1,038
Sodium molybdate	58	48	27	48	79
Other[2]	1,621	2,630	4,353	5,984	3,722
Total	8,502	27,007	44,961	r49,402	28,323
Consumers:					
Molybdic oxides[1]	5,102	3,816	3,217	2,103	1,467
Ferromolybdenum[3]	1,872	1,507	914	616	570
Ammonium and sodium molybdate	325	280	167	76	70
Other[4]	1,761	1,813	1,467	1,386	1,567
Total	9,060	7,416	5,765	4,181	3,674
Grand total	27,082	52,524	85,769	r92,093	43,634

rRevised.
[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 molybdenum and its products (per pound of contained molybdenum) rose from a low in January of $2.35 for oxide to a high in July of $4.20 for oxide. During the second half of the year the price moved slowly down, closing out the year at $3.75 for oxide. The average price of dealer oxide was $3.65 or $0.45 less than the average price in 1982.

Table 5.—Domestic price listings for molybdenum, in 1982

(Per pound)

	Price
Producer quotes:	
Concentrate	[1]$7.90
Oxide	[1]8.50
Oxide-export	[1]8.75
Ferromolybdenum	[1]9.40
Ferromolybdenum-export	[1]9.90
Dealer quotes:	
Oxide[2]	4.10

[1]Standard Climax listing suspended Dec. 16, 1982.
[2]Dealer quote for oxide is $3.65 for 1983.

FOREIGN TRADE

Exports.—Exports of molybdenum in concentrate and oxide dropped to 47.1 million pounds, 5.5% below that of 1982. Molybdenum concentrate exports were about 136% of domestic mine production. Approximately 87% of reported concentrate and oxides was shipped to Belgium-Luxembourg, the Federal Republic of Germany, Japan, the Netherlands, and the United Kingdom. Exports of other molybdenum materials were almost negligible and varied slightly from those of 1982. The calculated molybdenum content of all exports increased from 51.3 million pounds in 1982 to 57.6 million pounds in 1983. Because of lower unit price, the total value of exports fell from $294 million in 1982 to $224 million in 1983.

Imports.—Approximately 8.2 million pounds of molybdenum in various forms was imported into the United States, a decrease of 14.3% compared with that of 1982. This quantity represented 7.5% of supply and 49% of apparent demand for 1983. Total value of all forms of molybdenum imported decreased 30% from $50 million in 1982 to $35 million in 1983. In terms of both value and quantity, the major forms imported were as concentrate, miscellaneous materials in chief value molybdenum, and ammonium molybdate. The principal originating countries for these imports were Canada, Chile, China, and Peru. China was a notable supplier of ammonium molybdate.

Table 6.—Molybdenum reported by producers as shipments for export from the United States

(Thousand pounds of contained molybdenum)

	1982	1983
Molybdenite concentrate	21,870	9,341
Molybdic oxide	22,938	18,847
All other primary products	437	839

Table 7.—U.S. exports of molybdenum ore and concentrates (including roasted concentrates), by country

(Thousand pounds of contained molybdenum and thousand dollars)

Country	1981		1982		1983	
	Quantity	Value	Quantity	Value	Quantity	Value
Austria	2,723	21,793	1,523	8,485	2,179	8,105
Belgium-Luxembourg	2,518	24,069	2,458	14,312	4,354	20,171
Brazil	115	1,052	30	167	55	246
Canada	369	2,204	1,482	4,236	475	1,377
Chile	2,315	7,691	3,197	6,062	1,394	1,988
France	408	3,381	304	413	274	593
Germany, Federal Republic of	5,080	30,374	7,502	22,712	6,148	20,918
Japan	7,958	73,567	5,411	37,394	4,531	17,706
Mexico	863	5,969	68	330	13	52
Netherlands	22,027	189,116	20,688	115,358	20,700	95,598
Sweden	1,840	13,556	1,928	5,099	1,475	3,032
Switzerland	81	395	40	135	--	--
U.S.S.R	1,080	9,547	--	--	--	--
United Kingdom	3,501	20,047	4,740	15,191	5,208	14,336
Other	472	4,055	412	2,320	262	1,000
Total	51,350	406,816	49,783	232,214	47,068	185,122

Table 8.—U.S. exports of molybdenum products, by country

(Thousand pounds, gross weight, and thousand dollars)

Product and country	1982		1983	
	Quantity	Value	Quantity	Value
Ferromolybdenum:[1]				
Australia	67	376	--	--
Canada	8	36	18	65
Japan	129	400	5	20
Malaysia	--	--	4	6
Mexico	34	133	--	--
Philippines	2	11	20	72
South Africa, Republic of	--	--	9	30
Other	15	79	116	494
Total[2]	255	1,035	171	687
Metal and alloys in crude form and scrap:				
Belgium	254	109	141	132
Canada	23	168	39	288
France	--	--	1	12
Germany, Federal Republic of	198	434	42	75
India	4	34	3	21
Japan	116	740	105	430
Mexico	53	595	--	--
Netherlands	5	40	36	66
Spain	27	79	--	--
Sweden	2	26	--	--
United Kingdom	([3])	9	112	592

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	1982 Quantity	1982 Value	1983 Quantity	1983 Value
Metal and alloys in crude form and scrap —Continued				
Other	15	83	98	242
Total[2]	697	2,317	577	1,860
Wire:				
Argentina	(3)	12	2	53
Australia	(3)	14	--	--
Austria	(3)	9	--	--
Bahamas	128	186	141	212
Belgium-Luxembourg	1	28	4	69
Brazil	17	444	5	99
Canada	28	468	16	225
France	12	232	8	136
Germany, Federal Republic of	130	2,188	49	708
India	3	92	8	103
Italy	54	1,033	48	929
Japan	131	1,720	116	1,792
Mexico	12	289	7	204
Netherlands	27	930	33	902
Singapore	(3)	2	--	--
South Africa, Republic of	4	71	1	8
Spain	22	347	27	350
Sweden	10	206	6	82
United Kingdom	5	55	7	87
Other	48	746	132	1,126
Total	632	9,072	610	7,085
Powder:				
Australia	1	4	1	3
Belgium-Luxembourg	224	295	(3)	2
Canada	8	72	3	26
France	9	148	68	305
Germany, Federal Republic of	49	225	1	15
Italy	1	30	2	44
Japan	8	64	13	50
Mexico	29	190	7	31
Netherlands	3	18	33	162
Sweden	--	--	9	71
Taiwan	83	1,225	121	1,502
United Kingdom	5	26	59	242
Other	6	59	80	284
Total[2]	426	2,356	396	2,737
Semifabricated forms, n.e.c.:				
Australia	(3)	19	(3)	5
Belgium-Luxembourg	(3)	17	39	380
Brazil	22	698	10	339
Canada	33	800	25	546
France	6	237	14	500
Germany, Federal Republic of	31	647	13	224
Japan	24	613	4	143
Mexico	5	120	1	11
Netherlands	4	47	24	618
Philippines	(3)	6	1	59
Singapore	(3)	6	2	63
South Africa, Republic of	18	439	2	59
United Kingdom	40	914	76	1,483
Other	7	199	6	159
Total[2]	190	4,762	216	4,589
Molybdenum compounds:				
Argentina	2	18	2	14
Australia	87	378	117	418
Belgium-Luxembourg	244	447	(3)	1
Brazil	85	255	27	84
Canada	1,088	5,338	223	832
Germany, Federal Republic of	635	1,311	880	1,464
Japan	5,333	20,469	6,310	17,118
Mexico	281	447	8	37
Netherlands	2,178	5,303	90	181
Sweden	160	260	32	55
Taiwan	22	121	(3)	2
United Kingdom	2,025	6,134	379	943
Other	301	1,325	529	1,009
Total	12,441	41,806	8,597	22,158

[1]Ferromolybdenum contains about 60% to 65% molybdenum.
[2]Data may not add to totals shown because of independent rounding.
[3]Less than 1/2 unit.

Table 9.—U.S. imports for consumption of molybdenum materials

(Thousand pounds and thousand dollars)

TSUS No.	Material	1982			1983		
		Gross weight	Contained molybdenum	Value	Gross weight	Contained molybdenum	Value
601.33	Ore and concentrate	6,332	3,115	13,429	2,986	1,673	3,528
603.40	Material in chief value molybdenum	4,577	2,749	12,143	5,711	3,445	12,985
606.31	Ferromolybdenum	1,665	1,218	6,308	1,157	799	3,189
628.70	Waste and scrap	NA	258	1,474	NA	406	2,141
628.72	Unwrought	NA	67	1,370	NA	97	1,398
628.74	Wrought	79	NA	1,959	94	NA	2,331
417.28	Ammonium molybdate	3,193	1,782	8,298	1,718	1,037	3,966
419.60	Molybdenum compounds	507	293	1,833	2,407	677	3,048
421.10	Sodium molybdate	38	15	96	149	88	305
423.88	Mixtures of inorganic compounds, chief value molybdenum	164	121	1,643	41	18	265
473.18	Molybdenum orange	870	NA	1,160	1,476	NA	1,841
	Total	17,425	9,618	49,713	15,739	8,240	34,997

NA Not available.

Table 10.—U.S. import duties on molybdenum materials

TSUS No.	Material	Most favored nation (MFN)		Non-MFN
		Jan. 1, 1984	Jan. 1, 1987	Jan. 1, 1984
601.33	Ore and concentrate	10.1 cents per pound	9 cents per pound	35 cents per pound.
603.40	Material in chief value molybdenum.	7.5 cents per pound plus 2.3% ad valorem.	6 cents per pound plus 1.9% ad valorem.	50 cents per pound plus 15% ad valorem.
606.31	Ferromolybdenum	5.6% ad valorem	4.5% ad valorem	31.5% ad valorem.
	Molybdenum:			
628.70	Waste and scrap	7.7% ad valorem	6% ad valorem	50% ad valorem.
628.72	Unwrought	7.6 cents per pound plus 2.3% ad valorem.	6.3 cents per pound plus 1.9% ad valorem.	50 cents per pound plus 15% ad valorem.
628.74	Wrought	8.8% ad valorem	6.6% ad valorem	60% ad valorem.
	Molybdenum chemicals:			
417.28	Ammonium molybdate	5.0% ad valorem	4.3% ad valorem	29% ad valorem.
418.26	Calcium molybdate	4.8% ad valorem	4.7% ad valorem	24.5% ad valorem.
419.60	Molybdenum compounds.	3.5% ad valorem	3.2% ad valorem	20.5% ad valorem.
420.22	Potassium molybdate	3.3% ad valorem	3% ad valorem	23% ad valorem.
421.10	Sodium molybdate	4.2% ad valorem	3.7% ad valorem	25.5% ad valorem.
423.88	Mixtures of inorganic compounds, chief value molybdenum.	3.1% ad valorem	2.8% ad valorem	18% ad valorem.
473.18	Molybdenum orange	4.2% ad valorem	3.7% ad valorem	25% ad valorem.

WORLD REVIEW

World mine production of molybdenum was 138 million pounds, a decrease of 34% from that produced in 1982. Over 83% of world production was supplied by Canada, Chile, the U.S.S.R. (production 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 continued to decline and production was reduced. Stocks decreased, but they exceeded more than 1 year's demand.

Canada.—Molybdenum production (shipments) in Canada decreased by about 25% in 1983 below that of 1982. Molybdenum output from Lornex Mining Corp. Ltd. increased by 16% during 1983 as a result of increased output, higher grade ore, and improvement in mill recovery. In February, Noranda Mines Ltd. closed its Boss Mountain Mine.

Brenda Mines Ltd., a subsidiary of Noranda, suspended operations in September. A sand flotation circuit and larger flotation cells that were installed in 1982 resulted in a 4% improvement in mill recovery. Placer Development Ltd.'s Endako Mine remained closed. However, the Endako roaster operation was continued on a partial operation throughout the year. Gibraltar Mines Ltd.

finished processing the last of its stockpiled low-grade ore in August. The source of mill feed was switched to the small west zone, supplemented with ore from the East Pit. AMAX of Canada Kitsault Mine remained closed.

Chile.—Molybdenum production in Chile decreased 25% in 1983 compared with that of 1982. The Corporación Nacional del Cobre de Chile was the sole producer of molybdenum from its four divisions: Chuquicamata, El Teniente, El Salvador, and Andina. The decreased production of molybdenum was due to a large drop in ore grade.

[1]Physical scientist, Division of Ferrous Metals.

Table 11.—Molybdenum: World mine production, by country[1]

(Thousand pounds of contained molybdenum)

Country[2]	1979	1980	1981	1982[p]	1983[e]
Bulgaria[e]	330	330	330	330	330
Canada (shipments)	24,634	26,211	31,160	30,779	23,100
Chile	29,895	30,133	33,863	44,198	33,100
China[e]	4,400	4,400	4,400	4,400	4,400
Japan	154	[r]123	163	214	210
Korea, Republic of	417	661	1,025	796	880
Mexico	105	163	992	11,442	11,700
Peru	2,637	5,926	5,485	6,378	5,800
Philippines	311	[r]201	207	126	90
U.S.S.R.[e]	22,500	22,900	23,600	24,300	24,300
United States	143,967	150,686	139,900	84,381	33,951
Total	229,350	[r]241,734	241,125	207,344	137,861

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

[1]Table includes data available through May 24, 1984.

[2]In addition to the countries listed, North Korea, Mongolia, Niger, 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.

Nickel

By Scott F. Sibley[1]

The nickel market rebounded in 1983 as general economic conditions improved. Reported domestic consumption increased about 23% compared with that of 1982, reversing a 3-year downward trend. Demand recovery was most pronounced in nickel consumption for stainless steel and corrosion-resistant alloy production, as well as electroplating. However, the recovery was not as dramatic in alloy steels, superalloys, and nickel-copper alloys. The market for nickel was tempered by continuing high interest rates, which effectively curtailed investment in the capital goods sector of the economy on which more than 40% of the nickel demand depends. This sector includes new chemical and petrochemical plant construction and expansion, which was expected to revive in late 1984. The surge in demand in 1983 was largely attributed to a recovery in durable goods demand, beginning early in the year. Producer inventories in the United States declined to 72 million pounds. Producers worldwide operated on average at about 50% of capacity and managed to pare their inventories considerably. Despite the more favorable demand situation, prices remained at relatively depressed levels.

Major consumption occurred in stainless and alloy steel, 44%; nonferrous alloys, 34%; and electroplating, 18%. Cathode nickel prices, listed by several major producers, remained at $3.20 per pound, but spot prices averaging $2.20 per pound prevailed.

Table 1.—Salient nickel statistics

(Short tons of contained nickel unless otherwise specified)

	1979	1980	1981	1982	1983
United States:					
Mine production[1]	15,065	14,653	12,099	3,203	--
Plant production:					
Domestic ores	11,691	11,225	10,305	3,456	W
Imported materials	32,500	33,000	38,500	41,500	33,400
Secondary[2]	13,201	11,338	11,696	8,557	NA
Exports (gross weight)	50,810	56,675	46,836	57,029	43,913
Imports for consumption	177,205	189,188	209,008	129,787	152,333
Consumption (primary)	196,293	156,299	144,851	103,981	127,845
Stocks, Dec. 31: Consumer	19,518	15,231	22,508	18,853	20,448
Price, cents per pound[3]	193-320	320-345	345-320	[r]150-260	178-235
World: Mine production	[r]756,467	[r]859,426	802,628	[p]705,136	[e]759,342

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available. W Withheld to avoid disclosing company proprietary data.

[1]Mine shipments.

[2]Nonferrous scrap only; does not include nickel from stainless or alloy steel scrap.

[3]Prices after 1981 are monthend New York dealer price ranges, based on Metals Week quotations.

Legislation and Government Programs.—The U.S. Department of the Treasury announced November 21 that effective December 21 all unfabricated nickel and nickel-bearing materials imported directly or indirectly from the U.S.S.R. would be detained by the U.S. Customs Service until such time as their release was authorized by the Office of Foreign Assets Control. The ban did not apply to Soviet nickel-bearing materials reexported to the United States from a third country, such as France or the

Federal Republic of Germany, where stainless steel or other alloys may be produced from Soviet nickel. This measure was taken to enforce the ban on importation of nickel from Cuba into the United States, based on information that almost one-half of the total nickel production of Cuba was exported to the U.S.S.R. Most of that material was concentrate for refining to electrolytic nickel. U.S. imports of Soviet nickel in 1983 comprised 3% of total U.S. imports. In addition, an agreement was reached with Japan, whereby Japan would certify that its exports of stainless steel to the United States contained no Cuban nickel. Similar certification agreements were being negotiated with other countries.

AMAX Nickel Inc. sold 750,000 pounds of nickel to the Bureau of the Mint during the week of September 19. The nickel was bought from AMAX Nickel at $2.37 per pound, considerably above the free market price of about $2.25 per pound. The purchase was made less that 3 weeks before bids were to be opened from companies seeking to supply the Mint with an additional 4 million pounds of nickel. Under regulations governing procurement, the Mint may bypass formal bidding processes in an emergency. In this case, the emergency was declared because of a shortfall in nickel supplies at Olin Corp., East Alton, IL, where nickel is alloyed with copper and rolled into strips for making coin blanks.

Both the inventory and goal for nickel in the National Defense Stockpile remained unchanged at 32,209 and 200,000 short tons, respectively.

An Exclusive Economic Zone (EEZ), which extended U.S. jurisdiction off the coast of the United States and its island territories to 200 nautical miles, was proclaimed by the President March 10, 1983. The action followed by several months the rejection by the United States of the International Law of the Sea Treaty, signed by 117 nations December 10, 1982, in Caracas, Venezuela. The declaration of an EEZ was potentially important with respect to minerals because of the discovery of nickel-bearing, mineral-rich crusts located within this zone.

Under the Clean Water Act of 1977, effluent limitations on 65 priority pollutants were required to be achieved by July 1, 1984, including nickel salts. On October 25, 1983, the Environmental Protection Agency (EPA) published proposed regulations concerning effluent limitations on nickel salts under the best practicable control technology.[2] Seventeen facilities were identified as nickel salt producers that were direct or indirect dischargers. For nickel sulfate, chloride, nitrate, and fluoborate, the proposed limitation was 0.0096 pound per 1,000 pounds of product. For nickel carbonate, the proposed limitation was 0.00074 pound per 1,000 pounds of product. There was not expected to be any problem of industry compliance with the new regulations. The EPA, in a separate action, released a draft of its health assessment on nickel. This was the first step in determining whether nickel should be regulated as a hazardous pollutant under the Clean Air Act. According to the draft, the general population has between 0.2 and 0.3 microgram of nickel per deciliter of blood, while nickel refinery workers show levels three or four times that amount. Urban dwellers inhale less than 1 microgram of nickel per day. The report notes that no data exist to show whether these low levels of exposure lead to increased cancer risks to the population at large.

DOMESTIC PRODUCTION

On November 4, the Hanna Mining Co., the Nation's only integrated nickel producer, announced the reopening of its mine and smelter in Riddle, OR. However, because of the time required for preparation of equipment (about 45 days), production of ferronickel had not yet resumed by yearend. New power and labor agreements were the principal factors that enabled the company to end an 18-month shutdown. Concerning power, on September 30, the Bonneville Power Administration approved Hanna's power proposal, which called for Hanna to operate at a reduced power rate during off-peak hours: 13 hours at night Monday through Friday, 15 hours on Saturday, and 24 hours on Sunday. The base rate was 7 mils (0.007 cent per kilowatt-hour). In addition, a 2-year labor agreement with the United Steelworkers of America Local 5074 brought approximately 280 employees back to work. Hanna officials stated that although the nickel market remained unfavorable, it was hoped that prices would improve and that significant cost reductions would be achieved. Mine production capacity is about 15,000 short tons of nickel in ore per year.

AMAX Nickel shut down its Braithwaite, LA, nickel refinery for 2 months for inventory adjustment. Production resumed August 29. Production for the year was 33,400 tons, 19% less than that of 1982.

California Nickel Corp. planned to build a $5 million demonstration plant near its Gasquet Mountain nickel laterite property in Del Norte County, northern California. The plant was to be completed by the end of 1984. About 30 people were to be employed at the plant, which was to process 75 tons of ore per day to produce 1,000 pounds of nickel and 100 pounds of cobalt per day.

Table 2.—Nickel recovered from nonferrous scrap processed in the United States, by kind of scrap and form of recovery

(Short tons)

	1982	1983
KIND OF SCRAP		
New scrap:		
Nickel-base	1,055	NA
Copper-base	1,929	NA
Aluminum-base	1,656	NA
Total	4,640	NA
Old scrap:		
Nickel-base	3,036	NA
Copper-base	395	NA
Aluminum-base	486	NA
Total	3,917	NA
Grand total	8,557	NA
FORM OF RECOVERY		
As metal	515	NA
In nickel-base alloys	1,470	NA
In copper-base alloys	2,714	NA
In aluminum-base alloys	2,441	NA
In ferrous and high-temperature alloys[1]	1,022	NA
In chemical compounds	395	NA
Total	8,557	NA

NA Not available.

[1]Includes only nonferrous scrap added to ferrous high-temperature alloys.

CONSUMPTION

Total demand, including secondary nickel, was estimated to be 204,379 tons, an increase of 13% over that of 1982. Apparent consumption of primary nickel of 153,379 tons was a marked improvement over that of 1982. Reported consumption of primary nickel was about 23% higher than that of 1982, reflecting general economic conditions. The most significant increases occurred in stainless steel and other nickel alloys.

The share of the primary nickel market held by unwrought nickel was about 76% in 1983, the same as that in 1982; ferronickel decreased its share from 15% in 1982 to 12% in 1983, while nickel oxide sinter increased from 4% to 8% of the market. The pure nickel forms (Class I) were utilized principally in electroplating and in the production of wrought and cast nickel products—including high-nickel, heat- and corrosion-resistant alloys—and copper-base alloys. Ferronickel and oxide sinter were used primarily in the production of stainless and alloy steels. The latter is often referred to as charge or Class II nickel. The pattern of nickel consumption by type of product remained similar to that of 1982, as follows: stainless and heat-resistant steels, 37%; electroplating, 18%; heat- and corrosion-resistant alloys, 20%; superalloys, 9%; alloy steels, 8%; and other, 8%. In 1983, wrought products accounted for 97% of total nickel consumed in stainless steel production, 87% of that consumed in alloy steel production, 82% of that consumed in superalloy production, and 92% of that consumed in nickel-copper and copper-nickel alloys production. The balance of nickel in each category was consumed in castings.

Table 3.—Nickel (exclusive of scrap) consumed in the United States, by form

(Short tons of contained nickel)

Form	1979	1980	1981	1982	1983
Metal	135,987	111,609	101,847	79,032	96,981
Ferronickel	39,977	29,919	26,290	15,426	15,595
Oxide powder and oxide sinter	14,189	8,492	9,412	4,196	9,670
Salts[1]	3,944	3,330	4,197	3,874	4,402
Other	2,196	2,949	3,105	1,453	1,197
Total	196,293	156,299	144,851	103,981	127,845

[1]Metallic nickel salts consumed by plating industry are estimated.

Table 4.—U.S. consumption of nickel (exclusive of scrap) in 1983, by use and form

(Short tons of contained nickel)

Use	Commercially pure unwrought nickel	Ferronickel	Nickel oxide	Nickel sulfate and other nickel salts	Other forms	Total
Steel:						
Stainless and heat-resisting	26,377	13,987	6,530	--	154	47,048
Alloys (excludes stainless)	6,781	589	2,147	227	44	9,788
Superalloys	11,030	330	--	49	87	11,496
Nickel-copper and copper-nickel alloys	5,695	--	314	38	222	6,269
Permanent magnet alloys	606	20	--	14	9	649
Other nickel and nickel alloys	24,061	570	168	7	125	24,931
Cast irons	553	98	193	5	239	1,088
Electroplating (sales to platers)[1]	18,630	--	--	3,883	103	22,616
Chemicals and chemical uses	1,443	--	171	172	168	1,954
Other[2]	1,805	1	147	7	46	2,006
Total reported by companies canvassed and estimated	96,981	15,595	9,670	4,402	1,197	127,845

[1]Based on monthly estimated sales to platers.
[2]Includes batteries, ceramics, and other alloys containing nickel.

Table 5.—Nickel (exclusive of scrap) in consumer stocks in the United States, by form

(Short tons of contained nickel)

Form	1981	1982	1983
Metal	18,355	16,743	17,359
Ferronickel	2,257	1,122	893
Oxide powder and oxide sinter	1,039	488	1,677
Salts	508	226	268
Other	349	274	251
Total	22,508	18,853	20,448

Table 6.—U.S. consumption, stocks, receipts, shipments, and/or sales of secondary nickel in 1983, by use

(Short tons of contained nickel)

Use	Receipts	Consumption	Shipments or sales	Stocks, end of year
Steel (stainless, heat-resisting, alloy)[1]	30,506	26,938	3,331	9,856
Nonferrous alloys (super, nickel-copper and copper-nickel, permanent magnet, other nickel)	6,482	6,420	1	439
Foundry (cast irons)	440	438	--	8
Chemicals (catalysts, ceramics, plating salts, other chemical uses)	1	--	--	1
Total reported by companies canvassed and estimated	37,429	33,796	3,332	10,304

[1]Purchased scrap only.

STOCKS

Consumer stocks at yearend increased by 8% compared with those at the end of 1982. Stocks held by producers or their agents in the United States decreased by 42% compared with those at yearend 1982. Estimated yearend stocks of nickel in the foundry industry were as follows, in tons: iron (156), steel (56), high-nickel alloy (191), copper-base alloy (61), and permanent magnet alloy (14). Stocks on the London Metal Exchange (LME) were about 31,000 tons at yearend 1983, composed of approximately one-half cathode and one-half briquets. The LME stock level at the end of 1982 was about 7,300 tons.

PRICES

The weighted average free market price for the year in the United States was $2.20 per pound of cathode nickel. Consumers bought nickel throughout the year at free market prices, which ranged from a low of $1.78 per pound for cathode nickel at the end of January to a high of $2.35 per pound at the end of May. The New York dealer price was about $2.22 per pound at yearend. Major producers were generally able to obtain a price several cents per pound over the free market price. The price for ferronickel or oxide sinter per pound of contained nickel was about 2.5% less than the cathode price, and the price of vacuum-grade nickel was about 3% higher than that of regular cathode or briquet. Producer list prices, which were no longer a factor in the market, remained at $3.20 per pound. The LME price was dominant in determining worldwide price. Although demand strengthened, stocks on the LME rose toward yearend and prices remained soft. This was partly due to an influx of cathode nickel from the U.S.S.R.

FOREIGN TRADE

The estimated contained nickel in U.S. exports of unwrought nickel, powders, flakes, and anodes in 1983 was 15% of total primary demand, compared with 27% in 1982.

Canada remained the principal supplier of nickel to the United States, accounting for 43% of total imports, 35% directly from Canada and 8% indirectly through Norway. The next most important sources were Australia (16%), Botswana (11%), and the Dominican Republic (5%). Other important sources were Finland, the Republic of South Africa, the U.S.S.R., and Zimbabwe. In the aggregate, these nine countries accounted for 87% of total imports for consumption. Total imports increased about 17% over those of 1982, 5% less than the increase in the demand for primary nickel.

Table 7.—U.S. exports of nickel and nickel alloy products, by class

Class	1981 Quantity (short tons)	1981 Value (thousands)	1982 Quantity (short tons)	1982 Value (thousands)	1983 Quantity (short tons)	1983 Value (thousands)
Unwrought	16,298	$116,494	33,772	$178,337	22,165	$99,097
Bars, rods, angles, shapes, sections	2,463	39,066	2,589	28,018	1,582	18,747
Plates, sheets, strip	8,057	81,648	2,218	29,460	1,430	18,351
Anodes	94	909	127	1,231	177	1,235
Wire	660	8,262	481	6,011	1,039	8,831
Powders and flakes	3,282	23,929	3,457	22,441	1,017	6,973
Catalysts	3,890	25,601	2,874	19,654	3,165	13,940
Tubes, pipes, blanks, and fittings thereof, hollow bars	1,333	16,164	488	9,807	348	7,447
Waste and scrap	10,759	21,595	11,023	20,136	12,990	17,106
Total	46,836	333,668	57,029	315,095	43,913	191,727

Table 8.—U.S. imports for consumption of nickel products, by class

Class	1981 Quantity (short tons)	1981 Value (thousands)	1982 Quantity (short tons)	1982 Value (thousands)	1983 Quantity (short tons)	1983 Value (thousands)
Ore	513	$42	--	--	--	--
Unwrought	123,141	747,920	82,297	$446,850	90,839	$418,943
Oxide and oxide sinter	4,330	21,779	3,144	13,461	4,209	19,083
Slurry[1]	94,786	223,060	58,568	105,633	62,454	83,613
Bars, plates, sheets, anodes	1,011	9,321	1,384	11,217	1,235	11,531
Rods and wire	2,198	18,317	2,362	19,217	2,241	17,935
Shapes, sections, angles	21	552	8	226	54	313
Pipes, tubes, fittings	634	8,707	1,366	19,688	575	54,774
Powder	13,909	91,944	11,953	71,825	12,629	65,320
Flakes	215	1,381	179	1,020	96	427
Waste and scrap	5,226	17,496	4,300	13,349	6,071	17,691
Ferronickel	69,853	119,321	21,352	28,215	45,134	65,264
Total (gross weight)	315,837	1,259,840	186,913	730,701	225,537	754,894
Nickel content[2]	209,008	XX	129,787	XX	152,333	XX

XX Not applicable.
[1]Nickel-containing material in slurry or any other form derived from ore by chemical, physical, or any other means, and requiring further processing to recover nickel or other metals; principally matte for further refining; also includes salts and compounds.
[2]Estimated from gross weight of primary nickel products.

Table 9.—U.S. imports for consumption of new nickel products, by country

(Short tons of contained nickel)

Country	Metal		Powder and flakes		Oxide and oxide sinter		Ferronickel		Slurry and other[e 1]	
	1982	1983	1982	1983	1982	1983	1982	1983	1982	1983
Australia	8,618	11,096	2,450	2,023	29	1,302	--	--	9,868	10,684
Botswana	--	121	--	--	--	--	--	--	14,072	16,354
Canada	42,440	42,435	6,956	7,753	1,908	1,922	--	--	727	1,060
Dominican Republic	--	--	--	--	--	--	--	8,014	--	--
Finland	3,318	3,367	--	--	--	--	--	--	154	158
France	730	563	--	--	77	--	--	--	--	25
Germany, Federal Republic of	1,272	2,972	116	82	--	--	1	--	28	247
Japan	95	143	--	--	--	--	2,041	899	18	55
Netherlands	79	176	--	182	--	--	--	322	3	50
New Caledonia	--	--	--	--	--	--	3,213	2,564	--	--
Norway	12,859	12,342	78	110	3	17	--	--	--	--
Philippines	2,616	1,217	1,415	1,880	--	--	--	--	--	--
South Africa, Republic of	4,217	4,382	698	558	--	--	6	6	2,636	--
Sweden	--	20	--	1	--	--	--	--	--	--
U.S.S.R	2,463	4,420	--	20	--	--	--	--	--	--
United Kingdom	608	2,635	400	96	--	--	--	--	2	46
Zimbabwe	2,981	4,831	--	--	--	--	--	--	--	--
Other	1	119	19	20	404	--	83	4,891	85	153
Total	82,297	90,839	12,132	12,725	2,421	3,241	5,344	16,696	27,593	28,832

[e]Estimated nickel content.
[1]Nickel-containing material in slurry or in any other form derived from ore by chemical, physical, or any other means and requiring further processing; principally matte for further refining; includes nickel in laterite ores for testing purposes; excludes bars, plates, sheets, and anodes.

WORLD REVIEW

Three European nickel producers lodged a complaint with the European Economic Community (EEC) alleging dumping of refined nickel by the U.S.S.R. in Europe. These producers were Société Minière et Métallurgique de Larymna S.A. (Larco) of Greece, Société Métallurgique le Nickel (SLN) of France, and Inco Europe Ltd. The complaint alleged that imports to the EEC of cut and uncut cathodes from the U.S.S.R. increased from 14,400 tons in 1981 to 20,955 tons in the first 9 months of 1982, representing an increase from 9% to 18.5% of the EEC market. The impact on the EEC industry was claimed to be a reduction of 34% in production, 16% in utilization of capacity, loss of sales and market share, the inability to make a profit, and a reduction of 1,440 in employment.

Antidumping duties as allowed under the regulations were requested by the companies, and an EEC commission determined that an investigation was warranted. Consequently, on June 17, 1983, a 7% duty on imports of unwrought nickel from the Soviet Union was imposed. In addition to initially confirming the European producers allegations, the EEC commission found that resale prices of these imports were 14% to 23% lower than those of the producers, and undercut import prices of other suppliers to the EEC by an average of 7%. The commission also stated that the Soviet Union was the largest single supplier to the EEC in 1981 and 1982 and was the price leader in both years. In July 1983, after imposition of the duty, an initial appeal by Raznoimport (the Soviet trade organization) to the European Court of Justice for an interim removal of the duty was dismissed. However, the appeal was significant in that it marked the first time that the Soviet Union had recognized the jurisdiction of the EEC over trade matters. Reversing its earlier decision on appeal, the Court officially lifted the 7% duty October 18, 4 months after it was put into effect. In addition, the 7% duty, which had been held in escrow, was refunded to the Soviet Union. The three nickel producers that originally filed the complaint did not rule out future petitions to the EEC if the market situation deteriorated further.

Australia.—The Agnew nickel mine, jointly owned by Seltrust Mining Corp. Pty. Ltd. (60%) and MIM Holdings Ltd. (40%), continued operations uninterrupted despite a 2-month shutdown of its customer, AMAX Nickel, in Braithwaite, LA. The company reported an increase in losses for the first half-year compared with that of the first half of 1982. This was attributed mainly to lower grade material at the site in addition to low prices. Agnew began commercial production in mid-1979, when Seltrust signed a 10-year contract to supply AMAX Nickel with up to 17,000 short tons per year of contained nickel in nickel matte, which was toll smelted at the Western Mining Corp. Holdings Ltd. (WMC) Kalgoorlie smelter.

Production was halved at the Greenvale laterite nickel-cobalt mine owned by Metals Exploration Ltd. and Freeport Queensland Ltd. Output was curtailed to an annual 12,000 tons of contained nickel because of continued weakness in the world nickel market. In addition, forward sales agreements with Japanese and European customers were concluded prior to the cutback. Part of Greenvale's production was refined to 90% nickel oxide at the Yabulu treatment plant near Townsville, Queensland, and part, in the form of a nickel-cobalt sulfide concentrate, was shipped to Japan for refining. The company considerably reduced its losses compared with those of 1982. However, the future of the operation could be in jeopardy if it is required to pay a new excise tax on fuel oil (1.872 cents per liter) announced in the Australian Federal budget. Although ore dryers and boilers at Greenvale were converted from oil to coal in 1982, the operation still relied on oil for about 50% of its energy requirements. Queensland State government officials claimed the tax would cost Greenvale about \$3.5 million annually at full production. The Queensland government is a guarantor of a major loan that has enabled the company to remain in operation.

Shell Co. of Australia Ltd., a subsidiary of Royal Dutch/Shell of the Netherlands, reportedly sold its 50% share in the Mount Windarra nickel operations to WMC. Windarra began production in 1974 and was closed from 1979 until 1982, when it was reopened by WMC. Shell was to receive \$500,000 per year for 10 years and a royalty related to nickel and gold produced for a period of up to 15 years. The purchase by WMC added between 3,800 and 4,400 tons to WMC's annual capacity, raising it to about 65,000 tons per year. The mine operated at only a fraction of its capacity in 1983. Concentrate from Windarra was shipped by rail to the Kalgoorlie smelter. Matte from Kalgoorlie was processed to briquets at the Kwinana refinery. WMC was the third largest producer of nickel in the Western World after Inco Ltd. and Falconbridge Ltd. of Canada.

The Nepean nickel mine of Metals Exploration Ltd. remained closed during the year, removing about 4,000 tons per year of nickel from the market. Ore from the mine had been processed at WMC's concentrator at Kambalda.

Botswana.—AMAX Nickel, a 29.8% owner of Botswana RST Ltd., announced early in the year that it had reached an agreement with Bamangwato Concessions Ltd. (BCL) to resume purchasing its entire production of matte, about 40,000 tons per year. Since February 1982, 25% of its production had been diverted to Rio Tinto (Zimbabwe) Ltd. (RTZ) and Falconbridge Nikkelverk AS in Norway. The major shareholders of Botswana RST Ltd. (Anglo American Corp. of South Africa Ltd. and AMAX Nickel) agreed to provide $18 million in emergency funding for the year. This was in addition to $12 million emergency funding provided in 1982. The mine is Botswana's largest private sector employer.

Brazil.—Nickel output of electrolytic nickel from Cia. Níquel Tocantins was raised from 230 tons per month to 460 tons per month (full capacity) at yearend. In 1984, the company plans to export about 230 tons per month to the United States and Europe. The second furnace of the Empresa de Desenvolvimento de Recursos Minerais S.A. Goias ferronickel plant went into operation in June 1983, after a delay caused by technical problems. The furnace was commissioned in August 1982.

Burundi.—Exploration continued on the Musongati deposit under the United Nations Development Program during 1983. A team from the Federal Republic of Germany drilled at the deposit site for samples to confirm the extent of resources of greater than 2% nickel. Average ore grade was determined to be 1.6% nickel, 0.1% cobalt, and 0.3% copper.

Canada.—In April, Inco resumed production of nickel at Sudbury in Ontario Province after a 9-month shutdown. Smelting and refining of stockpiled concentrates began April 4 on schedule, and underground mining and milling were restarted on April 18. The total work force recalled numbered about 11,000. Although Inco's Port Colborne refinery had resumed production February 7, the full work force did not return until April 4. However, Inco closed its Ontario division again in July for a 4-week period.

With the reopening, Inco's improved milling process, designed to reject more of the sulfur-bearing pyrrhotite, was brought onstream. The process was developed and installed at a cost of more than $1.4 million and ensured compliance with an Ontario government regulation that limited sulfur dioxide emissions to 1,950 tons per day. In addition, a number of measures were taken to improve productivity and to research more efficient mining methods, including accelerated conversion from undercut and fill to lower cost bulk mining and startup of the Copper Cliff North Mine as a commercial-scale mine research facility for new mining methods and equipment. (See "Technology" section.)

In August, Inco also resumed dredging operations at its Thompson, Manitoba, open pit mine. Total estimated cost of mine development was to exceed $87 million by 1986. The company budgeted $10 million for development in 1983. The first phase of development included dredging of about 26 million cubic yards of mud and clay, which would permit mining to a depth of 400 feet. By about the time of completion, Inco will have phased out its Pipe open pit mine and transferred its 70-person work force to the Thompson pit. At the Thompson underground mine, a limited number of experienced miners were hired late in the year to maintain necessary work force levels. The attrition rate was 10 employees per month throughout the 2,000-person work force.

Inco announced on November 16 that it would suspend operations at its Port Colborne, Ontario, refinery for 5 weeks beginning December 26. The facility, which employed about 800 workers, was closed temporarily to reduce inventories. Also, Inco planned to shut down its Ontario and Manitoba operations for 1 month during the summer of 1984. Falconbridge, the Western World's second largest nickel producer, resumed operations January 2, 1983, after a 6-month shutdown.

Workers at Falconbridge's Sudbury operations approved a 3-year labor pact on March 7. The accord provided for a $1.00 per hour cost-of-living allowance, raising the average hourly rate to $10.14,[3] and improved pension and health benefits. In addition, wages and benefits could be renegotiated beginning in April 1984. Plans by the company to develop new reserves were deferred. Total Falconbridge reserves at Sudbury were about 2.3 billion pounds of nickel in 1.5% nickel ore.

Sherritt Gordon Mines Ltd. produced at a capacity level of about 46 million pounds of nickel in 1983, a 15% increase over that of 1982. The increase was the result of an improved recovery system.

China.—The first stage of construction of the Jinchuan No. 2 Mine was completed. The mine is located near Jinchang in Gansu Province. Nickel reserves in Gansu constituted about 70% of total Chinese reserves. One open pit and one underground mine were already in operation. Construction was also begun on the second stage of the project. Electrolytic nickel production capacity was about 17,000 tons in 1983.

Colombia.—The Cerro Matoso S.A. ferronickel plant produced at about 70% of capacity. Full capacity production of 22,600 tons per year of nickel in ferronickel was not expected to be reached until the second half of 1984. Nickel content of the ferronickel was about 37.5%. Plans were made at midyear for the installation of a granulating plant by late 1984, enabling the company to produce a variety of sizes of ferronickel shot for the world market. In 1983, Gran-Tech Inc. of Auburn Heights, MI, was awarded a $1 million contract for the licensing, procurement of equipment, and engineering for the plant. Total cost was expected to exceed $1.6 million.

In mid-May, the company's Elkem-type electric furnace developed problems with its refractory materials. Although the plant used ores of high acidity (pH 0.3), officials stated that the erosion of furnace walls was caused by other factors. One furnace was shut down for about 2 months beginning in early December for repairs.

Cuba.—Construction continued on the Punta Gorda nickel oxide plant, which was expected to be completed by mid-1984, at a cost of more than $510 million, with Soviet financing and equipment. Development of the 33,000-ton-per-year facility reportedly was given priority over another new project with the same capacity at Las Camariocas. The Pedro Sotto Alba processing plant at Moa Bay was being expanded from an annual capacity of about 18,000 tons to about 26,000 tons, at a cost of about $100 million. Excluding Las Camariocas, total Cuban nickel production capacity could be raised to about 75,000 tons by yearend 1984.

Cuba strove to increase its sale of nickel oxide in Western Europe and Japan and was highly successful in Europe, despite the U.S. ban on imports of fabricated alloys containing Cuban nickel, particularly stainless steel. Cuba's success was partially attributed to the EEC import duty on Soviet nickel and a lack of nickel oxide from Greenvale in Australia. However, Japanese steelmakers were more reluctant to purchase from Cuba because of the U.S. embargo.

Dominican Republic.—Falconbridge Dominicana C. por A. operated at about 60% of capacity while using only one of three furnaces. This was made possible by using higher grade ore than usual and maximizing production on the single furnace. Ore reserves of the nickel laterite were about 46 million tons, with an average grade of 1.78% nickel.

The Dominican General Directorate of Mining launched a campaign early in the year to attract foreign investment to its mining industry. One goal was to obtain $50 million over a 2-year period for exploration and other preproduction work. The initiative follows the publication of a new mining policy in March.

Finland.—Outokumpu Oy investigated a mineralized black schist, near Sotkamo in eastern Finland. Average grade of the deposit was 0.26% nickel, 0.52% zinc, 0.14% copper, and 0.02% cobalt. Resources were estimated at 300 million tons of ore. Because conventional flotation methods would not achieve adequate concentration, the company began developing a new concentration technique based on leaching technology. A pilot plant was constructed in 1982, and testing of the technical and economic feasibility of the process was carried out in 1983. If results prove favorable, about 10 million tons of ore would be produced annually.

The Hitura Mine and concentrator of Outokumpu, which had provided about 20% of the company's domestic nickel feed, was put on care-and-maintenance status early in the year, to last for about 2 years. Replacement feedstock for Outokumpu's Harjavalta smelter was easily obtained. Capacity of the smelter had been recently expanded from about 15,000 to 18,000 tons of nickel per year.

France.—Under a plan announced in early May, SLN was to receive further Government support when the state-controlled company, Entreprise de Recherche et d'Activite Petrolières, took over 70% interest in SLN, which produced nickel in France and New Caledonia. The joint owners of the nickel company at that time, Société National Elf Aquitaine and Imetal S.A., were to reduce their 50% share to 15% each. SLN was to receive $211 million in aid from the companies that were to own it, including a 15-year loan at a reduced interest rate and 5-year deferred payment, in order to consolidate an estimated $341 million in SLN debts. Additional tax relief was granted.

Greece.—Larco, the Greek ferronickel producer, suspended sales in the European market from mid-September through November because of depressed prices. The company operated at about 50% of its annual capacity of 25,000 tons during much of the year.

India.—Inco Tech Inc., a consulting unit of Inco Ltd., proposed the establishment of a roasting facility with an annual feed capacity of 12,000 tons of matte on the east coast of India, possibly adjacent to the Vishakhapatnam smelter complex of Hindustan Zinc Ltd. In addition, a 12,000-ton-per-year sulfuric acid plant would be built. An electric arc furnace would be used to produce a 97% nickel pig from a portion of the oxide sinter produced from the roasting stage. Both products are used as charge material in the specialty steel industry. Oxide sinter capacity was given as 7,000 tons per year (nickel content). Feedstock for the refinery would be matte from the P.T. International Nickel Indonesia (P.T. Inco) Soroako Mine in Indonesia. The main impediment to development appeared to be Inco's request for exemption from India's 55% duty on imported nickel. Inco offered to pay for $23 million of equipment costs and participate in the equity up to 40%. The proposal was under consideration by the Planning Commission of India and the Ministry of Industry. Consumption of nickel in India in 1983 was estimated at 12,000 tons.

Indonesia.—In order to improve its financial position, P.T. Inco held discussions with its lenders concerning amendments to the financing arrangements for the Soroako nickel project. The company was 98% owned by Inco Ltd. of Canada, which proposed that 25% of P.T. Inco's outstanding debt be prepayed, with the remaining debt to be repaid as it matures. P.T. Inco had a debt in the neighborhood of $480 million. Inco reportedly would raise about $60 million of the required amount by drawing on its unused credit, which totaled about $400 million. Also, P.T. Inco was unsuccessful in selling a portion (up to 20%) of its equity in Soroako to the Indonesian Government. Late in the year, P.T. Inco began capacity production of nickel matte owing to increased demand from the Japanese nickel oxide producers, Tokyo Nickel Co. Ltd. and Nippon Nickel Co. Ltd. At capacity, the three electric furnaces of P.T. Inco could produce altogether about 60 million pounds of nickel per year.

P.T. Aneka Tambang, the Government-owned ferronickel producer at Sulawesi, terminated its long-term contract relations with an agent for four Japanese smelters and began dealing with Japanese steel companies directly in hopes of increasing sales volume. Indonesia was the second largest supplier of nickel raw materials to Japan after New Caledonia.

Ivory Coast.—A feasibility study of the Sipilow nickel-cobalt prospect, near the town of Man in the northwest part of the country, was begun by Falconbridge. Nearly 30,000 feet of core was drilled at the laterite site during 1981 and 1982.

Japan.—Nippon Steel Corp. planned to undertake a feasibility study of a nickel segregation process being jointly developed by Rio Tuba Nickel Mining Corp. of the Philippines, the Minerals Processing Research Institute (MINPRO) of Japan, and Pacific Metals Corp. of Japan. (See "Technology" section.)

The four Japanese ferronickel producers—Pacific Metals, Nippon Mining Co. Ltd., Sumitomo Metal Mining Co. Ltd., and Nippon Yakin Kogyo Co.—made a request to the Ministry of International Trade and Industry (MITI) through the Japan Mining Industry Association to enforce in fiscal year 1984 the planned advance allotment of duty-free (preferential tariff) import quotas. Developing countries were granted the preferential tariff, and those which had taken advantage of the annual duty-free program were Colombia, the Dominican Republic, and Indonesia. The Japanese producers claimed that they were hurt by excessive imports. In addition, MITI planned to reduce its annual purchase of nickel for the Japanese stockpile from a 12-day consumption equivalent to a 6-day equivalent in fiscal year 1984.

The Japanese Government, in a significant trade concession, agreed in 1983 to an advance reduction of tariff of the Tokyo Round tariff schedule. Import duties for ferronickel were to be reduced from 9.3% to 6.5%, effective April 1, 1984. This was 3 years ahead of schedule.

On June 27, 1983, the Japanese and U.S. Governments agreed to take the following measures: (1) On or after August 19, any Japanese exports of nickel-bearing stainless steel to the United States should be accompanied by a certificate of origin of raw materials used in making the stainless steel showing that the steel contains no Cuban nickel, and (2) the United States could deny its customs clearance for imports of Japanese stainless steel that are not accompanied by such a certificate of origin.

Tokyo Nickel completed renovation of the furnace at its Matsuzaka plant on October 16. The renovation enabled production of three forms of nickel—utility (96% to 98% nickel), oxide sinter (76% to 78% nickel), and Tonimet (95% to 96% nickel)—so as to meet users' varying needs.

New Caledonia.—SLN closed two of its mines about midyear. These were the Nepoui Mine on the west coast and the Poro Mine on the east coast. This left only the Kouaoua and Thio Mines in production. SLN planned to produce about 32,000 tons of nickel in ferronickel in 1984, operating two of three electric furnaces at capacity levels.

New Zealand.—After results of a feasibility study proved unfavorable, the Austrian stainless steelmaker Voest-Alpine AG dropped its interest in a joint venture with New Zealand Nickel Smelters Ltd. for a ferronickel plant.

Papua New Guinea.—Nord Resources Corp. sought a joint venture partner to participate in development of the Ramu River chromite-nickel-cobalt deposit, which contained about 1.12% nickel, 0.16% cobalt, and 8% to 9% chromite. The property was 69.5% owned by Nord Resources and a group of U.S. companies, and 30.5% owned by MIM Holdings, an Australian company. Development costs of the project were estimated to exceed $90 million. The three-tiered deposit is located in Marum near Madang.

Peru.—In October, an agreement was reached between the Governments of Spain and Peru to conduct a $1.8 million prefeasibility study on the Peruvian Chinchao nickel deposit. Work was begun in November. The project was chosen from several possibilities under an existing bilateral cooperation agreement on mining between the two countries. Chinchao is located in the Department of Huánuco in the central region. If results prove encouraging, the deposit would be developed through a joint Spanish-Peruvian company. A Peruvian agency, Instituto Geológico Minero Metalúrgico (INGEMMET), made the original proposal. INGEMMET officials reportedly feel that Peru should explore for nickel and other strategic and critical metals in order to diversify Peru's mineral production base.

Philippines.—The nickel refinery of Marinduque Mining and Industrial Corp. (MMIC) near Surigao on the Philippine island of Mindanao resumed full production June 17 with the firing of its new coal-fired boilers. The refinery, with a rated production capacity of about 35,000 tons per year of nickel metal, was shut down December 1, 1982, to install the coal conversion units. About 14,000 tons of nickel was produced by the facility in 1982. Included in the $130 million renovation project were a new pier and a 250,000-ton-capacity coal park; four converted ore dryers; and two new 750,000-pound-per-hour, coal-fired boilers. Projected annual savings was $55 million at prevailing fuel oil and coal prices.

In addition, coal mining began in 1983 at Bagacay, which provided a cheaper source of coal. Also, the old gasifiers of 14 roasters were replaced at a total cost of $6 million. Projected savings from the latter was $20 million per year. Production levels of 70% to 80% of capacity were reached after the conversion.

In October, MMIC was granted an extension of its exemption from all taxes, fees, and other official charges by the Government until the end of 1988. In addition, a proposed financial rescue plan would reduce the company's debt burden by converting some of its debt to equity. Because of its huge debt and depressed nickel prices, the MMIC refinery closed on a temporary basis at yearend.

Saudi Arabia.—The Arabian Shield Development Co. completed prefeasibility studies on the development of a nickel and iron ore deposit at Wadi Qatan, Saudi Arabia. The West German firm, Klöckner Werke AG, examined the possibility of mining enough ore to produce 200,000 tons per year (gross weight) of ferronickel, in addition to sponge iron and cobalt.

Sweden.—Sweden purchased about 44 tons of nickel briquets for its national stockpile.

Taiwan.—Inco received its first order under a 10-year contract to supply nickel oxide to Talent Metals Corp. in Taiwan. Inco's nickel oxide from its Canadian operations was to be the only feedstock for the refinery, which was expected to be completed by March 1984. Capacity of the plant was to be about 7,700 tons, and most of Talent Metals' production would supply Taiwan's growing stainless steel and nickel sulfate industries. Inco held a 30% equity interest in Talent Metals. Falconbridge also indirectly competed with Inco to supply one of Taiwan's main steel companies, Tang Eng Iron Works Co. Ltd.

U.S.S.R.—The Soviet Union offered nickel for sale directly to Japanese steelmakers. This marked the first time that the Soviet Union had bypassed Japanese trading companies in selling in Japan. Soviet exports of nickel to Japan rose significantly compared with those of 1982.

Soviet metallurgists devised a technique of producing nickel directly from concentrates by use of a new hydrometallurgical process. (See "Technology" section.)

Production of high-grade nickel began at the new Taymyr Mine at the Norilsk nickel-platinum complex in northern Siberia, near Talnakh. Installation of equipment for new nickel production at the Severo Montschegorsk was completed.

Yugoslavia.—A new 13,000-ton-per-year ferronickel plant in the Kosovo region of Yugoslavia at Glogovac was completed at midyear. The $300 million project followed by 1 year the initiation of ferronickel production at Kavadarci. Commercial production began in October, and production was not expected to exceed 2,200 tons in 1983. The Yugoslav company, Feronikel, in Pristina, owns the new mine and smelter, which cost $305 million. Two open pit mines (Ciktovo and Glavica) supplied a 1.5% nickel ore to the smelter. Reserves of ore were estimated at more than 20 million tons. Utilities (electricity, gas, oxygen, and water) accounted for 70% of total production costs. Production capacity could be expanded to 20,000 tons per year of nickel without major new investment.

Production of nickel at the Kavadarci (Feni) ferronickel plant, with a capacity of 22,000 tons per year of nickel, did not exceed a 3,500-ton-per-year level owing to energy restrictions and relatively low nickel prices, and production in 1984 was not expected to exceed 7,000 tons. The Feni project was refinanced early in 1983.

Zimbabwe.—The Eiffel Flats refinery of RTZ was forced to close because a long-term source of raw material supply was not found. In 1982, the Empress Mine of RTZ was closed because of heavy losses, forcing RTZ to obtain matte from BCL on an interim basis. Subsequently, RTZ reached an agreement with AMAX Nickel in August 1983, whereby RTZ would receive a temporary supply of matte from the BCL smelter. Because of contractual arrangements, AMAX Nickel had priority in obtaining matte from BCL.

Table 10.—Nickel: World mine production, by country[1]

(Short tons)

Country	1979	1980	1981	1982[p]	1983[e]
Albania[e]	5,800	6,100	6,200	6,400	6,400
Australia (content of concentrate)	76,841	81,927	82,095	97,613	99,200
Botswana	17,828	17,022	18,200	19,573	19,300
Brazil (content of ore)	3,267	[r]4,730	7,508	[r e]7,700	7,900
Burma (content of speiss)	19	15	22	[e]22	22
Canada[2]	139,422	203,709	176,642	97,824	134,300
China[e]	12,000	12,000	12,000	12,000	8,800
Colombia	--	--	--	1,100	[3]15,000
Cuba (content of oxide and sulfide)	34,275	[r]40,338	42,489	39,790	41,170
Dominican Republic	27,680	18,019	20,601	[e]6,600	22,300
Finland (content of concentrate)	6,393	7,199	7,566	6,852	6,600
German Democratic Republic[e]	2,800	3,000	3,000	[r]2,800	2,400
Greece (recoverable content of ore)[4]	22,214	16,796	17,200	[e]16,800	16,500
Guatemala	6,833	7,650	--	--	--
Indonesia (content of ore)[4]	[r]41,059	[r]58,739	53,848	60,592	51,400
Mexico (content of ore)	1	--	--	--	--
Morocco (content of nickel ore and cobalt ore)	176	148	140	[e]110	--
New Caledonia (recoverable content of ore)	[r]88,178	95,451	86,079	66,250	69,400
Norway (content of concentrate)[e]	550	550	550	550	[3]550
Philippines	36,693	51,934	32,239	22,936	20,900
Poland (content of ore)[e]	2,300	2,300	2,300	2,300	2,300
South Africa, Republic of	33,339	28,329	29,100	24,250	22,600
U.S.S.R. (content of ore)[e]	166,000	170,000	174,000	[r]182,000	187,000
United States (content of ore shipped)	15,065	14,653	12,099	3,203	--

See footnotes at end of table.

Table 10.—Nickel: World mine production, by country[1] —Continued

(Short tons)

Country	1979	1980	1981	1982[p]	1983[e]
Yugoslavia[e]	1,650	2,200	4,400	13,200	13,200
Zimbabwe (content of concentrate)	16,084	16,617	14,350	14,671	12,100
Total	[r]756,467	[r]859,426	802,628	705,136	759,342

[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 2, 1984.
[2]Refined 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 11.—Nickel: World smelter production, by country[1]

(Short tons)

Country[2]	1979	1980	1981	1982[p]	1983[e]
Australia[3]	43,366	38,921	46,854	50,630	50,700
Brazil[4]	2,715	2,760	2,574	[e]2,200	2,200
Canada[5]	92,315	167,881	127,000	[e]69,900	96,100
China[e]	11,000	11,000	11,000	10,000	7,700
Colombia	--	--	--	[e]1,000	14,000
Cuba[6]	8,923	[r]8,737	9,355	9,910	10,000
Czechoslovakia	2,202	2,240	2,425	[e]2,425	2,425
Dominican Republic[4]	27,680	18,019	20,601	5,812	22,300
Finland	12,632	14,117	14,672	13,906	14,300
France[5]	3,660	10,802	11,000	[e]9,900	11,000
German Democratic Republic[e]	3,300	3,300	[r]3,100	3,300	3,100
Germany, Federal Republic of[7]	1,348	1,361	[e]1,320	[e]1,320	NA
Greece	16,129	15,300	14,000	[e]13,800	13,200
Indonesia[4]	4,409	[r]4,873	5,184	5,523	5,000
Japan	111,333	108,428	95,679	91,886	[8]76,755
Mexico	1	--	--	--	--
New Caledonia[4]	33,480	35,913	30,853	30,871	30,900
Norway	33,826	[9]40,921	[9]40,890	28,268	28,700
Philippines	23,675	27,978	23,683	14,876	10,500
Poland[e]	2,300	2,300	2,300	2,300	2,300
South Africa, Republic of	8,863	19,950	19,800	19,070	18,700
U.S.S.R.[e]	[r]181,900	189,600	[r]196,200	[r]198,400	204,000
United Kingdom	20,793	21,275	27,999	[e]7,600	7,200
United States[10]	44,191	44,225	48,805	44,956	33,400
Yugoslavia	--	--	--	[e]8,800	10,000
Zimbabwe[e]	14,600	15,500	13,200	[r]13,400	10,600
Total	[r]704,641	[r]805,401	768,494	660,053	685,080

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available.
[1]Refined nickel plus nickel content of ferronickel produced from ore and/or concentrates unless otherwise specified. Table includes data available through May 3, 1984.
[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 in order to avoid double counting. Countries producing matte include the following, with output indicated in short tons of contained nickel: Australia: 1979—42,626; 1980—35,625 (revised); 1981—36,223; 1982—54,444 (estimated); and 1983—54,900 (estimated); Botswana: 1979—17,828; 1980—17,022; 1981—20,143 (revised); 1982—19,573; and 1983—20,080; Indonesia: 1979—7,402; 1980—17,428; 1981—16,499; 1982—11,371; and 1983—19,842; and New Caledonia: 1979—13,517; 1980—17,063; 1981—16,954; 1982—8,800 (estimated); and 1983—7,800 (estimated).
[3]Refined nickel plus the nickel content of oxide.
[4]Nickel content of ferronickel only. (No refined nickel is produced.)
[5]Includes nickel content of refined nickel, nickel oxide, and nickel matte.
[6]Content of granular nickel oxide and powder only; Cuba also produces nickel oxide sinter and a processed sulfide, but these are not included in order to avoid double counting, as they may be processed to metal elsewhere. Output of sinter was as follows, in short tons: 1979—11,828; 1980—13,069 (revised); 1981—13,354; 1982—12,963; and 1983—11,400 (estimated). Output of processed sulfide was as follows, in short tons: 1979—13,524; 1980—18,532 (revised); 1981—19,779; 1982—16,920; and 1983—19,800 (estimated).
[7]Includes nickel content of nickel alloys.
[8]Reported figure.
[9]Data derived from estimated metal content of reported concentrate.
[10]Byproduct of metal refining, including that derived from both domestic ores and imported materials. In 1983, the former was excluded to avoid disclosing company proprietary data.

TECHNOLOGY

A series of high-performance stainless steels gained wider acceptance in the marketplace. The nickel-bearing types were known as either superaustenitics or duplex stainless steels. The second generation of the duplex stainless steels and some superaustenitics contain nitrogen, which improves the strength, corrosion resistance, and weldability of the alloy. In addition, high chromium content (greater than 20% chromium) is a characteristic of many of these alloys. Some of the major applications are stack scrubbers, sour gas wells, and heat exchanger tubing. In some cases, superaustenitic alloys containing 24% nickel have replaced cupronickel alloys containing only 10% nickel in powerplant condensers. One segment of the market expected to experience exceptionally high growth was that of gas pipelines in the Western United States.[4]

A new stainless steel without nickel or chromium was developed for marine applications. The iron-manganese-aluminum-silicon alloy (Fe-30Mn-10Al-Si) was used experimentally as an alternative to brass for seagoing ship propellers. This composition was found to have good resistance to marine corrosion and to cavitation erosion. Moreover, the strength, hardness, and ductility properties of this material were demonstrated to be superior to those of the brass generally used for seagoing propellers. In addition, the alloy was not susceptible to stress corrosion cracking. Research continued at Ohio State University and in China, where a propeller made of the new alloy was being tested in service.[5]

A new nickel-base superalloy containing 20.3% cobalt, 22.8% molybdenum, 2.9% iron, 0.5% boron, 0.8% carbon, and the balance nickel was said to have high strength and excellent resistance to wear, oxidation, and corrosion. Applications ranged from chemical and petrochemical equipment to oil and gas processing equipment. Also, a new low-expansion alloy for gas turbine engines was developed, as well as a new alloy that resists corrosive carbon dioxide and hydrogen sulfide in forged wellhead valves, pumps, packers and hangars. The low-expansion alloy belongs to a family of nickel-cobalt-iron-base alloys to which columbium was added for age hardening and 0.4% silicon for improved tensile strength.[6]

Abex Corp. developed a series of heat-resistant alloys with improved resistance to creep, oxidation, carburization, and thermal fatigue. Also improved were rupture strength and age ductility. The new alloys were designed to greatly increase the service life of castings subject to high-temperature environments. A 10-year development program did not follow traditional methods of strengthening heat-resistant alloys through addition of more nickel and chromium. Rather, micro amounts of such refractory metals as titanium, tungsten, columbium, and rare earths were utilized.[7]

Electroless plating was increasingly used throughout the plating industry, with significant growth in the electronics field. A typical electroless bath contains nickel sulfate; a reducing agent, usually sodium hypophosphite; chelates; brighteners; pH adjuster; and water. Bath temperature is about 190° F. Less than one-half of the market was estimated to be in the traditional automotive sector, while electronics accounted for about 20%.[8] In a related development, use of electroless plating on plastics for shielding against electromagnetic and radio frequency interference was expected to grow. The equipment in which plating would be used was electronic housings used in business machines, personal computers, and medical devices.[9]

A new nickel-base alloy that provided excellent resistance to oxidation, carburization, and chlorine was developed by the Cabot Corp. Designated as Alloy 214, the new material's composition is 15% to 17% chromium; 4% to 5% aluminum; 2% to 5% iron; less than 0.4% yttrium; and the balance nickel. Superior resistance to oxidation was attributed to a tenacious and protective Al_2O_3-type oxide surface film modified by yttrium. The alloy also withstood chlorine-contaminated environments. Potential applications were incinerators, radiant tubes, retorts, furnace hardware, heating elements, and heat shields.[10]

Copper-nickel piping was tested in the saltwater environment of an offshore drilling rig by Dolphin Titan International Inc. The test of the 90% copper-10% nickel alloy was devised to determine whether this pipe can retard corrosion and marine biofouling better than the conventional carbon steel pipe. While copper-nickel pipe was more than two times the price of steel, the copper-nickel pipe could pay for itself within 6 years because it would not have to be replaced. A 2-year test program was undertaken on an eight-pile platform drilling rig.[11]

Soviet metallurgists at the Gipronikel Institute in Leningrad devised a method of producing nickel directly from concentrates. According to reports, nickel was extracted electrolytically from concentrates in solution, thereby saving considerable energy and allowing more complete recovery of byproduct metals. The new process was to be installed at refining facilities in the Norilsk mining district.[12]

A detailed study was conducted for treatment of ocean nodules. In this process, the manganese oxide matrix in the ore is reduced by carbon monoxide in an ammonia-ammonium carbonate-seawater slurry. The reduction step makes the other metal values (nickel, cobalt, copper, and molybdenum) accessible to the leach liquor, leading to the efficient extraction of these metals. A mathematical simulation of the system suitable for scale-up and design was also carried out.[13]

Nippon Steel, MINPRO, and Pacific Metals, all of Japan, in cooperation with Rio Tuba Mining of the Philippines, developed a nickel segregation process. The process utilized a ball mill in which nickel ore, carbon, and calcium chloride are ground at a temperature of about 1,000° C to reduce and partially separate nickel, cobalt, and iron, principally from silica. Nickel, cobalt, and iron then undergo a two-stage wet magnetic separation. The end product contains 30% to 40% nickel in finely ground form, with a recovery rate for nickel of 90%. The advantages claimed for the process were energy savings and recovery of byproduct cobalt. By the currently used rotary kiln-electric furnace process, a temperature of 1,250° C is required to produce ferronickel at Pacific Metals. Use of this newer technology, originally patented in 1963-64, could result in the more efficient processing of acidic ores, such as those of Rio Tuba Mining in the Philippines. Those ores were being processed in 1983 by conventional technology.[14]

AMAX developed a hydrometallurgical process to refine a mixed nickel-cobalt sulfide precipitate containing copper, tin, and zinc as the main impurities. The AMAX acid leach process for treatment of nickel oxide ores, such as laterites, produces this type of precipitate. The precipitate is refined in a chloride medium. An important feature of the process is the recycling of reagents, which results in the virtual elimination of waste effluent streams from the refinery. Feasibility of the process was demonstrated in a pilot plant.[15]

Inco continued conversion of its basic mining method for more than 50% of ore mined in 1983. The improved mining technique is called block vertical retreat mining (VRM). The traditional existing method, mainly cut and fill stoping, was found to be labor intensive and inefficient if the amount of time spent doing support tasks was compared with the time doing production tasks. By this old method, relatively small horizontal slices are cut, and the void is backfilled after each cut. However, with VRM, large vertical blocks as high as 200 feet are removed and then backfilled. Adjacent blocks to be mined are outlined with a drill drift running across the top and an extraction drift along the bottom. The driller then sinks holes from the top to the bottom of each block, and the bottom slice of the block is blasted, using a crater blasting technique. This is done on each slice to the top, and only enough ore is removed for the next slice to be blasted off. Blocks are mined in an alternate pattern. Completed blocks are backfilled with cemented fill from the mill, and drilling is begun on another block. Within a few years, Inco expects to be using this method to produce most of its ore from underground operations.[16]

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[1]Physical scientist, Division of Ferrous Metals.

[2]Federal Register. Environmental Protection Agency. Inorganic Chemicals Manufacturing Point Source Category; Effluent Limitations Guidelines, Pretreatment Standards, and New Source Performance Standards; Proposed Rule. Part II. V. 48, No. 207, pp. 49418-49436.

[3]Value converted from Canadian dollars (CAN$) to U.S. dollars at the rate of CAN$1.2324=US$1.00.

[4]Irving, R. L. Look Into Those High-Performance Stainless Steels. Iron Age, v. 226, No. 29, Dec. 5, 1983, pp. 68-73.

[5]Wang, R., and F. H. Beck. New Stainless Steel Without Nickel or Chromium for Marine Applications. Met. Prog., v. 123, No. 4, Mar. 1983, pp. 72-76.

[6]Chandler, H. E. Trends in Superalloy Technology. Met. Prog., v. 125, No. 1, Jan. 1984, pp. 80-86.

[7]Iron Age. Abex Unveils New Series of Alloys. V. 226, No. 29, Dec. 5, 1983, p. MP-5.

[8]Chemical Marketing Reporter. Is Electroless Nickel Plating as Bright as It Seems? V. 224, No. 20, Nov. 14, 1983, p. 8.

[9]Travis, J. E. Thermoplastic Composites for Electrostatic Dissipation and EMI Attenuation. Pres. at 39th Annu. Conf., Reinforced Plastic/Composites Inst., The Society of the Plastics Industry Inc., New York, NY, Jan. 16-19, 1984. Sess. 13-E, 10 pp.; available from J. E. Travis, LNP Corp., Malvern, PA.

[10]Iron Age. Protective Film Makes a Difference in a New Nickel-Base Alloy. V. 226, No. 28, Nov. 25, 1983, p. 77.

[11]Sfiligoj, M. Rig Tests Copper-Nickel for Salt Water Piping. Am. Met. Mark., v. 91, No. 100, May 23, 1983, p. 21.

[12]Metal Bulletin (London). U.S.S.R. Develops New Nickel Process. No. 6792, June 3, 1983, p. 12.

[13]Barner, H. E., and R. N. Kust. Design and Scale-up of Three-Phase Reactors for Sea Nodules. J. Met., v. 35, No. 5, May 1983, pp. 59-66.

[14]The Tex Report. Pacific Metals Ni Ore Segregation. The Tex Report Ltd. (Tokyo), v. 15, No. 3,520, Aug. 1, 1983, pp. 11-12.

———. Nippon Steel To Prepare Feasibility Study Report on Nickel Segregation. The Tex Report Ltd. (Tokyo), v. 15, No. 3,520, Aug. 1, 1983, pp. 17-18.

[15]Jha, M. C., and G. A. Meyer. AMAX Chloride Refining Process for Recovery of Nickel and Cobalt From Mixed Sulfide Precipitates. Paper in Hydrometallurgy-Research, Development and Practice (Proc. 3d Int. Symp. on Hydrometall., SME-AIME Annu. Meeting, Altanta, GA, Mar. 6-10, 1983). Soc. Min. Eng. AIME, Littleton, CO, 1983, pp. 903-924.

[16]Kossatz, E. Inco Boosts Productivity Using Bulk Mining Methods. Can. Min. J., v. 104, No. 12, Dec. 1983, pp. 23-25.

Nitrogen

By Charles L. Davis[1]

U.S. production and apparent consumption of fixed nitrogen in the form of ammonia decreased for the third consecutive year. Monthly production was below 1982 levels for the first three-quarters of the year. The total value of ammonia produced and sold was about $1.9 billion. The value of apparent consumption was about $2.2 billion. Production and apparent consumption values were based on average annual 1983 f.o.b. gulf coast spot prices. A 51% decrease in total tonnage of exported ammonia was attributed to the strong U.S. dollar compared with foreign currency. Imports of ammonia increased 25%.

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 133 firms manufacturing inorganic fertilizer chemicals. Production estimates were supplied for reports not received in time for tabulation.

Table 1.—Salient ammonia statistics

(Thousand short tons of contained nitrogen)

	1979	1980	1981	1982	1983[p]
United States:					
Production[1 2]	15,420	16,244	[r]15,655	12,968	11,246
Exports	[r]647	681	506	610	298
Imports for consumption	1,603	1,921	1,719	1,737	2,169
Consumption[2 3]	[r]16,565	[r]17,665	[r]16,390	14,084	13,668
World: Production	[r]78,413	[r]81,384	84,523	[p]83,563	[e]85,442

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Synthetic anhydrous ammonia and coke oven ammonia.
[2]Coke oven ammonia not available after 1980.
[3]Includes producers' stock changes in synthetic anhydrous ammonia and coke oven ammonia.

DOMESTIC PRODUCTION

Since 1980, recession, drought, and competition from imports had reduced ammonia demand, leaving U.S. producers with up to one-third of their capacity idled. The 1983 farm acreage reduction programs of the Federal Government encouraged farmers to reduce land under cultivation by about 187 million acres, further reducing demand for all fertilizers, including those made with ammonia. Monthly production of ammonia was below that of 1982 until the fourth quarter. The greatest production was in March, 1.26 million short tons, and the least in July, 0.97 million tons. After July, monthly production of ammonia increased steadily through yearend.

Table 2.—Fixed nitrogen production in the United States

(Thousand short tons of contained nitrogen)

	1979	1980	1981	1982	1983[p]
Anhydrous ammonia, synthetic plants[1]	15,317	16,155	[r]15,655	12,968	11,246
Ammonium compounds, coking plants:					
Ammonia liquor	7	7	NA	NA	NA
Ammonium sulfate	96	82	NA	NA	NA
Ammonium phosphates	(2)	(2)	NA	NA	NA
Total	15,420	16,244	[r]15,655	12,968	11,246

[p]Preliminary. [r]Revised. NA Not available.
[1]Current Industrial Reports, U.S. Department of Commerce, Bureau of the Census.
[2]Included 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	1981[r]	1982	1983[p]
Acrylonitrile	998	1,018	1,073
Ammonium nitrate	8,861	7,091	6,628
Ammonium sulfate[1]	2,185	1,768	1,964
Ammonium phosphates	11,967	10,307	12,814
Nitric acid	9,093	7,390	7,367
Urea	8,062	6,518	5,771

[p]Preliminary. [r]Revised.
[1]Excludes ammonium sulfate from coking plants.

Sources: Bureau of the Census and International Trade Commission.

Table 4.—Domestic producers of anhydrous ammonia in 1983

(Thousand short tons per year of ammonia)

Company	Location	Capacity
Agrico Chemical Co	Donaldsonville, LA	468
Do	Verdigris, OK	840
Air Products & Chemicals Inc	New Orleans, LA	210
Do	Pace Junction, FL	100
Allied Chemical Corp	LaPlatte, NE	172
Do	Hopewell, VA	340
Do	Geismar, LA	340
American Cyanamid Co	Fortier, LA	580
Atlas Chemical Industries Inc	Joplin, MO	136
Borden Chemical Co	Geismar, LA	400
Cargill Inc	Columbus, MS	68
CF Industries Inc	Donaldsonville, LA	1,170
Chevron Chemical Co	Pascagoula, MS	530
Do	El Segundo, CA	20
Columbia Nitrogen Corp	Augusta, GA	510
Cominco American Inc	Boger, 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, KA	210
Do	Enid, OK	840
Do	Lawrence, KA	340
Do	Pollock, LA	420
Felmont Oil Corp	Olean, NY	85
First Mississippi Corp	Donaldsonville, LA	400
Georgia Pacific Corp	Plaquemine, LA	196
Goodpasture Inc	Dimmitt, TX	40
Grace-Oklahoma Nitrogen	Woodward, OK	450
W. R. Grace & Co	Woodstock, TN	340
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 1983 —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	850
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	210
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		16,876

Source: Economics and Marketing Research Section, Tennessee Valley Authority. World Fertilizer Capacity, Ammonia. Muscle Shoals, AL, Feb. 25, 1984.

CONSUMPTION AND USES

The 3% decrease in domestic ammonia consumption was attributed to low demand influenced by the reduction of farm acreage under cultivation, relatively low crop prices, and poor weather conditions. Approximately 80% of the ammonia consumed was used in fertilizers that contained anhydrous ammonia, urea, ammonium phosphates, ammonium nitrate, and other nitrogen compounds. Ammonia also was used to produce plastics, fibers, and resins, 10%; explosives, 4%; and numerous other chemicals, 6%.

STOCKS

Producers' stocks on hand at the beginning of the year totaled about 1.97 million tons of contained nitrogen. At yearend, stocks totaled about 1.42 million tons of contained nitrogen. The smaller yearend stocks reflected the lack of incentive to replace stocks while demand was low.

PRICES

Ammonia prices firmed early in the year, then rose in expectation of higher Mexican prices, possible shortages, and plant shutdowns. A decline in sales was caused by the announcement in January of the Government's "payment-in-kind" program, but prices continued to rise slowly. Prices stayed firm during the early spring when the Nation suffered a very wet period but then declined until they steadied at the annual low of $115 in July. The price recovery began in August with expectations for a large fall planting to offset the small harvest caused by the summer drought and possible foreign purchases of U.S. grain. By yearend, prices had risen to the annual high of $180.

Table 5.—Price quotations for major nitrogen compounds at yearend 1983

(Per short ton)

Compound	Price
Anhydrous ammonia:	
F.o.b. gulf coast	$175-$180
Delivered Corn Belt	175- 185
Ammonium sulfate: F.o.b. Corn Belt	99- 113
Ammonium nitrate: Delivered Corn Belt	135- 145
Urea:	
F.o.b. gulf coast	135- 140
Delivered Corn Belt	160- 167
Diammonium phosphate: F.o.b. central Florida	176- 181

FOREIGN TRADE

Exports of anhydrous ammonia decreased 51% from the nearly 742,000 tons exported in 1982. The combined gross weight of downstream ammonium compounds exported for industrial and fertilizer uses decreased 4%. Diammonium phosphates and urea led in export tonnage of nitrogen compounds.

Imports of ammonia increased by 25%. Canada was the leading foreign supplier of ammonia to the United States with 779,146 tons. The U.S.S.R. supplied about 642,000 tons; Mexico, more than 575,000 tons; and Trinidad and Tobago, more than 535,000 tons. Ammonia imports from Canada and Trinidad and Tobago increased, whereas ammonia imports from Mexico and the U.S.S.R. decreased slightly.

Table 6.—U.S. exports and imports for consumption of major nitrogen compounds in 1983

(Thousand short tons and thousand dollars)

Compound	Gross weight	Nitrogen content	Value
EXPORTS			
Industrial chemicals:			
Ammonia, aqua (ammonia content)	3	2	215
Ammonium nitrate	4	1	268
Ammonium phosphate	3	1	4,568
Ammonium sulfate	2	([1])	94
Fertilizer materials:			
Ammonium nitrate	45	15	5,830
Diammonium phosphates	4,707	847	734,389
Other ammonium phosphates	364	40	60,021
Ammonium sulfates	728	153	40,871
Anhydrous ammonia	363	298	48,336
Sodium nitrate	21	3	3,410
Urea	1,099	506	126,062
Nitrogen solutions	20	7	2,198
Other nitrogen fertilizers	41	8	4,166
Mixed chemical fertilizers	84	8	19,633
Total	7,484	1,889	1,050,061
IMPORTS			
Industrial chemicals:			
Anhydrous ammonia and chemical-grade aqua	2	2	327
Ammonium nitrate	163	57	18,808
Ammonium phosphate	([1])	([1])	157
Ammonium sulfate	([1])	([1])	42
Fertilizer materials:			
Ammonium nitrate	347	116	42,101
Ammonium nitrate-limestone mixtures	([1])	([1])	3
Diammonium phosphates	52	10	9,330
Other ammonium phosphates	142	16	26,400
Ammonium sulfate	285	60	24,100
Calcium cyanamide or lime nitrogen	1	([1])	265
Calcium nitrate	155	23	11,111

See footnotes at end of table.

Table 6.—U.S. exports and imports for consumption of major nitrogen compounds in 1983 —Continued

(Thousand short tons and thousand dollars)

Compound	Gross weight	Nitrogen content	Value
IMPORTS —Continued			
Fertilizer materials —Continued			
Nitrogen solutions	232	74	23,891
Anhydrous ammonia	2,639	2,169	344,320
Potassium nitrate	37	5	8,870
Potassium nitrate-sodium nitrate mixtures	21	3	2,650
Sodium nitrate	97	16	10,383
Urea	1,919	883	235,946
Other nitrogenous fertilizers	56	11	10,795
Mixed chemical fertilizers	133	13	24,075
Total	6,281	3,458	793,574

[1]Less than 1/2 unit.

WORLD REVIEW

World ammonia production increased to approximately 85 million tons of contained nitrogen. Idle plant capacity was estimated to be over 7 million tons per year and included plants in Italy, Japan, the Persian Gulf area, the Republic of South Africa, Sri Lanka, Trinidad and Tobago, Turkey, and the United States. The high cost of feedstock, competition, revalued currency that made payment on debt difficult, plant inefficiencies, and international conflict were some reasons for plant closures. Nitrogen plants were under construction in Burma, China, India, Indonesia, North Korea, Madagascar, the Middle East, the Netherlands, Poland, Somalia, Sudan, the U.S.S.R., and Yugoslavia. New plants were planned for Argentina, India, Indonesia, Nigeria, and Thailand. Many countries continued to suffer from an economic recession but there were indications of a recovery in the Federal Republic of Germany where slight economic growth was expected, in Japan with an export-led recovery, and in the United States.

In Western Europe, where natural gas prices were linked to oil prices, oil price fluctuations affected natural gas-based ammonia producers. Most ammonia plants in Western Europe used natural gas as feedstock. In Persian Gulf countries, production rates of byproduct natural gas were directly affected by oil production rates. An expected increase in world prices improved the outlook for ammonia producers.

Abu Dhabi.—A fertilizer complex was to come on-stream in 1984 at Ruwais with a capacity of 300,000 tons per year of ammonia and 500,000 tons per year of urea. The complex was built by Chiyoda Chemical Engineering and Construction Co. for the Ruwais Fertilizer Industries Co.[2]

Burma.—The state-owned Petrochemical Industries Corp. announced plans to commission a new ammonia-urea facility by yearend. The urea plant was to have a capacity of 39,000 tons per year.[3]

Canada.—Esso Chemicals Co.'s new 1,600-ton-per-day ammonia plant at Redwater, Alberta, began operation in February using natural gas for feedstock. The new plant was expected to be more energy efficient than older plants.[4]

China.—One of China's fertilizer projects was nearing completion. The 330,000-ton-per-year ammonia and 530,000-ton-per-year urea complex is located in Zhejiang Province. The ammonia unit was designed by Haldor Topsoe and Linde.[5]

Construction of China's first large fertilizer complex was to begin at Weizizhen, Shanxi Province. The new plant was designed to produce 272,000 tons of ammonia and consume about 1 million tons of coal feedstock annually. Plant completion was planned for 1986.[6]

India.—Ammonia production began in July 1983 at Hindustan Fertilizer Corp. Ltd.'s giant Haldia complex. Trial production of the 198,000-ton-per-year unit continued for 1 week before continuous production started.[7]

The Krishak Bharati Cooperative began construction on two 1,350-ton-per-day ammonia plants at the Hazira fertilizer complex near Surat in the State of Gujarat.[8]

Indonesia.—A 560,000-ton-per-year urea plant at Bontang, East Kalimantan, was completed. Indonesia planned to export to the Philippines when its new ammonia-urea facilities start production.[9]

Iraq.—In May, the fertilizer complex at Al Qaim came on-stream with capacity to produce about 60,000 tons per year of ammonia.[10]

Italy.—Fertimont, the fertilizer division of Italy's Montedison Group, announced plans to build an energy saving ammonia pilot plant adjacent to the company's existing fertilizer facilities at Ferrara. The project was to cost about $32 million.[11]

Japan.—Ube Ammonia Co., Ube Industries Ltd.'s subsidiary, started construction in June on its 1,000-ton-per-day ammonia plant at Ube City that was designed to utilize Texaco Inc.'s coal gasification process.[12]

Libya.—The Socialist People's Libyan Arab Jamahira was constructing two 1,350-ton-per-day ammonia units at Sirte. Contracts were let for the construction of a new harbor at Sirte to serve the fertilizer complex.[13]

Madagascar.— An ammonia-urea plant was under construction at Tamatave. The plant capacity was to be 80,000 tons per year of ammonia and 46,000 tons per year of urea.[14]

New Zealand.—The first natural gas-based project in New Zealand's energy growth program was completed in Kapuni. When in full operation, Petrochem N.Z. Ltd.'s ammonia-urea plant was expected to provide more than $30 million annually in overseas earnings. The bulk of the Taranaki plant production initially would be for export.[15]

Nigeria.—The Nigerian Government awarded a contract to a consortium of five companies for a fertilizer complex at Port Harcourt. Facilities to produce 300,000 tons per year of ammonia were scheduled to come on-stream in 1984.[16]

Saudi Arabia.—The Al Jubail Fertilizer Co., a joint-venture company established by the Taiwan Fertilizer Co. and Saudi Basic Industries Corp. in 1983, commissioned a new ammonia-urea complex at Al Jubail that was expected to increase Saudi Arabia's ammonia capacity by 330,000 tons per year.[17]

U.S.S.R.—Production began in September at the 450,000-ton-per-year ammonia plant at Angarsk.[18]

Table 7.—Ammonia: World production, by country[1]

(Thousand short tons of contained nitrogen)

Country[2]	1979	1980	1981	1982[p]	1983[e]
Afghanistan[e]	30	11	10	9	71
Albania[e]	79	83	84	84	84
Algeria	23	33	47	180	144
Argentina	67	72	44	64	[3]63
Australia	340	389	352	270	[3]424
Austria	573	540	536	535	545
Bangladesh	184	154	168	201	175
Belgium	584	596	648	561	500
Brazil	293	388	414	555	[3]814
Bulgaria	860	912	924	934	925
Burma[e]	61	66	65	56	60
Canada	2,184	[r]2,310	2,399	2,273	[3]2,617
China[e]	9,723	11,012	[r]13,440	[r]14,010	16,540
Colombia	77	77	101	108	[3]112
Cuba	171	150	184	108	85
Czechoslovakia	883	930	937	795	770
Denmark	36	34	34	34	[3]13
Egypt	290	441	571	722	[3]713
Finland	126	77	76	76	[3]76
France[e]	2,370	2,298	[r]2,500	[r]2,100	2,200
German Democratic Republic	1,188	1,303	1,328	1,323	1,200
Germany, Federal Republic of	2,382	2,253	2,163	1,731	[3]1,877
Greece	316	249	248	281	[3]280
Hungary	885	876	902	873	880
Iceland[e]	8	8	8	[r]9	9
India[4]	2,487	2,448	3,520	3,624	3,500
Indonesia	687	1,034	1,014	1,133	1,300
Iran	202	240	220	29	30
Iraq	496	551	88	[e]88	88
Ireland	188	280	321	[e]276	325
Israel	76	60	47	55	60
Italy	[r]1,576	[r]1,540	1,331	1,153	[3]1,169
Japan	2,566	2,326	2,020	1,821	1,700
Korea, North[e]	500	500	500	500	500

See footnotes at end of table.

Table 7.—Ammonia: World production, by country[1] —Continued

(Thousand short tons of contained nitrogen)

Country[2]	1979	1980	1981	1982[p]	1983[e]
Korea, Republic of	1,059	935	823	599	475
Kuwait	[e]480	485	420	358	[3]345
Libya[e]	147	165	165	[r]270	490
Malaysia	57	45	41	31	[3]32
Mexico	1,498	1,706	1,979	2,239	[3]2,133
Netherlands	2,112	2,066	2,000	1,824	1,922
Norway	600	568	601	574	[3]565
Pakistan[5]	425	474	654	1,033	1,100
Peru[e]	88	68	107	[r]93	94
Philippines	44	43	36	16	22
Poland	1,681	[r]1,629	1,531	1,433	1,430
Portugal	245	221	145	146	[3]122
Qatar	334	461	419	478	[3]531
Romania	2,574	2,478	2,625	2,852	2,870
Saudi Arabia	171	184	187	229	320
South Africa, Republic of	621	605	608	629	[3]652
Spain	[r]911	818	819	593	[3]557
Sweden	98	95	87	85	[3]53
Switzerland	[e]50	[e]50	36	36	[3]39
Syria	84	53	66	72	[3]125
Taiwan	431	457	448	350	[3]342
Trinidad and Tobago	428	506	384	777	[3]1,082
Turkey	226	168	252	[e]254	[3]307
U.S.S.R	13,448	13,889	14,220	16,090	16,000
United Kingdom	1,836	1,800	1,962	1,892	1,870
United States	15,420	16,244	15,655	12,968	[3]11,246
Venezuela	285	397	457	485	[3]310
Yugoslavia	[r]461	[r]445	464	463	450
Zambia	[e]22	22	[e]22	30	[3]31
Zimbabwe[e]	66	66	66	[r]93	78
Total	[r]78,413	[r]81,384	84,523	83,563	85,442

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

[1]Table includes data available through May 23, 1984.

[2]In addition to the countries listed, Vietnam has a nitrogen (N content of ammonia) production capacity of about 60,000 short tons per year; it is not known at what output level the plant is operating.

[3]Reported figure.

[4]Data are for years beginning Apr. 1 of that stated.

[5]Data as reported by Pakistan in fiscal year July 1 through June 30; production for 1982 includes some other forms of nitrogen.

TECHNOLOGY

The Tennessee Valley Authority developed a use for impure phosphoric acid, referred to as sludge acid, a sidestream product of impurity removal in the production of diammonium phosphate. The use of sludge acid in the production of granular monoammonium phosphate was tested in a pilot plant that employed a pipe reactor and a drum granulator. The pipe reactor, recommended by the U.S. Department of Energy, reportedly can save $1 to $2 per ton in production cost. It is actually a prereactor in which sludge acid, ammonia, and water react before they are sprayed into the drum granulator. The heat of reaction generated shortens the product drying process.[19]

A new horizontal ammonia converter was designed to be more energy efficient, cost less than standard converters, have a high capacity, and be easily serviceable. The horizontal configuration eliminates the disadvantages of a large pressure drop, large vessel diameter, and the large volume of catalysts that are characteristic of the vertical axial flow converter. Two catalyst beds in the converter act as three beds because the second bed is split into two parts, with the gas flowing in series through them. This arrangement was selected because of the dependence of gas flow distribution on the ratio of bed pressure drop to the dynamic head of the stream flow.[20]

Imperial Chemical Industries PLC (United Kingdom) designed an ammonia plant that was less complicated than traditional plants, required less capital costs, and produced ammonia cheaper than other designs. It also enables optimum use of natural gas, reducing consumption to about 23 million British thermal units per short ton of ammonia.[21]

A new 1,100-ton-per-day ammonia plant,

designed by M. W. Kellogg, was started up by Sherritt Gordon Mines Ltd. at Fort Saskatchewan, Alberta, Canada. The designer claimed the new installation was the most energy efficient ammonia plant that it had constructed. M. W. Kellogg claimed that producers purchasing natural gas at $3 per 1,000 standard cubic feet could save more than $20 per ton in ammonia production cost using the new design.[22]

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[1]Physical scientist, Division of Industrial Minerals.
[2]Fertilizer International. No. 173, Nov. 1983, p. 7.
[3]Nitrogen (London). No. 144, July-Aug. 1983, p. 12.
[4]———. No. 143, May-June 1983, p. 10.
[5]Nitrogen (London). No. 141, Jan.-Feb. 1983, p. 13.
[6]———. No. 145, Sept.-Oct. 1983, p. 11.
[7]Fertilizer International. No. 170, Aug. 1983, p. 1.
[8]European Chemical News. V. 40, No. 1077, Apr. 11, 1983, p. 26.
[9]Nitrogen (London). No. 145, Sept.-Oct. 1983, p. 18.
[10]Work cited in footnote 2.
[11]Fertilizer International. No. 164, Feb. 1983, p. 11.
[12]Page 12 of work cited in footnote 9.
[13]Fertilizer International. No. 171, Sept. 1983, p. 1.
[14]Nitrogen (London). Africa. No. 142, Mar.-Apr. 1983, p. 23.
[15]———. No. 141, Jan.-Feb. 1983, p. 24.
[16]Page 20 of work cited in footnote 14.
[17]Work cited in footnote 2.
[18]Nitrogen (London). No. 146, Nov.-Dec. 1983, p. 9.
[19]Farm Chemicals. V. 147, No. 10, Oct. 1983, pp. 37, 40.
[20]Chemical Engineering Progress. V. 79, No. 5, May 1983, p. 56.
[21]Page 62 of work cited in footnote 20.
[22]Chemical Week. V. 133, No. 23, Dec. 7, 1983, p. 50.

Peat

By Charles L. Davis[1]

U.S. production of all types of peat decreased 12%. Michigan, Florida, Illinois, Indiana, and Colorado continued to be the major peat-producing States. Reed-sedge peat was the most common kind produced, followed by humus, unclassified, hypnum, and sphagnum. Sales of peat, mostly in packaged form, by domestic producers decreased 6% in quantity but increased 11% in value. Apparent consumption was essentially unchanged. Imports, nearly all from Canada, increased 13% and provided about 37% of apparent consumption. Peat was used predominantly for agricultural and horticultural purposes, but a minor quantity, 850 short tons, was used for fuel.

The U.S.S.R. produced about 96% of total world peat production.

Domestic Data Coverage.—Domestic production data for peat are developed by the Bureau of Mines from a voluntary survey of U.S. operations. Of the 109 operations to which a survey request was sent, 93 responded, representing 85% of the total production shown in table 1. Production for the 16 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
United States:				
Number of active operations	96	90	[r]93	94
Production thousand short tons	785	686	[r]798	704
Sales by producers do.	788	757	[r]769	725
Bulk do.	298	276	[r]259	223
Packaged do.	491	481	[r]511	503
Value of sales thousands	$16,190	$18,784	[r]$16,871	$18,667
Average per ton	$20.54	$24.82	[r]$21.94	$25.73
Average per ton, bulk	$15.46	$17.28	[r]$16.34	$18.34
Average per ton, packaged or baled	$23.61	$29.14	[r]$24.77	$29.00
Imports for consumption thousand short tons	402	342	370	419
Consumption, apparent[1] do.	1,190	1,099	[r]1,139	1,144
Stocks, yearend producers' do.	330	269	[r]357	438
World: Production do.	[r]337,144	387,277	[p]414,039	[e]413,511

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Sales plus imports.

DOMESTIC PRODUCTION

Peat was produced by 94 active operations in the United States. Eight large mines, with annual capacities greater than 25,000 tons, accounted for 46% of the production compared with 54% in 1982. These operations included three reed-sedge mines in Michigan and one each in Florida, Illinois, and Indiana; one humus mine in Georgia; and one unclassified peat mine in Florida.

Production of reed-sedge peat decreased 10% and accounted for 59% of total peat production. The remainder was humus, 25%; unclassified peat, 8%; hypnum moss, 5%; and sphagnum moss peat, 3%.

Rajso Torv AB, a Swedish company, was

granted a 25-year lease on 2,625 acres of State-owned peat land in Minnesota. The company planned to compress the peat into briquets for fuel and develop a Midwestern U.S. market. The company had been the first to produce peat in Sweden on a large scale for fuel. The success or failure of this imported Swedish technology was expected to influence future peat use in Minnesota.

Table 2.—Relative size of peat operations in the United States

Size in short tons per year	Active operations		Production (thousand short tons)	
	1982	1983	1982	1983
25,000 and over	r8	8	r431	322
15,000 to 24,999	r5	6	r91	103
10,000 to 14,999	r8	7	r97	92
5,000 to 9,999	r14	9	r90	69
2,000 to 4,999	r20	25	r65	91
1,000 to 1,999	11	12	16	17
Under 1,000	r27	27	r8	9
Total	r93	94	r798	[1]704

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

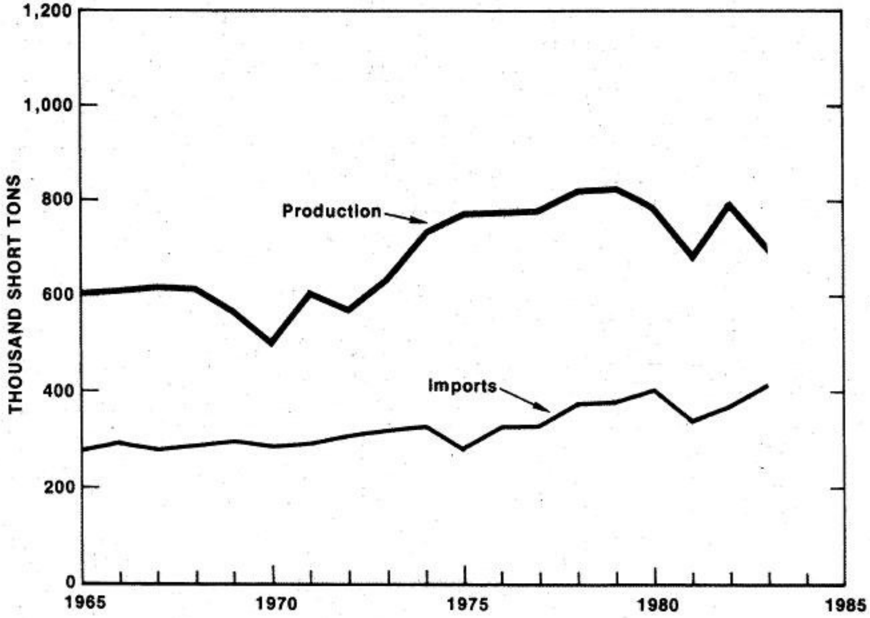

Figure 1.—Production and imports of peat in the United States.

CONSUMPTION AND USES

Domestic sales by U.S. peat producers decreased 6% and consisted of 63% reed-sedge, 23% humus, 6% unclassified, 4% hypnum, and 4% sphagnum. Bulk sales declined 14% and packaged sales decreased 2%. Peat sold in packaged form was 69% of sales, and consisted of 74% reed-sedge, 16% humus, 5% sphagnum, and 5% hypnum. Decreased sales of peat occurred for use in potting soils, earthworm culture, and mixed fertilizers. Sales increased for growing vegetables and for nurseries. Apparent consumption of peat was essentially unchanged.

Table 3.—U.S. peat sales by producers in 1983, 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	1,033	$16	67	$1	1,100	$17
General soil improvement	74,393	1,283	411,815	10,731	486,208	12,013
Golf course	20,922	478	1,500	77	22,422	555
Ingredient for potting soils	54,887	1,126	52,222	1,891	107,109	3,017
Mixed fertilizers	15,000	125	500	35	15,500	160
Mushroom beds	4,149	75	2,998	210	7,147	285
Nursery	45,385	837	12,671	502	58,056	1,340
Packing flowers, plants, shrubs, etc	390	4	6,500	85	6,890	89
Seed inoculant	232	53	3,775	766	4,007	820
Vegetable growing	2,993	35	6,500	85	9,493	120
Other	3,178	51	4,320	200	7,498	251
Total	222,562	4,083	502,868	[1]14,584	725,430	18,667

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

Table 4.—U.S. peat production and sales by producers in 1983, by State

State	Active operations	Production	Sales		
		Quantity (thousand short tons)	Quantity (thousand short tons)	Value[1] (thousands)	Percent packaged
California	3	16	13	$612	72
Colorado	5	W	W	W	36
Florida	6	128	114	1,999	35
Georgia	2	W	W	W	99
Illinois	5	W	W	W	93
Indiana	8	65	81	1,973	85
Iowa	3	W	W	W	25
Maine	3	W	W	W	96
Maryland	1	5	4	W	12
Massachusetts	1	W	W	W	10
Michigan	16	180	215	4,286	80
Minnesota	4	W	W	W	84
Montana	2	W	W	W	93
New Jersey	5	6	W	W	42
New York	6	W	18	W	89
North Carolina	2	W	W	W	81
North Dakota	1	W	W	W	--
Ohio	6	W	W	W	89
Pennsylvania	8	23	22	628	25
South Carolina	1	W	W	W	96
Washington	3	W	W	W	--
Wisconsin	3	9	9	W	39
Total or average	94	704	[2]725	18,667	69

W Withheld to avoid disclosing company proprietary data; included in "Total."
[1]Values are f.o.b. producing plant.
[2]Data do not add to total shown because of independent rounding.

Table 5.—U.S. peat sales by producers in 1983, 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	90	300	$2	125	250	$2	330	728	$7
General soil improvement	17,973	158,794	1,131	21,532	54,522	812	371,138	815,939	8,649
Golf course	680	5,596	40	840	1,680	11	13,976	25,995	379
Ingredient for potting soils	500	4,996	35	1,751	4,190	21	34,474	79,178	1,474
Mixed fertilizers	500	4,996	35	--	--	--	--	--	--
Mushroom beds	2,998	29,976	210	900	3,000	45	3,249	5,957	30
Nursery	3,798	25,984	167	5,276	19,575	302	21,714	46,125	522
Packing flowers, plants, shrubs, etc	500	4,996	35	--	--	--	--	--	--
Seed inoculant	500	4,996	35	--	--	--	3,000	5,455	660
Vegetable growing	500	4,996	35	--	--	--	607	953	8
Other	--	--	--	--	--	--	4,320	8,000	200
Total[2]	28,039	245,630	1,725	30,424	83,217	1,193	452,808	988,330	11,930

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	330	560	$3	225	500	$3	1,100	2,338	$17
General soil improvement	68,124	126,589	1,298	7,441	13,688	122	486,208	1,169,532	12,013
Golf course	6,926	12,836	125	--	--	--	22,422	46,107	555
Ingredient for potting soils	38,359	69,624	833	32,025	71,000	655	107,109	228,988	3,017
Mixed fertilizers	15,000	25,000	125	--	--	--	15,500	29,996	160
Mushroom beds	--	--	--	--	--	--	7,147	38,933	285
Nursery	24,768	43,063	300	2,500	5,088	48	58,056	139,835	1,340
Packing flowers, plants, shrubs, etc	6,390	10,680	54	--	--	--	6,890	15,676	89
Seed inoculant	507	696	125	--	--	--	4,007	11,147	820
Vegetable growing	8,386	14,441	77	--	--	--	9,493	20,390	120
Other	--	--	--	3,178	6,695	51	7,498	14,695	251
Total[2]	168,790	303,489	2,939	45,369	96,971	880	725,430	1,717,637	18,667

[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 1983, by kind

Kind	Active operations	Production (short tons)	Percent of production	Yearend stocks (short tons)
Sphagnum moss	6	23,952	3.4	23,924
Hypnum moss	6	32,825	4.7	12,690
Reed-sedge	44	412,792	58.6	356,459
Humus	31	175,573	24.9	27,484
Other	10	58,769	8.4	17,544
Total	[1]97	703,911	100.0	438,101

[1]Includes three additional bogs.

PRICES AND SPECIFICATIONS

The average price per ton for all types of peat, f.o.b. mine, increased 17%. The unit price for bulk peat increased 12% and for packaged peat 17%. The price per ton of imported sphagnum peat remained at about $125.

Table 7.—Prices[1] for peat in 1983

(Dollars per unit)

	Sphagnum moss	Hypnum moss	Reed-sedge	Humus	Other	Average
Domestic:						
Bulk:						
Per short ton	17.69	23.50	23.58	12.78	19.43	18.34
Per cubic yard	5.31	9.21	11.28	7.27	9.08	9.20
Packaged or baled:						
Per short ton	65.50	44.11	26.93	22.62	16.00	29.00
Per cubic yard	7.08	15.80	12.23	12.26	8.00	11.45
Average:						
Per short ton	61.51	39.22	26.35	17.41	19.39	25.73
Per cubic yard	7.02	14.34	12.07	9.68	9.07	10.87
Imported, total, per short ton[2]	124.35	XX	XX	XX	XX	124.35

XX Not applicable.
[1]Prices are f.o.b. mine.
[2]Average customs price.

Table 8.—Average density of domestic peat sold in 1983

(Pounds per cubic yard)

	Sphagnum moss	Hypnum moss	Reed-sedge	Humus	Other
Bulk	600	784	957	1,139	935
Packaged	216	716	908	1,084	1,000
Bulk and packaged	228	731	916	1,112	936

FOREIGN TRADE

Peat imports increased 13% in quantity and 12% in value. More than 99% of these imports continued to be sphagnum moss peat from Canada. This Canadian peat had more desirable qualities than most domestically produced peat. Approximately 46% entered the United States through customs districts in New York. Significant quantities also entered through customs districts in North Dakota, Michigan, Montana, Washington, Maine, and Vermont. 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 1983, by country

Country	Poultry- and stable-grade Quantity (short tons)	Poultry- and stable-grade Value (thousands)	Fertilizer-grade Quantity (short tons)	Fertilizer-grade Value (thousands)	Total[2] Quantity (short tons)	Total[2] Value (thousands)
Canada	47,143	$6,034	371,371	$45,985	418,514	$52,019
Germany, Federal Republic of	4	3	110	14	114	17
Ireland	69	26	--	--	69	26
Other[1]	5	3	5	2	10	5
Total[2]	47,220	6,066	371,486	46,001	418,706	52,066

[1]Includes Finland, the Netherlands, New Zealand, and the United Kingdom.
[2]Data may not add to totals shown because of independent rounding.

Source: Bureau of the Census.

Table 10.—U.S. imports for consumption of peat moss in 1983, by customs district

Customs district	Poultry- and stable-grade Quantity (short tons)	Poultry- and stable-grade Value (thousands)	Fertilizer-grade Quantity (short tons)	Fertilizer-grade Value (thousands)	Total[1] Quantity (short tons)	Total[1] Value (thousands)
Baltimore, MD	13	$16	--	--	13	$16
Boston, MA	3	3	5	$2	8	5
Buffalo, NY[2]	19,948	2,846	5,977	674	25,925	3,520
Detroit, MI[2]	26,602	3,094	22,492	1,806	49,094	4,900
Duluth, MN[2]	--	--	441	97	441	97
Great Falls, MT[2]	--	--	37,041	5,552	37,041	5,552
Honolulu, HA[2]	1	1	33	5	34	6
Houston, TX	1	1	--	--	1	1
Los Angeles, CA	--	--	128	14	128	14
Minneapolis, MN	--	--	20	5	20	5
Norfolk, VA	12	25	--	--	12	25
Ogdensburg, NY[2]	430	36	168,512	19,410	168,942	19,446
Pembina, ND[2]	--	--	52,754	8,429	52,754	8,429
Philadelphia, PA	56	10	--	--	56	10
Portland, ME[2]	18	3	26,973	3,217	26,991	3,220
San Francisco, CA[2]	3	1	15	2	18	3
San Juan, PR[2]	95	23	--	--	95	23
Seattle, WA[2]	--	--	32,986	4,138	32,986	4,138
St. Albans, VT[2]	20	3	24,109	2,649	24,129	2,652
Virgin Islands[2]	18	4	--	--	18	4
Total[1]	47,220	6,066	371,486	46,001	418,706	52,066

[1]Data may not add to totals shown because of independent rounding.
[2]Predominately of Canadian origin.

WORLD REVIEW

Peat-fueled plants, with a total installed capacity of 450 megawatts, supplied 20% to 30% of Ireland's electric power. Finland used peat as a fuel to produce both heat and electric power to supply 3% of the country's energy needs. One of the Finnish stations had an electrical generating capacity of 60 megawatts and a thermal heating capacity of 117 megawatts. The U.S.S.R. had 76 peat-fueled power stations with a total capacity of about 5,000 megawatts. Officials from the United States visited these European countries to study their peat-burning heat and electric power generation industries and technology.

Table 11.—Peat: World production, by country[1]

(Thousand short tons)

Country[2]	1979	1980	1981	1982[p]	1983[e]
Argentina: Agricultural use	4	5	3	4	[3]5
Australia	[r]16	13	[e]15	[r] [e]15	14
Burundi	10	10	10	15	22
Canada: Agricultural use	529	[e]538	509	537	[3]600
Denmark: Agricultural use[4]	50	34	36	104	110
Finland:					
Agricultural use	852	637	225	97	110
Fuel	1,710	2,029	1,436	6,063	5,500
France: Agricultural use[e]	155	155	155	143	130
Germany, Federal Republic of:					
Agricultural use	2,038	1,607	1,920	2,023	2,040
Fuel	254	308	271	279	290
Hungary: Agricultural use[e]	77	77	77	77	77
Ireland:					
Agricultural use	100	97	89	105	105
Fuel	4,041	4,879	5,906	5,819	5,850
Israel: Agricultural use[e]	20	22	22	22	22
Netherlands[e]	441	441	441	441	441
Norway:[e]					
Agricultural use	66	66	66	66	66
Fuel	1	1	1	1	1
Poland: Fuel and agricultural use[e]	220	223	222	220	220
Spain	51	49	43	66	60
Sweden: Agricultural use	192	148	144	[r] [e]144	144
U.S.S.R.:					
Agricultural use	[e]220,000	259,000	309,000	[e]331,000	331,000
Fuel[e]	66,000	66,000	66,000	66,000	66,000
United States:					
Agricultural use	825	785	686	798	[3]703
Fuel	--	--	--	--	[3]1
Venezuela: Agricultural use[e]	20	20	NA	NA	NA
Total	[r]297,672	[r]337,144	387,277	414,039	413,511
Fuel peat included in total	72,226	73,440	73,836	78,382	77,862

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available.
[1]Table includes data available through June 13, 1984.
[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]Reported figure.
[4]Sales.

TECHNOLOGY

The U.S. Department of Energy and the Institute of Gas Technology funded a project to operate a pilot plant in Chicago, IL, to produce substitute natural gas (SNG) from peat. The project included plant design, procurement, and installation of drying, grinding, screening, and lockhopper feed systems. Operation of the pilot plant confirmed that peat was an excellent raw material for SNG production.[2]

[1]Physical scientist, Division of Industrial Minerals.
[2]Institute of Gas Technology. Peat Gasification Pilot Plant Program. Project 70105, Final Rep., Mar. 1983, 134 pp.

Perlite

By Arthur C. Meisinger[1]

U.S. production of both processed and expanded perlite declined for the fifth consecutive year. Processed perlite sold and used by producers decreased 6% to 474,000 short tons valued at $15.7 million. Sales of expanded perlite, from 68 plants in 33 States, decreased 10% to 385,000 short tons valued at $63.5 million.

The United States became a net importer of processed perlite with imports exceeding exports by about 19,000 tons.

Domestic Data Coverage.—Domestic production data for perlite were developed by the Bureau of Mines from two separate voluntary surveys, one for domestic mine operations and the other for plant operations. Of the 13 mining operations to which a request was sent, 7, or 54%, responded, representing 86% of the total processed ore sold and used shown in table 1. Mine data for the six nonrespondents were estimated using reported prior year production levels adjusted by trends in employment and other guidelines. Of the 68 expanding plants to which a request was sent, 40 plants, or 59%, responded, representing 67% of the total expanded perlite sold and used shown in table 1. Plant data for the 28 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
1979	847	322	7,996	338	8,439	660	551	543	61,200
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

[1]Crude ore mined and stockpiled for processing.

DOMESTIC PRODUCTION

Processed Perlite.—The quantity of perlite mined for processing, by 11 companies from 13 operations in 7 Western States, decreased 2% to 608,000 short tons. Perlite mines in New Mexico accounted for 86% of the U.S. total; the remainder came from mines in Arizona, California, Colorado, Idaho, Nevada, and Utah. 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; Grefco Inc., Manville Products Corp., Silbrico Corp., and United States Gypsum in New Mexico; and Holly Corp. in Utah.

Processed perlite sold and used for expansion declined 6%.

Expanded Perlite.—Expanded perlite was produced by 68 plants in 33 States. The quantity produced decreased 10%. Leading States, in descending order of volume, were California, Illinois, Mississippi, Pennsylvania, Virginia, Texas, Indiana, Florida, Kentucky, and Colorado. California and Texas each had seven active plants, followed by Indiana and Pennsylvania with five each, and Florida with four. Grefco sold its three insulation-board plants in California, Kentucky, and New Jersey to International Permalite Inc., Ontario, CA. The New Jersey plant was closed during the year.

Table 2.—Expanded perlite produced and sold and used by producers in the United States, by State

State	1982				1983			
	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	800	800	W	W	1,100	1,100	W	W
California	43,300	42,400	$6,162	$145	44,900	43,700	$7,015	$160
Florida	28,400	28,300	3,967	140	21,200	21,300	3,527	166
Indiana	18,800	19,000	3,840	202	24,200	24,300	5,257	217
Massachusetts	2,200	2,000	756	378	2,700	2,600	792	302
New York	4,300	4,100	782	191	W	W	W	W
Pennsylvania	38,700	38,600	5,751	149	31,700	31,400	5,059	161
Texas	30,300	29,600	5,907	200	27,700	27,400	5,704	208
Other[2]	266,500	263,500	36,428	138	233,500	233,000	36,144	155
Total[3]	433,000	428,000	63,600	149	387,000	385,000	63,500	165

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 (1983), Colorado, Georgia, Idaho, Illinois, Iowa, Kansas, Kentucky, Louisiana, Maine, Michigan, Minnesota, Mississippi, Missouri, Nevada, New Jersey, North Carolina, Ohio, 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 declined 10%. Sales of expanded perlite for concrete aggregate use increased 29%, while that for filter aid use decreased 24%. Construction-industry-related uses, such as aggregates for concrete, plaster, and formed products, and loose-fill insulation, continued to account for two-thirds of sales.

Table 3.—Expanded perlite sold and used by producers in the United States, by use

(Short tons)

Use	1982	1983
Concrete aggregate	15,200	19,600
Fillers	4,700	4,200
Filter aid	83,700	63,900
Formed products[1]	245,800	210,800
Horticultural aggregate[2]	28,200	29,200
Low-temperature insulation	3,400	6,000
Masonry and cavity-fill insulation	12,700	13,600
Plaster aggregate	14,400	15,400
Other[3]	20,300	21,900
Total[4]	428,000	385,000

[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 increased slightly to $33.93 per ton. The average price of expanded perlite used by producers in their own plants was $31.56 per ton, an increase of 5%. The average value of all processed perlite sold and used was $33.05 per ton, an increase of 4%. The value of expanded perlite sold and used averaged $165 per ton, an 11% increase.

FOREIGN TRADE

The United States imported approximately 36,000 tons of processed perlite from Greece and exported approximately 17,000 tons to Canada compared with imports of 16,000 tons and exports of 20,000 tons in 1982, according to industry sources.

WORLD REVIEW

Estimated world production of crude and/or processed perlite declined slightly. The United States, the U.S.S.R., and Greece continued to be the leading producing countries and, together, accounted for two-thirds of total world production.

[1] Industry economist, Division of Industrial Minerals.

Table 4.—Perlite: World production, by country[1]

(Thousand short tons)

Country[2]	1979	1980	1981	1982[p]	1983[e]
Australia[3]	2	2	2	3	3
Czechoslovakia[e]	33	44	46	44	44
Greece	[r]149	[r]218	145	[r e]150	150
Hungary[3]	108	109	105	99	100
Italy[e]	100	100	94	88	88
Japan[e]	83	85	83	[r]83	83
Mexico[3]	46	49	63	43	44
New Zealand[3]	2	1	1	2	2
Philippines	4	9	8	4	4
Turkey	33	28	50	134	140
U.S.S.R.[e]	400	400	400	400	400
United States (processed ore sold and used by producers)	660	638	591	506	[4]474
Total	[r]1,620	[r]1,683	1,588	1,556	1,532

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

[1]Unless otherwise specified, figures represent processed ore output. Table includes data available through June 6, 1984.

[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 1979-83 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]

The decline in U.S. phosphate rock production that started in 1981 and continued through 1982 was reversed in 1983 when the industry began to recover from the economic recession and produced 42.6 million metric tons of phosphate rock. The U.S. Government implemented the "payment-in-kind" program to attempt to reduce grain inventories and the oversupply of farm products. A coincidental drought reduced agricultural production and thereby improved the supply-demand balance in the agricultural sector. Demand for phosphate fertilizers and therefore phosphate rock increased in the latter half of the year.

The estimated value of phosphate rock produced was $1,021 million, somewhat less than the value in recent years prior to 1982 because of the decline in prices since 1981. Phosphate rock exports increased from 10 million tons in 1982 to 12 million tons in 1983, indicating improvement in world demand for phosphate rock, phosphate fertilizers, and agricultural products.

In Florida, the combination of unfavorable economics, concern for the environment, and political attitudes virtually ended prospects for the development of new mines in the next several years. The fertilizer segment of the Western U.S. phosphate industry was expected to continue to supply markets in the Western United States and Canada.

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.

Table 1.—Salient phosphate rock statistics

(Thousand metric tons and thousand dollars unless otherwise specified)

	1979	1980	1981	1982	1983
United States:					
Mine production	185,757	209,883	183,733	104,135	125,691
Marketable production	51,611	54,415	53,624	37,414	42,573
Value	$1,045,655	$1,256,947	$1,437,986	$950,326	$1,020,901
Average per metric ton	$20.26	$23.10	$26.82	$25.40	$23.98
Sold or used by producers	53,063	54,581	45,526	38,571	46,839
Value	$1,063,517	$1,243,297	$1,212,433	$983,465	$1,122,966
Average per metric ton	$20.04	$22.78	$26.63	$25.50	$23.97
Exports[1]	14,358	14,276	10,395	9,842	12,010
P_2O_5 content	4,611	4,554	3,300	3,138	3,839
Value	$356,481	$431,419	$373,192	$293,626	$327,345
Average per metric ton	$24.83	$30.22	$35.90	$29.83	$27.26
Imports for consumption[2]	886	486	13	31	9
Customs value	$21,595	$12,856	$420	$1,302	$427
Average per metric ton	$24.37	$26.45	$32.31	$42.00	$47.44
Consumption[3]	39,591	40,791	35,144	28,760	34,840
World: Production	[r]131,825	[r]139,214	138,169	[p]122,202	[e]135,000

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Exports reported to the Bureau of Mines by companies.
[2]Bureau of the Census data.
[3]Measured by sold or used plus imports minus exports.

Legislation and Government Programs.—A comprehensive examination of Federal, State, and local environmental protection controls applicable to phosphate rock mining was published by the Bureau of Mines.[2]

The U.S. Government implemented the payment-in-kind program designed to remove from production about 20% of the 1983 season's corn, wheat, cotton, rice, and sorghum acreage. The U.S. Department of Agriculture program encouraged farmers to let land lie fallow in the 1983-84 planting season, and in return, they were paid with surplus grain from Government stockpiles. The purpose of the program was to tighten supplies, raise farm commodity prices, and save $3 billion to $5 billion in storage costs and loans to farmers.

DOMESTIC PRODUCTION

Florida and North Carolina produced 36 million tons of phosphate rock, 84% of total U.S. marketable production; the Western States produced 5.4 million tons, 13%; and Tennessee produced 1.2 million tons, 3%.

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 Chemical Corp., and USS Agri-Chemicals Inc. Occidental Chemical Co. produced marketable phosphate rock in Hamilton County, in north Florida.

Several small companies in north-central Florida intermittently mined soft phosphate rock from tailing ponds associated with old inactive hard-rock mines. The companies have an estimated 45,000-ton-per-year capacity that is seldom achieved. The low-fluorine soft rock was sold in the animal feed supplement market.

In North Carolina, Texasgulf Chemicals Co., a subsidiary of Société National Elf Aquitaine, operated the Lee Creek Mine and an extensive fertilizer complex near Aurora, NC. Hydraulic dredges were used to remove the upper level of overburden, and draglines were used to remove the remaining overburden and the phosphate matrix. North Carolina Phosphate Corp., an Agrico mining company, deferred plans to begin mining phosphate rock in eastern North Carolina until the economics become more favorable. Agrico created two 50-50 partnerships, one with Française de l'Azote for 19% of the North Carolina mine and the other with Azienda Nazionale Idrogenazione Combustible S.p.A., an Italian state-owned company, for 21.6% of the mine.

In central Florida, Agrico operated the Fort Green, Payne Creek, and Saddle Creek Mines. Most of the phosphate rock was obtained from the Fort Green Mine; the Payne Creek Mine was idled, and only a small tonnage was recovered from the Saddle Creek Mine. Agrico planned to develop a mine in North Carolina to replace depleted mines in Florida.

Amax Chemical operated the Big Four Mine in Hillsborough County at less than capacity. This mine, depending on mining rates, was expected to be depleted by the end of the decade. Amax Chemical indicated that it might develop its Pine Level property in De Soto and Manatee Counties when the Big Four Mine closes if demand and rock prices justify the investment.

Beker operated the only phosphate mine in Manatee County, FL. The Wingate Creek Mine operated near its rated capacity of 0.8 million tons per year. Production was trucked to the port and barged to Beker's wet-process phosphoric acid and diammonium phosphate plant in Taft, LA.

Brewster Phosphates, a partnership of American Cyanamid Co., 75%, and Kerr-McGee Corp., 25%, operated the Haynesworth and Lonesome Mines in Polk and Hillsborough Counties, respectively. The Haynesworth Mine was scheduled to deplete its reserves near the end of the 1980's, and the Lonesome Mine was scheduled to increase capacity, with available Haynesworth equipment, and mine out prior to 2000.

CF Industries purchased phosphate rock reserves in north Hardee County in 1975 and began mining the "North Pasture" part of the reserve in 1979. The capacity of the North Pasture Mine was about 1 million tons per year. Production was shipped to CF Industries Plant City chemical plant in 1983, while the Bartow plant was supplied by IMC. It was uncertain if CF Industries will exercise an option to open a permitted mine on the "South Pasture."

Estech operated the Silver City and Watson Mines, in Polk County, FL, which were scheduled to mine out in 1987 and the 1989-91 period, respectively. Zen-Noh/Mitsubishi of Japan purchased 70% of the Watson Mine production until mine out. Estech with Zen-Noh attempted unsuccessfully to obtain permits to mine the Duette deposit in Manatee County.

Farmland Industries Inc. purchased phosphate rock for its phosphate chemical plant at Green Bay, FL. Plans for a phosphate rock mine on a deposit near Ona, FL, were canceled because of costs and market conditions.

Gardinier operated the Fort Meade Mine and shipped phosphate rock to its phosphate chemical complex at East Tampa, FL. The mine was expected to continue to operate within its capacity of 2.4 million tons per year until the mid-1990's.

W. R. Grace was expected to mine out the Bonny Lake Mine in early 1984, to continue producing from the Hookers Prairie Mine through the late 1990's, and to start up its Four Corners venture with IMC in early 1985.

IMC, the largest privately owned phosphate rock mining company in the world, operated the Clear Springs, Kingsford, and Noralyn/Phosphoria Mines in central Florida. It is expected to receive its share of future production from the Four Corners Mine, a joint venture with W. R. Grace. The Noralyn/Phosphoria Mine could be the first IMC mine to mine out, and IMC was expected to invest in a replacement mine in Hardee or Hillsborough County, where the company owns property, to maintain its 1983 capacity.

Mobil Chemical operated phosphate rock mines at Fort Meade and Nichols, FL. The mines were scheduled to be depleted, depending on mining rates, during the latter part of the 1980's. Mobil Chemical planned to replace mines by developing a reserve at South Fort Meade to maintain its 1983 capacity of about 4.5 million tons per year.

USS Agri-Chemicals and Freeport Phosphate Rock Co. stopped production at their Rockland/Little Payne Mine in May 1982 because of high mining costs and low phosphate rock prices. Plans to restart the mine remained uncertain although the reserve base is substantial.

Occidental was the only company mining phosphate rock in north Florida and had sufficient reserves to operate the Swift Creek and Suwannee River Mines for the balance of the 20th century. The mines were operated mainly to produce superphosphoric acid to meet Occidental's contractual commitment to supply highly concentrated superphosphoric acid to the U.S.S.R.

Tennessee.—All of the phosphate rock mined in Tennessee by Occidental, Monsanto Co., and Stauffer Chemical Co. was used to produce elemental phosphorus in electric furnaces. In June, Monsanto mined out the Gilbert pit in Alabama that was supplying phosphate rock to Monsanto's electric furnaces in Tennessee. Stauffer and Monsanto appeared to have sufficient reserves to continue mining throughout the 20th century, but Occidental, depending on mining rates, was expected to mine out as early as 1995. Both Monsanto and Stauffer had similar electric-furnace operations in the Western United States. Because of lower power costs in the West, Tennessee furnaces were at times operated only to make up the difference between Western production and overall demand. Tennessee elemental phosphate producers, with the exception of Occidental, have furnaces in the Western United States.

Western States.—Western phosphate rock was mined in two grade ranges, 24% to 28% phosphorus pentoxide (P_2O_5) phosphate rock for elemental phosphorus production and 30% to 33% P_2O_5 phosphate rock for wet-process phosphoric acid production. Low-grade shale was mined and used directly in Monsanto, FMC Corp., and Stauffer electric furnaces. As a general rule, the phosphate rock mined in the Western States was consumed in equal quantities in furnaces and wet-process acid plants.

The Conda Partnership, a 50-50 association between Beker and Western Cooperative Fertilizers Ltd., Canada, mined phosphate rock from various properties known as Maybie Canyon, Champ, Mount Fuel, North Dry Ridge, and Husky. The partnership includes phosphate rock reserves and a beneficiation plant at Conda, ID. Beker's share of the mined rock was used in the adjacent fertilizer complex at Conda, while Western Cooperative's share was shipped to plants in Alberta, Canada.

Monsanto obtained phosphate rock for its electric furnaces from the Henry Mine. The phosphate ore was trucked from the mine to electric furnaces at Soda Springs, ID. Mine capacity was about 0.9 million tons per year.

Stauffer operated the Wooley Valley Mine northeast of Soda Springs, ID, and shipped the rock to the two-electric-furnace plant at Silver Bow, MT. The Wooley Valley Mine was projected to mine out about 1990.

Chevron Resources Co. deferred plans to expand its Vernal phosphate rock mine and planned fertilizer complex near Rock Springs, WY. The phosphate concentrates were shipped by truck to Phoston, UT.

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's electric furnaces west of Pocatello. Simplot obtained the balance of its phosphate rock requirement from the Woodall Peak Mine that was scheduled to close or reduce production in 1984. The Smokey Canyon Mine was scheduled to replace Woodall Peak in 1984.

Table 2.—Production of phosphate rock in the United States, by State

(Thousand metric tons and thousand dollars)

	Mine production		Mine production used directly		Beneficiated production		Marketable production		
	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content	Value
1982:									
Florida and North Carolina	98,045	11,988	4,362	1,304	27,357	8,594	31,724	9,897	820,849
Tennessee	1,597	324	--	--	897	229	897	229	11,596
Western States[1]	4,493	1,116	2,231	592	2,561	785	4,793	1,377	117,881
Total[2]	104,135	13,428	6,594	1,896	30,815	9,608	37,414	11,504	950,326
1983:									
Florida and North Carolina	117,192	15,077	2,388	717	33,572	10,495	35,960	11,212	842,926
Tennessee	2,217	898	--	--	1,193	307	1,193	307	28,879
Western States[1]	6,281	1,584	2,531	665	2,888	904	5,419	1,569	149,096
Total[2]	125,691	17,559	4,920	1,382	37,653	11,706	42,573	13,088	1,020,901

[1]Includes Alabama, Idaho, Montana, and Utah.
[2]Data may not add to totals shown because of independent rounding.

CONSUMPTION AND USES

Domestic consumption of marketable phosphate rock increased 21%, to near the 1981 level.

Trends in the percent distribution by grade of marketable phosphate rock consumed in the United States and sold in the export market tabulated in this report are somewhat disguised because of the mix of furnace and wet-process phosphoric acid-phosphate rock feed in the total distribution pattern.

Table 3.—U.S. phosphate rock grade distribution pattern

Grade (percent BPL[1] content)	Distribution (percent)				
	1979	1980	1981	1982	1983
Less than 60	5.4	5.3	5.6	4.9	8.0
60 to 66	14.2	15.7	15.7	15.6	14.6
66 to 70	56.3	56.7	60.1	63.8	60.6
70 to 72	13.6	12.7	9.6	5.8	8.3
72 to 74	6.6	6.0	6.0	6.1	5.5
Over 74	3.9	3.6	3.0	3.8	3.0

[1]1.0% BPL (bone phosphate of lime or tricalcium phosphate)=0.458% P_2O_5.

Table 4.—Florida and North Carolina phosphate rock grade distribution pattern

Grade (percent BPL[1] content)	Distribution (percent)				
	1979	1980	1981	1982	1983
Less than 60	0.2	0.1	0.2	0.6	3.3
60 to 66	12.6	15.3	14.4	12.2	13.0
66 to 70	62.4	62.2	67.0	68.5	64.2
70 to 72	12.7	11.2	7.7	6.9	9.6
72 to 74	7.6	7.0	7.1	7.2	6.4
Over 74	4.6	4.2	3.6	4.5	3.5

[1]1.0% BPL (bone phosphate of lime or tricalcium phosphate)=0.458% P_2O_5.

All of the rock produced in Tennessee was used in electric furnaces to produce elemental phosphorus and industrial chemicals. Most of the phosphorus was converted into intermediate phosphoric acid, the base for a large number of sodium, calcium, and potassium chemicals.

Table 5.—Tennessee phosphate rock grade distribution pattern

Grade (percent BPL[1] content)	Distribution (percent) 1979	1980	1981	1982	1983
Less than 60	60.3	75.3	50.6	38.0	89.4
60 to 66	37.0	24.7	49.4	62.0	10.6
66 to 70	2.7	--	--	--	--

[1]1.0% BPL (bone phosphate of lime or tricalcium phosphate)=0.458% P_2O_5.

Of marketable phosphate rock sold or used in the Western States, 82% was consumed in the United States, and 18% was exported to Canada.

Table 6.—Western States phosphate rock grade distribution pattern

Grade (percent BPL[1] content)	Distribution (percent) 1979	1980	1981	1982	1983
Less than 60	27.4	27.7	31.4	27.2	25.2
60 to 66	18.9	16.5	16.0	29.4	27.5
66 to 70	26.8	27.7	28.5	43.4	47.3
70 to 72	26.5	28.1	24.1	--	--
72 to 74	.4	--	--	--	--

[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	1982 Rock	1982 P_2O_5 content	1983 Rock	1983 P_2O_5 content
Domestic:[1]				
Wet-process phosphoric acid	24,223	7,423	30,354	9,275
Normal superphosphate	100	33	194	63
Triple superphosphate	876	280	677	213
Defluorinated rock	184	67	68	24
Direct applications	61	19	184	62
Elemental phosphorus	3,259	847	3,321	851
Ferrophosphorus	25	7	32	9
Total	[2]28,729	8,676	34,830	10,497
Exports[3]	9,842	3,138	12,010	3,839
Grand total	38,571	11,814	[2]46,839	14,336

[1]Includes rock converted to products and exported.
[2]Data do not add to total 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 State in 1983

(Thousand metric tons and thousand dollars)

Grade (percent BPL[1] content)	Florida and North Carolina Rock	Florida and North Carolina P_2O_5 content	Florida and North Carolina Value	Tennessee Rock	Tennessee P_2O_5 content	Tennessee Value
Below 60	1,335	339	35,965	1,061	271	26,007
60 to 66	5,239	1,514	131,138	126	36	2,928
66 to 70	25,792	7,988	566,209	--	--	--
70 to 72	3,870	1,261	96,081	--	--	--
72 to 74	2,586	868	66,179	--	--	--
Plus 74	1,401	485	48,937	--	--	--
Total[2]	40,223	12,456	944,509	1,187	307	28,935
	Western States Rock	Western States P_2O_5 content	Western States Value	Total United States Rock	Total United States P_2O_5 content	Total United States Value
Below 60	1,366	334	18,522	3,762	944	80,494
60 to 66	1,495	427	28,839	6,860	1,977	162,905
66 to 70	2,567	813	102,159	28,359	8,801	668,368
70 to 72	--	--	--	3,870	1,261	96,081
72 to 74	--	--	--	2,586	868	66,179
Plus 74	--	--	--	1,401	485	48,937
Total[2]	5,428	1,573	149,520	46,839	14,336	1,122,966

[1]1.0% BPL (bone phosphate of lime or tricalcium phosphate)=0.458% P_2O_5.
[2]Data may not add to totals shown because of independent rounding.

Table 9.—Phosphate rock sold or used by producers, by use and State

(Thousand metric tons)

Use	Florida and North Carolina		Tennessee		Western States		Total[1] United States	
	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content
1982:								
Domestic:[2]								
Agricultural	23,544	7,236	--	--	1,901	586	25,444	7,822
Industrial	106	32	960	248	2,219	575	3,284	854
Total	23,650	7,268	960	248	4,120	1,161	28,728	8,676
Exports[3]	9,156	2,924	--	--	687	214	9,842	3,138
Total[1]	32,806	10,192	960	248	4,807	1,375	38,571	11,814
1983:								
Domestic:[2]								
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[3]	11,045	3,538	--	--	964	301	12,010	3,839
Total[1]	40,223	12,456	1,187	307	5,428	1,573	46,839	14,336

[1]Data may not add to totals shown because of independent rounding.
[2]Includes rock converted to products and exported.
[3]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)	Average per ton
1979	45,459	14,189	$935,127	$20.57
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

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)	Average per ton
1979	2,140	545	$17,008	$7.95
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

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)	Average per ton
1979	5,439	1,585	$110,837	$20.38
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

STOCKS

Inventories of marketable phosphate rock are reported to the Bureau of Mines by producing companies on a monthly and semiannual basis. The monthly reports enable the Bureau to publish stock trends in its monthly Phosphate Rock Mineral Industry Surveys (MIS). The semiannual reports provide the data for stock levels reported in the annual MIS, crop year MIS, and the Minerals Yearbook.

An abrupt increase in stock levels had occurred when, in 1981, demand dropped and production was maintained. Inventories were returned to a more normal level in 1983 by closing mines for various lengths of time.

Table 13.—Marketable phosphate rock yearend stocks

(Million metric tons)

Year	Quantity
1974	5.8
1975	9.9
1976	15.2
1977	13.7
1978	15.7
1979	14.5
1980	13.8
1981	20.2
1982	18.3
1983	14.6

PRICES

Phosphate rock is sold under contracts negotiated between buyers and sellers. Although list prices have been published on occasion by the Florida Phosphate Rock Export Association, Tampa, FL, and the Moroccan Office Cherifien des Phosphates, Casablanca, Morocco, actual contract prices negotiated between buyers and sellers are not published.

The weighted average prices or values, f.o.b. mine, for each grade of phosphate rock and for each State are calculated by the Bureau of Mines from a semiannual survey of the producing mines.

Table 14.—Phosphate rock estimated export prices[1] per metric ton, unground, f.o.b. vessel Tampa Range or Jacksonville, FL

Grade (percent BPL[2] content)	1980[3]	1981[4]	1982[5]	1983[6]
75	$44.00	$43.00	$34.00	$35.00
72	40.00	36.00	27.00	30.00
70	36.00	30.50	23.50	28.00
68	34.00	30.00	23.00	27.00
66	34.00	NA	NA	NA

NA Not available.
[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 $1.54 severance tax.
[4]Estimated selling price including $1.84 severance tax.
[5]Estimated selling price including $2.03 severance tax.
[6]Estimated selling price including $2.25 severance tax.

Table 15.—Moroccan phosphate rock export prices, U.S. dollars per metric ton, f.a.s. Safi or Casablanca[e]

Grade (percent BPL[1] content)	1980	1981	1982	1983
Khouribga:				
76 to 77	56.00	58.00	50.00	45.00
75 to 76	54.00	--	--	--
72 to 73	52.00	--	--	--
70 to 71	48.50	52.00	42.00	35.00
Youssoufia:				
68 to 69	45.50	44.00	38.00	29.00
74 to 75	53.00	56.00	47.00	41.00

[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

(Dollars per metric ton, f.o.b. mine)

Grade (percent BPL[1] content)	1982 Domestic	1982 Export	1982 Average	1983 Domestic	1983 Export	1983 Average
Less than 60	28.58	--	28.58	35.28	34.70	34.92
60 to 66	29.23	26.60	28.40	25.59	25.59	25.59
66 to 70	23.25	28.33	24.15	27.12	23.93	24.83
70 to 72	31.59	29.54	30.61	21.33	25.91	21.95
72 to 74	29.74	29.69	20.70	24.97	25.19	25.03
Over 74	34.11	32.45	33.11	26.94	--	26.94
Average	24.78	28.92	25.93	22.64	25.70	23.48

[1]1.0% BPL (bone phosphate of lime or tricalcium phosphate)=0.458% P_2O_5.

Table 17.—Price or value of Western States phosphate rock

(Dollars per metric ton, f.o.b. mine)

Grade (percent BPL[1] content)	1982 Domestic	1982 Export	1982 Average	1983 Domestic	1983 Export	1983 Average
Less than 60	11.61	--	11.61	36.99	46.29	39.80
60 to 66	14.22	41.83	16.82	16.24	40.14	19.28
66 to 70	37.47	42.05	38.68	13.56	--	13.56
Average	22.05	42.00	24.90	23.76	45.07	27.54

[1]1.0% BPL (bone phosphate of lime or tricalcium phosphate)=0.458% P_2O_5.

Table 18.—Price or value of Tennessee phosphate rock

(Dollars per metric ton, f.o.b. mine)

Grade (percent BPL[1] content)	1982	1983
Less than 60	8.30	23.15
60 to 66	16.71	24.52
Average	13.51	24.37

[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

(Dollars per metric ton, f.o.b. mine)

Grade (percent BPL[1] content)	1982 Domestic	1982 Export	1982 Average	1983 Domestic	1983 Export	1983 Average
Less than 60	12.72	--	12.72	35.28	34.70	34.92
60 to 66	23.48	28.04	24.53	25.59	25.59	25.59
66 to 70	24.33	30.00	25.38	27.12	23.93	24.83
70 to 72	31.59	29.54	30.61	22.53	28.53	23.57
72 to 74	29.74	29.69	29.70	22.76	26.97	23.74
Over 74	34.11	32.45	33.11	21.40	--	21.40
Average	24.01	29.83	25.50	22.84	27.26	23.97

[1]1.0% BPL (bone phosphate of lime or tricalcium phosphate)=0.458% P_2O_5.

FOREIGN TRADE

The decline in phosphate rock exports since 1980 was reversed in 1983. The reversal was attributed to recovery from a world recession with improved demand from the agricultural sector of the world economy. World trade in phosphate rock was expected to recede as new phosphoric acid capacity under construction in African and Mideastern countries is placed in operation. Increased supplies of phosphoric acid were expected to replace phosphate rock in international trade.

The competitive position of the export-oriented Florida phosphate rock industry has weakened as the rail freight, loading, and weighing costs of moving phosphate rock from mine to vessel have more than doubled since 1975. The severance tax assessed by the State of Florida has also increased in recent years.

The quantities of phosphate rock imported into the United States in 1983, as reported by the Bureau of the Census, are shown in the following tabulation:

Country of origin	Metric tons
Israel	83
Mexico	15
Netherlands Antilles	8,559
South Africa, Republic of	39
Total	8,696

Table 20.—U.S. exports of phosphate rock, by country

(Thousand metric tons and thousand dollars)

Country	1982 Quantity	1982 Value[1]	1983 Quantity	1983 Value[1]
Australia	203	6,958	338	10,226
Austria	109	5,088	207	7,502
Belgium-Luxembourg	451	16,902	505	15,850
Brazil	85	3,466	--	--
Canada	2,334	91,847	2,762	101,305
Finland	120	5,038	106	3,520
France	672	24,627	843	26,384
Germany, Federal Republic of	596	22,916	770	24,262
India	256	9,678	305	14,755
Italy	115	4,083	224	6,766
Japan	1,132	49,724	1,528	63,110
Korea, Republic of	1,549	57,958	1,516	52,139
Mexico	396	20,106	370	11,109
Netherlands	672	23,833	974	27,915
New Zealand	79	2,811	90	3,492
Norway	15	633	46	1,951
Philippines	49	2,394	80	3,083
Poland	432	15,712	769	22,181
Romania	125	5,225	317	11,492
Sweden	102	4,108	159	6,117
Taiwan	42	1,803	29	1,022
United Kingdom	52	2,229	122	4,288
Other	148	6,415	137	4,892
Total	[2]9,735	383,554	12,197	423,361

[1]All values f.a.s. (free alongside ship).
[2]Data do not add to total shown because of independent rounding.

Source: U.S. 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	1982		1983	
	Quantity	Value[1]	Quantity	Value[1]
Argentina	10	1,472	6	830
Belgium-Luxembourg	52	6,958	34	4,291
Brazil	50	6,919	--	--
Bulgaria	86	11,264	90	10,612
Burma	30	4,627	--	--
Canada	50	6,953	89	14,607
Chile	35	5,120	96	11,956
China	48	6,198	281	35,175
Colombia	12	1,997	18	3,625
Costa Rica	7	948	8	1,214
Dominican Republic	6	1,117	9	1,736
France	32	1,933	30	4,037
Germany, Federal Republic of	99	13,388	100	13,830
Hungary	15	2,099	21	2,704
Indonesia	130	19,960	57	8,432
Ireland	16	2,150	23	2,887
Italy	--	--	7	955
Japan	31	5,092	30	4,081
Peru	12	1,780	12	1,566
Singapore	30	4,020	5	648
Uruguay	5	739	1	205
Venezuela	17	4,077	1	377
Other	340	48,451	276	40,902
Total	[2]1,112	157,262	1,194	164,670

[1]All values f.a.s. (free alongside ship).
[2]Data do not add to total shown because of independent rounding.

Source: U.S. Bureau of the Census.

Table 22.—U.S. exports of superphosphates, less than 40% P_2O_5, by country

Country	1982		1983	
	Quantity (metric tons)	Value[1] (thousands)	Quantity (metric tons)	Value[1] (thousands)
Canada	34,258	$738	65,838	$1,445
Other	2,110	140	2,772	62
Total	36,368	878	68,610	1,507

[1]All values f.a.s. (free alongside ship).

Source: U.S. Bureau of the Census.

Table 23.—U.S. exports of diammonium phosphates, by country

(Thousand metric tons and thousand dollars)

Country	1982		1983	
	Quantity	Value[1]	Quantity	Value[1]
Argentina	79	14,808	61	10,641
Australia	116	21,912	187	32,144
Bangladesh	42	8,449	100	18,106
Belgium-Luxembourg	418	65,025	679	114,214
Brazil	88	16,143	--	--
Canada	117	21,586	173	27,728
Chile	9	1,491	26	4,381
China	458	85,797	585	99,820
Colombia	52	9,816	47	8,127
Costa Rica	20	3,788	196	3,404
Dominican Republic	28	5,100	34	5,683
Ecuador	23	4,562	3	488
Ethiopia	45	8,346	22	3,826
France	31	6,127	61	10,908
Germany, Federal Republic of	36	6,231	32	5,869
Guatemala	2	304	225	4,316
India	182	34,549	141	24,560
Ireland	43	8,075	42	7,226
Italy	178	32,416	--	--
Japan	304	53,371	444	75,190
Mexico	238	45,279	185	31,885
Netherlands	72	13,281	--	--
New Zealand	36	6,489	56	9,646
Nicaragua	13	2,470	149	2,580
Pakistan	319	62,206	328	62,788
Spain	24	4,367	122	18,731
Thailand	45	8,386	46	7,684
Turkey	--	--	60	9,812
Uruguay	36	6,371	13	2,244
Yugoslavia	94	18,167	66	11,666
Other	558	103,772	675	115,566
Total[2]	3,707	678,685	4,758	729,233

[1]All values f.a.s. (free alongside ship).
[2]Data may not add to totals shown because of independent rounding.

Source: U.S. 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	1982		1983	
	Quantity	Value[1]	Quantity	Value[1]
Brazil	47	9,897	--	--
Canada	1	165	1	124
Colombia	10	2,534	6	1,162
Germany, Federal Republic of	--	--	7	1,827
India	264	55,889	154	30,203
Indonesia	64	18,620	109	28,368
Mexico	60	10,857	(2)	2
Turkey	29	7,209	54	13,459
U.S.S.R	--	--	9	2,925
Venezuela	55	12,575	37	6,865
Other	(2)	38	(2)	44
Total	530	[3]117,785	377	84,979

[1]All values f.a.s. (free alongside ship).
[2]Less than 1/2 unit.
[3]Data do not add to total shown because of independent rounding.

Source: U.S. 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	1982		1983	
	Quantity	Value[1]	Quantity	Value[1]
Brazil	14	4,079	--	--
Canada	42	9,038	39	8,680
U.S.S.R	808	268,485	730	214,810
Other	29	7,694	73	13,677
Total	893	289,296	842	237,167

[1]All values f.a.s. (free alongside ship).

Source: U.S. Bureau of the Census.

Table 26.—U.S. exports of elemental phosphorus, by country

Country	1982 Quantity (metric tons)	1982 Value[1] (thousands)	1983 Quantity (metric tons)	1983 Value[1] (thousands)
Argentina	20	$38	(2)	$2
Belgium	186	291	17	53
Brazil	5,749	10,153	7,438	13,347
Canada	1,125	1,315	1,264	1,441
China	--	--	3,000	3,798
Japan	6,855	11,167	8,985	13,926
Korea, Republic of	543	730	761	1,051
Mexico	236	396	22	47
Taiwan	175	299	168	232
Other	195	736	97	219
Total	15,084	25,125	21,752	34,116

[1]All values f.a.s. (free alongside ship).
[2]Less than 1/2 unit.

Source: U.S. Bureau of the Census.

Table 27.—U.S. imports for consumption of phosphate rock and phosphatic materials

(Thousand metric tons and thousand dollars)

Fertilizer	1982 Quantity	1982 Value[1]	1983 Quantity	1983 Value[1]
Phosphates, crude and apatite	(2)	1,302	9	376
Phosphatic fertilizers and fertilizer materials	8	1,672	36	3,622
Dicalcium phosphate	(2)	353	(2)	676
Phosphorus	(2)	1,017	2	3,410
Phosphoric acid	5	1,684	9	2,930
Phosphoric acid, fertilizer grade	14	1,143	(2)	686
Normal superphosphate	11	2,198	2	277
Triple superphosphate	11	1,434	9	1,272

[1]Declared customs valuation.
[2]Less than 1/2 unit.

Source: U.S. Bureau of the Census.

WORLD REVIEW

World phosphate rock production increased by approximately 10% to an estimated 135 million tons. The increase was attributed to an improved world economy and, in the United States, to the impact of Government programs and inclement weather that reduced grain inventories and restored incentives to use fertilizers in the 1983 crop year.

In the United States, the phosphate mining industry deferred plans to increase phosphate rock capacity because the industry could not justify committing large amounts of high-cost capital to marginally profitable phosphate mines and because of problems in obtaining permits.

A number of less developed countries (LDC) played an important role in world supply and demand for phosphate rock and phosphate fertilizer. The LDC were expanding phosphate rock mines and constructing phosphoric acid plants as rapidly as possible to permit them to export high-value phosphate intermediates and finished fertilizer. Much of the expansion in LDC with phosphate rock resources was subsidized by the LDC governments with loans from the International Monetary Fund and other world financial organizations. The expansions were frequently begun without an adequate assessment of the economics of production, the impact on world markets, and the continuing problem of oversupply of phosphate rock in the world.

Algeria.—The Société Nationale de Recherches et d'Exploitations Minières produced phosphate rock from the Djebel Onk Mine, the only mine operating in Algeria since the Kouif Mine was closed. The capacity of the Djebel Onk Mine was about 0.5 million tons per year of 34% to 35% P_2O_5 calcined-washed-dried phosphate rock and 1.8 million tons per year of 29% P_2O_5 phosphate rock.

Australia.—B. H. South Ltd. closed the Duchess Mine at yearend 1982 because it could not reach an agreement with Australian fertilizer producers on phosphate rock prices in 1982-83. The company continued to ship from inventory in early 1983. In addition, a small quantity of phosphate rock was produced in South Australia. However, this rock was unsuitable for superphosphate manufacture because of its high iron and aluminum content and was used locally for direct application to the soil.

An apatite-bearing carbonatite deposit, discovered several years ago near Laverton, Western Australia, was being evaluated.

Brazil.—Phosphate rock was produced from mines at Araxa (Arafértil), Araxa (Arafértil/Camig), Catalao (Fosfago), Catalao (Goíasfertil), Cerrado, Jacupiranga (Serrana), Patos de Minas (Fosfértil), and Tapira (Fosfértil). Total mine capacity in 1983 was about 4 million tons. Phosphoric acid capacity was Copebras, 100,000 tons P_2O_5; Fosfértil, 296,100; ICC, 118,800; Quimbrasil, 65,700; and Ultrafértil, 79,860. The total capacity of 660,000 tons P_2O_5 per year made Brazil self-sufficient in 1983.

China.—About two-thirds of the country's production was believed to come from relatively small mines in Yunnan, Guizhou, Sichuan, Hubei, and Shandong Provinces. The balance was obtained from small, local mines and was ground for direct application or used to manufacture single superphosphate. The principal mines were Kunyang, 38 kilometers south-southwest of Kunming City; Xiangfen, 58 kilometers northeast of Kunming; and Haikow, 35 kilometers southwest of Kunming City.

Christmas Island.—Phosphate ore mined on this island was classified, in order of decreasing quality, as A, B, or C grade depending on the phosphate, iron, and aluminum content. When all three grades are present in a mining location, C grade, the overburden fraction, overlies B grade, which in turn overlies A grade. Estimates of ore reserves were 9, 50, and 145 million tons of A, B, and C grades, respectively. Based on minable reserves and projected sales patterns, the mining operation was projected to continue 13 to 14 years.

Egypt.—Phosphate rock mine capacity was about 700,000 tons per year based on mining operations near Sebaiya, south of Luxor. A new Hamrawein Mine, 30 kilometers north of Quseir, became operational in 1983. Another new mine being developed at Abu Sheigela was scheduled to operate in 1985 to replace the mines at Safaga and Quseir. Of immediate interest, however, was the expansion of the Sebaiya West Mines from 120,000 to 440,000 tons per year in 1983. Only limited progress was made on developing the Abu Tartur phosphate project in the Western Desert where an experimental mine has been operating since 1980.

Iraq.—Because the Iraqi-Iranian war closed the seaport of Khor-al-Zuber, it was not certain if the Iraqis were able to export production from their mining or chemical complexes in 1983.

Israel.—Negev Phosphates Ltd. responded to the recession in phosphate markets by stopping production of calcined phosphates at Oron. It was the intent at Oron to produce a washed phosphate concentrate comparable to the Nahal Zin Mines' low-chloride, 70% to 72% bone phosphate of lime phosphate rock. The Arad Mine was developed as a replacement for the closed Makhtesh Mine. The estimated phosphate mining capacity at Arad of 3.5 million tons per year was expected to remain at this level for the next several years.

Jordan.—Deliveries of domestic rock were made to the new phosphoric acid fertilizer plants at Aqaba. The 413,000-ton-per-year P_2O_5 phosphoric acid plant could consume 1.3 million tons per year of high-grade phosphate rock. The El Hassa-El Abyad Mines had a capacity of 5.2 million tons per year. It was not clear, given 1983 phosphate rock markets and prices, when the Jordan Phosphate Mines Co. would develop the Esh Shidiya deposit. Initial planning called for a mine startup in 1986, which might be deferred pending an improvement in world demand.

Mexico.—Production of phosphate rock from mines in the Sierra Madre Range has ranged from 0.15 to 0.30 million tons per year, and the product has been used domestically or shipped in small tonnages to the United States for animal feed supplements. The Mexican Government decided to develop the San Juan de la Costa deposits, and some production was achieved in 1981. Capacity was 0.25 million tons in 1982 and about 0.7 million tons in 1983. The deposit on the Gulf of California was mined by both open pit bench and underground room-and-pillar techniques. Dried rock was shipped to fertilizer plants at Guadalajara and Coatzacoalcos. The Santo Domingo phosphates are low-grade beach sands on the Pacific Coast. It had been planned to start this mine in 1982 or 1983; however, financial problems delayed completion of the mine and beneficiation plant.

Morocco.—The most recent significant event in the Moroccan phosphate industry was the start of construction of the massive chemical complex and port at Jorf Lasfar. Phosphate rock conversion capacity was scheduled to increase from 1 million tons P_2O_5 per year in 1981 to 1.5 million tons in 1985. As this capacity becomes available, larger tonnages of phosphate rock were expected to be consumed domestically to produce phosphate intermediates and finished phosphate fertilizers for export. Phosphate rock was mined from both underground and open pit mines in the Khouribga District, from Ben Guerir, from black and white phosphate rock deposits at Youssoufia, and from Bu-Craa in the Western Sahara. Total phosphate rock capacity in 1983 was about 24 million tons.

Senegal.—Phosphate rock continued to be mined by Compagnie Senegalaise des Phosphates de Taiba at its Keur Mor Fall pit, an extension of the Taiba deposit. Société Senegalaise des Phosphates de Thies continued to produce aluminum phosphates from the Thies deposit. Capacity was 0.6 million tons per year. Although only 50,000 tons per year of phosphate rock has been converted into fertilizers in Senegal, a new phosphoric acid plant was under construction at Taiba. A 280,000-ton-per-year P_2O_5 phosphoric acid plant and also ammonium phosphate and triple superphosphate plants were under construction at M'bao.

South Africa, Republic of.—The principal phosphate mine in the Republic of South Africa was at Phalaborwa, Transvaal Province. Palabora Mining Co. Ltd. (PMC) mined a foskorite-carbonatite pipe to recover copper, magnetite, and zirconium oxide. PMC delivered to the Phosphate Development Corp. Ltd. (Foskor) the foskorite portion of the mined ore and the apatite-bearing tailings from copper ore concentration. Foskor had the capacity to produce 3 million to 3.2 million tons per year of plus 36% P_2O_5 concentrates from (1) pyroxenite ore, (2) foskorite mined by PMC, and (3) copper sulfide flotation tailings. Most of the phosphate rock produced was converted into phosphoric acid at Richards Bay.

Togo.—Phosphate rock was produced from the Hahotoe-K'pogame Mines with a 1983 phosphate rock capacity of 3.2 million tons per year. The ore was shipped to a beneficiation plant at the Port of K'peme where it was washed with seawater, screened, cycloned, and washed with freshwater. The phosphate rock was dried for export. A wet-process phosphoric acid plant at K'peme was planned, and the potential exists to recover additional product from the beneficiation plant tailings.

Tunisia.—Most of Tunisia's phosphate rock production was in the Gafsa Basin where the mine of Kef Eschafaier and the beneficiation plants at Metlaoui, M'Dilla, Moulares, M'Rata, Redeyef, Sehib, and Sector 100 had a total capacity of 6.1 million tons per year. The Kalaa Djerda Mine in the North Basin produced about 0.3 million tons per year. Gradual development of the Jellabia, Kef Eddour, and Oum el Kecheb Mines in the Gafsa Basin was scheduled for the balance of the 1980's.

U.S.S.R.—The U.S.S.R., the world's second largest producer of phosphate rock, produced from mines in European Russia and Kazakhstan. The estimated total capacity was 30 million tons per year. European Russia apatite mines, Kirov, Yukspov, Rasvumchov, Tsentralny, Koashva, and Niorpakh on the Kola Peninsula, accounted for about 60% of the U.S.S.R. production. Eastern European sedimentary phosphate deposits mined at Kingisepp and Maardu together had a capacity of about 2 million tons per year of phosphate rock concentrates. Additional mines in European Russia, with combined capacity of as much as 3.5 million tons per year, produced phosphate rock for direct application. In Kazakhstan, phosphate rock was mined in the Kara Tau foothills. The capacity of the mines was estimated to be about 6 million tons per year. The phosphate rock was smelted in electric furnaces, and the elemental phosphorus product was converted into phosphoric acid, feed phosphates, and other chemicals. In northern Kazakhstan, near Aktyubinsk, the Chilisaisk Mine was being developed to produce 1.5 million tons per year of concentrates. In Siberia, a phosphate rock mine under construction at Oshurkov, on Lake Baikal, was scheduled to produce 1.5 million tons per year when completed.

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				
	1979	1980	1981	1982[p]	1983[e]	1979	1980	1981	1982[p]	1983[e]
Phosphate rock:										
Algeria	1,084	1,025	916	947	893	337	317	262	289	272
Australia	[r]8	7	22	235	21	2	2	6	73	1
Brazil[3]	1,628	2,612	3,238	2,732	3,208	603	989	979	1,141	1,300
China[e]	8,517	10,726	11,500	[r]11,720	12,500	1,874	2,360	2,530	[r]2,580	2,750
Christmas Island (Indian Ocean)	1,367	1,713	1,423	1,328	[4]1,094	491	602	499	466	384
Colombia	6	[r]6	7	7	18	2	1	4	4	7
Egypt	645	658	720	711	647	182	184	203	200	205
Finland	3	138	201	233	381	1	50	72	83	83
France	12	14	12	11	10	1	1	1	1	1
India	681	541	562	560	600	210	167	173	173	185
Indonesia	5	11	8	5	6	2	4	3	2	2
Iraq	--	--	[e]50	363	1,199	--	--	--	81	80
Israel	2,086	2,307	1,919	2,148	2,969	678	750	624	698	1,179
Jordan	2,825	3,911	4,244	4,390	4,749	[r]918	[r]1,271	1,379	1,427	1,440
Kiribati	420	--	--	--	--	160	--	--	--	--
Korea, North[e]	500	500	500	500	500	150	150	150	150	150
Mexico	274	397	503	653	700	82	119	150	195	210
Morocco[5]	20,032	18,824	18,562	17,754	20,106	[e]6,210	[e]5,835	[e]5,958	[e]5,700	6,455
Nauru	1,828	2,087	1,480	1,359	1,684	704	803	570	523	650
Netherlands Antilles	49	--	--	--	--	15	--	--	--	--
Peru	5	14	98	29	3	2	4	30	9	1
Philippines	2	17	8	6	10	([6])	4	2	2	3
Senegal[7]	1,835	1,632	1,699	975	1,249	[e]562	[e]497	[e]518	[e]352	436
South Africa, Republic of	3,221	3,185	2,718	3,173	2,742	[e]1,171	[e]1,147	[e]942	[e]1,149	1,044
Sri Lanka	[r]9	[r]5	15	[e]20	16	[r]2	[r]1	4	7	6
Sweden	58	88	124	131	107	23	34	48	50	50
Syria	1,272	1,319	1,321	1,455	1,229	356	402	402	443	375
Thailand	5	6	6	4	4	2	2	1	1	1
Togo	2,920	2,933	2,215	2,128	2,081	1,056	1,061	806	775	758
Tunisia	4,154	4,582	4,596	4,196	5,924	1,164	1,283	1,287	1,213	1,700
Turkey	27	21	43	[8]35	50	6	[r]6	11	9	5
Uganda[e]	--	--	--	([6])	([6])	--	--	--	([6])	([6])
U.S.S.R.[e]	24,400	25,300	25,600	[r]26,700	27,000	8,400	8,800	8,900	[r]9,300	9,400
United States	51,611	54,415	53,624	37,414	[4]42,573	15,843	16,711	16,365	11,504	13,088
Vietnam[e]	[r]200	[r]90	[r]110	[r]160	220	[r]70	[r]32	[r]39	[r]56	77
Zimbabwe	136	130	125	120	133	48	45	44	42	42
Total[9]	[r]131,825	[r]139,214	138,169	122,202	135,000	[r]41,327	[r]43,634	42,962	38,698	42,000

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				
	1979	1980	1981	1982[p]	1983[e]	1979	1980	1981	1982[p]	1983[e]
Basic (Thomas) slag:										
Argentina	7	4	1	1	1	1	1	([6])	([6])	([6])
Belgium	1,052	893	496	393	400	189	161	89	71	72
Egypt	9	10	[e]10	10	10	2	2	[e]2	[e]2	2
France	2,072	[r]1,862	1,451	1,343	1,300	373	[r]335	261	242	216
Germany, Federal Republic of	[r]1,099	[r]1,103	824	502	550	145	162	138	135	135
Luxembourg	[r]730	[r]688	595	572	500	114	122	106	85	90
United Kingdom	13	([6])	4	4	4	2	([6])	1	1	1
Total[9]	[r]4,982	[r]4,560	3,381	2,825	2,800	826	[r]783	597	536	500
Guano:										
Chile	--	--	1	1	1	--	--	([6])	([6])	([6])
Kenya	--	--	--	500	500	--	--	--	([6])	([6])
Philippines	3	25	2	15	3	1	5	([6])	3	1
Seychelles Islands (exports)	7	4	[e]5	[e]5	5	2	1	2	2	2
Total[9]	10	29	8	521	500	3	6	2	5	3

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

[1]Data for major phosphate rock producing countries obtained in part from the International Fertilizer Industry Association; other figures are from official country sources where available. Table includes data available through Apr. 4, 1984.

[2]In addition to the countries listed, Belgium and Tanzania 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]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 metric tons: 1979—39; 1980—50; 1981—53; 1982—45 (estimated); and 1983-55 (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.

[4]Reported figure.

[5]Production from Western Sahara area included with Morocco.

[6]Less than 1/2 unit.

[7]Includes aluminum phosphate as follows, in thousand metric tons: 1979—184; 1980—224; 1981—200; 1982—200 (estimated); and 1983—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.

[8]Run-of-mine ore.

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

TECHNOLOGY

Domestic and world studies of phosphate rock reserves and resources were made by the Bureau of Mines. Published in 1983 were Information Circular (IC) 8937, Phosphate Rock Availability—Domestic,[3] and IC 8926, Minerals Availability Commodity Directory on Phosphates.[4] IC 8926 includes nonconfidential information from the Phosphate Minerals Availability Program data base, covering 148 domestic and 103 foreign phosphate deposits and properties. The abstracts on each deposit or property include data on location, published reserves and resources, geology, mine and beneficiation systems, and operating information.

A publication, New Developments in Hydraulic Borehole Mining of Phosphates, concluded that air borehole mining invited cavity roof failure whereas submerged mining was feasible if the cutting water jet was air shielded.[5] Additional field trials by interested corporations were deferred until the industry recovers from the recent recession.

IC 8914, The Florida Phosphate Industry's Technological and Environmental Problems, A Review, describes the technological ability of the industry to comply with environmental regulations and management of the clay fraction separated during the beneficiation of phosphate ores.[6] Other issues of concern to the industry and reviewed in this circular are environmental-based restrictions and regulations that involve mining and reclamation of wetlands, reclamation of disturbed mined land, and water consumed in mining and beneficiating phosphate rock.

IC 8932 reviews the costs and effects of environmental protection controls regulating U.S. phosphate rock mining in 1983.[7]

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[1]Physical scientist, Division of Industrial Minerals.

[2]Balazik, R. F. Environmental Laws and Regulations. Ch. 2 in Costs and Effects of Environmental Protection Controls Regulating U.S. Phosphate Rock Mining. BuMines IC 8932, 1983, pp. 10-20.

[3]Fantel, D. E., D. E. Sullivan, and G. R. Peterson. Phosphate Rock Availability—Domestic. BuMines IC 8937, 1983, 57 pp.

[4]Spangenberg, D. R., E. F. Carey, and P. M. Takosky. Minerals Availability Commodity Directory on Phosphates. BuMines IC 8926, 1983, 678 pp.

[5]Savanick, G. A. New Developments in Hydraulic Borehole Mining of Phosphates. Paper in Phosphates: What Prospects for Growth? (Ind. Miner. Conf., Orlando, FL, Dec. 11-14, 1983). Ind. Miner., London, 1984, pp. 57-67.

[6]Staff, Bureau of Mines, Tuscaloosa Research Center. The Florida Phosphate Industry's Technological and Environmental Problems, A Review. BuMines IC 8914, 1983, 42 pp.

[7]Balazik, R. F. Costs and Effects of Environmental Protection Controls Regulating U.S. Phosphate Rock Mining. BuMines IC 8932, 1983, 37 pp.

Platinum-Group Metals

By J. Roger Loebenstein[1]

World mine production of platinum and palladium remained essentially unchanged in 1983 at 2.6 million troy ounces and 3.2 million ounces, respectively. Demand for platinum in market economy countries decreased from 2.2 million ounces to 2.1 million ounces, while demand for palladium in these countries increased from 2.6 million ounces to 2.9 million ounces.

The Republic of South Africa remained the leading producer of platinum, and the U.S.S.R. remained the leading producer of palladium.

Domestic Data Coverage.—Domestic production data for the platinum-group metals (PGM) are developed by the Bureau of Mines from a voluntary survey of U.S. refiners. Of the 46 operations to which a survey request was sent, 63% responded, representing an estimated 96% of the total

Table 1.—Salient platinum-group metals[1] statistics

(Thousand troy ounces unless otherwise specified)

	1979	1980	1981	1982	1983
United States:					
Mine production[2]	7	3	7	8	6
Value ... thousand dollars	$1,288	$923	$1,571	$1,278	$1,133
Refinery production:					
Primary refined	9	3	7	9	9
Secondary:					
Nontoll-refined	309	331	392	[r]344	287
Toll-refined	1,090	1,079	1,191	868	995
Total refined metal	1,408	1,413	1,590	[r]1,221	1,291
Stocks, yearend:					
Industry (refined)	761	973	918	1,107	943
National Defense Stockpile:					
Platinum	453	453	453	453	453
Palladium	1,255	1,255	1,255	1,255	1,255
Iridium[3]	17	17	17	21	25
Exports:					
Refined[4]	710	592	651	439	446
Total	900	765	863	[r]836	1,229
Imports for consumption:					
Refined[4]	3,303	3,109	2,611	2,150	2,790
Total	3,479	3,502	2,850	2,494	3,218
Imports, general	5,682	3,772	3,191	2,494	3,218
Consumption (reported sales to industry)	2,756	2,206	1,921	[r]1,873	1,914
Consumption, apparent[5]	3,011	2,639	2,413	1,872	2,800
Net import reliance[6] as a percent of apparent consumption	89	87	83	81	89
Price, producer, average, per ounce:					
Platinum	$352	$439	$475	$475	$475
Palladium	$113	$214	$130	$110	$130
World: Mine production	6,487	[r]6,848	6,931	[p]6,431	[e]6,482

[e]Estimated. [p]Preliminary. [r]Revised.
[1]The platinum group comprises six metals: Platinum, palladium, iridium, osmium, rhodium, and ruthenium.
[2]Byproduct of copper refining.
[3]Excludes 2,400 troy ounces purchased in 1983, but not yet added to inventory.
[4]Includes both unwrought and semimanufactured.
[5]Nontoll-refined production plus refined imports for consumption minus refined exports plus or minus changes in Government and industry stocks.
[6]Imports for consumption minus exports plus or minus changes in Government and industry stocks.

refined metal production shown in tables 1, 2, and 9. Production of refined metal for the 17 nonrespondents was estimated using reported prior year production levels.

Legislation and Government Programs.—The General Services Administration purchased grade B (99.8% minimum) iridium for the National Defense Stockpile. Purchases totaled 4,200 ounces.

The Federal Government sets the exhaust emission standards for U.S. automobiles and trucks. Currently, the technology for meeting these standards requires the use of PGM catalysts. The Environmental Protection Agency emission standards for light-duty trucks (8,500 pounds or less) for the 1983 model year were established at 1.7 grams per mile (gpm) hydrocarbons and 18.0 gpm carbon monoxide. For the 1984 model year, the standards were lowered to 1.0 gpm hydrocarbons and 14.0 gpm carbon monoxide. Heavy-duty trucks (8,500 pounds or more) were required to meet a 1.5-gpm hydrocarbon standard for both 1983 and 1984, while the carbon monoxide standard was eased from 15.5 gpm in 1983 to 24.8 gpm in 1984.[2]

DOMESTIC PRODUCTION

U.S. Metals Refining Co., ASARCO Incorporated, and Kennecott produced platinum and palladium as a byproduct of copper refining. Secondary metal was refined by about 30 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 Engelhard Minerals and Chemicals Corp., Johnson Matthey Inc., and U.S. Metals.

Mid-States Recycling Inc., Chicago, IL, was established in early 1983 as the successor to the liquidated Simmons Refining Co. Mid-States refined all types of precious metals scrap.[3]

Also early in the year, Leytess Metal and Chemical Corp., New York, NY; Platina Laboratories Inc., South Plainfield, NJ; and Gemini Industries Inc., Santa Ana, CA, announced an agreement to cooperate in precious metals marketing, manufacturing, and refining.[4]

Refinemet International Co. of Woonsocket, RI, sold all of its refining and fabricating plants, reportedly to provide the company with the funds needed to concentrate its efforts entirely on trading in precious metals.[5]

Eastern Smelting and Refining Corp. of Lynn, MA, completed the construction of a new precious metals assay laboratory.[6]

Stillwater PGM Resources, a joint venture between Manville International Corp. and Chevron USA Inc., formed a joint venture with Anaconda Minerals Co. to explore and evaluate the Stillwater Complex in Montana.[7]

Table 2.—Platinum-group metals refined in the United States

(Troy ounces)

Year	Platinum	Palladium	Iridium	Osmium	Rhodium	Ruthenium	Total
PRIMARY METAL							
Nontoll-refined:							
1979	1,980	6,412	--	--	--	--	8,392
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
Toll-refined:							
1979	56	420	--	--	--	--	476
1980	128	673	--	--	--	--	801
1981	235	934	--	--	--	--	1,169
1982	434	1,421	--	--	--	--	1,855
1983	1,150	2,026	--	--	--	--	3,176
SECONDARY METAL							
Nontoll-refined:							
1979	75,038	220,639	1,647	--	7,964	3,734	309,022
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	r190,249	r139,286	2,896	--	11,302	427	r344,160
1983	118,579	160,854	3,303	--	3,663	750	287,149

See footnote at end of table.

Table 2.—Platinum-group metals refined in the United States —Continued

(Troy ounces)

Year	Platinum	Palladium	Iridium	Osmium	Rhodium	Ruthenium	Total
SECONDARY METAL — Continued							
Toll-refined:							
1979	585,932	446,189	5,487	--	38,875	13,719	1,090,202
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
1982 TOTALS							
Total primary	1,381	7,552	--	--	--	--	8,933
Total secondary	r584,081	r569,850	13,004	885	37,995	6,728	r1,212,543
Grand total	r585,462	r577,402	13,004	885	37,995	6,728	r1,221,476
1983 TOTALS							
Total primary	2,029	7,031	--	--	--	--	9,060
Total secondary	552,279	617,586	9,123	925	45,287	56,538	1,281,738
Grand total	554,308	624,617	9,123	925	45,287	56,538	1,290,798

rRevised.

CONSUMPTION AND USES

The principal domestic uses of PGM were in catalysts to control automobile exhaust emissions; in reforming catalysts to upgrade the octane rating of gasolines; in catalysts to produce acids and organic chemicals; in electrical contacts, capacitors, and electronic coatings; in bushings for glass fiber manufacture; and in dental alloys.

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
1979	1,408,925	1,132,621	17,301	974	83,470	112,730	2,756,021
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:							
Automotive	477,774	118,445	23	--	26,323	--	622,565
Chemical	63,601	128,778	981	332	6,873	63,600	264,165
Dental and medical	22,806	310,754	103	1,026	7	226	334,922
Electrical	89,994	312,372	5,450	--	9,392	21,178	438,386
Glass	20,595	213	2	--	2,005	--	22,815
Jewelry and decorative	15,995	7,866	1,059	--	3,372	361	28,653
Petroleum	21,576	20,845	892	--	4	--	43,317
Miscellaneous	67,805	27,031	2,090	--	1,939	r19,565	r118,430
Total	780,146	926,304	10,600	1,358	49,915	r104,930	r1,873,253
1983:							
Automotive	508,499	172,050	43	--	19,734	--	700,326
Chemical	65,369	39,892	590	356	3,984	54,969	165,160
Dental and medical	16,745	343,517	134	1,033	173	237	361,839
Electrical	74,721	250,047	1,014	--	8,472	71,251	405,505
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	796,722	921,815	5,021	1,389	44,225	144,780	1,913,952

rRevised.

[1]Comprises primary and nontoll-refined secondary metals.

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
1979	305,605	323,865	18,303	1,487	49,678	62,344	761,282
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	433,417	412,140	16,945	489	51,114	28,972	943,077

[1]Includes metal in depositories of the New York Mercantile Exchange (NYMEX); on Dec. 30, 1983, this comprised 235,300 troy ounces of platinum and 79,100 troy ounces of palladium.

PRICES

Dealer prices for both platinum and palladium increased substantially, while other PGM dealer prices changed only slightly.

Beginning in January, the U.S.S.R. changed its pricing contract terms for palladium. The new terms called for about 75% of its metal to be sold to U.S. dealers based on monthly prices of the New York Mercantile Exchange (NYMEX), and the remainder to be sold at market economy prices. The latter purchase was optional for each dealer. Previously, the U.S.S.R. used annual contracts where one price was set for all metal shipments.[8]

Rustenburg Platinum Holdings Ltd. of the Republic of South Africa decided early in the year to begin selling over 60% of its metal at market economy prices and the remainder at producer prices to long-term industrial customers. Previously, Rustenburg Platinum officially sold all of its output at producer prices through its exclusive sales agent, Johnson Matthey PLC. Reportedly, the decision was made to increase Rustenburg Platinum's market competitiveness.[9] The other major PGM producer, Impala Platinum Holdings Ltd., continued quoting its producer prices for all customers.

Producers, dealers, consumers, and investors of PGM increased trading activity in futures contracts on the NYMEX. Futures trading allowed businesses to protect themselves against damaging price fluctuations in metal prices by "hedging," and allowed investors a chance to earn a profit and, at the same time, contribute to market liquidity. Some dealers based their prices on the prices of NYMEX futures contracts. Volume of trading in futures contracts for 1982 and 1983 is shown in the following tabulation:

	Platinum[1]	Palladium[2]
1981	490,493	62,217
1982	669,024	63,829
1983	1,053,282	241,224

[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
1979	352	445	113	120	733	770	257	280	45	32	150	130
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

[1]Average prices calculated at the low end of the ranges of weekly averages rounded to the nearest dollar.

Source: Metals Week.

FOREIGN TRADE

Imports of platinum and palladium from major source countries are shown in table 8. The figures include estimates of the metal content of the PGM in the following categories: unspecified combinations, ores, sweepings and scrap, and materials not elsewhere specified.

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)
1979	13,921	175,297	188,185	214,558	258,827	19,647	29,163	899,598	$202,157
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	r8,870	388,437	125,581	167,397	84,832	50,224	10,535	r835,876	r182,460
1983:									
Australia	--	80	12	45	752	--	196	1,085	238
Belgium-Luxembourg	8,444	107,141	42	292	1,869	--	--	117,788	25,517
Canada	924	47,681	2,433	9,794	19,055	2,350	671	82,908	26,187
China	--	145	--	--	2,928	--	--	3,073	202
Cyprus	--	--	--	634	--	--	--	634	43
France	--	415	362	2,161	658	4	1,189	4,789	836
Germany, Federal Republic of	576	24,593	25,586	15,176	502	1,022	3,536	70,991	20,090
Greece	--	--	--	1,738	855	15	5	2,613	348
Hong Kong	--	--	300	666	323	--	--	1,289	361
Israel	--	--	--	176	793	--	--	969	187
Italy	--	72,661	877	1,388	2,460	2	32	77,420	24,420
Jamaica	--	--	--	1,000	--	--	--	1,000	149
Japan	4,977	2,141	80,088	47,104	13,080	24,585	4,922	176,897	55,598
Korea, Republic of	--	--	146	1,112	54	7	318	1,637	249
Mexico	10	114	104	--	83	88	122	521	220
Netherlands	539	228	3,313	8,649	3,367	1,584	15,179	32,859	5,245
Poland	--	--	--	--	650	--	--	650	16
Saudi Arabia	--	--	10,080	356	35	--	--	10,471	111
Singapore	--	39	--	--	503	--	203	745	130
South Africa, Republic of	--	--	400	7,833	144	5	--	8,382	1,302
Spain	300	385	--	343	424	--	--	1,452	283
Sweden	--	38,576	--	813	4,101	--	95	43,585	6,550
Switzerland	1,887	461	9,380	542	11,795	15,717	2	39,784	14,181
Taiwan	--	--	30	3,325	754	--	2,115	6,224	1,111
U.S.S.R	--	--	--	--	--	--	2,464	2,464	773
United Kingdom	14,103	456,448	5,441	51,301	4,089	128	2,902	534,412	124,547
Other	67	32	334	1,159	2,015	164	341	4,112	1,023
Total	31,827	751,140	138,928	155,607	71,289	45,671	34,292	1,228,754	309,917

rRevised.

Table 7.—U.S. imports for consumption of platinum-group metals, by year and country

Year and country	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
	Unwrought (troy ounces)										
1979	8,232	1,352,054	1,435,808	33,166	300	7,125	104,337	124,887	85,115	11,100	156,674
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:											
Australia	--	32	--	--	--	--	--	--	--	--	20,218
Belgium-Luxembourg	--	41,844	135,481	--	--	--	2,700	--	--	--	27,298
Canada	41	29,428	32,643	146	--	--	856	--	47	2,137	160,661
China	--	2,219	1,481	336	--	--	--	--	2,926	--	--
Colombia	--	2,463	--	--	--	--	112	4,535	--	--	225
Costa Rica	--	--	--	--	--	--	--	--	--	--	3,578
Finland	--	--	--	--	--	--	--	--	--	--	2,671
Germany, Federal Republic of	1,340	24,856	32,057	4,756	345	--	559	3,363	--	--	7,830
Hong Kong	--	400	--	--	--	--	--	--	--	--	455
Italy	1,591	42,300	9,560	--	--	--	10	--	--	--	2
Japan	--	4,580	1,030	--	--	--	--	--	--	--	--
Korea, Republic of	--	--	--	--	--	--	--	--	--	--	892
Mexico	--	--	248	--	--	--	--	--	--	--	78,045
Netherlands	--	1,120	32,768	200	--	--	158	500	--	--	--
Norway	--	2,627	7,000	100	--	--	454	2,500	--	--	4,651
Singapore	--	--	--	--	--	--	--	--	--	--	5,241
South Africa, Republic of	--	616,637	401,164	8,982	128	848	84,029	87,785	6,666	--	5,294
Spain	--	263	4,561	--	--	--	--	--	--	--	826
Sweden	--	--	--	--	--	--	--	--	--	--	23,325
Switzerland	--	15,450	17,506	500	--	--	1,065	8,133	--	--	1
Taiwan	--	--	319	--	--	--	--	--	--	--	57,597
U.S.S.R.	3,479	7,577	348,587	--	--	--	4,732	2,184	5,401	--	--
United Kingdom	2,041	213,122	199,423	8,202	1,274	--	25,133	54,623	2,881	--	3,019
Venezuela	7	--	--	--	--	--	--	--	--	--	14,520
Zimbabwe	--	--	--	--	--	--	--	--	--	--	--
Other	14	290	123	44	--	--	150	--	222	--	1,082
Total	8,513	1,005,208	1,223,951	23,266	1,747	848	119,958	163,623	18,143	2,137	417,431

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)
1979	73,925	68,626	650	4,681	134	12,314	3,479,128	$840,533
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:								
Australia	--	--	--	--	--	--	20,250	2,108
Belgium-Luxembourg	--	993	--	--	--	--	208,316	45,796
Canada	655	1,060	--	17	--	2,935	230,626	33,635
China	--	--	--	--	--	--	6,962	2,374
Colombia	--	--	--	--	--	--	7,335	1,141
Costa Rica	--	--	--	--	--	--	3,578	230
Finland	--	--	--	--	--	--	2,671	1,041
Germany, Federal Republic of	387	7,627	6	3	--	13	83,142	18,919
Hong Kong	--	--	--	--	--	--	855	215
Italy	673	--	--	--	--	--	54,136	19,506
Japan	4,823	--	--	--	--	--	10,433	4,224
Korea, Republic of	--	--	--	--	--	--	892	539
Mexico	--	--	--	--	--	--	78,293	5,215
Netherlands	--	--	--	--	--	--	34,746	4,466
Norway	--	--	--	--	--	--	17,332	3,528
Singapore	--	--	--	--	--	--	5,241	30
South Africa, Republic of	3,783	3,208	--	--	--	--	1,218,524	370,773
Spain	--	--	--	--	--	--	5,650	738
Sweden	--	--	--	--	--	--	23,325	3,100
Switzerland	2,986	14,763	--	223	--	--	60,627	13,607
Taiwan	--	402	--	--	--	--	58,318	1,009
U.S.S.R.	6,542	40,653	--	11,002	--	--	430,157	57,746
United Kingdom	89,455	39,522	7	--	--	--	638,702	161,780
Venezuela	--	--	--	--	--	--	14,527	58
Zimbabwe	--	--	--	--	--	1,168	1,168	296
Other	72	19	200	--	--	--	2,216	682
Total	109,376	108,247	213	11,245	--	4,116	3,218,022	752,756

Table 8.—Estimated U.S. imports of platinum and palladium, by year and country

(Thousand troy ounces)

Country	Platinum 1982	Platinum 1983	Palladium 1982	Palladium 1983
South Africa, Republic of	576	626	464	409
U.S.S.R	16	23	380	392
United Kingdom	147	308	137	242
Other	187	305	334	568
Total	926	1,262	1,315	1,611

WORLD REVIEW

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 mining nickel-copper deposits. Most of the rest-of-world supply was derived from scrap.

Canada.—PGM were produced as byproducts of nickel-copper mining by Inco Ltd. and Falconbridge Ltd. Inco's mines reopened in April 1983, after having been shut down since July 1982, owing to a labor strike and weak demand for nickel.

China.—In China's Kansu Province, PGM were produced as byproducts of nickel and copper from the Jinchuan nickel mine. The United States imported less than 10,000 ounces of PGM from China in 1983.[10]

Germany, Federal Republic of.—Legislation passed in the Federal Republic of Germany in 1983 reportedly requires new cars registered in the country from January 1, 1986, to be engineered to use unleaded gasoline and to be fitted with catalysts. In addition, the Federal Republic of Germany has urged other member countries of the European Economic Community to adopt similar measures.[11]

Japan.—Japan imported 942,000 ounces of platinum, primarily from the Republic of South Africa, and 1,024,000 ounces of palladium, primarily from the U.S.S.R. Consumption of platinum in jewelry uses declined and consumption of palladium in electrical uses increased in 1983. Estimated consumption of platinum and palladium in Japan, in thousand troy ounces, was reported as follows:[12]

	Platinum	Palladium
Automotive	150	90
Chemical	110	370
Dental	--	210
Electrical	130	540
Jewelry	490	50
Miscellaneous	70	70
Total[1]	960	1,340

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

Source: Sumitomo Corp.

South Africa, Republic of.—Gold Fields of South Africa Ltd. studied the feasibility of developing a new platinum mine located north of Rustenburg in the western Transvaal, near the Amandelbult section of Rustenburg Platinum. By yearend, only preliminary drilling had been done, while mining costs and markets were still being analyzed. Sources said that the new mine, to be called "Northern Platinum," should probably reach full production by 1988, producing 246,000 ounces of platinum, 103,000 ounces of palladium, 24,000 ounces of ruthenium, 13,000 ounces of rhodium, and 24,000 ounces of gold per year.[13]

In September 1983, Johnson Matthey PLC of the United Kingdom, the marketing agent for Rustenburg Platinum, began selling small platinum bars to investors in sizes ranging from 5 grams to 10 ounces. The other major South African producer, Impala Platinum, began selling a 1-ounce platinum coin, called the "Noble," through its London-based marketing agent, Ayrton Metals Ltd. The coins were introduced to European markets in November.[14]

Table 9.—Platinum-group metals: World mine production, by country[1]

(Troy ounces)

Country[2]	1979	1980	1981	1982[p]	1983[e]
Australia, metal content, from domestic nickel ore:[3]					
Palladium	6,880	10,545	12,896	[e]12,000	12,000
Platinum	2,765	2,058	2,093	[e]1,900	1,900
Ruthenium	(4)	(4)	(4)	(4)	---
Canada: Platinum-group metals from nickel ore	197,943	410,757	382,658	228,425	[5]167,019
Colombia: Placer platinum	12,933	14,345	14,801	[re]20,000	20,000
Ethiopia: Placer platinum	108	113	[e]125	[e]125	125
Finland:					
Palladium	932	675	1,993	4,662	5,000
Platinum	711	225	1,608	4,147	4,000
Japan, metal from nickel-copper ores:[6]					
Palladium	22,495	28,968	25,748	27,862	[5]37,122
Platinum	12,142	12,366	10,521	15,411	[5]21,460
South Africa, Republic of: Platinum-group metals from platinum ore[e 7]	3,017,000	3,100,000	3,110,000	2,600,000	2,600,000
U.S.S.R.: Placer platinum and platinum-group metals from nickel-copper ores[e]	3,200,000	3,250,000	3,350,000	3,500,000	3,600,000
United States: Placer platinum and platinum-group metals from gold-copper ores	7,300	3,348	7,318	8,033	[5]6,257
Yugoslavia:					
Palladium	5,241	4,501	3,119	[e]3,000	2,900
Platinum	675	418	482	[e]480	400
Zimbabwe:					
Palladium	--	6,784	5,200	2,765	2,500
Platinum	--	2,990	2,300	1,704	1,500
Total	[r]6,487,125	[r]6,848,093	6,930,862	6,430,514	6,482,183

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

[1]Table includes data available through May 9, 1984. Platinum-group metal production by the Federal Republic of Germany, Norway, and the United Kingdom was not included in this table because the production was 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 6.)

[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 6.)

[4]Revised to zero.

[5]Reported figure.

[6]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 Guinea, and Philippine origin are not duplicative, but output from Canadian material might duplicate a part of reported Canadian production.

[7]Includes osmiridium produced in gold mines.

TECHNOLOGY

The Bureau of Mines studied methods for beneficiating PGM ores from the Stillwater Complex in Montana. A pilot flotation mill was operated using a mercaptobenzothiazole-sulfuric acid reagent. The system was successful in concentrating most of the PGM ores, but consumed more sulfuric acid than expected. It was concluded that an auxiliary system was needed to treat acid-consuming minerals.[15]

In another study, the Bureau evaluated platinum-coated metals as substitutes for solid platinum shapes. The Bureau studied four electroplating methods for producing pore-free platinum coatings from molten cyanide baths and concluded that pulse plating produced the most corrosion-resistant coating.[16]

The Bureau, in cooperation with the National Association of Recycling Industries and the Defense Property Disposal Service, studied the concentrating of precious metals contained in scrapped electronic materials, such as electronic reed switches and telephone relays. Both mechanical and hydrometallurgical methods were used to separate a PGM-gold residue from the base metals. The residue could then be refined to commercial specifications.[17]

Researchers at the U.S. Department of Energy's Pacific Northwest Laboratory began the second stage in a study of a process to recover PGM from spent nuclear reactor fuel. A spokesperson for Battelle Memorial Institute, which operates the laboratory, said that the spent fuel contains significant amounts of palladium, rhodium, and ruthenium, created in the reactor during the fission process. Part of the process involves adding lead oxide to the spent fuel to extract the precious metals, similar to the fire assay process. If economically viable, the process would require allowing time for the radioactive decay of the precious metals to occur.[18] The presence of small but significant quantities of recoverable PGM in spent nuclear fuels has been known for many years, but recovery methods proposed previously were not economically feasible.

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[1]Physical scientist, Division of Nonferrous Metals.

[2]Wards Automotive Reports. V. 58, No. 4, Jan. 24, 1983, p. 29.

[3]International Precious Metals Institute. Precious Metals News and Review. V. 7, No. 2, Feb. 1983, p. 5.

[4]———. V. 7, No. 6, June 1983, p. 5.

[5]———. V. 7, No. 7, July 1983, p. 6.

———. V. 7, No. 12, Dec. 1983, p. 6.

[6]———. V. 7, No. 8, Aug. 1983. p. 5.

[7]Burger, J. R. (ed.). Ongoing Projects. Eng. and Min. J., v. 184, No. 8, Aug. 1983, p. 9.

[8]Metal Bulletin. Russians Conclude Frame Contracts. No. 6757, Jan. 25, 1983, p. 13.

[9]Metals Week. Rustenburg Now Selling Most Metal at Free Market Prices in Effort To Increase Sales. V. 54, No. 4, Jan. 24, 1983, p. 6.

[10]Foreign Broadcast Information Service. China Report. JPRS 84244, No. 378, Sept. 1, 1983, p. 80.

[11]Emmel, P. G. Catalysts For Europe—Motor Vechicle Emissions Control Regulations in Europe and Future Platinum Demand. Pres. at 2d Int. Platinum Seminar (sponsored by Met. Bull. Ltd.-Futures World, New York, NY, Dec. 14, 1983), 17 pp.

[12]Sumitomo Corporation. Precious Metals Market in Japan. 14th ed., Feb. 1984, 17 pp.

[13]Engineering and Mining Journal. Gold Fields Assesses Potential New PGM Mine. V. 184, No. 8, Aug. 1983, pp. 13-15.

[14]International Precious Metals Institute. Precious Metals News and Review. V. 7, No. 12, Dec. 1983, p. 7.

American Metal Market. Ayrton Eyes Platinum Coin Sales in U.S. V. 91, No. 22, Nov. 10, 1983, p. 7.

[15]Morrice, E. Pilot Mill Flotation of Anorthositic Platinum-Palladium Ore From the Stillwater Complex. BuMines RI 8763, 1983, 8 pp.

[16]Lynch, M. J., R. P. Walters, and D. R. Flinn. Structure and Porosity of Electrodeposited Platinum: Evaluation of Four Plating Methods. BuMines RI 8829, 1983, 18 pp.

[17]Hilliard, H. E., and B. W. Dunning, Jr. Recovery of Platinum-Group Metals and Gold From Electronic Scrap. Paper in 1983 IPMI Int. Seminar (Williamsburg, VA, Apr. 10-13, 1983). Int. Precious Met. Inst., Allentown, PA, 1983, pp. 129-142.

Hillard, H. E., B. W. Dunning, Jr., and H. V. Makar. Hydrometallurgical Treatment of Electronic Scrap Concentrates Containing Precious Metals. BuMines RI 8757, 1983, 15 pp.

[18]The Northern Miner (Toronto). Researchers Investigating Process To Recover Platinum From Spent Fuel. V. 68, No. 46, Jan. 20, 1983, p. A-25.

Potash

By James P. Searls[1]

U.S. potash production in terms of potassium oxide (K_2O) equivalent declined 20% but apparent consumption increased 10% in 1983. Domestic production declined to below that of 1952. Second half production was 9% below first half production owing to several operations undergoing extended vacations during the summer and fall. Sales declined 15% from that of 1982, to a level below that of 1953, and also declined 20% from the first to the second half of 1983. However, yearend stocks decreased. Prices, f.o.b. mine, decreased for the second consecutive year. The United States continued to be a net importer of potash; net import reliance as a percentage of apparent consumption increased 10 percentage points to 75%. Canada provided an amount equal to 69% of the domestic apparent consumption.

Latin American imports of U.S. potash fell strongly primarily because Brazil imported only one-tenth as much as in 1982. Japan and India also imported less. Some medium-sized importers, including Mexico and New Zealand, increased imports of U.S. potash.

Near Carlsbad, NM, one economically marginal mine, at present prices, was closed for an extended period and two others were idled for nearly 3 months. One of the three operations in Utah was idled owing to extraordinarily wet weather that caused flooding of its brine gathering ditches. Another Utah producer from brine continued production despite the inclement weather.

Domestic Data Coverage.—Domestic production data for potash are developed by the Bureau of Mines from a voluntary semian-

Table 1.—Salient potash[1] statistics

(Thousand metric tons and thousand dollars unless otherwise specified)

	1979	1980	1981	1982	1983
United States:					
Production	4,271	4,315	4,153	3,366	2,770
K_2O equivalent	2,225	2,239	2,156	1,784	1,429
Sales by producers	4,549	4,265	3,670	3,387	2,950
K_2O equivalent	2,388	2,217	1,908	1,784	1,513
Value[2]	$279,200	$353,900	$328,900	$265,600	$220,800
Average value per ton of product — dollars	$61.38	$82.98	$89.62	$78.42	$74.85
Average value per ton of K_2O equivalent — do.	$116.92	$159.63	$172.40	$148.87	$145.97
Exports[3]	1,119	1,584	887	952	[p]564
K_2O equivalent	635	840	491	519	[p]300
Value[4]	$79,500	$179,830	$107,950	$93,200	[p]$55,760
Imports for consumption[3 5]	8,505	8,193	7,903	6,338	[p]7,322
K_2O equivalent	5,165	4,972	4,796	3,858	[p]4,440
Customs value	$520,800	$648,000	$750,400	$575,400	[p]$600,600
Apparent consumption[6]	11,935	10,874	10,686	8,773	[p]9,708
K_2O equivalent	6,918	6,349	6,213	5,123	[p]5,653
Yearend producers' stocks, K_2O equivalent	251	273	520	520	437
World: Production, marketable K_2O equivalent	[r]25,768	[r]27,857	27,080	[p]24,664	[e]26,678

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

nual survey of U.S. operations. Of the 10 operations to which a survey request was sent, 100% responded, representing 100% of the total production shown in table 1. The permanently closed plant reported ending stocks. Reports from two plants were incomplete for the second half of the year and required some adjustment.

DOMESTIC PRODUCTION

Domestic K_2O production declined 20% in 1983, the second consecutive year of significant decline. Of the total production, 74% was standard, coarse, or granular muriate of potash and 13% was sulfate of potash. The remaining production comprised manure salts, soluble and chemical grades of muriate of potash, and potassium magnesium sulfate. The New Mexico producers accounted for 85% of the total domestic potash production. New Mexico mine production was 12.4 million metric tons, and these crude salts had an average K_2O content of 12.9%. Production in other States was from natural brines and a solution mine.

At the beginning of the year, six 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.; Kerr-McGee Chemical of Kerr-McGee Corp., which commenced granular muriate of potash production at the otherwise defunct National Potash Co. plant; Mississippi Chemical Corp.; and Potash Co. of America (PCA) of Ideal Basic Industries Inc. Muriate of potash and potassium magnesium sulfate continued to be produced from sylvinite and langbeinite ores, respectively. One company reacted muriate of potash and potassium magnesium sulfate to produce sulfate of potash. On January 19, Mississippi Chemical shut down its potash mine near Carlsbad, NM, for an extended period. This period may be at least 2 years if not permanently. This was the oldest mine in the Carlsbad area. AMAX Chemical and PCA both shut down for July, August, and September owing to large inventories of product and poor sales.

Eddy County, NM, which contains most of the Carlsbad potash mines, raised its tax rate from 5.5 to 7.5 mils per $1,000 of property owned. The State of New Mexico considered collecting taxes on product sales, retroactive to 1976. It had been collecting taxes on an arbitrary valuation of ore produced.

Sulfate of potash was produced at two Texas plants operated by Permian Chemical Corp. and PCA. Permian reported production of about 12,000 tons in 1982 and 14,000 tons in 1983. The PCA plant produced sulfate of potash from muriate of potash and sulfur dioxide, whereas the Permian plant used muriate of potash and sulfuric acid.

Three companies continued to produce potash in Utah. Great Salt Lake Minerals & Chemicals Corp., a subsidiary of Gulf Resources & Chemicals Corp., produced sulfate of potash in the face of several weather-related problems as a coproduct of salt, magnesium chloride, and sodium sulfate from Great Salt Lake brines. Kaiser Chemicals of Kaiser Aluminum & Chemical Corp. produced muriate of potash from natural near-surface brines at the west end of the Bonneville Salt Flats near Wendover. Kaiser Chemicals shut down its plant on September 30 for the duration of the year because of extraordinarily wet weather that flooded its brine collection area. Texasgulf Inc. produced muriate of potash from an underground solution mine near Moab.

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	
	1982	1983	1982	1983	1982	1983	1982	1983	1982	1983	1982	1983	1982	1983
January-June:														
Muriate of potash, 60% K_2O minimum:														
Standard	628	346	383	211	559	468	341	286	39,100	26,800	465	274	282	166
Coarse	180	137	110	84	213	142	130	84	16,400	9,000	85	98	52	60
Granular	365	464	222	282	368	452	223	274	25,900	28,700	125	176	76	107
Chemical	28	25	18	15	27	27	17	17	W	W	1	2	(2)	1
Potassium sulfate	164	158	84	81	172	169	88	86	31,800	30,500	83	59	43	31
Other potassium salts[3]	317	298	79	75	398	361	100	92	W	W	285	277	64	62
Total[4]	1,682	1,428	896	749	1,737	1,619	899	839	143,600	122,400	1,044	887	517	428
July-December:														
Muriate of potash, 60% K_2O minimum:														
Standard	527	292	322	180	597	288	363	176	35,400	17,300	396	232	241	171
Coarse	215	99	131	61	197	96	120	59	12,700	6,200	103	92	63	65
Granular	411	393	249	239	372	419	226	254	23,300	25,300	164	135	99	92
Chemical	26	24	16	15	22	25	14	16	W	W	5	1	3	(2)
Potassium sulfate	159	278	82	111	173	264	88	98	30,100	32,300	70	285	36	44
Other potassium salts[3]	346	256	88	73	289	239	74	70	W	W	339	82	74	65
Total[4]	1,684	1,342	888	679	1,650	1,331	885	673	122,000	98,400	1,078	827	520	437
Grand total[4]	3,366	2,770	1,784	1,429	3,387	2,950	1,784	1,513	265,600	220,800	XX	XX	XX	XX

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]
1982:							
January-June	7,732	1,013	1,434	758	1,471	751	110,600
July-December	7,960	1,026	1,464	766	1,401	745	94,000
Total[3]	15,691	2,039	2,898	1,524	2,872	1,497	204,600
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

[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)

	1979	1980	1981	1982	1983
Production	205	203	200	166	191
Sales by producers	204	201	178	176	184
Value[2]	$46,230	$60,080	$61,993	$61,934	$62,881
Exports[3]	81	70	40	71	[P]44
Value[4]	NA	$23,113	$16,095	$27,648	[P]$16,390
Imports[5]	10	22	18	6	[P]29
Value[6]	$2,710	$7,111	$7,380	$2,409	[P]$12,300
Apparent consumption[7]	133	153	156	111	[P]169
Yearend producers' stocks	22	24	46	36	44

[P]Preliminary. NA Not available.
[1]Excluding potassium magnesium sulfate.
[2]F.o.b. mine.
[3]Export data supplied by Potash & Phosphate Institute (1979) and the Bureau of the Census (1980-83).
[4]F.a.s. U.S. port.
[5]Bureau of the Census.
[6]C.i.f. to U.S. port.
[7]Sales plus imports minus exports.

CONSUMPTION AND USES

Apparent domestic consumption of all forms of potash increased about 10% over the 1982 level primarily owing to an autumnal increase in demand for fertilizers following the "payment-in-kind" (PIK) program. Surplus grains from the 1982 and 1981 harvests brought about the U.S. Department of Agriculture PIK program whereby farmers were paid-in-kind with surplus crops in the fall for refraining from planting corn, sorghum, wheat, cotton, and rice in the spring. Along with other acreage diversion programs, 82 million acres was removed from production during the summer. This had a negative effect on spring sales of potash in the United States. Domestic producers' fall sales decreased by 24%, compared with that of 1982, whereas increased sales had been expected.

According to the Potash & Phosphate Institute, which reports sales of U.S. and Canadian producers, consumption of muriate of potash for agricultural uses changed as follows: Standard grade fell 29% to 399,000 tons, K_2O equivalent; coarse grade rose 37% to 2.4 million tons; granular grade rose 24% to 1.5 million tons; and sulfate of potash and sulfate of potash magnesia, combined, fell 2% to 184,000 tons. The percentage breakdown by grade was 48% coarse, 31% granular, 9% soluble, 8% standard, and 4% sulfates. Potash sales from U.S. mines represented 9% of the coarse muriate, 26% of the granular, 51% of the standard, 4% of the soluble muriate, and 100% of the sulfates.

The Potash & Phosphate Institute also reported that 312,000 tons of potash was sold for nonagricultural (chemical) uses. Of this, standard muriate was 63%, soluble muriate was 36%, and the balance was sulfates. Nonagricultural use of potash was primarily for producing caustic potash and chlorine. Caustic potash, or potassium hydroxide, was the major precursor to other potassium chemicals. Caustic potash was in oversupply and one caustic potash plant closed down. 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.

According to the Potash & Phosphate Institute, the major consuming States of agricultural potash, in decreasing order, continued to be Illinois, Iowa, Indiana, Ohio, Minnesota, and Wisconsin. These six States consumed 59% of the total from U.S. and Canadian producers. The major agricultural consumers of domestically produced potash, in decreasing order, were Texas, Missouri, Illinois, Mississippi, Kentucky, and Florida. These six States accounted for 55% of the total. The major agricultural consumers of domestically produced sulfates of potash, in decreasing order, were Florida, Kentucky, California, Georgia, Tennessee, and Texas, which consumed 61% of the total.

Table 5.—Sales of North American potash, by State of destination

(Metric tons of K_2O equivalent)

State	Agricultural potash		Nonagricultural potash	
	1982	1983	1982	1983
Alabama	72,747	67,906	52,973	52,298
Alaska	544	167	--	--
Arizona	1,355	513	55	43
Arkansas	39,385	44,421	561	476
California	54,415	53,657	10,399	9,672
Colorado	23,082	18,705	61	163
Connecticut	3,322	5,513	67	47
Delaware	20,739	23,503	22,072	32,082
Florida	113,709	112,475	557	821
Georgia	116,806	109,014	1,054	422
Hawaii	14,663	11,650	--	--
Idaho	15,100	18,192	656	55
Illinois	525,883	829,863	25,267	24,526
Indiana	286,381	429,723	4,050	3,533
Iowa	388,403	551,731	1,835	350
Kansas	41,334	31,944	2,688	2,614
Kentucky	136,344	148,205	2,700	369
Louisiana	39,186	42,517	3,197	1,881
Maine	4,751	4,979	94	25
Maryland	27,754	26,960	698	476
Massachusetts	4,094	3,831	491	584
Michigan	174,684	227,179	2,769	2,693
Minnesota	327,854	391,068	39	30
Mississippi	158,810	89,248	2,561	2,094
Missouri	184,218	265,801	3,947	2,806
Montana	10,675	12,530	106	172
Nebraska	35,316	42,972	1,551	530
Nevada	16	--	220	320
New Hampshire	459	457	74	--
New Jersey	6,631	6,426	668	920
New Mexico	4,053	1,516	42,312	31,575
New York	63,463	71,341	47,776	42,429
North Carolina	80,676	86,610	45	12
North Dakota	20,345	23,450	63	--
Ohio	363,318	406,765	31,823	43,097
Oklahoma	16,240	22,680	8,836	7,038
Oregon	18,909	22,124	945	1,168
Pennsylvania	42,525	49,748	3,373	3,394
Rhode Island	2,097	2,231	89	132
South Carolina	47,546	54,535	173	120
South Dakota	10,870	11,946	23	--
Tennessee	93,014	109,582	147	143
Texas	149,932	141,526	33,580	34,202
Utah	2,283	2,839	2,219	2,074
Vermont	4,483	3,450	--	--
Virginia	41,221	45,731	833	316
Washington	33,081	36,039	2,608	2,980
West Virginia	4,123	5,786	728	898
Wisconsin	265,909	297,844	434	311
Wyoming	1,881	2,181	1,440	1,940
Total	4,094,629	4,969,074	318,857	311,831

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	1980	1981	1982	1983
Agricultural:				
Standard	948	873	563	399
Coarse	2,228	2,070	1,750	2,402
Granular	1,687	1,549	1,237	1,533
Soluble	447	435	357	451
Total	5,310	4,927	3,907	4,785
Nonagricultural:				
Soluble	108	118	106	114
Other	242	260	210	195
Total	350	378	316	309
Grand total	5,660	5,305	4,223	5,094

Source: Potash & Phosphate Institute.

STOCKS

Yearend producers' stocks of potash were down 16% from that of yearend 1982. However, because of reduced production, yearend stocks rose slightly to 31% of production.

TRANSPORTATION

Domestic rail tariffs were essentially unchanged while ocean rates rose during the first half of the year and remained level thereafter. Several railroad contracts with potash producers were signed during the year under the terms of the Staggers Act but these agreed-upon charges or rates were unpublished. A bill (S. 1554) was introduced in the Senate to add a ton-mile fee on barges for increased recovery of the cost of maintaining the inland waterway system.

About 800,000 tons of muriate of potash was shipped from Saskatchewan, Canada, to Thunder Bay, Ontario, for lake freightage, mostly to U.S. Great Lakes ports. About 750,000 tons of muriate of potash was shipped to Minneapolis or St. Louis for transfer to barges.

The Canadian Parliament amended the "Crow's Nest" rate for grain traffic to allow both Canadian railroads a better rate of return for grain haulage. The new funds were to be used to increase traffic capacity through the Western Canadian mountain ranges to Pacific ports. Tariffs on potash were reported to have remained unchanged. Both Canadian railroads announced facility improvements for transfer of potash to lake freighters at Thunder Bay on Lake Superior.

The German Democratic Republic started construction of a potash export quay in Rostock, with two bulk warehouses, each to be 722 feet by 131 feet by 98 feet high.

The Suez Canal raised tariffs up to 6.5% on all freight.

Table 7.—Prices[1] of U.S. potash, by type and grade

(Dollars per metric ton of K_2O equivalent)

Type and grade	1981		1982		1983	
	January-June	July-December	January-June	July-December	January-June	July-December
Muriate, 60% K_2O minimum:						
Standard	140.18	132.45	114.76	97.59	93.56	98.52
Coarse	144.92	137.28	125.76	105.25	108.13	104.73
Granular	142.42	130.94	115.81	103.30	104.46	99.44
All muriate[2]	141.70	132.71	117.16	100.71	100.10	99.75
Sulfate, 50% K_2O minimum	344.84	354.55	362.85	341.91	353.19	331.41

[1]Average prices, f.o.b. mine, based on sales.
[2]Excluding soluble and chemical muriates.

PRICES

The average value, f.o.b. mine, of U.S. potash sales of all types and grades was $145.97 per ton. This average value was essentially the same for both halves of the year. The average annual price for muriate of potash, f.o.b. mine, decreased 8% from about $109 to $100 per ton. The average annual price of sulfate of potash declined 3% to $342 per ton. Standard-grade muriate of potash averaged $95 per ton, coarse-grade averaged $107 per ton, and granular averaged $102 per ton.

FOREIGN TRADE

U.S. potash exports fell 42%. Exports to Latin America fell 56%, largely owing to a 90% reduction in Brazil's purchases of U.S. potash. Brazil's problems revolved around its foreign debt and balance-of-payments difficulties. Exports to the Far East, notably India and Japan, decreased significantly. Generally, worldwide price competition continued to push domestic producers out of individual markets as the world market remained in a slight oversupply condition, with few producers, other than North American producers, exerting efforts to keep markets in balance, and two new operations coming on-stream. The strong U.S. dollar continued to cause problems in the U.S. export trade.

A 15% increase in total U.S. imports for consumption of potash represented increases in imports of all potash products. Imports of muriate of potash from Canada increased 11% over the 1982 level and amounted to 89% of all muriate imports and 88%, by K_2O equivalent, of all potash imports. Israel was the second largest source of imports, with 7% of muriate of potash imports and 8% of total potash imports.

Table 8.—U.S. exports of potash

	1982				1983[p]			
	Approximate average K_2O content (percent)	Quantity (metric tons)		Value[1] (thousands)	Approximate average K_2O content (percent)	Quantity (metric tons)		Value[1] (thousands)
		Product	K_2O equivalent			Product	K_2O equivalent	
Potassium chloride, all grades	61	691,040	421,520	$56,710	61	385,980	235,450	$30,700
Potassium sulfates[2]	([3])	261,120	97,920	36,490	51	86,320	44,020	16,390
Potassium magnesium sulfate[4]	NA	NA	NA	NA	22	91,440	20,120	8,670
Total[5]	XX	952,160	519,440	93,200	XX	563,730	299,580	55,760

[p]Preliminary. NA Not available. XX Not applicable.
[1]F.a.s. U.S. port.
[2]Includes potassium magnesium sulfate for 1982; includes only potassium sulfate for 1983.
[3]Varies from year to year according to relative quantities of the two types of sulfates exported.
[4]1983 only.
[5]Data may not add to totals shown because of independent rounding.

Source: Bureau of the Census.

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]			
	1982	1983[p]	1982	1983[p]	1982	1983[p]	1982	1983[p]
Argentina	2,100	--	4,310	6,850	6,410	6,850	$820	$750
Australia	--	--	5,430	7,010	5,430	7,010	1,150	1,770
Bahamas	--	20	2,500	1,710	2,500	1,720	470	340
Belgium	8,800	7,600	20	--	8,820	7,600	740	580
Brazil	200,940	11,970	18,410	9,210	219,350	21,180	17,180	1,790

See footnotes at end of table.

Table 9.—U.S. exports of potash, by country —Continued

Country	Metric tons of product						Total value[3] (thousands)	
	Potassium chloride		Potassium sulfates, all grades[1]		Total[2]			
	1982	1983[p]	1982	1983[p]	1982	1983[p]	1982	1983[p]
Canada	2,540	4,710	41,650	18,830	44,190	23,540	$4,070	$2,760
Chile	10,490	--	3,300	10,020	13,790	10,020	1,470	1,940
Colombia	22,500	6,720	7,850	6,060	30,350	12,770	2,530	1,170
Costa Rica	13,800	16,000	11,750	3,760	25,550	19,760	2,380	1,660
Denmark	23,700	23,790	13,000	--	36,700	23,790	2,525	1,830
Dominican Republic	18,960	19,850	5,490	1,520	24,450	21,370	2,530	1,890
Ecuador	14,300	5,440	2,230	--	16,530	5,440	1,390	420
Egypt	10	--	9,840	10,120	9,850	10,120	2,060	1,920
French West Indies	--	14,690	--	--	--	14,690	--	1,290
Greece	--	--	390	--	390	--	40	--
Guatemala	--	1,680	2,630	200	2,630	1,880	330	220
Haiti	640	--	--	110	640	110	70	10
Honduras	--	1,150	2,940	70	2,940	1,220	220	150
India	84,970	30,430	--	--	84,970	30,430	6,320	2,040
Italy	270	1,600	--	--	270	1,600	21	120
Jamaica	--	--	1,610	120	1,610	120	310	10
Japan	111,710	85,590	73,220	53,920	184,930	139,510	22,830	14,120
Korea, Republic of	21,410	180	40	110	21,450	290	1,750	30
Leeward and Windward Islands	6,700	1,100	--	350	6,700	1,450	650	130
Liberia	180	--	--	--	180	--	14	--
Malaysia	--	--	8,200	--	8,200	--	660	--
Mexico	36,480	36,100	10,090	18,720	46,570	54,820	4,800	6,170
New Zealand	86,960	94,190	160	420	87,120	94,620	7,850	7,710
Nicaragua	4,450	--	--	5,900	4,450	5,900	350	530
Norway	--	1,410	--	--	--	1,410	--	100
Panama	2,800	2,820	50	1,470	2,850	4,290	290	360
Peru	10	5,430	5,450	4,750	5,460	10,180	860	760
Philippines	90	10	830	430	920	440	170	90
Portugal	2,670	--	--	--	2,670	--	210	--
Saudi Arabia	280	90	220	100	500	190	50	20
Sweden	--	6,600	--	--	--	6,600	--	450
Switzerland	--	6,200	--	--	--	6,200	--	420
Taiwan	80	20	14,520	--	14,600	20	2,690	1
Thailand	--	--	4,800	6,000	4,800	6,000	410	500
Turkey	--	--	10,000	--	10,000	--	1,930	--
Uruguay	2,000	--	--	--	2,000	--	180	--
Venezuela	11,000	60	30	9,150	11,030	9,210	800	1,560
Other	200	530	157	850	357	1,380	41	140
Total[2]	691,040	385,980	261,120	177,760	952,160	563,730	93,200	55,760

[p]Preliminary.
[1]Includes potassium magnesium sulfate.
[2]Data may not add to totals shown because of independent rounding.
[3]F.a.s. U.S. port.

Source: Bureau of the Census.

Table 10.—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.
1982					
Potassium chloride	61	6,290,400	3,840,000	$564,500	$595,050
Potassium sulfate	50	11,800	5,900	2,230	2,410
Potassium nitrate	45	22,800	10,300	6,840	7,630
Potassium sodium nitrate mixtures	14	12,900	1,800	1,790	1,920
Total[1]	XX	6,337,900	3,858,000	575,400	607,000
1983[p]					
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

[e]Estimated. [p]Preliminary. XX Not applicable.
[1]Data may not add to totals shown because of independent rounding.

Source: Bureau of the Census.

Table 11.—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		Customs		C.i.f.	
	1982	1983p	1982	1983p	1982	1983p	1982	1983p	1982	1983p	1982	1983p	1982	1983p
Belgium-Luxembourg	--	--	7,700	--	--	--	--	--	7,700	--	$1,410	--	$1,520	--
Canada	5,724,000	6,371,200	--	100	--	860	--	60	5,724,000	6,372,200	514,600	$485,380	539,130	$507,410
Chile	--	1,300	--	--	--	900	12,900	19,500	12,900	21,700	1,790	26,300	1,920	29,270
German Democratic Republic	86,100	136,100	--	20	--	--	--	--	86,100	136,100	6,430	9,510	7,900	10,980
Germany, Federal Republic of	3,200	29,900	4,100	58,600	--	--	--	--	7,300	88,500	1,210	11,230	1,380	12,600
Israel	352,800	509,500	--	--	22,800	64,400	--	--	375,600	573,900	40,280	59,790	44,300	66,770
Japan	--	4	--	--	--	--	--	200	--	200	--	3	--	3
Spain	50,100	53,100	--	--	--	--	--	--	50,100	53,100	4,240	3,050	4,470	4,110
U.S.S.R	74,200	76,000	--	--	--	--	--	--	74,200	76,000	5,400	5,100	6,350	5,700
United Kingdom	--	300	--	--	--	--	--	--	--	300	--	200	--	230
Total[1]	6,290,400	7,177,400	11,800	58,700	22,800	66,200	12,900	19,800	6,337,900	7,322,100	575,400	600,600	607,000	637,100

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

Source: Bureau of the Census.

WORLD REVIEW

World production rebounded from its 1982 decline to near 1981 levels. The increases occurred in the U.S.S.R., Canada, and France, in decreasing order.

Canada.—PCA started up its new potash mine and mill near Sussex, New Brunswick, in August. Initial mill capacity was 390,000 tons per year with projected capability up to 550,000 tons per year. The mill apparently had some starting problems, and mine production was intermittent because of problems with passageways for both potash and salt production, air movement, and mill tailings' return to the mine. Proven ore reserves were about 51 million tons crude ore with an average ore grade estimated at 25.5% K_2O and 2.5% insolubles. Plant yield was estimated at 11 million tons.

Potash Corp. of Saskatchewan (PCS) offered to sell an equity position in the Lanigan Mine mill expansion to China.

Central Canada Potash of Noranda Mines Ltd. was idle for about 3 months during the summer. The other mines endured shorter summer idle periods, and a few were idle during the beginning of the year. The Premier of Saskatchewan expressed concern that the Saskatchewan potash industry had absorbed a disproportionate share of the world decrease in potash consumption for the year.

PCS announced a research effort to produce sulfate of potash in the Saskatoon area using locally available muriate of potash and sodium sulfate as feedstocks. The process produces an intermediate solid phase of glaserite, a sodium-potassium sulfate, to which more muriate of potash is added to obtain sulfate of potash. This was expected to broaden the product line of PCS, and the product was expected to be used in the tobacco fields in the southern part of the Province of Ontario.

The Denison-Potacan Potash Co. joint venture in the Province of New Brunswick announced its intentions to produce potash from the Clover Hill site, south of Sussex, New Brunswick, by September 1985, after concluding detailed underground exploration. Planned capacity was 800,000 tons per year from a reserve of 230 million tons of probable and possible crude ore averaging 28% K_2O and less than 1% insolubles. BP Canada continued its exploration of the Millstream site. Pronto Explorations Ltd. of Toronto continued exploration for potash on the southwest coast of Newfoundland. Chevron Standard Ltd. apparently abandoned its exploration for potash in Nova Scotia.

Table 12.—Salient Canadian potash statistics

(Thousand metric tons of K_2O equivalent)

	1980	1981	1982	1983
Production[1]	7,300	7,175	5,208	5,928
Domestic sales by domestic producers[1]	378	332	273	385
Exports:				
United States[1]	4,563	4,182	3,202	3,965
Overseas[1]	2,170	1,823	1,576	2,026
Imports for consumption[2]	33	11	13	[p]17
Domestic consumption[3]	411	343	286	[p]402
Yearend producers' stocks[1]	564	1,308	1,486	862

[p]Preliminary.
[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.

Chile.—The governmental corporation, Corporación de Fomento de la Producción, asked for bids to develop the potash rights in the Salar de Atacama. Preliminary studies concluded that 500,000 tons of product per year of muriate of potash and 150,000 tons of product per year of sulfate of potash could be produced. The preliminary study assumed the use of solar ponding.

Ethiopia.—A feasibility study of the old Dallolin Mine was started by Entreprise Minière et Chimique for the Ethiopia-Libya Mining Co. This site produced small tonnages of potash before the Second World War.

France.—The Rhine Treaty concerning potash mine tailings that enter the Rhine River was approved by the French Assembly. The French Senate must also approve the Treaty. Plans were announced for a portion of the Amelie mill of Mines de Potasse d'Alsace to be converted from the dissolution-recrystallization process to a flotation process to reduce production costs. This mine has the longest expected lifetime of the three French mines. The Theodore Mine was scheduled to close in 1985 or 1986 owing to depletion.

German Democratic Republic.—The expansion of the Port of Rostock was to include conversion of the fertilizer export quay into a modern transfer point with railcar bottom dumping to conveyor belts, two large storage sheds, and bulk and bagged shipping facilities.

The Werra River pollution cleanup was delayed only by the Federal Republic of Germany's internal discussions of its contribution to the costs.

Germany, Federal Republic of.—Friedrichshall, the former Kali-Chemie Mine that was sold to Kali und Salz AG in 1981, was linked underground to the Bergmanssegin-Hugo Mine in 1982. The Friedrichshall shafts were filled in and the surface facilities became redundant. In 1983, the Siegfried-Giesen Mine ceased production of muriate of potash with its energy-intensive crystallization process. The site was expected to produce only kainite and other related minerals in the future.

Israel.—Israel announced that its exports in 1982 to the United States were 253,200 tons of K_2O equivalent, or 415,100 tons of product assuming a K_2O content of 61%. The second stage of the "Makleff" cold crystallization project, a 450,000-ton product increase, was scheduled for completion in 1984 and would increase the Dead Sea Works Ltd. capacity to 2.1 million tons product of muriate of potash. Transportation of finished potash from the plant to the nearest railway loading dock, presently by truck haulage, was to be by conveyor belt from Sdom to Nahal Zin. The potash then would travel by railroad to the Port of Ashdod, which the Ports Authority would increase in import and export capacity and water depth. The Dead Sea Works was considering producing sulfate of potash, probably using sulfuric acid from the Rotem Fertilizers Ltd. plant at Sdom.

Jordan.—Arab Potash Co. started limited potash production from Dead Sea brine in nine small evaporating ponds created by subdividing the three regular carnallite ponds into thirds while the large salt and precarnallite ponds went through startup phases. The carnallite ponds were scheduled to return to carnallite harvesting once the brines finished moving through the large ponds. The pond system was expected to be at full production in 1985. Meanwhile, the producers were contemplating an increase to double design capacity.

Mexico.—The development plans for muriate of potash production at Cerro Prieto geothermal wells, 20 miles south of Mexicali, had been shelved in 1982 because of Government difficulties in servicing debts to international banks. In late 1983, the Government announced reactivation of the plans.

Spain.—Debt restructuring by Unión Explosivos Rio Tinto S.A. apparently included sale of a portion of Potasas de Sallent to Instituto Nacional de Industria (INI), the governmental owner of Potasas de Navarra S.A. INI purchased 51% of Minas de Potasas de Suria S.A. from Solvay & Cie in February 1982. Suria obtained approval for an expansion of 50,000 to 220,000 tons per year to be completed by 1986.

Tunisia.—The French consortium of Spie Batignolles and Mines de Potasse d'Alsace won a Government contract to study the feasibility of sulfate of potash production from Sebkhet el Melah, southwest of Zarzis. Target capacity was 140,000 tons per year.

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

(Thousand metric tons of K_2O equivalent)

Country	1979	1980	1981	1982[p]	1983[e]
Canada (sales)[2]	7,074	7,532	6,549	5,309	[3]6,203
Chile[4]	22	[r]25	21	[e]22	22
China[5]	16	12	20	26	25
France	1,921	1,894	1,831	1,701	1,900
German Democratic Republic	3,395	3,422	3,460	3,434	3,430
Germany, Federal Republic of	2,616	2,737	2,592	2,057	2,100
Israel	737	797	839	1,004	1,000
Italy	182	156	146	146	140
Jordan	--	--	--	9	170
Spain	668	658	732	692	[3]657
U.S.S.R	6,635	8,064	8,449	8,079	9,300
United Kingdom	[r]277	321	285	401	[3]302
United States	2,225	2,239	2,156	1,784	[3]1,429
Total	[r]25,768	[r]27,857	27,080	24,664	26,678

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through Mar. 27, 1984.
[2]Official Government figures. Potash & Phosphate Institute production data are given in table 12.
[3]Reported figure.
[4]Data represent officially reported output of potassium nitrate product (gross weight basis) converted assuming 14% K_2O equivalent.
[5]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.

U.S.S.R.—The solution mine pilot plant at Karlyuk, Turkmen S.S.R., operated satisfactorily, and Soyuzkali, the potash industry's all-union enterprise, decided to build a 440,000-ton-per-year plant. The tailings lake of the Stebnik potassium plant in the Ukraine broke through its dam and polluted the Dneister River in September. This plant processes both langbeinite and kainite.

United Kingdom.—Cleveland Potash Ltd. announced a profitable first half of the year, a first for this troubled mine. The company also developed a straight line conveyor passage in the salt layer below the potash zone to bring ore directly from the working face to the shaft. The miners were allowed to ride this conveyor belt to and from the working face area.

TECHNOLOGY

PCS began a development program to increase the underground recovery rate of the Canadian ore bodies by returning the potash plant tailings to the mine galleries.[2] The stowed tailings apparently become load bearing as the overburden pressure forces ore zone subsidence to about 60% of original gallery height. A portion of the previous support pillars can then be mined.

[1]Physical scientist, Division of Industrial Minerals.

[2]Taylor, W. E. G., and M. Butcher. Total Extraction Mining. Paper in Potash '83. Potash Technology: Mining, Processing, Maintenance, Transportation, Occupational Health and Safety, Environment, ed. by R. M. McKercher (1st Int. Potash Technol. Conf., Saskatoon, Saskatchewan, Canada, Oct. 3-5, 1983). Pergamon Press, New York, NY, 1983, pp. 85-90.

Pumice and Pumicite

By Arthur C. Meisinger[1]

Production of pumice and pumicite by domestic producers in 1983 increased 8% to 449,000 short tons and 20% in value to $4.5 million. Pumice imported for consumption increased 52%, and U.S. apparent consumption increased 18%. Estimated world production declined 7% to 11.8 million tons.

Domestic Data Coverage.—Domestic production data for pumice and pumicite were 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, 20, or 91%, responded, representing 99% of total production data shown in table 1. Production for the two 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)

	1979	1980	1981	1982	1983
United States: Sold and used by producers:					
Pumice and pumicite	1,172	543	499	416	449
Value (f.o.b. mine and/or mill)	$4,864	$4,267	$4,311	$3,750	$4,486
Average value per ton	$4.15	$7.86	$8.64	$9.01	$9.99
Exports[e]	2	1	1	1	1
Imports for consumption	62	194	92	121	184
Apparent consumption[1]	1,232	736	590	536	632
World: Production, pumice and related volcanic materials	[r]15,249	[r]13,305	13,308	[p]12,707	[e]11,766

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

[1]Quantity sold or used, plus imports, minus exports.

DOMESTIC PRODUCTION

Pumice and pumicite production by domestic producers increased 8% in quantity and 20% in value. Twenty-one companies operated twenty-two mines in 8 States, of which 4 States—California, Idaho, New Mexico, and Oregon—accounted for 97% of total 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 90% of the tonnage and 67% 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	1982		1983	
	Quantity	Value	Quantity	Value
Arizona	1	7	2	15
California	59	1,285	65	1,582
Kansas	W	W	W	W
New Mexico	97	809	110	1,070
Oklahoma	1	W	1	W
Oregon	W	W	W	W
Other[1]	258	1,649	271	1,819
Total	416	3,750	449	4,486

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes Hawaii, Idaho, and States indicated by symbol W.

CONSUMPTION AND USES

U.S. apparent consumption was 632,000 tons, an increase of 18% over that of 1982. Pumice and pumicite produced for domestic use as concrete aggregate and admixture declined 26%. This was attributed mostly to several aggregate producers switching to building block production, a higher value product, during the year. As a result, decorative building block use increased 90%, to 200,000 tons.

Table 3.—Pumice and pumicite sold and used by producers in the United States, by use

(Thousand short tons and thousand dollars)

Use	1982		1983	
	Quantity	Value	Quantity	Value
Abrasives (includes cleaning and scouring compounds)	19	479	15	446
Concrete admixture and concrete aggregate	254	1,199	189	1,195
Decorative building block	105	1,340	200	2,131
Landscaping	13	100	9	84
Other[1]	r25	r632	36	630
Total	416	3,750	449	4,486

rRevised.
[1]Includes heat-or-cold insulating medium, pesticide carriers, road construction material, roofing granules, and miscellaneous uses.

PRICES

Prices quoted in Chemical Marketing Reporter at yearend, for domestic grades of pumice bagged in 1-ton lots, were $175 to $205 per ton for fine, $225 per ton for medium, and $200 per ton for coarse and 2-extra coarse. Yearend quoted prices on imported (Italian) pumice, f.o.b. east coast, bagged in 1-ton lots, increased to $259 per ton for fine, $325 per ton for medium, and $250 to $300 per ton for coarse. Crude or unmanufactured Italian pumice was imported at a customs-declared average value of $166.05 per ton, an increase of 22% over that of 1982.

The average value, f.o.b. mine or mill, for pumice and pumicite sold and used by domestic producers increased by 11% to $9.99 per ton. The average customs declared value of pumice imported from Greece for use in concrete masonry products increased 10% to $6.35 per ton.

FOREIGN TRADE

Pumice imported for consumption, nearly all from Greece, increased by 52%. Imports from Greece totaled 183,737 tons, of which 99% was used to produce concrete masonry products.

Table 4.—U.S. imports of pumice for consumption, 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)
1982:							
Greece	2,368	$34	--	--	118,173	^{r}$681	--
Italy	442	60	^{r}58	$7	--	--	$24
Mexico	4	4	--	--	--	--	2
Other[1]	73	4	^{r}1	^{r}6	1	1	^{r}77
Total	2,887	102	^{r}59	^{r}13	118,174	^{r}682	^{r}103
1983:							
Greece	2,262	31	--	--	181,475	1,150	--
Iceland	158	27	--	--	--	--	--
Italy	271	45	2	2	--	--	27
Mexico	--	--	--	--	123	4	--
Other[2]	8	10	6	10	--	--	79
Total	2,699	113	8	12	181,598	1,154	106

^{r}Revised.
[1]Includes Austria, Canada, Denmark, France, the Federal Republic of Germany, Japan, the Netherlands, Taiwan, and the United Kingdom.
[2]Includes Austria, Canada, Denmark, France, the Federal Republic of Germany, Japan, the Republic of Korea, Switzerland, Taiwan, and the United Kingdom.

WORLD REVIEW

World production of pumice and related volcanic materials declined for the second year to an estimated 11.8 million tons. The combined production of Greece and Italy accounted for 73% of the world's total.

[1]Industry economist, Division of Industrial Minerals.

Table 5.—Pumice and related volcanic materials: World production, by country[1]

(Thousand short tons)

Country[2]	1979	1980	1981	1982^{p}	1983^{e}
Argentina[3]	51	40	56	59	60
Austria: Trass	9	9	9	11	12
Cape Verde Islands: Pozzolan^{e}	^{r}17	^{r}17	^{r}11	^{r}11	11
Chile: Pozzolan	^{r}243	275	306	190	200
Costa Rica^{e}	1	1	1	^{r}2	2
Dominica: Pumice and volcanic ash^{e}	120	120	120	120	120
France: Pozzolan and lapilli	^{r}616	^{r}513	^{r} ^{e}500	^{r} ^{e}500	440
Germany, Federal Republic of:					
Pumice (marketable)	1,579	890	440	^{r} ^{e}240	165
Pozzolan	215	^{e}220	^{e}220	^{e}220	NA
Greece: ^{r}					
Pumice	1,368	1,609	1,634	^{e}1,650	1,650
Pozzolan	1,041	1,024	684	^{e}690	690
Guadeloupe: Pozzolan^{e}	220	275	265	265	265
Guatemala:					
Pumice	20	^{e}20	^{e}17	^{r} ^{e}13	13
Volcanic ash	^{r}40	14	6	^{r} ^{e}4	4
Iceland	27	40	37	96	95
Italy:					
Pumice and pumiceous lapilli	^{e}940	[4]629	^{r} ^{e}660	^{e}825	770
Pozzolan^{e}	6,500	[4]5,684	6,600	6,100	5,500
Martinique: Pumice	183	169	172	^{r} ^{e}170	165
New Zealand	28	15	37	55	55
Spain[5]	859	1,198	1,034	1,070	1,100
United States (sold or used by producers)	1,172	543	499	416	[4]449
Total	^{r}15,249	^{r}13,305	13,308	12,707	11,766

^{e}Estimated. ^{p}Preliminary. ^{r}Revised. NA Not available.
[1]Table includes data available through Apr. 9, 1984.
[2]Pumice and related volcanic materials are also produced in a number of other countries, including (but not limited to) 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]Includes Canary Islands.

Rare-Earth Minerals and Metals

By James B. Hedrick[1]

Associated Minerals Ltd. Inc. (AMC) and Molycorp Inc., a subsidiary of Unocal Corp. (previously Union Oil Co. of California), were the only domestic mine producers of rare-earth minerals. Molycorp; W. R. Grace & Co.'s Davison Chemical Div.; Research Chemicals, a division of NUCOR Corp.; and Rhône-Poulenc Inc. were the principal processors of rare earths in the United States. Major end uses were in petroleum catalysis, metallurgical applications, and glass polishing.

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.—Lower U.S. import duties for imported rare earths, resulting from the 1979 Tokyo Round of negotiations, continued for nations having most-favored-nation status. The import duties for these countries were scheduled to decline annually through January 1, 1987.

Table 1.—Salient U.S. rare earth statistics

(Metric tons of rare-earth oxides (REO) unless otherwise specified)

	1979	1980	1981	1982	1983
Production of rare-earth concentrates[1]	16,515	15,986	17,082	17,501	17,083
Exports:[e]					
Ore and concentrate	4,334	4,741	5,056	2,565	2,684
Ferrocerium and pyrophoric alloys	34	14	9	22	59
Imports for consumption:[e]					
Monazite	3,458	2,831	4,108	3,962	2,215
Metals, alloys, oxides, compounds	1,004	1,624	1,631	[r]1,695	1,857
Shipments from Government stockpile	1,100	1,257	802	364	--
Stocks, producers and processors, yearend	W	W	W	W	W
Consumption, apparent[e]	16,000	18,100	20,000	[r]17,100	19,600
Prices, yearend, dollars per kilogram:					
Bastnasite concentrate, REO basis	$1.98	$1.98	$2.14	$2.31	$2.14
Monazite concentrate, REO basis	$0.76	$0.81	$0.83	$0.75	$0.71
Mischmetal, metal basis	$9.26	$12.35	$12.35	$12.35	$12.35
Employment, mine and mill[e 2]	325	250	275	303	266
Net import reliance[e 3] as a percent of apparent consumption	7	11	14	[r]([4])	12

[e]Estimated. [r]Revised. W Withheld to avoid disclosing company proprietary data.
[1]Comprises only the rare earths derived from bastnasite, as reported in Molycorp Inc. company annual report.
[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 rutile, ilmenite, and zircon, and employees were not assigned to specific commodities.
[3]Imports minus exports plus adjustments for Government and industry stock changes.
[4]Increase in industry stocks exceeded net imports.

DOMESTIC PRODUCTION

Domestic production did not change significantly in 1983, as low demand for iron and steel alloying agents was offset by increased demand for permanent magnet alloys and petroleum catalysts. Bastnasite was the major domestic ore of rare earths. The only other rare-earth ore produced domestically was monazite. Molycorp, the only U.S. producer of bastnasite, operated a mine at Mountain Pass, CA. AMC, the only domestic producer of monazite, operated a placer mine at Green Cove Springs, FL, to recover monazite as a byproduct of minerals sands mined for titanium and zirconium minerals.

Marathon Gold Corp. announced that it would recover monazite as a byproduct of its placer gold mining deposits near Craig, CO, starting in 1985. The minerals sands reportedly contain from 7.5 to 20 kilograms of heavy minerals per ton,[2] of which 5% to 21% is monazite. Marathon was reportedly negotiating with domestic rare-earth processors for the sale of its monazite concentrates.

Williams Strategic Metals (WSM), a subsidiary of Williams Resources Inc., announced plans to recover rare earth- and thorium-bearing apatite from 16 million tons of iron ore tailings near Mineville, NY. The Mineville Mine and facilities were purchased from Republic Steel Corp., which operated the iron mine until 1971. WSM reportedly expected to begin processing in 1985 at an annual rate of 90,000 tons of iron ore tailings, which would yield about 1,000 tons of rare-earth oxides (REO). WSM would produce magnetite and yttrium, including rare earths, as coproducts, and phosphoric acid as a byproduct.

CONSUMPTION AND USES

Domestic rare-earth processors consumed an estimated 19,200 metric tons of REO in various forms in 1983, a 4% increase above the 18,500 tons of REO consumed in 1982. Bastnasite consumption was 14% higher in 1983 than in 1982, but consumption of monazite decreased 31%.

Shipments of rare-earth products from domestic processors amounted to 16,900 tons of contained REO, an increase over the 15,200 tons of contained REO shipped in 1982.

The approximate distribution of rare earths by end use, based on information supplied by primary processors and some consumers, was as follows: petroleum catalysts, 65%; metallurgical uses (including iron and steel additives, alloys, and mischmetal), 20%; ceramics and glass (including polishing compounds and glass additives), 12%; and miscellaneous (including phosphors, electronics, nuclear energy, lighting, and research), 3%.

Consumption of mixed rare-earth compounds in 1983 decreased 36% below the 1982 level, while consumption of purified rare-earth compounds was 52% higher. Strong demand for samarium oxide for use in permanent magnets, europium and yttrium oxides for use in phosphors, and the new uses of neodymium oxide in color television faceplates and permanent magnets contributed to the higher consumption of purified compounds. This trend was expected to continue as neodymium oxide's use in the high-strength neodymium-iron-boron magnet develops.

The producers of mischmetal, rare-earth silicide, and other rare-earth alloys consumed 10% more contained REO in 1983 than in 1982. Although alloy producers consumed more rare earths, alloy production remained far below historical levels. Shipments of rare-earth alloys were 46% lower than those of 1982. Consumption of high-purity rare-earth metals was 34% higher.

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 other 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. These 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 intensify-ing screens, low- and high-pressure mercury vapor lights, electronic thermometers, and trichromatic fluorescent lamps.

The ceramics industry used purified rare earths in pigments, heating elements, dielectric and conductive ceramics, thermal and/or flash protective devices, stereoviewing systems, data printers, welder's electronic safety goggles, image storage devices, and as principal constituents and stabilizers in high temperature ceramics, glazes, and paints.

Purified rare-earth compounds also had applications in petroleum cracking catalysts, noncracking catalysts, oxygen-sensing electrolytes, computer bubble domain memories, substrates for bubble domain memories, dyes and softeners for textiles, electronic components, nuclear control rods, nuclear fuel reprocessing, microwave applications, incandescent gas mantles, 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, earring and necklace clasps, medical and dental applications, traveling wave tubes, drill bit salvage, metallic separators, aerospace applications, 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, all classified as excess inventory, increased from 443 tons at yearend 1982 to 457 tons at yearend 1983 as a result of inventory adjustments. Additional unshipped stocks of rare-earth materials previously sold from the stockpile decreased from 435 tons at yearend 1982 to 419 tons at yearend 1983, also as a result of inventory adjustments. All rare-earth stocks held in the stockpile were contained in sodium sulfate and were inventoried on a contained-REO basis.

Industry stocks of rare earths in all forms held by 22 producing, processing, and consuming companies decreased 8%. Bastnasite concentrate stocks held by the principal producer and two other processors decreased about 27%. Yearend inventories of monazite and other rare-earth concentrates also decreased.

Stocks of mixed rare-earth compounds and purified compounds increased during the year. Yearend stocks of contained REO equivalent in mischmetal, rare-earth silicide, and alloys containing rare earths decreased 27% as a result of weak demand for mischmetal and associated cutbacks in production. Inventories of high-purity rare-earth metals also decreased, but as a result of strong demand, primarily for magnet alloys.

PRICES

The price of Australian monazite (minimum 55% rare-earth oxides including thoria, f.o.b./f.i.d.),[3] as quoted in Metal Bulletin (London), increased from $A400-$A440 per ton at yearend 1982 to $A410-$A450 per ton by yearend 1983. However, changes in the foreign exchange rate caused the corresponding U.S. dollar price to decrease, from US$392-US$432 in 1982[4] to US$369-US$405 in 1983.[5]

Yearend prices quoted in Industrial Minerals (London) for yttrium concentrate (60% Y_2O_3, f.o.b. Malaysia) were $46 per kilogram.

Prices quoted by Molycorp for unleached, leached, and calcined bastnasite, containing 60%, 70%, and 85% REO, decreased from $1.00, $1.05, and $1.25 per pound of contained REO at yearend 1982 to $0.92, $0.97, and $1.17 per pound of contained REO, respectively, at yearend 1983.

The price of cerium concentrate quoted by American Metal Market increased from $1.30 per pound of contained cerium oxide at yearend 1982 to $1.40 per pound of contained cerium oxide at yearend 1983. Lanthanum concentrate increased from $1.08 per pound REO contained at yearend 1982 to $1.32 per pound REO contained at yearend 1983.

Mischmetal (99.8%, 50 to 100 pound lots, f.o.b. Newark, NJ) prices quoted in American Metal Market, remained at the yearend 1980 level of $5.60 per pound throughout 1981, 1982, and 1983. Rhône-Poulenc quoted rare-earth prices, per kilogram, net 30 days, f.o.b. New Brunswick, NJ, or duty paid at point of entry, effective January 1, 1983, 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	50	17.00
Praseodymium	96.0	20	43.40
Samarium	96.0	20	59.50
Terbium	99.9	20	920.00
Yttrium	99.99	50	96.60

[1]Dysprosium, holmium, lutetium, thulium, and ytterbium oxide prices on request.

Rhône-Poulenc also quoted prices for rare earths produced at its Freeport, TX, plant, net 30 days, f.o.b. Freeport, TX, effective January 1, 1983, as follows:

Product (compound)	Percent purity	Quantity (kilograms)	Price[1] per kilogram
Cerium hydroxide	99.5	540	$13.10
Cerium nitrate	99.5	Truckload	10.80
Cerium oxide	99.5	540	15.85
Lanthanum-neodymium nitrate	98	Truckload bulk	3.85
Neodymium carbonate	95	540	6.30
Neodymium oxide	95	540	7.90

[1]Priced on a contained REO basis.

Molycorp quoted prices for rare-earth oxides, net 30 days, f.o.b. Louviers, CO, Mountain Pass, CA, or York, PA, effective August 1, 1983, as follows:

Product (oxide)	Percent[1] purity	Quantity (pounds)	Price per pound
Cerium	99.9	1-199	$8.75
Europium	99.99	1-39	65.00
Gadolinium	99.99	1-24	725.00
Lanthanum	99.99	1-299	7.50
Neodymium	99.99	1-49	60.00
Praseodymium	95.0	1-299	17.50
Samarium	95.0	1-109	30.00
Terbium	99.99	1-49	575.00
Yttrium	99.99	1-49	47.00

[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, 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	94	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

Exports of ferrocerium and other pyrophoric alloys containing rare earths totaled 66,174 kilograms, a 171% increase over the 1982 level. Major destinations were the Federal Republic of Germany (43%), Mexico (34%), and Japan (15%).

Exports of rare-earth metal ores, excluding monazite, increased 5% over the 1982 total of 4,836,389 kilograms to a total of 5,101,583 kilograms in 1983. Exports were valued at $9,762,869. Major destinations were Japan (63%), Austria (10%), and the Federal Republic of Germany (8%).

Exports of thorium ore, including monazite, decreased 38%. France was the destination of all of the reported total of 57,139 kilograms valued at $51,678.

Australia has been the principal import source of monazite for the United States since 1977.

Table 2.—U.S. import duties for rare earths

TSUS No.	Item	Most favored nation (MFN)			Non-MFN	
		Jan. 1, 1983	Jan. 1, 1984	Jan. 1, 1987	Jan. 1, 1983	Jan. 1, 1984
601.12, 601.45	Ore and concentrate[1]	Free	Free	Free	Free	Free.
418.40, 418.42, 418.44	Cerium chloride, oxide, compounds	11.1% ad valorem	10.1% ad valorem	7.2% ad valorem	35% ad valorem	35% ad valorem.
423.0030	Rare-earth oxides except cerium oxide	4.4% ad valorem	4.2% ad valorem	3.7% ad valorem	25% ad valorem	25% ad valorem.
632.38	Rare-earth metals (including scandium and yttrium).	do	do	do	do	Do.
632.78	Alloys wholly or almost wholly of rare-earth metals (mischmetal).	41 cents per pound.	38 cents per pound.	32 cents per pound.	$2 per pound	$2 per pound.
632.79	Other alloys wholly or almost wholly of rare-earth metals.	35 cents per pound plus 4.2% ad valorem.	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.	$2 per pound plus 25% ad valorem.
755.35	Ferrocerium and other pyrophoric alloys.	36 cents per pound plus 4.3% ad valorem.	32 cents per pound plus 3.9% ad valorem.	22 cents per pound plus 2.6% ad valorem.	do	Do.
603.70	Inorganic chemicals (includes yttrium concentrates).[2]	6.3% ad valorem	5.9% ad valorem	5% ad valorem	30% 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	1979		1980		1981		1982		1983	
	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	5,686	$1,501	4,933	$1,749	7,469	$3,158	6,600	$2,830	3,726	$1,395
Malaysia	561	161	215	101	--	--	603	240	302	122
South Africa, Republic of	3	2	--	--	--	--	--	--	--	--
Thailand	37	13	--	--	--	--	--	--	--	--
Total	6,287	1,677	5,148	1,850	7,469	3,158	7,203	3,070	4,028	1,517
REO content[e]	3,458	XX	2,831	XX	4,108	XX	3,962	XX	2,215	XX

[e]Estimated. XX Not applicable.

Table 4.—U.S. imports for consumption of rare earths, by country

Country	1981		1982		1983	
	Quantity (kilograms)	Value	Quantity (kilograms)	Value	Quantity (kilograms)	Value
Cerium oxide:						
Austria	--	--	--	--	68	$674
Belgium	--	--	--	--	18,120	6,504
France	7,450	$51,644	26,239	$72,912	6,239	78,136
Germany, Federal Republic of	--	--	7	1,727	2	381
Japan	--	--	--	--	835	7,692
Switzerland	--	--	--	--	3	335
United Kingdom	127	1,068	--	--	50	536
Total	7,577	52,712	26,246	74,639	25,317	94,258
Rare-earth oxide excluding cerium oxide:						
Austria	100	1,339	--	--	--	--
Belgium	4,097	466,781	--	--	55	25,906
Brazil	NA	299	300	27,235	54,999	575,850
Canada	1	950	--	--	100	128,611
China	--	--	1,300	71,168	19,575	450,033
France	147,256	8,169,455	140,020	7,141,420	206,345	9,393,632
Germany, Federal Republic of	10,808	1,947,385	17,116	2,258,877	702	191,953
Guyana	--	--	38	19,543	--	--
Italy	--	--	--	--	22,640	10,466
Japan	14,736	1,154,744	10,292	1,221,724	10,983	585,262
Malaysia	--	--	--	--	273,597	251,022
Netherlands	--	--	50	26,269	--	--
Norway	3,984	419,193	4,770	517,124	7,128	778,743
Switzerland	--	--	6	3,180	5	4,790
Taiwan	--	--	--	--	500	31,184
U.S.S.R.	11,728	895,932	10,746	1,143,593	12,657	1,237,136
United Kingdom	3,443	121,927	8,316	79,889	31	6,196
Total	196,153	13,178,005	192,954	12,510,022	609,317	13,670,784
Rare-earth alloys:[1]						
Austria	--	--	17,500	161,506	--	--
Brazil	179,998	1,518,469	40,000	312,758	65,147	457,419
France	37	833	--	--	--	--
Germany, Federal Republic of	950	8,157	4,858	44,531	9,870	143,328
United Kingdom	555	123,503	769	139,542	237	41,038
Total	181,540	1,650,962	63,127	658,337	75,254	641,785
Rare-earth metals, and scandium and yttrium:						
China	--	--	2,100	52,068	--	--
France	200	11,568	500	14,984	50	1,805
Germany, Federal Republic of	15	1,415	--	--	--	--
Japan	3	9,329	550	47,483	81	12,679
U.S.S.R.	1,000	34,638	--	--	300	70,500
United Kingdom	483	110,940	68	24,394	370	97,258
Total	1,701	167,890	3,218	138,929	801	182,242

See footnotes at end of table.

Table 4.—U.S. imports for consumption of rare earths, by country —Continued

Country	1981 Quantity (kilograms)	1981 Value	1982 Quantity (kilograms)	1982 Value	1983 Quantity (kilograms)	1983 Value
Other rare-earth metals:						
Germany, Federal Republic of	168	$10,848	6	$928	46	$5,524
Japan	--	--	45	2,233	422	8,237
United Kingdom	25	2,874	--	--	5	359
Total	193	13,722	51	3,161	473	14,120
Ferrocerium and other pyrophoric alloys:						
Austria	840	13,314	2,367	33,340	953	13,430
Brazil	6,725	102,818	14,954	212,450	28,839	396,715
France	50,443	745,169	47,968	571,079	54,321	576,549
Germany, Federal Republic of	100	1,854	462	7,266	--	--
Italy	--	--	6	286	--	--
Japan	23,741	332,733	19,375	257,589	13,190	176,108
Sweden	--	--	--	--	6,694	7,816
Taiwan	--	--	--	--	91	410
United Kingdom	1,310	53,287	606	10,163	608	14,288
Total	83,159	1,249,175	85,738	1,092,173	104,696	1,185,316

NA Not available.
[1]Essentially all mischmetal.

WORLD REVIEW

Bastnasite, the world's principal source of rare earths, was mined as a primary product in the United States and as a byproduct of iron ore mining in China. Significant quantities of rare earths were also recovered from monazite, a byproduct of minerals sands mined for titanium and zirconium in several countries, and for tin in Malaysia and Thailand. Small quantities of rare earths were also obtained from an yttrium-rich minerals sands byproduct, xenotime.

Australia.—Allied Eneabba Ltd. produced 10,429 tons of monazite in 1983, an increase over the 5,693 tons produced in 1982. During the year, Allied acquired the assets of its mining contractors, Astek Pty. Ltd., through its wholly owned subsidiary, Indoon Resources Pty. Ltd.

Figures for identified resources for Australian monazite were updated. Economic demonstrated resources of monazite were 329,300 tons, with additional subeconomic resources of 105,800 tons. Inferred economic and subeconomic resources were 2,360 tons and 36,700 tons, respectively.[6]

Brazil.—Production of various rare-earth materials, in kilograms, was as follows:

Year	Carbonate	Chloride	Oxide
1978	7,000	2,799,000	21,000
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

Production of crude monazite ore in 1982 was 200 tons from the State of Espírito Santo and 1,767 tons from the State of Rio de Janeiro.

According to Anuario Mineral Brasileiro 1983, measured reserves of monazite were 25,086 tons with a REO content of 15,017 tons. The largest reserves were located in the São João da Barra region in the State of Rio de Janeiro. Additional rare-earth resources were obtained in clay-like ore in the Poços de Caldas region. The deposit was estimated to contain 1 million tons of ore grading 4% REO in a surface zone and an additional 500,000 tons grading 1.5 tons of 2% REO in a lower zone.[7]

Canada.—Iron Ore Co. of Canada continued preliminary feasibility studies on the Strange Lake yttrium-beryllium-zirconium deposit northeast of Schefferville, Quebec. Further studies were planned for 1984.

China.—Exports of monazite from China increased from 1,000 tons valued at $75,000 in 1981 to 11,520 tons valued at $719,000 in 1982. France received all of the reported monazite exports. Monazite was reportedly being produced in Guangxi and in Guangdong. Strict Chinese national standards for radioactive materials made the handling of monazite increasingly difficult. As a result, Chinese monazite was often converted to rare-earth chloride and the radioactive thorium extracted.[8]

Deposits of rare earths in clays were reported in Guangxi.[9] The new ore is either rich in samarium, europium, and terbium or rich in yttrium. The cerium content, however, is reportedly very low, unlike bastnasite and monazite. It was considered likely that the rare-earth clay is a residual enrichment product of the weathering of phosphatic minerals, such as apatite and xenotime. Hydrometallurgical processing of the clay reportedly produced concentrates containing more than 90% REO.

A review of the rare-earth industry in China from 1949 to the present was published by a group of authors from the Yao Long Chemical Plant, Shanghai, China. Analyses of various Chinese rare-earth ores and concentrates and a flowsheet of the Yao Long Chemical Plant were given.[10]

France.—Pechiney S.A.'s subsidiary, Société Française d'Electrometallurgic (Sofrem), was reportedly producing samarium metal from samarium oxide materials obtained from the French rare-earth processor, Rhône-Poulenc S.A. Sofrem's capacity was about 500 kilograms of samarium metal per month.[11]

Rhône-Poulenc of France, and Showa Denko K.K., of Japan, announced a joint venture to develop new applications for rare earths. Showa Denko, which had no current activities in rare earths, would contribute its experience in researching fine ceramics, metals, monocrystals, and high-purity mineral products.[12]

India.—Decreased production in 1982-83[13] was attributed to severe power shortages caused by drought conditions.[14] Rare-earth chloride production declined from 3,861 tons in 1981-82 to 3,460 tons in 1982-83, while exports of the compound dropped from 3,700 tons to 3,600 tons. The United States was the principal destination of exports.

Construction work at Indian Rare Earths Ltd.'s Orissa Sands Complex was in an advanced phase, with completion scheduled for mid-1984. Power shortages, labor unrest, and late deliveries of equipment caused construction delays.[15]

Kerala Minerals & Metals Ltd. announced plans to build an additional minerals sands separation plant in Kerala with capacity to produce 1,800 tons of monazite per year. Completion of the plant is set for 1987. Kerala's present capacity to produce monazite is about 300 tons per year.

Japan.—Japanese demand for rare earths in 1982 was reported as follows:[16] cerium oxide, 1,500 tons; lanthanum oxide, 180 tons; europium oxide, 2.5 tons; yttrium oxide, 100 tons; catalysts, 140 tons; mischmetal, 330 tons; and rare-earth fluoride, 40 tons.

About 4,941 tons of rare-earth raw materials was imported containing an estimated 3,048 tons of REO, compared with a revised 6,497 tons in 1981 containing 4,048 tons of REO. Imports for 1982 included 1,584 tons of rare-earth chlorides, 1,032 tons of rare-earth hydroxides, 1,900 tons of bastnasite concentrates, and 30 tons of crude yttrium oxides.

Imports of rare earths in 1983 were reported in the Japan Metal Journal, as follows:

Product	Quantity (kilograms)
Cerium fluoride	372
Cerium oxide	52,509
Ferrocerium and other pyrophoric alloys	1,763,084
Lanthanum nitrate	4,490
Lanthanum oxide	115,000
Rare-earth metals including yytrium and scandium	26,416
Yttrium oxide	110,186

Principal sources of imported compounds were Brazil, China, France, India, and the United States. Leading sources of rare-earth metals and alloys were Austria, Brazil, China, and the United States.

Mitsubishi Steel Manufacturing Co. and Mitsubishi Chemical Industries Ltd. announced a joint venture company, Dia Rare Earth Magnetics K.K., to produce plastic magnets by injection molding. The magnets are produced from powdered magnetic alloys containing rare earths in a plastic binder. Annual capacity of the production facilities, located in Ichikawa City, China Prefecture, was 30 tons.[17]

Thailand.—Monazite and xenotime were byproducts of tin mining. Production of xenotime from Ranong was, as follows:[18]

Year	Quantity (metric tons)
1978	--
1979	6
1980	52
1981	45
1982	46

The destinations of exports in 1982 were the Federal Republic of Germany, 50 tons; Malaysia, 30 tons; Japan, 26 tons; and Singapore, 14 tons.

Production of monazite was 2 tons at Rayong and 160 tons at Ranong.

Table 5.—Monazite concentrate: World production, by country[1]

(Metric tons)

Country[2]	1979	1980	1981	1982[p]	1983[e]
Australia	16,340	14,079	13,251	9,433	14,500
Brazil	1,900	2,532	2,100	[r] [e]1,768	2,000
India[3]	3,254	3,395	3,704	[e]4,000	4,000
Malaysia (exports)	542	347	320	[e]450	340
Sri Lanka	213	63	[e]60	304	300
Thailand	32	152	107	162	140
United States	W	W	W	W	W
Zaire	90	51	50	[e]50	50
Total	22,371	20,619	19,592	16,167	21,330

[e]Estimated. [p]Preliminary. [r]Revised. W Withheld to avoid disclosing company proprietary data.
[1]Table includes data available through Apr. 27, 1984.
[2]In addition to the countries listed, China, Indonesia, the Republic of Korea, North 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

General Motors Corp.; Sumitomo Special Metals Co.; Colt Industries, Crucible Magnetic Div.; and IG Technologies Inc. announced separately the development of high-energy permanent magnets with magnetic strengths exceeding that of samarium-cobalt magnets. The new magnets, alloys of neodymium, iron, and boron have energy products reportedly between 30 and 42.9 megagauss oesteds (MgOe). As a result of its higher strength and lower cost alloying materials, the neodymium-iron-boron magnets may partially replace the best previously available magnets, samarium-cobalt, which have magnetic energy products in the range of 16 to 25 MgOe. Ordinary household magnets (ferrites) have energy products around 3 to 4 MgOe. Prices of the neodymium-iron-boron magnets were expected to be lower than for samarium-cobalt magnets—potentially 50% to 75% lower. Demand for samarium-cobalt and ferrite magnets was expected to be significantly reduced by the new magnets, especially in low-temperature applications.[19]

A rare-earth-aluminum-magnesium high-voltage transmission line, reportedly produced in China, was said to be stronger than conventionally produced wire and was reportedly less costly.[20]

Initial tests with fertilizers containing rare earths reportedly increased crop yields from 5% to 10%. The fertilizers are also credited with increasing the latex content of rubber trees and with increasing the sugar content of watermelons, sugar cane, and sugar beets.[21]

The Chinese Academy of Agricultural Science developed an instrument using samarium-cobalt magnets for retrieving metal fragments from the stomachs of cattle. Use of the instruments reportedly will protect livestock from injuries and reduce associated costs.[22]

Rare earths permanent magnets were also used to salvage broken oil well drill bits. The removal of bit fragments reportedly improved subsequent drilling rates and increased the service length of the replacement bit.[23]

Mitsubishi Steel and Mitsubishi Chemical jointly developed the technology to produce plastic magnets by injection-molding samarium, cobalt, and other rare-earth metal powders that are held in a plastic binder. The injection-molded magnets are said to be superior in impact resistance, bending strength, and tensile strength compared with sintered magnets. The injection-process can also produce complex shapes with higher precision and less cost than previous methods.[24]

A laser material was developed in the U.S.S.R having 3-1/2 times the efficiency of an equivalent commercially available neodymium-doped yttrium-aluminum-garnet (YAG) laser. The new high-efficiency laser material is chromium-neodymium-doped gadolinium-scandium-gallium-garnet. Development of this laser may have been responsible for recent shortages of scandium from the U.S.S.R.[25]

The Los Alamos National Laboratory, the American Iron and Steel Institute, and the

U.S. Department of Energy developed an analytical system that uses a commercially available neodymium-doped YAG laser. Intense bursts of light from the laser reduce materials to their elemental components, generating the characteristic atomic spectra that can be analyzed rapidly. Researchers hoped to apply this laser-induced breakdown spectroscopy to the analysis of molten steel for trace elements while it is still in the ladle. The new technique reportedly could save millions of dollars in energy by quickly analyzing steel and other alloys.[26]

Researchers at the Jet Propulsion Laboratory in Pasadena, CA, developed a method of refrigeration, involving the use of a lanthanum compound, that can reportedly produce temperatures around -400°F. Using solar heat or low-temperature "waste heat," the refrigerator can cool without the use of electricity and with few moving parts. Lanthanum pentanickel, the main ingredient of the system, absorbs hydrogen gas at room temperature and then releases it when heated and compressed. The released hydrogen gas expands as it passes through a heat-exchanger, cooling to -424° F, and partially liquefying in the process. After absorbing heat from the heat exchanger, the hydrogen is reabsorbed by the rare-earth metal powder and the cycle is ready to be repeated.[27]

Abex Corp. announced a series of new heat-resistant alloys containing rare earths that reportedly outperform existing alloys in almost every measurable category. The alloys are nickel-chromium-based and contain small amounts of titanium, niobium, tungsten, and certain rare earths. They were expected to provide longer life to parts, and to require less material per part for the same performance.[28]

Scientists at the California Institute of Technology in Pasadena, CA, developed a lower cost method of producing amorphous metals. Carefully chosen pairs of metals are interdiffused, creating alloys with glasslike structures. Two pairs, gold-lanthanum and gold-yttrium, have been used successfully in the process, which reportedly could lead to the production of lower cost amorphous metal powders.[29]

Allied Corp. developed single crystal lanthanum yttrium-iron-garnet (YIG) films on gadolinium-gallium-garnet substrates. The material was intended for use primarily in advanced magnetostatic signal processing technology.[30]

Physicists at Tokyo University achieved a new record low temperature using a rare-earth intermetallic compound. A temperature of 27 millionths of a degree above absolute zero was obtained using praseodymium nickel as a refrigerant.[31]

ZYP Coating Inc. announced the commercial availability of two new crucible-mold paints and a neutron absorbing paint. Yttrium oxide and zirconium oxide, respectively, were used as separate crucible-mold paints. The paints were expected to be usable at temperatures up to 2,000° C on nonreactive or ceramic surfaces, and may prove useful in crucibles for melting and transporting of molten materials, such as metal, alloys, glasses, or slags. Gadolinium oxide in ethanol-diglyme ether was developed as a neutron-absorbing paint using gadolinium's high neutron capture cross section as its principal property. The gadolinium paint could provide a means of shielding radiation detection equipment and facilities from neutrons.[32]

An article on the abundance of the rare-earth elements in seawater was published by researchers at the University of Leeds, United Kingdom. The chemistry of the rare-earth elements makes them particularly useful in studies of marine geochemistry. Their relative abundances can be used to determine their sources in sedimentary deposits, to evaluate the marine geochemical cycle, and apply the distributions to tracing mass movements of seawater.[33]

An appraisal of calibration errors in determining abundances of the rare-earth elements in several international standard rock specimens was completed. Using neutron activation analysis, standard calibration adjustments were made to an estimated absolute accuracy of better than 5% and were used to determine the elemental abundances of rare earths in 29 standard rocks. Improved analyses of standard rocks was expected to lead to improved data on the crustal abundance of the rare earths.[34]

The proceedings of the Sixteenth Rare Earth Research Conference, held April 18-21, 1983, in Tallahassee, FL, were published.[35]

Potentially significant concentrates of heavy minerals sands, including monazite, were reported by the U.S. Geological Survey in surficial U.S. Atlantic Continental Shelf sediments. Comparison of offshore sediments from Virginia, South Carolina, and northeastern Florida indicated that monazite enrichment was highest off the coast of Virginia.[36] Additional indepth studies of

Atlantic Continental Shelf sediments were started.[37]

Researchers at the Bureau of Mines published a report on the magnetic properties of natural mischmetal, and of synthetic mischmetal alloyed with cobalt, copper, and magnesium. Alloyed synthetic mischmetal demonstrated better magnetic properties than natural mischmetal.[38]

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[1]Physical scientist, Division of Nonferrous Metals.

[2]All quantities are in metric units unless otherwise specified.

[3]Free on board and/or free into container depot.

[4]Values have been converted from Australian dollars ($A) to U.S. dollars (US$) at the rate of $A1.1019=US$1.00 based on yearend 1982 foreign exchange rates from the Wall Street Journal.

[5]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.

[6]U.S. Embassy, Canberra, Australia. State Dep. Airgram A-57, Apr. 4, 1984. Australia's Identified Mineral Resources as of Dec. 31, 1983. Petroleum & Minerals Resources & Industry Information. Bureau of Minerals Resources, Mar. 1984, 3 pp.

[7]Griffiths, J. Rare-Earths—Attracting Increasing Attention. Ind. Miner. (London), No. 199, Apr. 1984, pp. 19-37.

[8]Roskill's Letter From China. China's Rare Earth Deposits. No. 5, Spring 1982, p. 2.

[9]Hong-ru, S. A Brief Introduction to the Mineral Resources and Production of Less Common Metals in China. Rare Met., v. 2, No. 1, May 1983, pp. 4-9.

Zang, B. Z., K. Y. Lu, K. C. King, W. C. Wei, and W. C. Wang. Rare Earth Industry in China. Hydrometal., v. 9, No. 2, Nov. 1982, pp. 205-210.

[10]Work cited in footnote 9.

[11]Roskill's Letter From Japan. PUK Japan Improve Quality of Samarium, Hope to Increase Imports Into Japan. No. 88, Aug. 1983, p. 6.

[12]Chemical Marketing Reporter. Rhône-Poulenc, Japanese, Form Rare Earth Venture. Aug. 29, 1983, p. 4.

[13]Data are for Apr. 1 to Mar. 31 of the years stated.

[14]U.S. Embassy, New Dehli, India. State Dep. Airgram A-11, Feb. 1984, pp. 49-51.

[15]Work cited in footnote 7.

[16]Roskill's Letter From Japan. Rare Earths: Six Year Growth in Demand Halted. No. 88, Aug. 1983, pp. 5-9.

[17]Furukawa, T. Joint Firm to Make Plastic Magnets. Am. Met. Mark., Jan. 24, 1983, p. 11.

[18]Thailand Department of Mineral Resources. Mineral Statistics of Thailand 1978-82. P. 59.

[19]Koten, J. GM, Sumitomo Race to Develop Magnet to Reduce Cost and Size of Electric Motors. The Wall Street J., Aug. 29, 1983, p. 6.

Kingston, J. Neodymium-Iron Magnets Should Spur Rare Earths. Am. Met. Mark., Sept. 12, 1983, p. 29.

[20]Industrial Minerals. China—Novel Applications for Rare Earths.

[21]Work cited in footnote 20.

[22]Work cited in footnote 20.

[23]Work cited in footnote 20.

[24]American Metal Market. New Injection-Molding Use Produces Plastic Magnets. June 6, 1982, p. 7.

[25]Rare-Earth Information Center News. High Efficiency Laser. V. 18, June 1, 1983, p. 6; Kvant. Electron., v. 9, Dec. 1982, p. 2533.

[26]Iron Age. Techfront: Laser Spectroscopy Vies for Instant Analysis of Molten Steel. V. 226, No. 4, Sept. 23, 1983, p. 60.

[27]Chemical & Engineering News. Science/Technology Concentrates. Technology-Hydride Refrigerator Uses Low-Level Heat. Aug. 15, 1983, p. 24.

[28]Salak, J. New Heat-Resistant Alloys Make Debut. Am. Met. Mark., Nov. 28, 1983, p. 21.

[29]Iron Age. Techfront. Amorphous Metals: Will the Price Come Tumbling Down. V. 226, No. 4, Sept. 23, 1983, p. 60.

[30]Rare-Earth Information Center News. La-YIG Films. V. 18, No. 2, June 1, 1983, p. 3.

[31]———. That's Cold! V. 18, June 1, 1983, p. 6.

[32]———. Rare Earth Paints. V. 18, No. 2, June 1, 1983, p. 3.

[33]Elderfield, H., and M. J. Greaves. The Rare Earth Elements in Seawater. Nature, v. 296, No. 5854, Mar. 18, 1982, pp. 214-219.

[34]Potts, P. J., O. W. Thorpe, and J. S. Watson. Determination of the Rare-Earth Element Abundances in 29 International Rock Standards by Instrumental Neutron Activation Analysis: A Critical Appraisal of Calibration Errors. Chem. Geol., v. 34, Elsevier Sci. Publ. BV, Amsterdam, 1981, pp. 331-352.

[35]Rhyne, J. J., H. B. Silber, and G. J. McCarthy (ed.). The Rare Earths in Modern Science and Technology 1983. Proceesings of the Sixteenth Rare Earth Research Conference, Tallahassee, FL, Apr. 18-21, 1983. Elsevier Sequoia S.A., New York, 2 vols., 1983.

[36]Grosz, A. E., and E. C. Escowitz. Economics of Heavy Minerals of the U.S. Atlantic Continental Shelf. Paper in 6th Symp. on Coastal Sedimentology in Connection with the Southwestern Geol. Soc. Am. Meeting, Mar. 1983, 12 pp.

[37]Grosz, A. E. Personal communication.

[38]Walkiewicz, E., E. Morrice, and M. M. Wang. Comparison of Magnetic Properties of Natural Mischmetal and Synthetic Mischmetal Alloyed With Cobalt, Copper and Magnesium. Pres. at 21st Intermag. Conf., Philadelphia, PA, Apr. 5-8, 1983; pub. in IEEE Trans. on Magnetics, v. MAG-19, No. 5, Sept. 1983, pp. 2053-2055.

Salt

By Dennis S. Kostick[1]

Total salt production declined for the fourth consecutive year to the lowest level since 1964. Despite a decrease in exports and an increase in imports for consumption, domestic apparent consumption fell, primarily because of reduced demand for deicing salt. Production of salt in brine used as feedstock for the chloralkali industry rebounded as demand improved for chloralkali-based products. Salt consumption by food-related industries was virtually unchanged despite increased consumer awareness of the allegedly harmful effects of excess salt in the diet.

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 these surveys is the salt company survey. Of the 48 companies to which a survey request was sent, 45 responded, representing 94% of the total production shown in table 1. Production for the three nonrespondents was estimated using reported 1982 production levels adjusted by trends in employment and other guidelines. Two producers closed and two producers reported no production.

Table 1.—Salient salt statistics

(Thousand short tons and thousand dollars)

	1979	1980	1981	1982	1983
United States:					
Production[1]	46,317	41,483	38,899	r37,665	32,973
Sold or used by producers[1]	45,793	40,352	38,907	r37,894	34,573
Value	$538,352	$656,164	$637,568	r$671,424	$597,081
Exports	697	831	1,046	1,001	517
Value	$9,025	$12,829	$17,429	$16,647	$12,368
Imports for consumption	5,275	5,263	4,319	5,451	5,997
Value	$40,860	$44,071	$44,523	$56,184	$60,194
Consumption, apparent[2]	50,371	44,784	42,180	r42,344	40,053
World: Production	r191,107	r186,180	188,926	p181,951	e182,752

eEstimated. pPreliminary. rRevised.
[1]Excludes Puerto Rico.
[2]Sold or used plus imports minus exports.

DOMESTIC PRODUCTION

The total quantities of salt produced and salt sold or used decreased 12% and 9%, respectively. Forty-four companies operated 83 salt-producing plants in 15 States. Nine of the companies sold or used over 1 million short tons each, accounting for 74% of the U.S. total.

The six leading States in quantity of salt sold or used were Louisiana, 33%; Texas, 23%; New York, 14%; Ohio, 7%; Kansas, 5%; and Michigan, 4%.

The large quantities of rock salt purchased and stockpiled by State and municipal governments in 1982 caused demand for deicing salt to decline in 1983 and contributed significantly to the large decrease in domestic rock salt sales. Despite the closure of nine obsolete chloralkali plants since the beginning of 1982, production of salt in brine increased 5% in 1983 as demand improved after midyear for chlorine-based products, mainly polyvinyl chloride for use in automobiles and buildings. Production of solar salt decreased 21%.

The percentage of salt sold or used by domestic producers, by type, follows:

Type	Percent	
	1982	1983
Salt in brine	48	55
Mined rock salt	36	29
Vacuum pan salt and grainer or open pan salt	r9	10
Solar-evaporated salt	r7	6
Total	100	100

rRevised.

In April, International Salt Co. placed its evaporative salt refinery at Avery Island, LA, on an indefinite standby basis because of rising energy costs and an oversupply of vacuum pan salt in the region; however, the operation continued to produce rock salt. International Salt's rock salt mine in Detroit, MI, was idle most of the year because of reduced demand for rock salt, but the company continued conducting public underground mine tours to provide revenue to help offset low salt sales.[2]

Diamond Crystal Salt Co. accepted a $32 million settlement from Texaco Inc. and Wilson Bros. Corp. for the destruction of Diamond Crystal's Jefferson Island, LA, rock salt mine. The mine was flooded in November 1980 when Texaco and Wilson Bros. accidentally penetrated the mine cavity while drilling for oil and gas. In return for a settlement considerably less than the original $219 million suit, Texaco agreed to drop its countersuit claiming the accident was caused by Diamond Crystal's mining techniques.[3]

Table 2.—Salt sold or used by producers in the United States,[1] by recovery method

(Thousand short tons and thousand dollars)

Recovery method	1982		1983	
	Quantity	Value	Quantity	Value
Evaporated:				
Bulk:				
Open pan or grainer and vacuum pan	r3,379	r293,038	3,309	289,165
Solar	r2,478	r44,330	1,962	42,117
Pressed blocks	r447	r29,614	408	28,755
Total[2]	r6,305	r366,982	5,680	360,037
Rock:				
Bulk	r13,431	r186,610	9,867	132,537
Pressed blocks	72	5,592	73	5,644
Total[2]	r13,503	r192,202	9,941	138,180
Salt in brine (sold or used as such)	18,086	112,239	18,952	98,864
Grand total[2]	r37,894	r671,424	34,573	597,081

rRevised.
[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	1982 Quantity	1982 Value	1983 Quantity	1983 Value
Colorado	W	W	--	--
Kansas[1]	r1,601	r72,146	1,719	67,195
Louisiana	r12,171	117,569	11,544	100,936
Michigan	2,002	106,303	1,355	93,306
New York	6,205	117,718	4,859	100,119
Ohio	3,514	90,572	2,565	85,988
Texas	7,421	82,805	8,028	65,670
Utah	1,227	23,210	936	23,184
West Virginia	r942	W	1,026	W
Other[2]	2,810	r61,100	2,541	60,683
Total[3]	r37,894	r671,424	34,573	597,081
Puerto Rico[e]	16	290	32	670

[e]Estimated. [r]Revised. 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 may not add to totals 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	1982 Quantity	1982 Value	1983 Quantity	1983 Value
Kansas	r927	r65,184	928	59,402
Louisiana	289	22,990	219	18,868
Michigan	1,112	93,796	1,006	87,893
New York	616	52,588	627	55,531
Utah	1,181	22,847	893	22,692
Other[1]	r2,180	r109,575	2,006	115,651
Total[2]	r6,305	r366,982	5,680	360,037
Puerto Rico[e]	16	290	32	670

[e]Estimated. [r]Revised.
[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
1979	14,891	152,192
1980	11,806	176,541
1981	11,871	167,179
1982	r13,503	r192,202
1983	9,941	138,180

[r]Revised.

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 Quantity	From evaporated salt Value	From rock salt Quantity	From rock salt Value	Total[1] Quantity	Total[1] Value
1979	391	19,727	64	3,987	455	23,714
1980	393	24,412	65	4,502	458	28,914
1981	404	26,099	62	4,723	466	30,822
1982	r447	r29,614	72	5,592	r519	r35,207
1983	408	28,755	73	5,644	482	34,398

[r]Revised.
[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]
1982:					
Chlorine, caustic soda, soda ash	111	290	1,296	r17,164	r18,861
All other chemicals	255	119	349	142	865
Textile and dyeing	100	11	54	--	165
Meatpackers, tanners, casing manufacturers	173	89	287	--	550
Dairy	75	4	7	--	86
Canning	105	19	80	--	204
Baking	101	2	6	--	109
Flour processors (including cereal)	r65	1	18	--	83
Other food processing	193	44	30	--	267
Feed dealers	r403	205	r360	--	r967
Feed mixers	225	r143	r331	--	699
Metals	W	45	212	W	294
Rubber	6	W	5	W	51
Oil	r141	r311	r74	509	1,035
Paper and pulp	W	25	150	W	209
Water softener manufacturers and service companies	276	225	205	12	718
Grocery stores	745	102	206	--	1,053
Highway use	W	392	r8,652	W	r9,053
U.S. Government	20	W	123	W	152
Distributors (brokers, wholesalers, etc.)	605	W	806	W	1,720
Miscellaneous and undistributed[2]	r161	540	r636	r546	r1,444
Total[1]	r [3]3,760	r [3]2,566	r [3]13,888	r [3]18,372	r [4]38,586
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

rRevised. 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	1982 Evaporated: Vacuum pans and open pans	1982 Evaporated: Solar	1982 Rock	1983 Evaporated: Vacuum pans and open pans	1983 Evaporated: Solar	1983 Rock
Alabama	50	W	513	50	W	612
Alaska	W	10	--	W	10	--
Arizona	11	60	3	11	52	4
Arkansas	34	W	59	30	--	52
California	142	702	W	144	794	W
Colorado	25	122	33	23	100	47
Connecticut	12	18	210	12	20	125
Delaware	3	120	38	3	129	2
District of Columbia	1	W	W	W	W	W
Florida	74	50	43	76	49	39
Georgia	62	W	79	59	W	86
Hawaii	2	W	--	W	W	W
Idaho	5	72	W	5	58	W
Illinois	r368	42	1,380	379	25	1,018
Indiana	168	12	673	157	20	383
Iowa	146	29	321	182	39	381
Kansas	100	10	239	106	8	265
Kentucky	44	W	394	39	1	262
Louisiana	58	W	r369	51	W	344
Maine	7	W	156	7	1	137
Maryland	44	237	92	43	107	71
Massachusetts	36	88	414	38	75	W
Michigan	r212	W	1,348	224	12	799
Minnesota	r140	r78	354	146	73	333
Mississippi	20	--	93	22	W	102
Missouri	105	14	515	108	8	305
Montana	4	r63	5	W	46	W
Nebraska	99	60	121	97	34	120
Nevada	W	W	W	W	W	W
New Hampshire	2	W	W	2	W	W
New Jersey	119	r140	377	124	111	209
New Mexico	8	r115	r3	7	96	5
New York	271	63	2,125	246	59	1,654
North Carolina	146	102	100	134	91	100
North Dakota	r70	r46	7	49	26	6
Ohio	326	21	1,609	314	11	1,031
Oklahoma	51	18	74	72	W	66
Oregon	11	r227	W	11	43	W
Pennsylvania	157	162	972	163	88	664
Rhode Island	5	85	3	5	43	W
South Carolina	34	10	17	35	11	16
South Dakota	42	26	34	45	25	35
Tennessee	62	--	397	63	W	518
Texas	154	r66	r224	156	76	236
Utah	5	r273	W	6	175	W
Vermont	6	1	183	6	1	145
Virginia	65	172	146	66	61	106
Washington	15	r517	W	17	414	W
West Virginia	15	W	r113	15	W	65
Wisconsin	r202	r10	832	210	28	521
Wyoming	r(2)	37	2	2	30	W
Other[3]	r42	r563	r587	25	317	1,150
Total[4]	r3,780	r4,441	r15,257	3,780	3,366	12,012

rRevised. W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Each salt type includes domestic and imported quantities.
[2]Less than 1/2 unit; included with "Other."
[3]Includes shipments to overseas areas administered by the United States, Puerto Rico, exports, some shipments to unspecified destinations, shipments to States indicated by symbol W, and quantities less than 1/2 unit.
[4]Data may not add to totals shown because of independent rounding.

CONSUMPTION AND USES

Domestic apparent consumption of salt decreased 5%. Because of the large quantity of salt stockpiled by State and municipal governments in 1982, domestic and imported salt distributed by producers for highway deicing declined 36% in 1983.

Salt consumption in the chlorine, caustic soda, and synthetic soda ash industries increased because of increased demand for chloralkalis. Production of chlorine gas, sodium hydroxide, and metallic sodium, in thousand short tons, as reported by the Bureau of the Census, was as follows:

	1982	1983
Chlorine gas (100%)	r9,176	9,960
Sodium hydroxide, liquid (100%)	r9,385	10,230
Sodium, metallic	103	84

rRevised.

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. However, new research results released in December by the University of California suggested that sodium in itself might not be the culprit because other sodium-bearing compounds, such as sodium bicarbonate and sodium ascorbate, which are present in many foods, do not by themselves cause hypertension. The researchers concluded that the chloride component of sodium chloride might be more of a contributing factor to elevated blood pressure than previously had been suspected.[4]

STOCKS

Total yearend salt stocks reported by producers decreased 25% from 3.2 million tons in 1982 to 2.4 million tons. Most stocks were rock salt and solar salt.

PRICES

The average values of different classes of salt, f.o.b. works, based on actual sales as reported by producers, follow:

	Per short ton	
	1982	1983
Evaporated:		
Open pan or grainer and vacuum pan	r$86.72	$87.39
Solar	r17.89	21.47
Pressed blocks, all sources	r67.83	71.52
Rock salt, bulk	r13.89	13.43
Salt in brine	6.21	5.22

rRevised.

The following yearend salt prices were quoted in Chemical Marketing Reporter:[5]

Salt, evaporated, common, 80-pound bags, carlots or truckloads, North, works, 80 pounds	$3.00
Salt, chemical-grade, same basis, 80 pounds	3.20
Salt, rock, medium coarse, same basis, 80 pounds	2.00
Bulk, same basis, per ton	18.00

FOREIGN TRADE

Exports of salt decreased 48% because of the downturn in domestic salt production. About 92% of the exports was to Canada with the balance distributed to 57 other countries.

Salt imports for consumption increased 10%, the majority of which was bulk rock salt and bulk solar salt. More than 79% of salt imports was from the Bahamas, Canada, and Mexico. Imports of vacuum pan salt in bags, sacks, barrels, or other packages decreased 36% because domestic supply exceeded demand.

Table 9.—Salt shipped to the Commonwealth of Puerto Rico and the Virgin Islands

Area	1982		1983	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Puerto Rico	65,000	$8,450	30,000	$4,100
Virgin Islands	2	1	1	1

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

(Thousand short tons and thousand dollars)

Country	1982		1983	
	Quantity	Value	Quantity	Value
Angola	(1)	53	--	--
Australia	4	69	1	20
Bahamas	1	183	2	170
Canada	957	11,550	475	7,398
Costa Rica	(1)	24	(1)	10
Denmark	1	55	(1)	61
Germany, Federal Republic of	(1)	6	--	--
Honduras	1	32	(1)	178
Hong Kong	(1)	20	(1)	2
Iraq	2	790	2	394
Malaysia	1	10	(1)	2
Mexico	14	456	9	329
Netherlands Antilles	(1)	129	1	107
Saudi Arabia	10	2,449	14	2,806
South Africa, Republic of	1	5	(1)	1
Trinidad and Tobago	(1)	33	(1)	66
United Arab Emirates	(1)	97	(1)	39
United Kingdom	1	67	1	36
Venezuela	(1)	3	1	11
Other	8	616	11	738
Total	1,001	16,647	517	12,368

[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
1980	1	1,478	[1]5,263	[1]42,593
1981	27	1,483	[2]4,292	[2]43,040
1982	47	1,613	[3]5,404	[3]54,571
1983	30	1,826	[4]5,967	[4]58,368

[1]Includes salt brine from Canada through Ogdensburg, NY, customs district, 20 short tons ($1,406), and Detroit customs district, 11,490 short tons ($39,205); from Sweden through New York customs district, 36 short tons ($727); from Denmark through Cleveland customs district, 2 short tons ($20,498); from the Federal Republic of Germany through Boston customs district, 2 short tons ($1,774); from Austria through New York customs district, 50 short tons ($500); and from Poland through Cleveland customs district, less than 1 short ton ($300).

[2]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).

[3]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).

[4]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).

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	1982		1983	
	Quantity	Value	Quantity	Value
Bahamas	843	7,566	933	8,854
Brazil	147	1,287	133	1,247
Canada[1]	2,155	20,847	2,161	20,915
Chile	[2]383	[2]3,350	341	2,772
France[3]	85	674	133	987
Germany, Federal Republic of[4]	2	54	1	49
Italy[5]	17	132	32	610
Mexico[6]	1,350	16,522	1,669	18,521
Netherlands	72	1,731	114	1,956
Netherlands Antilles	112	1,184	184	1,750
Spain[7]	250	2,326	261	1,984
Tunisia	31	222	--	--
Other	[8]4	[8]289	35	549
Total	5,451	56,184	5,997	60,194

[1]In 1982, includes salt in sacks, bags, and barrels through eight customs districts, 20,109 short tons ($1,058,366); and salt in brine through two customs districts, 81 short tons ($3,075). 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 brine through Wilmington, NC, customs district, 100 pounds ($350).

[3]Includes salt in sacks, bags, and barrels through three customs districts, 87 short tons ($14,247) in 1982; six customs districts, 612 short tons ($18,801) in 1983.

[4]Includes salt in sacks, bags, and barrels through five customs districts, 2,161 short tons ($45,516) in 1982; four customs districts, 609 short tons ($48,736) in 1983.

[5]Includes salt in sacks, bags, and barrels through one customs district, 100 pounds ($300) in 1982; two customs districts, 111 short tons ($4,674) in 1983.

[6]Includes salt in sacks, bags, and barrels through two customs districts, 22,070 short tons ($241,200) in 1982; four customs districts, 190 short tons ($17,072); and salt in brine, 18 short tons ($1,126) in 1983.

[7]Includes salt in sacks, bags, and barrels through one customs district, 700 pounds ($543) in 1982; one customs district, 1,500 pounds ($1,318) in 1983.

[8]Includes salt brine from Denmark through Cleveland customs district, 300 pounds ($5,956); and from the United Kingdom through Washington, DC, customs district, 200 pounds ($2,152).

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	1982		1983	
	Quantity	Value	Quantity	Value
Anchorage, AK	1	154	1	103
Baltimore, MD	255	2,694	237	1,903
Boston, MA	([1])	13	128	707
Buffalo, NY	110	946	50	599
Charleston, SC	297	2,659	--	--
Chicago, IL	614	5,300	258	2,374
Cleveland, OH	22	189	112	1,011
Detroit, MI	813	7,749	645	6,434
Duluth, MN	101	1,097	147	1,364
Los Angeles, CA	148	2,018	227	3,075
Milwaukee, WS	354	3,292	565	5,103
Mobile, AL	12	56	--	--
New Orleans, LA	163	1,251	248	1,576
New York, NY	317	3,195	462	5,006
Norfolk, VA	103	850	124	1,152
Ogdensburg, NY	20	408	34	423
Philadelphia, PA	146	1,797	233	2,434
Portland, ME	449	3,968	428	4,001
Portland, OR	409	4,344	511	6,135
Providence, RI	185	1,489	129	1,220
St. Albans, VT	67	1,020	43	803
San Juan, PR	13	200	9	139
Savannah, GA	6	54	344	3,364
Seattle, WA	602	8,031	814	7,626
Tampa, FL	84	914	46	620
Wilmington, NC	160	2,449	201	2,987
Other	1	46	1	35
Total[2]	5,451	56,184	5,997	60,194

[1]Less than 1/2 unit.

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

Source: Bureau of the Census as adjusted by the Bureau of Mines.

Table 14.—U.S. imports for consumption of salt, by use as reported by salt producers

(Thousand short tons)

Use	1982	1983
Government (highway use)	1,786	1,848
Chemical industry	760	290
Water-conditioning service companies	117	88
Other	587	683
Total[1] [2]	3,249	2,910

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

WORLD REVIEW

Canada.—In September, Domtar Chemicals Ltd. commissioned its Goderich, Ontario, mine expansion project that increased Domtar's annual rock salt production capacity from 2.2 to 3.5 million tons. The company invested $40 million for a third shaft, new primary crushing and conveying equipment, and new storage facilities.[6]

India.—Hindustan Salt Ltd. announced plans to increase salt production at its rock salt mines at Drang and Guma in the Mandi district of Himachal Pradesh. The company intended to use solution mining to expand production from 5,000 to 60,000 tons per year.[7]

U.S.S.R.—Railcar scheduling problems disrupted shipments of salt to the animal feed, food, and chemical industries. In addition, salt deliveries were underestimated by 33% by the Sverdlovsk and Belorussian Railroads. According to the Soviet source, it appeared that the Ministry of Railroads was responsible for the misallocation of railcars and was attempting to rectify the problems.[8]

Yugoslavia.—A new solar salt facility with a capacity of 80,000 tons per year came on-stream at Ulcinj in Montenegro. This, combined with other salt operations in the country, was expected to make Yugoslavia self-sufficient in salt.[9]

Table 15.—Salt: World production, by country[1]

(Thousand short tons)

Country[2]	1979	1980	1981	1982[p]	1983[e]
Afghanistan[e]	22	6	7	[r]11	11
Albania[e]	70	75	75	75	80
Algeria	[3]162	[3]154	141	154	165
Angola[e]	55	55	55	55	45
Argentina:					
Rock salt	1	1	1	1	[4]2
Other salt	682	1,106	1,033	655	[4]606
Australia (marine salt and brine salt)	[r]5,700	[r]6,245	7,077	6,724	6,600
Austria:					
Rock salt	1	1	1	1	1
Evaporated salt	419	452	509	478	395
Salt in brine	[r]272	[r]287	291	236	155
Bahamas	485	754	1,069	899	937
Bangladesh[5]	743	510	304	[r e]275	275
Benin	([6])	([6])	([6])	([6])	([6])
Brazil:					
Rock salt	759	877	925	922	940
Marine salt	3,159	[r]3,354	3,049	3,183	3,300
Bulgaria[e]	95	[r]95	[r]95	95	95
Burma[7]	284	[r]295	298	297	[4]317
Canada	7,585	7,748	7,981	8,752	9,500
Chile	650	486	320	743	750
China	16,281	19,048	20,194	18,060	17,500
Colombia:					
Rock salt	422	[r]382	348	332	330
Other salt	407	541	440	223	440
Costa Rica	51	[e]44	[e]43	121	120
Cuba	134	144	177	218	220
Cyprus	[r]6	[r]8	10	11	11

See footnotes at end of table.

Table 15.—Salt: World production, by country[1] —Continued

(Thousand short tons)

Country[2]	1979	1980	1981	1982[p]	1983[e]
Czechoslovakia	299	305	343	360	360
Denmark[3]	419	[e]420	439	493	500
Dominican Republic[e]	42	[r][4]61	70	70	70
Egypt	679	701	748	913	940
El Salvador[e]	30	30	[r]28	[r]28	22
Ethiopia:[5]					
Rock salt[e]	17	17	17	[r]17	17
Marine salt	102	110	121	[e]120	120
France:					
Rock salt	631	[r]332	328	421	310
Brine salt	1,310	1,227	1,204	1,181	1,200
Marine salt	1,986	[e]1,405	1,517	1,687	1,700
Salt in solution	4,955	4,867	4,266	4,091	4,700
German Democratic Republic:					
Rock salt	3,304	3,391	3,369	3,329	3,300
Marine salt	60	57	62	61	57
Germany, Federal Republic of: Marketable:					
Rock salt	[r]9,877	[r]7,451	9,223	7,754	7,700
Marine salt and other salt	6,757	5,111	4,601	4,348	3,800
Ghana[e]	55	55	55	55	55
Greece	[r]171	133	145	[r][e]145	145
Guatemala	[r]16	[r]10	15	[e]15	15
Honduras[e]	35	35	35	35	35
Iceland	--	(6)	(6)	(6)	[4]1
India:					
Rock salt	[r]5	[r]5	[e]4	5	4
Marine salt	7,751	8,823	9,841	8,056	11,000
Indonesia	[r]778	761	315	881	770
Iran[e] [8]	770	660	660	770	830
Iraq[e]	100	100	90	90	80
Israel	118	130	146	163	160
Italy:					
Rock salt and brine salt	4,949	4,406	3,979	3,974	4,000
Marine salt[e]	1,300	1,400	[r]1,060	1,100	1,200
Japan[e]	1,189	1,226	1,213	1,124	1,300
Jordan	33	33	33	55	90
Kampuchea	29	[e]33	27	42	44
Kenya:					
Crude	24	30	[e]30	NA	NA
Refined	[e]13	22	[e]23	27	27
Korea, North[e]	600	630	630	630	630
Korea, Republic of	551	502	664	952	940
Kuwait	[r]22	[r]23	21	21	22
Laos[e]	20	22	22	[r][4]10	11
Lebanon[e]	11	13	17	11	6
Leeward and Windward Islands[e]	55	55	55	55	55
Libya[e]	11	11	11	11	11
Madagascar[e]	33	33	33	[r]33	33
Mali[e]	5	5	5	5	6
Malta	1	1	1	1	1
Mauritania[e]	1	1	--	[r][4]8	6
Mauritius	7	7	7	[r][e]7	7
Mexico	6,800	7,248	8,767	6,041	6,100
Mongolia[e]	17	17	17	[r]17	18
Morocco	112	74	52	70	[4]77
Mozambique[e]	30	30	30	30	30
Namibia (marine salt)	[e]250	[e]250	213	203	210
Netherlands	4,355	3,818	3,944	3,517	3,400
Netherlands Antilles[e]	440	440	440	440	440
New Zealand	61	[r]6	61	77	80
Nicaragua[e]	20	22	20	20	20
Niger[e]	3	3	3	[4]3	3
Pakistan:[5]					
Rock salt	564	546	567	589	600
Other salt	212	220	241	247	250
Panama	19	[r]20	16	12	12
Peru	440	504	558	535	540
Philippines	355	[r]382	392	402	400
Poland:					
Rock salt	1,607	[r]1,614	1,447	[e]1,500	1,500
Other salt	3,275	[r]3,383	3,261	[e]3,200	3,200
Portugal:					
Rock salt	450	442	450	448	440
Marine salt[e]	155	140	130	[r]110	120

See footnotes at end of table.

Table 15.—Salt: World production, by country[1] —Continued

(Thousand short tons)

Country[2]	1979	1980	1981	1982[p]	1983[e]
Romania:					
Rock salt	1,819	[r]1,951	[r][e]1,870	[r][e]1,870	1,870
Other salt	3,384	3,622	[r][e]3,600	[e]3,600	3,600
Senegal[e]	154	154	154	[r][4]176	[4]187
Sierra Leone[e]	220	220	[r]220	[r]220	220
Somalia[e]	33	[r]33	[r]33	[r]33	33
South Africa, Republic of	594	625	595	646	[4]801
Spain:					
Rock salt	2,411	[r]2,623	2,536	2,439	2,500
Marine salt and other evaporated salt	1,390	1,245	1,536	1,187	1,200
Sri Lanka	134	126	115	194	[4]142
Sudan	90	88	71	31	80
Switzerland	424	[r]416	475	399	[4]338
Syria[e]	83	[r]100	[r]100	[r][4]112	[4]96
Taiwan	404	796	387	289	[4]87
Tanzania	41	40	41	41	45
Thailand:					
Rock salt	12	[r]18	12	12	[4]6
Other salt[e]	180	180	180	180	180
Togo[e]	1	1	1	1	1
Tunisia	440	482	515	464	[4]413
Turkey	[r]1,042	[r]1,299	1,539	1,448	1,540
Uganda[e]	1	1	[r]22	[r]22	30
U.S.S.R	15,763	16,094	16,755	17,416	17,900
United Kingdom:					
Rock salt	[r]1,753	1,925	1,488	2,435	2,500
Brine salt[10]	2,111	1,773	1,603	1,713	1,700
Other salt[10]	4,756	4,189	4,317	4,270	4,300
United States including Puerto Rico:					
Rock salt	14,891	11,806	11,871	13,503	[4]9,941
Other salt:					
United States	30,902	28,545	27,036	24,391	[4]24,632
Puerto Rico[e]	27	27	8	16	32
Venezuela	[e]170	268	[r][e]275	375	275
Vietnam[e]	580	[r]480	[r]445	[r]720	980
Yemen (Aden)[e]	[r]80	90	80	80	80
Yemen (Sanaa)[e]	100	70	60	60	60
Yugoslavia:					
Rock salt	151	186	212		
Marine salt	23	[r]24	40	472	[4]468
Salt from brine	212	[r]206	209		
Total	[r]191,107	[r]186,180	188,926	181,951	182,752

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available.
[1]Table includes data available through June 6, 1984.
[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]Reported figure.
[5]Year ending June 30 of that stated.
[6]Less than 1/2 unit.
[7]Brine salt production as reported by the Burmese Government in metric tons, was as follows: 1980—80,701; 1981—83,795; 1982—73,901; and 1983—100,000 (estimated).
[8]Year beginning Mar. 21 of that stated.
[9]Fiscal year ending Mar. 31 of that stated.
[10]Data captioned "Brine salt" for the United Kingdom are the quantities of salt obtained from the evaporation of brines; that captioned "Other salt" are the salt content of brines used for purposes other than production of salt by evaporation.

TECHNOLOGY

The Atlantic Research Corp. developed a process that destroys harmful polychlorinated biphenyls (PCB) and produces a pure sodium chloride byproduct. The "light-activated reduction of chemicals," or LARC, process uses ultraviolet light and hydrogen, which replaces the chlorine atoms when passed through a PCB-containing liquid. A mobile LARC demonstration unit was built with funding from the National Aeronautics and Space Administration to treat 1,000 gallons per day of PCB-contaminated fluids. The unit was also capable of treating halogenated organic compounds other than those containing chlorine.[10]

[1]Physical scientist, Division of Industrial Minerals.
[2]Lansing State Journal. Salt Mine Under Detroit Fights Sales Slump by Offering Tours. Apr. 19, 1983, p. 5B.

[3]The Wall Street Journal (New York). Diamond Crystal Gets $32 Million Settlement for Flooded Salt Mine. V. 202, No. 4, July 7, 1983, p. 17.

[4]Science News. New Factor in Salt? V. 124, Dec. 10, 1983, p. 372.

[5]Chemical Marketing Reporter. Current Prices of Chemicals and Related Materials. V. 224, No. 26, Dec. 26, 1983, p. 36.

[6]The London Free Press. Sifto Salt. Sept. 27, 1983, p. 16.

[7]Industrial Minerals (London). Company News and Mineral Notes. No. 192, Sept. 1983, p. 81.

[8]Foreign Broadcast Information Service. Lack of Commercial Salt Criticized. U.S.S.R. Rep. Chem. No. 103, June 21, 1983, pp. 28-29.

[9]Work cited in footnote 7.

[10]The Washington Post. Atlantic Research Corp. Patents Method of Cleaning Up PCB's. Washington Business sec., Aug. 29, 1983, p. 13.

Sand and Gravel

By Valentin V. Tepordei[1]

A total of 655 million short tons of construction sand and gravel valued at $1.9 billion, f.o.b. plant, was estimated to have been produced in the United States in 1983. This was the second lowest production level since 1958, 32% below the record-high production of 1978, but 10% higher than that of 1982 when a full annual survey was conducted.

Production of industrial sand and gravel totaled 26.6 million short tons valued at $335 million, f.o.b. plant, a decrease of 3%, and 21% below the record-high production of 1979.

Table 1.—Salient U.S. sand and gravel statistics[1]

(Thousand short tons and thousand dollars)

	1979	1980	1981	1982	1983
Sold or used:					
Construction:					
Sand:					
Quantity	455,000	373,400	NA	[r]217,800	NA
Value	$974,100	$925,400	NA	[r]$622,200	NA
Gravel:					
Quantity	490,500	389,700	NA	[r]275,300	NA
Value	$1,170,000	$1,071,000	NA	[r]$874,000	NA
Sand and gravel, unprocessed:					
Quantity	NA	NA	NA	[r]100,800	NA
Value	NA	NA	NA	[r]$177,900	NA
Total construction:[2]					
Quantity	945,500	763,100	[e]690,000	[r]594,000	[e]655,100
Value	$2,144,000	$1,996,000	[e]$1,928,000	[r]$1,674,000	[e]$1,935,000
Industrial:					
Sand:					
Quantity	32,120	28,711	29,250	[r]26,350	26,080
Value	$275,200	$286,500	$326,300	[r]$316,900	$329,500
Gravel:					
Quantity	1,391	865	728	[r]1,024	537
Value	$8,574	$6,458	$5,997	[r]$6,846	$5,667
Total industrial:[2]					
Quantity	33,510	29,600	29,980	[r]27,400	26,620
Value	$283,800	$293,100	$332,300	[r]$323,800	$335,200
Exports:					
Quantity	2,076	2,451	2,397	1,946	2,350
Value	$32,440	$40,660	$36,736	$34,397	$32,487
Imports for consumption:					
Quantity	423	541	337	[r]275	181
Value	$2,321	$2,718	$2,608	$4,002	$2,666

[e]Estimated. [r]Revised. NA Not available.
[1]Puerto Rico excluded from all sand and gravel statistics.
[2]Data may not add to totals shown because of independent rounding.

Exports of construction sand and gravel increased 16% to 1.3 million tons valued at $6.4 million, while imports decreased 34% to 123,000 tons valued at $1.0 million. Apparent consumption of construction sand and gravel was 654 million tons.

Exports of industrial sand increased 28% to 1.0 million tons valued at $26.1 million, while imports decreased 36% to 58,000 tons valued at $1.6 million. Apparent consumption of industrial sand and gravel was 25.6 million tons.

Domestic Data Coverage.—Domestic production data for construction and industrial sand and gravel were developed by the Bureau of Mines from voluntary surveys of U.S. producers. Beginning with 1981, full surveys of construction sand and gravel producers have been conducted for even-numbered years only. For odd-numbered years, a sample survey was conducted to generate preliminary estimates at the State level. Industrial sand and gravel producers have continued to be surveyed every year. Of the 162 active industrial sand and gravel operations surveyed, 154, or 95%, responded. Their total production represented 93% of total U.S. industrial sand and gravel production shown in table 1. The nonrespondents' production was estimated using preliminary production reports, adjusted prior years production, and/or employment data. Of the 154 respondents, 17 did not indicate a breakdown by end uses. Their total production together with that of eight estimated operations, representing 17% of the U.S. total, was included in "Other uses." Fourteen industrial sand and gravel operations were idle.

Legislation and Government Programs.—On June 6, 1983, the U.S. Supreme Court ruled that gravel in lands patented under the 1916 Stock-Raising Homestead Act is a "mineral" reserved to the U.S. Government. The respondent, Western Nuclear Inc., was liable to the Government for $13,000 in damages for gravel removed from a site in Wyoming and used for road construction. Damages were based on a royalty payment rate of 30 cents per cubic yard.

In September, the Environmental Protection Agency (EPA) issued proposed new Standards of Performance for Stationary Sources of nonmetallic mineral operations. These standards would limit fugitive emissions from new, modified, and reconstructed sand, gravel, and crushed stone plants to 10% opacity for all facilities using a capture system, and 15% for those without it. EPA proposals also recognize wet dust suppression and baghouses as the best demonstrated emission control technology.

New regulations on the use of explosives in surface mining, developed by the Office of Surface Mining of the U.S. Department of the Interior, went into effect in April. The new regulations were designed to better control ground vibrations during blasting for mining or construction work.

The impact of the Surface Transportation Assistance Act of 1982 on the demand for construction aggregates at the national and State levels over a 4-year period was analyzed in a study published by the Bureau of Mines.[2] The study estimated that a total increase in production of road construction aggregates of between 428 and 514 million tons could result from the legislative program over the 4-year period beginning in 1983.

CONSTRUCTION SAND AND GRAVEL

DOMESTIC PRODUCTION

Revised production estimates indicate that U.S. output of construction sand and gravel increased 10%. All regions, except New England, registered increases, of 4% to 21%. The Pacific region continued to lead the Nation with an estimated 163 million tons or 25% of the U.S. total, followed by the East North Central region with about 100 million tons or 15%, and the West South Central region with about 87 million tons or 13%.

Among the four major regions, the West led the Nation in the production of construction sand and gravel with 37% of the total. The North Central region was second with 27%, and the South was third with 26%.

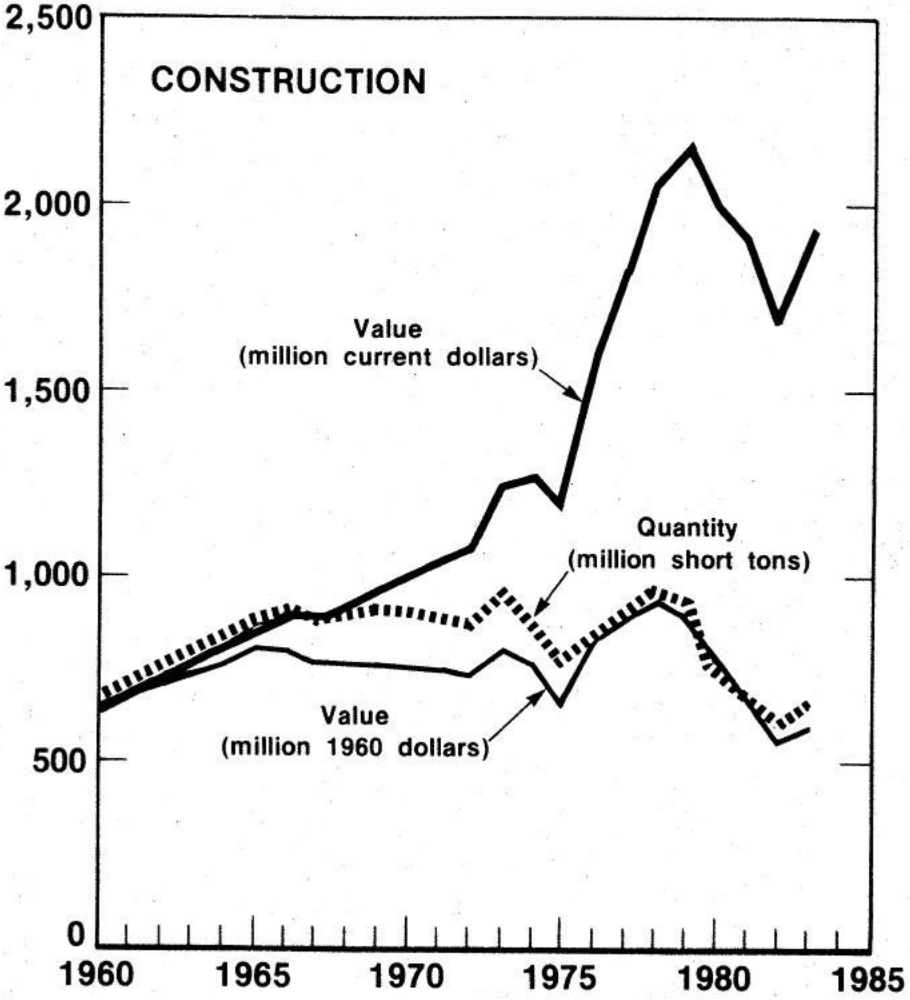

Figure 1.—Production and value of construction sand and gravel in the United States for 1960-83 (includes estimates for 1981 and 1983).

The five leading States, in descending order of volume, were California, Texas, Alaska, Ohio, and Minnesota. Their combined estimated production represented 38% of the national total.

In September, Martin Marietta Corp., the 12th largest producer of construction sand and gravel in the United States in 1982, reorganized two of its major divisions, construction materials and chemicals, by combining them into a new unit called Martin Marietta Basic Products. The newly combined division includes the cement, sand and gravel, and stone operations, as well as manufactured construction materials.

Conrock Co. of Arizona, a subsidiary of Conrock Co. of Los Angeles, CA, purchased the Phoenix and Sun City sand and gravel operations of Arizona Sand and Rock Co. The parent company, the third largest producer of construction sand and gravel in the United States, owned 17 operations in California and Arizona at yearend.

FOREIGN TRADE

Exports.—Exports of construction sand increased 48% to 934,000 tons; of which, 76% went to Canada and 17% went to Mexico. Exports of construction gravel decreased 26% to 369,000 tons, 89% of which went to Canada.

Imports.—Imports of construction sand and gravel decreased 34% to 123,000 tons, 85% of which came from Canada.

TECHNOLOGY

Two technology transfer seminars on surface mining equipment were organized by the Bureau of Mines. The purpose of these seminars was to disseminate information on recent advances in mining health and safety technology related to the use and maintenance of large mobile surface mining equipment.[3]

A new cost-effective approach to mapping of overburden thickness using computer-assisted geophysical techniques was implemented by Dunn Geoscience Corp.[4] Although geophysical techniques have been used in mineral exploration for many years, recent technologic advances have increased geophysical mapping speed, reduced costs, and expanded the range of their geophysical mapping applications.

The National Sand and Gravel Association, the American Society of Landscape Architects, and the National Crushed Stone Association cosponsored the First Landscape Architecture Student Competition in which various methods for reclaiming sand and gravel and crushed stone sites were proposed. The first-, second-, and third-place entries were won by Michigan State University, Colorado State University, and the University of Pennsylvania, respectively.[5]

A Dutch company, Aarding BV of Nunspeet, Netherlands, patented a strong granular material called Aardelite that can replace gravel in various applications. Aardelite is produced from a variety of residual materials such as fly ash, boiler ash, sea sand, etc. Manufacture of Aardelite consists of mixing and agglomerating powder-size materials using lime and other additives by a thermal curing process. The end product consists of spherical granules between 3 and 30 millimeters in diameter that has been used as a substitute for gravel in concrete.[6]

Quazite Corp. of Houston, TX, a subsidiary of Lone Star Industries Inc. and Shell Oil Corp. formed a joint venture to manufacture and market a new construction material brand named "Quazite." The product is a composite material made from selectively graded aggregates and high-performance polymers and monomers through a patented process. The material is impermeable and has high bending strength and good chemical resistance and dielectric properties. It has a wide range of applications in construction, transportation, telecommunications, and specialty item manufacturing as a precast or cast-in-place product.[7]

Several articles dealing with new surface mining equipment,[8] automation,[9] use of computers,[10] and reclamation,[11] were published.

Table 2.—Construction sand and gravel sold or used in the United States, by geographic region

Geographic region	1982				1983			
	Quantity[r] (thousand short tons)	Percent of total	Value[r] (thousands)	Percent of total	Quantity[e] (thousand short tons)	Percent of total	Value[e] (thousands)	Percent of total
Northeast:								
New England	32,287	5	$88,911	5	28,200	4	$86,900	4
Middle Atlantic	38,359	6	128,120	8	41,300	6	140,500	7
North Central:								
East North Central	95,896	16	253,687	15	99,900	15	262,000	14
West North Central	62,295	11	142,257	9	75,500	12	181,600	9
South:								
South Atlantic	45,456	8	134,504	8	49,400	8	148,000	8
East South Central	28,024	5	76,194	5	31,200	5	89,800	5
West South Central	76,511	13	241,914	14	87,100	13	291,500	15
West:								
Mountain	67,996	[r]11	190,485	11	79,100	12	240,600	12
Pacific	147,131	25	418,035	25	163,440	25	494,200	26
Total[1]	594,000	100	1,674,000	100	655,100	100	1,935,000	100

[e]Estimated. [r]Revised.
[1]Data may not add to totals shown because of independent rounding.

Table 3.—Construction sand and gravel sold or used in the United States, by State

(Thousand short tons and thousand dollars)

State	1982		1983[e]	
	Quantity	Value	Quantity	Value
Alabama	7,019	17,226	8,600	23,500
Alaska	40,832	74,895	45,200	97,200
Arizona	19,124	58,375	23,200	75,000
Arkansas	[r]6,936	[r]18,700	6,900	19,600
California	81,147	270,995	91,000	308,700
Colorado	[r]18,590	[r]58,465	21,200	81,600
Connecticut	[r]4,887	[r]16,237	5,000	17,900
Delaware	1,300	3,197	1,400	3,200
Florida	[r]13,616	[r]30,081	14,900	31,500
Georgia	3,166	8,361	3,800	9,400
Hawaii	449	1,221	440	1,000
Idaho	2,340	6,258	3,000	9,800
Illinois	21,557	59,149	21,100	58,400
Indiana	13,097	34,579	14,400	37,900
Iowa	10,064	25,618	11,800	32,800
Kansas	9,720	20,612	12,400	26,600
Kentucky	6,499	15,936	5,500	13,000
Louisiana	16,558	50,966	14,200	46,600
Maine	6,701	15,118	4,800	12,100
Maryland	9,720	32,386	10,600	37,800
Massachusetts	12,003	34,438	10,400	36,200
Michigan	20,567	47,726	23,000	52,300
Minnesota	20,276	44,222	24,600	53,000
Mississippi	9,455	27,115	11,000	34,600
Missouri	6,359	14,477	7,700	17,700
Montana	5,338	12,794	5,000	10,200
Nebraska	[r]9,713	[r]23,851	10,100	25,000
Nevada	6,027	11,724	7,500	16,200
New Hampshire	4,332	12,593	4,000	12,100
New Jersey	7,940	25,722	10,800	34,300
New Mexico	5,616	17,670	7,000	20,000
New York	[r]17,338	[r]46,871	18,700	54,200
North Carolina	5,198	15,395	5,600	16,900
North Dakota	2,347	4,873	3,800	15,000
Ohio	[r]26,160	[r]83,015	27,200	84,600
Oklahoma	7,490	17,733	7,500	17,300
Oregon	9,513	30,629	11,000	37,000
Pennsylvania	13,081	55,527	11,800	52,000
Rhode Island	1,146	3,671	1,000	2,400
South Carolina	4,727	13,170	5,200	15,000
South Dakota	3,816	8,604	5,100	11,500
Tennessee	5,051	15,917	6,100	18,700
Texas	45,527	154,515	58,500	208,000
Utah	7,579	14,920	9,800	19,800
Vermont	3,218	6,854	3,000	6,200
Virginia	6,978	28,522	7,200	30,800
Washington	15,190	40,295	15,800	50,300
West Virginia	751	3,392	700	3,400
Wisconsin	14,515	29,218	14,200	28,800
Wyoming	3,382	10,279	2,400	8,000
Total[1]	[r]594,000	[r]1,674,000	655,100	1,935,000

[e]Estimated. [r]Revised.
[1]Data do not add to totals shown because of independent rounding.

Table 4.—U.S. exports of construction sand and gravel, by country

(Thousand short tons and thousand dollars)

Country	Construction sand Quantity	Construction sand F.a.s. value[1]	Gravel Quantity	Gravel F.a.s. value[1]
1982				
Bahamas	(2)	12	29	150
Canada	573	1,943	434	1,307
Mexico	37	657	2	49
Panama	4	85	2	66
Peru	6	569	(2)	11
Saudi Arabia	2	161	(2)	103
South Africa, Republic of	(2)	3	5	401
Other	9	1,967	25	593
Total	631	5,397	497	2,680
1983				
Bahamas	(2)	10	21	114
Bermuda	3	27	--	--
Canada	712	2,234	328	1,225
Germany, Federal Republic of	3	103	--	--
Mexico	162	461	(2)	(2)
Peru	1	117	--	--
United Kingdom	43	112	--	--
Other	10	1,556	20	472
Total	934	4,620	369	[3]1,810

[1]Value of material at U.S. port of export; based on transaction price, including all charges incurred in placing material alongside ship.
[2]Less than 1/2 unit.
[3]Data do not add to total shown because of independent rounding.

Table 5.—U.S. imports for consumption of construction sand and gravel, by country

(Thousand short tons and thousand dollars)

Country	1982 Quantity	1982 C.i.f. value[1]	1983 Quantity	1983 C.i.f. value[1]
Antigua and Barbuda	17	210	1	11
Australia	4	476	--	--
Bahamas	9	32	9	32
Canada	155	659	104	652
Germany, Federal Republic of	(2)	53	1	247
Israel	--	--	6	11
Other	(2)	49	2	94
Total	185	1,479	123	1,047

[1]Value of material at U.S. port of entry; based on purchase price and includes all charges (except U.S. import duties) in bringing material from foreign country to alongside carrier.
[2]Less than 1/2 unit.

INDUSTRIAL SAND AND GRAVEL

DOMESTIC PRODUCTION

The total output of industrial sand and gravel decreased 3% to 26.6 million tons. The North Central region continued to lead the Nation with 42% of the U.S. total, followed by the South with 33%, and the Northeast and West, each with 13%. Output of industrial sand and gravel decreased 10% in the West and 6% in the South and increased 2% in the North Central and 1% in the Northeast.

Based on the 1980 census data on population, U.S. per capita industrial sand and gravel production was 0.12 ton. Per capita production by region was 0.19 ton in the North Central, followed by the South with 0.12 ton, the West with 0.08 ton, and the Northeast with 0.07 ton.

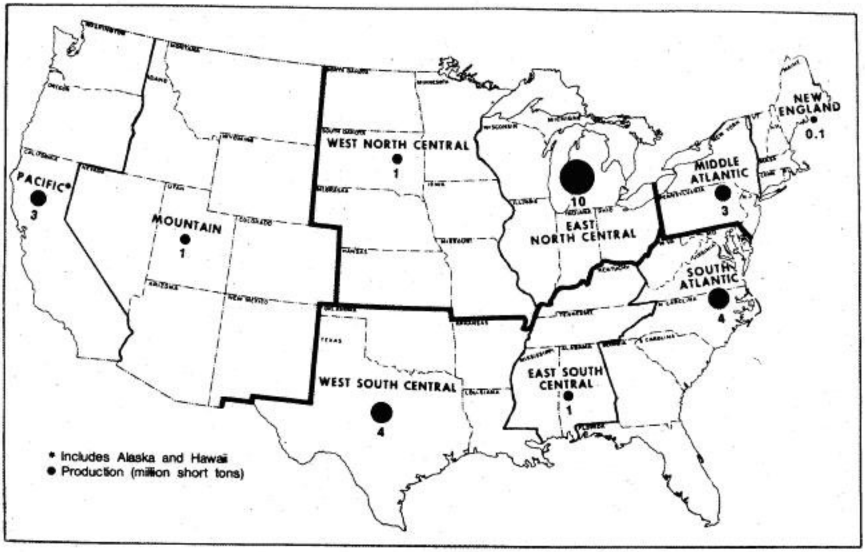

Figure 2.—Production of industrial sand and gravel in the United States in 1983, by geographic region.

The five leading States in the production of industrial sand and gravel in 1983 were, in descending order of volume, Illinois, Michigan, New Jersey, California, and Texas. Their combined production represented 52% of the national total. Production decreased significantly in Texas, 19%. Production increased in Michigan, 21%, and New Jersey, 11%.

Ninety-seven producers of industrial sand and gravel with 176 operations were canvassed by the Bureau of Mines. About 73% of the industrial sand and gravel produced came from 42 operations, each with an annual production larger than 200,000 tons. The 10 leading producers of industrial sand and gravel were, in descending order of tonnage, Martin Marietta Aggregates-Unimin Corp., Pennsylvania Glass Sand Corp., Ottawa Silica Co., Jesse S. Morie & Son Inc., Construction Aggregates Corp., Owens-Illinois Inc., Manley Bros. of Indiana Inc., Oglebay Norton Co., Badger-Mining Corp., and Nugent Sand Co. Inc. Their combined production, from 54 operations, represented 72% of the U.S. total.

In the second half of the year, Unimin of Canaan, CT, completed the purchase of 10 operations from Martin Marietta Industrial Sand Div. The acquired operations are located in Oregon and Troy Grove, IL; Michigan City, IN; Bridgman, MI; Byron, CA; Cleburne, TX; Lugoff, SC; Emmett, ID; Portage, WI; and Festus, MO. Martin Marietta retained its largest and most profitable operation, located at Wedron, IL. Shortly after completing this acquisition, Unimin announced plans for expanding its Marston, NC, operation, by installing a state-of-the-art silica grinding plant that can produce about 100,000 tons per year of silica flour. The major markets for silica flour are expected to be the chemical, filler, and fiberglass industries. The new plant was to be completed during the first quarter of 1985.[12]

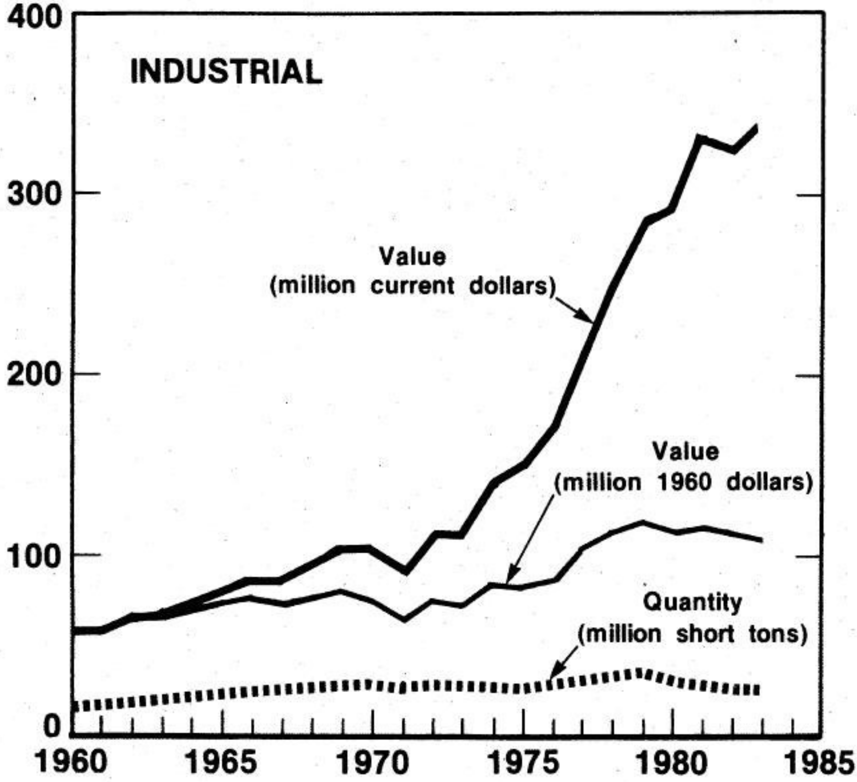

Figure 3.—Production and value of industrial sand and gravel in the United States, 1960-83.

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 approximately 27 million tons of industrial sand and gravel sold or used, 36% was consumed as glassmaking sand, and 25% as foundry sand. Other important uses were abrasive sand, about 7%, and hydraulic fracturing sand, about 4%. Because some companies did not report a breakdown by end use, their total production as well as estimations for nonrespondents were included in "Other uses," which represent about 21% of U.S. total. On a regional level, most of the glassmaking sand was produced in the South, 35%, followed by North Central, 26%, and the West, 24%, while most of the foundry sand was used in the North Central, 76%. Of the smaller but important end uses, most of the abrasive sand was used in the South, 64%, and most of the hydraulic fracturing sand was used in the South, 56%, and the North Central, 40%.

PRICES

The average value, f.o.b. plant, of U.S. industrial sand and gravel increased 7% to $12.59 per ton. Average unit values for industrial sand and industrial gravel were $12.64 and $10.55 per ton, respectively. Nationally, industrial sand used as fillers had the highest value per ton, $54.56, followed by sand used in ceramics, $33.89, and sawing and sanding sand, $32.00.

TRANSPORTATION

Of the total industrial sand and gravel produced, 68% was transported by truck from the plant to the site of first point of sale or use, 27% was transported by rail, and 4% by waterway. 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 28% to 1.0 million tons valued at $26.1 million. Of this, 88% went to Canada, and 6% went to Mexico.

Imports.—Imports of industrial sand decreased 36% to 58,000 tons valued at $1.6 million. Of this, 78% came from Australia, and 17% from Bahamas.

TECHNOLOGY

Textured Products Inc. of Hartsdale, NY, recently introduced a glass fiber fabric coated with a blend of ceramic and binder. The material, called Fibrecoat, is designed as a flame and heat barrier for temperatures up to 1200° F, and is being produced in two grades: Fibrecoat 120, which can withstand continuous use in temperatures up to 600° F, has intermittent flame resistance up to 1200° F, is 7 to 8 millimeters thick, and is not affected by water, steam, ice, ultraviolet radiations, solvents, and diluted acids or alkalis; and Fibrecoat 520, which has the same intermittent flame resistance as the 120 grade, but it can be used at continuous temperatures up to 1500° F, and is 25 to 50 millimeters thick. Both grades are lightweight and flexible, and combine some of the advantages of both glass fiber and high temperature ceramic fibers. Fibrecoat will be a good replacement in some applications for traditional glass fibers, mineral wools, and asbestos.[13]

A new state-of-the-art plant operated by the J. L. Shiely Co.'s Minnesota Frac Sand Co., of St. Paul, MN, was in its first full year of operation producing high-quality hydraulic fracturing sand from Jordan sandstone. The high-quality product was being shipped to sites as distant as Pennsylvania, Texas, California, and Alberta, Canada, and was competing with frac sand produced near Brady, TX.[14]

In February, the American Telephone & Telegraph Co. (AT&T) began operating its first major optical fiber communication line between New York and Washington, DC. This link is part of a 776-mile project that will extend from Cambridge, MA, to Moseley, VA, near Richmond. In March, AT&T began operating the first 168 miles of a 633-mile system that will ultimately connect Sacramento with San Diego, CA. Other projects that will connect Jacksonville with Miami, FL, and Chicago with New York were also announced by AT&T. As a result of recent technological advances, optical fiber is becoming a standard replacement for copper wires, because of its lower cost, better and larger transmission capabilities, and lack of electrical interference.[15]

A series of articles on blasting techniques that review problems facing quarry operators in today's congested areas was published by Rock Products magazine. Problems analyzed include blasting vibrations, airblast, the importance of quarry site geology in selecting blasting methods, and the characteristics of blasting agents and their most effective use in different environments.[16]

Several articles on industrial mineral processing, including crushing, grinding, screening, and classification, were published.[17]

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[1]Physical scientist, Division of Industrial Minerals.

[2]Block, F. Estimated Impact of the Surface Transportation Assistance Act of 1982 on the Demand for Road Construction Aggregate. BuMines Min. and Mat., June-July 1983, pp. 35-43.

[3]Bureau of Mines Staff (comp. by). Safety in the Use and Maintenance of Large Mobile Surface Mining Equipment. Proceedings: Bureau of Mines Technology Transfer Seminars, Tucson, AZ, August 16, 1983, Denver, CO, August 18, 1983, and St. Louis, MO, August 23, 1983. BuMines IC 8947, 1983, 97 pp.

[4]Peffer, J. R., and P. G. Robelen. Affordable: Overburden Mapping Using New Geophysical Techniques. Pit & Quarry, v. 76, No. 2, Aug. 1983, pp. 70-74.

[5]Weber, K. NSGA Sponsors First Landscape Architecture Student Competition for Sand and Gravel Operators. Rock Prod., v. 86, No. 7, July 1983, pp. 32-33.

[6]Aarding B. V. (Nunspeet, Holland). Aardelite, a New Product From Coal Residues. Sept. 1983, pp. 1-16.

[7]Quazite Corp. Quazite. A New Class of Engineered Materials. 1983.

[8]Robertson, J. L. Electric-Powered Excavator Virtually Maintenance Free. Rock Prod., v. 86, No. 2, Feb. 1983, pp. 40-41.

———. Switch From Trucks to Belt Conveyor Cuts Operating Costs. Rock Prod., v. 86, No. 7, July 1983, pp. 40-42.

[9]Herod, S. California Plant Displays Efficient Material Handling. Pit & Quarry, v. 75, No. 8, Feb. 1983, pp. 44-48.

Robertson, J. L. Computer Runs Genstar Plant. Rock Prod., v. 86, No. 9, Sept. 1983, pp. 41-43.

[10]Kuennen, T. Sand and Gravel Computer Use Studied. Rock Prod., v. 86, No. 9, Sept. 1983, pp. 60-61.

Pit & Quarry. Computer Tightens Control of Aggregate Dispatching at Busy N.J. Quarry. V. 76, No. 5, Nov. 1983, pp. 44-47.

———. J. L. Shiely Co. Makes Full Use of Computer Technology. V. 76, No. 5, pp. 60-62.

[11]Kuennen, T. Rocks to Riches: Reclaimed Sites Fine for Business. Rock. Prod., v. 86, No. 3, Mar. 1983, pp. 38-40.

[12]Industrial Minerals (London). Unimin Continues To Grow. No. 191, Aug. 1983, p. 16.

[13]———. Ceramic Coated Glass Fiber—A New Product. No. 189, June 1983, pp. 20-21.

[14]Kuennen, T. Mining, Marketing Frac Sand: A Cyclical, Special Product. Rock Prod., v. 86, No. 5, May 1983, pp. 37-39.

[15]Industrial Minerals (London). Optical Fibers Advance. No. 188, May 1983, p. 17.

[16]Borg, D. G. Some Pointers on Blasting Techniques. Rock Prod., v. 86, No. 2, Feb. 1983, pp. 26-28.

———. Quarry Site Geology Determines Drilling and Blasting Methods. Rock Prod., v. 86, No. 6, June 1983, pp. 44-48.

———. Some Pointers on Blasting Agents. Rock Prod., v. 86, No. 8, Aug. 1983, pp. 40-43.

[17]Buckley, S. Industrial Mineral Processing—Crushing and Grinding. Ind. Miner. (London), v. 189, June 1983, pp. 55-75.

Industrial Minerals (London). Screening and Classification. No. 190, July 1983, pp. 45-55.

Larnach, M. R. High-Energy Crushing Technology and Its Utilization in Plant Design. Quarry Management and Products, v. 10, No. 7, July 1983, pp. 414-419.

Table 6.—Industrial sand and gravel sold or used in the United States, by geographic region

Geographic region	1982				1983			
	Quantity (thousand short tons)	Percent of total	Value (thousands)	Percent of total	Quantity (thousand short tons)	Percent of total	Value (thousands)	Percent of total
Northeast:								
New England	225	1	$3,413	1	148	1	$3,250	1
Middle Atlantic	3,154	11	42,252	r13	3,265	12	44,257	13
North Central:								
East North Central	9,059	r33	96,385	r30	9,601	36	96,840	29
West North Central	1,837	r7	19,209	6	1,488	6	22,683	7
South:								
South Atlantic	3,574	13	45,980	14	4,115	15	55,328	16
East South Central	1,474	5	13,554	4	969	4	9,583	3
West South Central	r4,272	r16	r59,303	r18	3,649	14	51,906	15
West:								
Mountain	1,368	5	13,338	4	868	3	12,258	4
Pacific	r2,409	9	r30,337	r10	2,515	9	39,107	12
Total[1]	r27,400	100	r323,800	100	26,620	100	335,200	100

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

Table 7.—Industrial sand and gravel sold or used in the United States, by State

(Thousand short tons and thousand dollars)

State	1982		1983	
	Quantity	Value	Quantity	Value
Alabama	960	8,096	418	3,256
Arizona	107	1,617	W	W
Arkansas	r471	r5,625	386	4,796
California	r2,167	r27,528	2,150	34,066
Colorado	222	3,266	212	3,233
Connecticut	80	1,746	W	W
Florida	341	4,257	329	3,447
Georgia	541	6,793	539	7,298
Idaho	W	W	W	W
Illinois	3,989	45,665	4,060	42,871
Indiana	W	W	W	W
Iowa	W	W	--	--
Kansas	331	3,635	199	2,184
Kentucky	7	116	10	124
Louisiana	378	4,590	291	4,252
Massachusetts	140	1,615	W	W
Michigan	2,920	21,934	3,545	27,577
Minnesota	694	5,903	685	12,932
Mississippi	W	W	W	W
Missouri	750	8,997	600	7,541
Montana	W	W	W	W
Nebraska	14	105	4	W
Nevada	W	W	W	W
New Jersey	2,140	28,151	2,386	31,819
New Mexico	W	W	--	--
New York	45	512	W	W
North Carolina	716	4,878	1,066	11,689

See footnotes at end of table.

Table 7.—Industrial sand and gravel sold or used in the United States, by State —Continued

(Thousand short tons and thousand dollars)

State	1982 Quantity	1982 Value	1983 Quantity	1983 Value
Ohio	1,223	17,816	1,226	17,848
Oklahoma	1,222	13,114	1,184	13,221
Oregon	--	--	W	W
Pennsylvania	969	13,589	W	W
Rhode Island	5	52	--	--
South Carolina	720	10,902	842	13,169
Tennessee	468	4,826	483	5,455
Texas	r2,201	r35,974	1,788	29,637
Utah	W	W	24	W
Virginia	W	W	W	W
Washington	242	2,809	337	4,581
West Virginia	W	W	W	W
Wisconsin	788	9,662	621	7,208
Other	2,521	30,000	3,232	47,010
Total[1]	r27,400	r323,800	26,620	335,200

rRevised. W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Data do not add to totals shown because of independent rounding.

Table 8.—Industrial sand and gravel production in the United States in 1983, by size of operation

Size range	Number of operations	Percent of total	Quantity (thousand short tons)	Percent of total
Less than 25,000	37	22.8	361	1.4
25,000 to 49,999	30	18.5	1,083	4.1
50,000 to 99,999	29	17.9	2,175	8.2
100,000 to 199,999	24	14.8	3,480	13.1
200,000 to 299,999	12	7.4	2,992	11.2
300,000 to 399,999	9	5.6	3,109	11.7
400,000 to 499,999	6	3.7	2,728	10.2
500,000 to 599,999	5	3.1	2,912	10.9
600,000 to 699,999	5	3.1	3,188	12.0
800,000 and over	5	3.1	4,589	17.2
Total	162	100.0	[1]26,620	100.0

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

Table 9.—Number of industrial sand and gravel active operations and processing plants in the United States in 1983, by geographic region

Geographic region	Number of active operations: Total	Number of active operations: With plants[1]	Active operations with processing plants: Associated with extraction areas on land: Plants at site: Stationary	Plants at site: Portable	Plants not at site (stationary or portable)	Associated with dredging operations: Plants on board	Plants on land	Total number of active operations without plants[1]
Northeast:								
New England	4	3	2	--	--	--	1	--
Middle Atlantic	15	13	8	1	--	1	3	1
North Central:								
East North Central	39	37	31	3	2	--	1	--
West North Central	13	11	10	--	--	--	1	--
South:								
South Atlantic	24	22	18	--	--	1	3	--
East South Central	16	12	5	1	3	--	3	2
West South Central	23	22	16	1	1	1	3	--
West:								
Mountain	12	10	9	--	1	--	--	--
Pacific	16	13	10	2	--	--	1	1
Total	162	143	109	8	7	3	16	4

[1]Based on reports submitted by individual companies.

Table 10.—Industrial sand and gravel sold or used by U.S. producers, by major use

Major use	North East: Quantity (thousand short tons)	North East: Value (thousands)	North East: 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
1982															
Sand:															
Glassmaking:															
Containers	1,968	$25,340	$12.88	2,323	$20,882	$8.99	2,859	$32,421	$11.34	1,716	$21,195	$12.35	8,865	$99,839	$11.26
Flat (plate and window)	W	W	12.95	420	5,523	13.15	642	6,099	9.50	W	W	9.97	1,294	14,101	10.90
Specialty	W	W	13.18	173	2,570	14.86	236	2,456	10.41	W	W	13.75	637	8,095	12.71
Fiberglass (unground)	W	W	13.97	884	7,291	8.25	--	--	--	W	W	r12.33	r1,068	r9,654	9.04
Fiberglass (ground)	W	W	12.94	108	2,398	22.20	243	6,116	25.17	W	W	21.50	388	9,044	23.31
Foundry:															
Molding and core	452	5,588	12.36	4,658	37,807	8.12	r1,508	r14,587	r9.67	145	2,055	14.17	r6,763	r60,037	8.88
Molding and core facings (ground)	W	W	10.73	60	1,520	25.33	W	W	17.80	W	W	19.00	141	2,433	17.26
Refractory	W	W	22.33	181	2,668	14.74	W	W	14.50	--	--	--	214	3,264	15.25
Metallurgical:															
Silicon carbide	W	W	18.33	99	1,088	10.99	--	--	--	W	W	9.82	140	1,516	10.83
Flux for metal smelting	--	--	--	W	W	7.27	--	--	--	W	W	r7.67	r191	r1,460	7.64
Abrasives:															
Blasting	144	2,084	14.47	141	2,364	16.77	r1,375	r20,225	r14.71	219	1,534	7.00	r1,878	r26,206	r13.95
Scouring cleansers (ground)	W	W	W	94	2,021	21.50	W	W	22.09	--	--	--	160	3,461	21.63
Sawing and sanding	W	W	13.33	W	W	16.36	r132	r930	r7.05	W	W	17.50	r170	r1,546	r9.09
Chemicals (ground and unground)	W	W	12.65	W	W	14.00	156	2,157	13.83	--	--	--	335	4,610	13.76
Fillers (ground):															
Rubber, paints, putty, etc	W	W	47.31	80	2,003	25.04	W	W	41.88	W	W	r20.13	r192	r6,350	r33.07
Ceramic (ground):															
Pottery, brick, tile, etc	W	W	27.94	81	2,740	33.83	127	1,411	11.11	W	W	14.00	226	4,627	20.47
Filtration	71	980	13.80	84	827	9.85	132	1,237	9.37	13	158	12.15	299	3,202	10.71
Traction (engine)	18	218	12.11	204	1,938	9.50	r178	r1,113	r6.25	50	497	9.94	r450	r3,765	r8.37
Coal washing	W	W	10.00	W	W	11.50	W	W	9.48	--	--	--	40	396	9.90
Roofing granules and fillers	55	655	11.91	49	668	13.63	404	3,486	8.63	9	77	8.56	517	4,886	9.45
Hydraulic fracturing	W	W	15.00	728	12,281	16.87	r646	r16,835	r26.06	W	W	23.77	r1,481	r31,651	r21.37
Other uses	565	9,264	16.40	476	8,599	18.07	r351	r6,686	r19.05	r1,094	r16,333	r14.93	XX	XX	XX
Total[1] or average	3,272	44,126	13.49	10,843	115,189	10.62	r8,990	r115,761	r12.88	r3,243	r41,849	r12.90	r26,348	r316,925	r12.03
Gravel: Metallurgical:															
Silicon, ferrosilicon	W	W	W	W	W	7.98	230	2,251	9.79	W	W	11.12	326	3,169	9.72
Filtration	--	--	--	6	19	3.17	W	W	4.17	W	W	8.43	19	103	5.42
Grinding	W	W	W	--	--	--	W	W	8.87	--	--	--	146	1,885	12.91
Other uses	107	1,539	14.38	47	386	8.21	100	825	8.25	533	1,826	3.43	533	1,689	3.17

Total[1] or average	107	1,539	14.38	53	405	7.64	331	3,076	9.29	533	1,826	3.43	1,024	6,846	6.69
Grand total[1] or average	3,379	45,665	13.51	10,896	115,595	10.61	[r]9,320	[r]118,837	[r]12.75	[r]3,776	[r]43,675	[r]11.57	[r]27,400	[r]323,800	[r]11.82
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
Mold 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	--	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 cleansers (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	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	--	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

[r]Revised. W Withheld to avoid disclosing company proprietary data; included with "Other uses." XX Not applicable.
[1]Data may not add to totals shown because of independent rounding.

Table 11.—Transportation of industrial sand and gravel in the United States in 1983 to site of first sale or use

Method of shipment	Quantity (thousand short tons)	Percent of total
Truck	18,207	68
Rail	7,194	27
Waterway	995	4
Not shipped, used at site	222	1
Total	[1]26,620	100

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

Table 12.—U.S. exports of industrial sand, by country

(Thousand short tons and thousand dollars)

Country	1982		1983	
	Quantity	F.a.s. value[1]	Quantity	F.a.s. value[1]
Australia	2	432	1	422
Bahamas	13	152	4	115
Canada	584	10,890	918	12,566
Costa Rica	9	134	11	178
Germany, Federal Republic of	3	1,566	5	1,084
Japan	3	1,241	3	1,150
Mexico	165	3,756	58	2,167
Netherlands	3	1,735	6	3,442
Norway	(2)	22	2	168
Panama	4	129	11	280
Peru	4	436	2	229
Philippines	(2)	69	1	168
Saudi Arabia	1	184	(2)	177
Singapore	4	1,551	2	706
United Arab Emirates	1	81	2	245
United Kingdom	4	1,088	5	408
Venezuela	2	240	(2)	53
Other	16	2,614	17	2,499
Total	818	26,320	[3]1,047	26,057

[1]Value of material at U.S. port of export; based on transaction price, including all charges incurred in placing material alongside ship.
[2]Less than 1/2 unit.
[3]Data do not add to total shown because of independent rounding.

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

(Thousand short tons and thousand dollars)

Country	1982		1983	
	Quantity	C.i.f. value[1]	Quantity	C.i.f. value[1]
Australia	78	2,199	45	1,235
Bahamas	---	---	10	36
Canada	11	124	1	52
Germany, Federal Republic of	(2)	161	(2)	145
Other	(2)	[r]38	1	151
Total[3]	[r]90	2,523	58	1,619

[r]Revised.
[1]Value of material at U.S. port of entry; based on purchase price and includes all charges (except U.S. import duties) in bringing material from foreign country to alongside carrier.
[2]Less than 1/2 unit.
[3]Data may not add to totals shown because of independent rounding.

Silicon

By Gerald F. Murphy[1]

Demand for silicon materials increased significantly in 1983, a consequence of a strong recovery by the aluminum industry and a more modest recovery by the iron and steel industries. Accordingly, production and shipments of silicon metal increased dramatically. Compared with that of 1982, imports were slightly more than double in volume and nearly double in value for ferrosilicon overall. Imports of regular-grade ferrosilicon (60% to 80% silicon) were the most significant on a quantity basis, amounting to about two-thirds of total imports. Although the price of silicon metal decreased abruptly in January, domestic producers were able to substantially increase their prices for this material later in the year owing to strong demand by the aluminum industry. Exports of ferrosilicon declined moderately and were only about 8% of imports.

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, all responded, representing 100% of the total production shown in table 1.

Table 1.—Production, shipments, and stocks of silvery pig iron, ferrosilicon, and silicon metal in the United States in 1983

(Short tons, gross weight, unless otherwise specified)

Alloy	Silicon content (percent)		Producers' stocks[r] as of Dec. 31, 1982	Production	Shipments	Producers' stocks as of Dec. 31, 1983
	Range	Typical				
Silvery pig iron	5-24	18	W	W	W	W
Ferrosilicon (including briquets)	25-55	48	94,056	237,790	234,250	59,792
Do	56-95	76	27,953	80,070	76,104	22,701
Silicon metal (excluding semiconductor grades)	96-99	98	12,966	123,602	123,076	11,778
Miscellaneous silicon alloys (excluding silicomanganese)	32-65	--	16,674	52,189	48,930	11,861

[r]Revised. W Withheld to avoid disclosing company proprietary data.

Legislation and Government Programs.—In November, the U.S. Trade Representative, after consultation with the President, requested the International Trade Commission to promptly conduct an investigation under Section 406 of the Trade Act of 1974 to determine if Soviet imports of 50% grade ferrosilicon had caused market disruption. Section 406 deals with products from countries with centrally planned economies, which compete unfairly with domestic industry or cause market disruptions. In March 1983, following a request by The Ferroalloys Association, the President removed two grades of Brazilian ferrosilicon and silicomanganese from duty-free status under the Generalized System of Preferences for developing countries. Following an administrative review, the U.S. Department of Commerce directed the U.S. Customs Service to collect cash deposits of 1.53% in countervailing duties on shipments of ferroalloys from Spain.

DOMESTIC PRODUCTION

Production and shipments of silicon metal increased dramatically in 1983. Silicon metal is largely independent of the iron and steel industries and its strong recovery was mainly due to increased demand by the surging aluminum industry. Shipments of silicon alloys increased moderately, except for the 56% to 95% range, which showed a slight decrease. Demand for silicon alloys is closely tied to the iron and steel industries, which have been recovering slowly. The miscellaneous silicon alloys are special purpose alloys based on ferrosilicon but with other elements added. Magnesium ferrosilicon accounts for the major portion of this material. Other alloys include calcium silicon, silicon-manganese-zirconium, and proprietary inoculants.

Concessionary labor agreements enabled some ferroalloys companies, which had been supplying customers from stocks for extended periods, to resume production and replenish stocks of silicon alloys. Ohio Ferro-Alloys Corp., Canton, OH, restarted ferrosilicon production at its Philo plant in August, principally owing to a new labor contract that included all three of the company's plants and which contained a reduction in wages and benefits. The plant had been closed since late 1982 and inventories of several silicon alloys had reached extremely low levels. The company had resumed silicon metal production at its Powhatan Point facility early in 1983, responding to increased demand for the material from the secondary aluminum industry, as well as from producers of chemical and electronic products. On May 1, the Hanna Mining Co. reopened its Wenatchee, WA, plant, which produces silicon metal and ferrosilicon. Labor concessions, a temporary reduction in Bonneville Power Administration electrical power rates, and an increase in demand for silicon materials were the main factors in the company's decision to reopen the plant. Two ferroalloy plants were shut down by strikes during the year. Foote Mineral Co.'s plants at Graham, WV, and Cambridge, OH, were closed for about 1 month by a strike that began October 2. A new 3-year labor agreement that included wage and benefits concessions was ratified. The Graham plant produces ferrosilicon, while the Cambridge facility produces ferrovanadium and ferroboron. SKW Alloys Inc., Niagara Falls, NY, announced in December that it planned to reopen its Calvert City, KY, plant in January 1984, regardless of whether a strike that halted production since September 1 was settled. The Calvert City facility produced both 50% and 75% ferrosilicon and other alloys in 1983. The company needed to resume production before its current ferroalloy stocks were exhausted.

Table 2.—Producers of silicon alloys and/or silicon metal in the United States in 1983

Producer	Plant location	Product
Alabama Alloy Co. Inc	Bessemer, AL	FeSi.
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.
Interlake Inc., Globe Metallurgical Div	Beverly, OH	Do.
Do	Selma, AL	Si.
International Minerals & Chemical Corp., Industry Group, TAC Alloys Div	Bridgeport, AL	FeSi.
Do	Kimball, TN	Do.
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.
South African Manganese Amcor Ltd., Roane Alloys Div	Rockwood, TN	Si.

CONSUMPTION AND USES

Total reported consumption of silicon materials increased significantly to about 304,000 short tons of contained silicon, an increase of about one-eighth compared with the 1982 total of 272,000 tons. This increase in demand was attributed to a strong recovery by the aluminum industry and to a more modest recovery by the iron and steel industries. While production rates in the automotive industry increased significantly in the latter part of the year, downsizing and substitutions to achieve weight reduction have resulted in less consumption of iron and steel per unit. Cast iron shipments, exclusive of ingot molds, as reported by the Bureau of the Census, rose about 11% from 7.1 million net tons in 1982 to 7.9 million net tons in 1983. Except for silvery pig iron, which declined by a little more than one-half, reported consumption of silicon materials increased generally. The more pronounced increases occurred for the 85% and 65% ferosilicon and silicon metal. The largest demand was for the 50% ferrosilicon grade and silicon metal, followed, on the basis of silicon content, by the 75% ferrosilicon grade, miscellaneous silicon alloys, and silicon carbide. The decreasing order of end uses for silicon materials was cast iron, steel, silicones and silanes, and nonferrous alloys, with about 68% 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% ferrosilicon. Steel plants and iron foundries together accounted for about 98% of 50% ferrosilicon usage; slightly less than 90% of the silicon metal consumed went into nonferrous alloys and silicones and silanes.

Table 3.—Consumption, by major end use, and stocks of silicon alloys and metal in the United States in 1983

(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		19	42,708	(4)	17,193	(4)	592	1,426	(4)
Stainless and heat-resisting		--	27,708	(4)	23,265	(4)	155	(4)	--
Full alloy		(4)	18,142	(4)	6,860	(4)	(4)	1,041	(4)
High-strength low-alloy		(4)	4,568	--	1,170	(4)	(4)	(4)	(4)
Electric		--	(4)	(4)	(4)	--	--	--	--
Tool		--	(4)	--	828	--	7	--	--
Unspecified		55	7,769	3,036	22,468	881	715	358	191
Total		74	100,895	3,036	71,784	881	1,469	2,825	191
Cast irons		13,687	112,142	1,873	18,451	459	59	24,533	20,962
Superalloys		1	118	--	34	64	48	--	--
Alloys (excluding alloy steels and superalloys)		148	2,304	7	69	7	35,607	94	--
Silicones and silanes		--	--	--	--	--	53,467	--	--
Miscellaneous and unspecified		--	1,196	--	28	1	[5]9,198	8	--
Total		13,910	216,655	4,916	90,366	1,412	99,848	27,460	21,153
Percent of 1982		46	103	138	115	184	122	116	118
Total silicon content[6]		2,504	103,994	3,195	68,678	1,200	97,851	13,181	13,538
Consumers' stocks, Dec. 31		1,146	13,812	286	7,399	164	3,758	2,634	1,302

[1]Includes briquets.
[2]Primarily magnesium-ferrosilicon but also includes other silicon alloys. Average silicon content estimated as 48%, based on 1983 production survey.
[3]Does not include silicon carbide for abrasive or refractory uses.
[4]Included with "Steel: Unspecified."
[5]Includes an estimated 9,000 tons consumed for unspecified chemicals.
[6]Estimated based on typical percent content.

Unlike ferrosilicon, silicon metal demand is closely linked to the aluminum and chemical industries. The aluminum industry, which uses silicon metal to make wrought and cast products, rebounded strongly and substantially increased production. The increase was in large part caused by increases in the housing and transportation industries. Consumption of silicon metal for silicones and silanes also increased in 1983, by about two-fifths compared with that of 1982.

PPG Industries Inc., the largest producer of precipitated silicas in the United States, began a major modernization for production of high-purity silicas at its Lake Charles, LA, complex. The company announced that it was phasing out its titanium dioxide extender silica products, formerly produced at Barberton, OH, in favor of concentrating on markets and product lines in rubber reinforcing silicas and thixotropic agents. General Electric Co.'s Silicone Products Div. announced plans to build a 15-million-pound-per-year fumed silica plant at its Waterford, NY, complex. Fumed silica, a relatively high-cost material compared with other reinforcing-grade silicas, is used mainly as a premium reinforcing agent for silicone rubber, of which General Electric is a major producer.

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. Domestic production of polycrystalline silicon was estimated at 1,700 tons. Toth Aluminum Corp. started up its clay-based metals chloride plant in Vacherie, LA, and planned to move into commercial production in January 1984. The plant will produce silicon tetrachloride and other metal chlorides. Silicon tetrachloride is used to produce very pure fumed silica and high-purity polycrystalline silicon.

Consumer stocks of silicon material changed very little from those at the end of 1982, showing a slight decline.

PRICES

Although the price of silicon metal decreased abruptly in January, domestic producers were able to substantially increase their prices for this material later in the year owing to strong demand by the aluminum industry. Both 50% and 75% ferrosilicon prices decreased in May to their lowest level for the year. Ferrosilicon demand, unlike silicon metal, is tied primarily to the steel industry, and as a result has been much slower to recover than silicon metal. Domestic producers, because of a depressed demand, were able to only slightly increase prices in the second half of the year.

The price of domestic, lump silicon metal with 1% maximum iron and 0.07% maximum calcium decreased at the beginning of the year to 52 cents per pound from 62 cents per pound of contained silicon, and then increased periodically reaching 60.25 cents per pound in December. The price of imported silicon metal also increased at several intervals, beginning the year in the range of 47 cents to 49 cents per pound and ending the year in the range of 60 cents to 61 cents per pound.

The published price of regular-grade 50% and 75% ferrosilicon decreased from 45 and 47 cents per pound, respectively, to a low for the year of 39.5 cents per pound. Because of domestic discounting, actual transaction prices were even lower, reported to be in the range of 35 to 37 cents per pound. Ferrosilicon posted prices increased slightly by yearend to 43 cents per pound for the 50% grade and to the range of 43 to 45 cents per pound for the 75% grade. The f.o.b. warehouse price of imported 75% ferrosilicon, as quoted in Metals Week, began the year in the range of 32 to 34 cents per pound, but showed an upward trend and ended the year in the range of 39.5 to 40.5 cents per pound. Regular 5% magnesium ferrosilicon with no cerium decreased from 53 to 50 cents per pound of material, effective July 1, while the 9% grade went from 72 to 71 cents per pound of alloy. Also effective July 1, the price of calcium silicon increased from 66 to 72 cents per pound of alloy.

FOREIGN TRADE

Exports of ferrosilicon declined moderately and were only about 8% of imports. In terms of quantity and value, ferrosilicon exports reached their lowest level in 5 years. The largest quantities were exported to Canada and Australia, 8,284 and 2,714 tons, respectively, accounting for slightly more than 80% of total quantity and a little more than 75% of total value. Exports went to 29 countries. Silicon metal exports increased significantly to a total of 2,767 tons. Principal recipients were Japan, 1,238 tons, and Mexico, 897 tons, together accounting for about 80% of total quantity and 30% of total value. Exports of silicon metal went to 41 countries.

Compared with those of 1982, imports were slightly more than double in volume and nearly double in value for ferrosilicon overall. Silicon metal imports showed little change both in quantity and 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 imports. Norway shipped about one-fourth of the total in this range, while Brazil, Canada, and Venezuela, each with about one-fifth of the total, were the next largest sources. The next largest import class was regular-grade 50% ferrosilicon (30% to 60% silicon), which amounted to slightly more than one-fifth of ferrosilicon imports. The main sources of this material were the U.S.S.R., 16,647 tons; Canada, 8,684 tons; and Venezuela, 4,358 tons, together accounting for about 87% of the total. Average silicon content of all ferrosilicon in 1983 declined to 66% from 68% in 1982. Silicon metal imports in the 96% to 99% range decreased sharply by more than two-fifths in terms of gross weight. Canada and Yugoslavia were the dominant sources, together accounting for about 85% of the total. However, this drop was more than offset by a slightly more than three-fifths increase in the 99% to 99.7% range. Canada and Brazil were the principal shippers of this material.

The moderate decrease in ferrosilicon exports, combined with a very large increase in imports, left the United States a net importer of ferrosilicon material. Net imports amounted to about 146,000 tons and a trade deficit of about $61 million.

Table 4.—U.S. exports of ferrosilicon and silicon metal

Year	Quantity (short tons)	Value (thousands)
FERROSILICON		
1979	22,357	$14,740
1980	27,488	18,572
1981	15,768	12,136
1982	14,932	11,996
1983	11,338	10,712
SILICON METAL		
1979	4,987	45,752
1980	14,372	65,478
1981	8,673	57,001
1982	2,411	34,335
1983	2,767	47,826

Table 5.—U.S. imports for consumption of ferrosilicon and silicon metal, by grade and country

Grade and country	1982 Quantity (short tons) Gross weight	1982 Quantity (short tons) Silicon content	1982 Value (thousands)	1983 Quantity (short tons) Gross weight	1983 Quantity (short tons) Silicon content	1983 Value (thousands)
Ferrosilicon:						
Over 8% but not over 30% silicon:						
Brazil	100	15	$145	--	--	--
Canada	541	147	60	29	6	$11
Total[1]	641	162	204	29	6	11
Over 30% but not over 60% silicon, with over 2% magnesium:						
Brazil	4,705	2,131	3,649	3,911	1,817	3,091
Canada	341	163	314	2,395	1,141	840
France	561	270	517	587	276	401
Germany, Federal Republic of	13	6	18	62	33	93
Italy	--	--	--	19	9	12
Japan	5	2	8	14	6	24
Norway	180	80	152	4,512	2,087	3,412
Venezuela	--	--	--	2,075	1,003	436
Total[1]	5,805	2,653	4,657	13,575	6,372	8,308

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	1982 Quantity (short tons) Gross weight	1982 Quantity (short tons) Silicon content	1982 Value (thousands)	1983 Quantity (short tons) Gross weight	1983 Quantity (short tons) Silicon content	1983 Value (thousands)
Ferrosilicon —Continued						
Over 30% but not over 60% silicon, not elsewhere classified:						
Brazil	5,404	2,662	$1,738	1,652	810	$879
Canada	3,425	1,657	1,116	8,684	4,168	2,499
France	2,223	1,285	3,002	1,433	820	1,491
Germany, Federal Republic of	833	353	856	286	150	357
Japan	2	1	3	--	--	--
Mexico	55	27	18	1,048	539	249
U.S.S.R	--	--	--	16,647	7,749	2,804
Venezuela	--	--	--	4,358	2,214	988
Total[1]	11,940	5,984	6,733	34,108	16,449	9,267
Over 60% but not over 80% silicon, with over 3% calcium:						
Brazil	3,591	2,573	2,490	2,852	1,921	1,951
Canada	60	45	35	--	--	--
China	2	2	1	--	--	--
France	935	568	1,297	929	566	1,033
Germany, Federal Republic of	629	388	967	1,562	965	1,770
Italy	100	64	128	265	167	268
Spain	209	132	237	--	--	--
United Kingdom	--	--	--	63	39	72
Total[1]	5,526	3,771	5,155	5,671	3,658	5,094
Over 60% but not over 80% silicon, not elsewhere classified:						
Argentina	2,303	1,742	993	2,179	1,663	984
Brazil	16,995	12,686	7,887	22,021	16,510	9,599
Canada	6,013	4,432	3,294	19,733	14,905	11,154
China	2	2	1	--	--	--
France	3,044	2,338	1,573	3,741	2,874	1,957
Germany, Federal Republic of	532	397	1,018	513	381	887
Iceland	--	--	--	8,264	6,537	3,064
Italy	112	71	143	--	--	--
Japan	--	--	--	18	14	13
Mexico	114	87	62	1,863	1,323	802
Norway	8,764	6,586	3,468	27,021	20,384	11,447
South Africa, Republic of	4,131	3,039	1,747	--	--	--
Spain	133	83	161	--	--	--
Sweden	--	--	--	323	243	129
Venezuela	8,489	6,352	2,503	18,918	13,555	4,058
Yugoslavia	--	--	--	1,446	1,122	658
Total[1]	50,632	37,816	22,850	106,041	79,512	44,752
Over 80% but not over 90% silicon:						
Canada	--	--	--	20	15	13
Norway	698	601	208	--	--	--
Total	698	601	208	20	15	13
Over 90% but not over 96% silicon:						
Belgium-Luxembourg	156	150	133	--	--	--
Canada	--	--	--	(2)	(2)	(2)
Germany, Federal Republic of	40	37	33	--	--	--
Norway	1,294	1,174	371	--	--	--
Total[1]	1,490	1,361	536	(2)	(2)	(2)
Total ferrosilicon[1]	76,732	52,348	40,343	159,443	106,012	67,445
Silicon metal:						
Over 96% but not over 99% silicon:						
Argentina	1,400		1,191	494		374
Belgium-Luxembourg	7		96	--		--
Brazil	110		121	--		--
Canada	6,012		6,183	3,710		3,598
China	40	NA	81	--	NA	--
France	99		126	48		49
Japan	20		113	--		--
Norway	1,312		1,394	--		--
South Africa, Republic of	394		412	--		--

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	1982			1983		
	Quantity (short tons)		Value (thousands)	Quantity (short tons)		Value (thousands)
	Gross weight	Silicon content		Gross weight	Silicon content	
Silicon metal —Continued						
Over 96% but not over 99% silicon —Continued						
Sweden	1,649	NA	$1,578	553	NA	$512
United Kingdom	--		--	1		(2)
Yugoslavia	2,324		2,199	2,728		2,132
Total[1]	13,366	NA	13,494	7,535	NA	6,665
Over 99% but not over 99.7% silicon:						
Argentina	1,438	1,426	1,420	1,023	1,014	908
Belgium-Luxembourg	--	--	--	(2)	(2)	1
Brazil	1,991	1,972	1,968	5,926	5,582	5,691
Canada	5,514	5,463	6,251	7,990	7,864	8,698
China	1,035	1,026	1,018	682	676	558
France	987	981	1,119	1,027	1,020	1,066
Japan	5	5	28	--	--	--
Norway	827	819	867	602	596	444
South Africa, Republic of	528	520	574	1,462	1,450	1,445
United Kingdom	(2)	(2)	(2)	--	--	--
Yugoslavia	--	--	--	1,241	1,215	886
Total[1]	12,326	12,214	13,246	19,953	19,418	19,699
Over 99.7% silicon:						
Australia	--	NA	--	(2)	NA	61
Austria	(2)		(2)	1		3
Belgium-Luxembourg	(2)		(2)	33		1,214
Bulgaria	2		8	--		--
Canada	19		22	--		--
China	29		1,045	28		889
Denmark	16		356	22		320
France	2		495	1		255
German Democratic Republic	--		--	7		158
Germany, Federal Republic of	441		17,679	445		15,801
Italy	60		2,757	79		3,608
Japan	44		1,793	62		3,077
Korea, Republic of	(2)		6	(2)		22
Netherlands	(2)		6	--		--
Poland	--		--	(2)		(2)
Sweden	4		52	2		8
Switzerland	(2)		10	(2)		6
Taiwan	1		24	5		157
United Kingdom	31		1,202	1		78
Total[1]	649	NA	25,455	685	NA	25,659
Total silicon metal[1]	26,338	XX	52,195	28,173	XX	52,026

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

Overcapacity and oversupply were the principal problems troubling the world ferroalloy industry, mainly due to a continually shrinking world steel market. Technological developments in the steel industry, resulting in less ferroalloy consumption, also contributed to a decreasing market for these materials. Despite the continually shrinking world market, Brazil, Egypt, Iceland, and Yugoslavia added or planned to add substantial new ferrosilicon and/or silicon metal capacity. Silicon metal is largely independent of the steel world and the increase in production was primarily due to increased demand by the aluminum industry. Because of the reduced market, fierce competition arose among producers attempting to increase market share and offset lost sales. Many countries have applied trade restraints to protect their domestic market. Protectionist pressures were fueled by the high value of the dollar in the United States, by protracted high unemployment in Europe, and by the need to earn trade surpluses in developing countries to pay off very large debts.

Following a decision to raise prices for ferrosilicon exports to the European Economic Community (EEC) by producers in Venezuela, Yugoslavia, Iceland, Norway, and Sweden, the EEC decided against taking protective action on imports of ferrosilicon from these countries. Investigation by the EEC had established earlier that dumping had occurred and that there had been injury to EEC producers. The EEC maintained, however, that the price increases would eliminate injury to EEC ferrosilicon producers and also eliminate the dumping margin, estimated at 26% for Venezuelan and Yugoslavian ferrosilicon exports and at 12% for exports from Iceland, Norway, and Sweden. The EEC also set quotas for duty-free imports of ferrosilicon and other ferroalloys and set a minimum price for ferrosilicon imports.

Australia.—Comalco Pty. Ltd. and Agnew-Clough Ltd. planned to establish a joint venture company to produce 25,000 short tons per year of silicon metal. Silica raw material will be obtained from Agnew-Clough's deposit located north of Perth, near the town of Moora. The project was expected to be on-stream by mid-1984.[2]

Brazil.—Despite the current slump in world demand for ferrosilicon and the problem of world overcapacity, Brazilian ferroalloy producers are steadily increasing their total furnace capacity. Brazilian ferrosilicon and silicon metal producers claimed several natural cost advantages over other producers, including extensive reserves of high-purity quartz, ready access to low-cost reserves of charcoal, and abundant hydroelectric power.[3]

Camargo Correa S.A., a Brazilian construction company, received Government authorization to build a 35,000-ton-per-year silicon metal plant, which will contain four 8,800-ton-per-year furnaces. The first furnace was expected to come on-stream by the end of 1985, with the remaining three scheduled for completion in 1986. Electrical power will be furnished by the Tucurui hydroelectric project and silicon output will be destined exclusively for the export market.[4] Italmagnesio S.A., São Paulo, planned to add a 24-megavolt-ampere (MVA) furnace in 1984. The new furnace will produce either 18,000 tons per year of 75% ferrosilicon or 12,000 tons of silicon metal annually, with all the increased production slated for export. The company's total electric furnace capacity, with the addition of the new furnace, will increase to about 60 MVA.[5]

Electrometalur S.A. Indústria e Comércio, Belo Horizonte, a ferrosilicon producer, put a new 5,000-ton-per-year silicon metal furnace on-line early in 1983. Production is scheduled for the export market.[6] A second 6,000-ton-per-year furnace will be completed by the third quarter of 1984.[7] Electrometalur also planned to more than double its calcium silicide production. Cia. de Ferro-Ligas da Bahia S.A. resumed ferrosilicon production in 1983 after a shutdown of over 12 years. The company converted two electric furnaces, previously used to produce ferrochromium, to ferrosilicon production because of lack of demand. Late in the year, one of the furnaces was reconverted to ferrochromium production after a dramatic increase in demand for the material.

In 1983, the Brazilian state mining organization, Cia. Vale do Rio Doce, planned to build a 25,000-ton-per-year ferrosilicon furnace at Nova Era. Mitsubishi Mining Co., Japan, is expected to contribute to the required $25 million investment, with the entire production marked for the Japanese market.[8] Ferroligas de Minas Gerais, Pirapora, planned to expand its current ferrosilicon production threefold to about 12,000 tons per year by 1985. The expansion project will include two new electric furnaces that will be able to produce either ferrosilicon or silicon metal.[9]

Egypt.—The Egyptian Ferroalloy Co., a new state-owned firm, planned to start two of its four 21.5-MVA ferrosilicon furnaces early in 1984, with the remaining two furnaces scheduled for operation by the end of that year. Full plant production capacity was rated at about 62,000 tons per year, of which about 44,000 tons has been marked for export. Low-cost power will be made available from the Aswan Dam hydroelectric project. Currently, the Egyptian Chemical Co. is the only existing producer of ferrosilicon, with an output estimated at about 6,000 tons per year.[10]

France.—Rhône-Poulenc S.A. and Siltec Corp., United States, formed a joint venture, Rhône-Siltec, to build a $30 million silicon wafer factory in France. The agreement also required Rhône-Poulenc to buy a 10% interest in Siltec.[11] Rhône-Poulenc Specialists Chimiques, a wholly owned subsidiary of Rhône-Poulenc, and Dainippon Ink and Chemicals, Japan, signed an agreement for the creation of a joint venture to produce and market silicone products in Japan.[12]

Germany, Federal Republic of.—North America Silica Co., a joint venture company formed by Degussa AG, Frankfurt, and Philadelphia Quartz Corp. (PQ), United States, began construction of a microfine precipitated silica plant on a site next to PQ's Chester, PA, silicate manufacturing facility. PQ will provide sodium silicate raw material for the precipitated silica operation, which will use Degussa technology. Microfine precipitated silicas are used in a wide variety of specialty applications such as reinforcing fillers for elastomers and rubber products, as free-flow anticaking agents, and as carriers for vitamins and pesticides.[13]

Iceland.—Icelandic Metal PLC contracted with Mannesmann Demag, Federal Republic of Germany, for a complete silicon metal plant including engineering and auxiliary equipment to be built at Reydorfjordur. The order included two submerged arc furnaces with an installed load of 33 MVA each. The plant, with an annual capacity of about 25,000 tons per year, will need to import all of its raw materials, while the entire output will be exported.[14]

India.—Ferrosilicon production fell off sharply in 1983 because of power cuts in Orissa and Karnataka. However, production recovered somewhat with the beginning of good monsoon weather throughout the country. Sandur Manganese Iron Ores Ltd., Karnataka, converted one of its 20 MVA furnaces, previously used for ferrosilicon production, to 76% to 78% ferromanganese production. Nava Bharat Ferro Alloys Ltd., Andhra Pradesh, installed a third 16.5-megawatt Soviet furnace to be used for calcium silicon production. Another plant, with a capacity of about 10,000 tons per year of ferrosilicon, was scheduled to startup in 1983 in Andhra Pradesh. Its furnace was also supplied by the U.S.S.R.[15]

Japan.—The basic problem of the Japanese ferroalloy industry was that of high electricity cost. The industry has been designated as one that came under Japan's new 5-year Specific Industries Restructure Law that came into effect July 1 and replaced the Depressed Industries Law. Energy-intensive products such as ferrosilicon and silicon metal have been hardest hit by high energy costs. The Ministry of International Trade and Industry was expected to review a plan that would further reduce Japan's ferrosilicon capacity by about 14% to 330,000 tons per year by 1986. The balance of the country's total demand would be met by imports. Nippon Keiso, Japan's only silicon metal producer, ceased production at its Minamata plant at the end of 1982. This action made it necessary for Japan to rely solely on imports to meet its domestic demand for silicon metal in 1983. Demand for the metal comes mainly from the aluminum, chemical, and the semiconductor industries. Since there was no longer a producer, domestic consumers called for tariff removal. Japan imported an alltime high of about 88,000 tons of silicon metal, about a 30% increase over that of 1982. China, Norway, the Republic of South Africa, France, and Brazil were the main sources. Imports of ferrosilicon were about 300,000 tons, about a 15% increase over those of 1982. Norway, Brazil, Venezuela, the Philippines, France, Canada, Yugoslavia, and the Republic of South Africa were the principal suppliers of ferrosilicon. In response to the very high level of ferrosilicon imports, Japan's ferrosilicon producers have prepared a report aimed at prompting an antidumping investigation against seven countries.[16]

Japan's quotas for preferential tariff imports of ferrosilicon and other ferroalloys from developing countries for fiscal year 1983 were little changed from those of 1982. The quota for ferrosilicon was 14,000 tons. A normal tariff of 3.8% is applied to imports above this quantity.[17]

Shin-Etsu Itandotai Co. planned to start in the spring of 1984 on a new $62.5 million plant for silicon monocrystals and wafers in Iwaki City. The facility will be capable of producing about 17 tons of high-purity silicon ingot and 500,000 wafers per month in diameters of 4, 6, and 8 inches. The plant was scheduled for completion early in 1985. Mitsubishi Metal Corp. planned to begin work on a new $25 million facility that would double its silicon ingot production to about 9 tons per month. The company's monocrystals are processed into wafers at its subsidiary, Nippon Silicon Co.[18] Production of polycrystalline silicon for the Japanese semiconductor industry was approximately 652 tons, down slightly from about 666 tons in 1982.[19]

Norway.—Production of silicon metal and alloys recovered strongly in 1983. Producers were reported to have operated at near capacity for the year. In April, Bjölvefossen AS, Elkem AS, Hafslund AS, Ila og Lilleby Smelteverker AS, and Orkla Metall AS called off their discussions concerning a possible merger of their operations. The 5 companies control 11 ferroalloy plants. A major obstacle apparently was the question of transfer of power rights to the proposed new company, which would have required parliamentary approval. A sixth ferroalloy producer, Tinfos Jernverk AS, was not involved in the merger discussions.[20]

Elkem offered for sale one-half of its interest in Icelandic Alloys Ltd., Iceland, a ferrosilicon concern. Negotiations for sale were conducted with Sumitomo Metal Mining Co. Ltd. of Japan. The Icelandic Government holds majority ownership of the plant.[21] Elkem's 25,000-ton-per-year silicon metal furnace at its Fiskaa works, which was shut down owing to problems with the lining, was brought back on-line early in 1983. The stoppage apparently caused delay in meeting some deliveries.[22] Bjölvefossen planned to convert its four ferrochromium furnaces to ferrosilicon production if the Government implemented stringent new pollution regulations. The Finnfnes plant, which was brought back on-line earlier in the year under new ownership, Finnfjord Smelteverk AS, brought the last of its three furnaces on-line in October, which would add about 24,000 tons per year of ferrosilicon for export. Tinfos converted at least one ferrosilicon furnace to silicon metal production, resulting in a decrease of alloy production by about 5,000 to 10,000 tons per year.[23]

Philippines.— Maria Cristina Chemical Industries (MCCI) and two Japanese companies, Nippon Kokan K.K. and Marubeni Corp., planned to build a 15,000-ton-per-year ferrosilicon plant on Mindanao. A new company, the Mindanao Ferro-Alloy Co., will be established with MCCI, the majority owner. The new plant was expected to begin operation in October 1984 with the entire output destined for the Japanese market. Existing Philippine ferroalloy producers suffered a severe electricity shortage in 1983.[24]

Portugal.—Milnorte-Metalurgia do Norte S.A.R.L.'s two silicon metal furnaces were out of operation during the year. Cia. Portugesa de Fornos Electrico S.A.R.L. announced that its production remained at about 12,000 tons per year.[25] Fornos Electrico was reported to have prepared a 12,000-ton-per-year furnace for production and was awaiting Government approval for startup. Output would be destined for the free market.[26]

Spain.—Hidro Nitro Españolas S.A. notified the Spanish Government in midyear that it planned to halt ferrosilicon production unless some agreement was reached on reduced electricity rates for the industry. Spain's ferroalloy producers have claimed that they were forced to pay much higher electricity prices than their European competitors.[27] Silicio de Sabon planned to resume production of silicon metal for export in October, after a break of over 1 year. The startup was made possible by a reduction in electricity costs of 1.40 pesetas per kilowatt hour and sharply improved prices for silicon metal in the international market.[28]

Yugoslavia.—Dalmacija Metallurgical Industry planned to bring on-stream a new 30-megawatt ferrosilicon furnace at its ferroalloy plant at Dugi Rat. The furnace, supplied by Elkem, Norway, will provide about 25,000 to 30,000 tons per year of ferrosilicon for the export market.[29]

TECHNOLOGY

High-technology ceramics such as silicon carbide, silicon nitride, and sialon (a material of silicon, aluminum, oxygen, and nitrogen) have seen little use as load-bearing machine and engine components because they are too brittle. The tendency of technical ceramics to break has been getting much attention from researchers. Development of procedures to produce flaw-free parts is essential if a practical ceramic engine is to be built. Flaws that can lead to catastrophic failure are much smaller than critical size flaws in metal parts, making detection of cracks in ceramic parts very difficult. However, advances in processing and design engineering are expected to improve the reliability of ceramics. Because of their resistance to wear, corrosion, chemical attack, and thermal shock, technical ceramics have found application in high-temperature heat-recovery systems, chemical-processing, oil and gas recovery equipment, cutting tools, and coatings for engine parts, among others. High-technology ceramic raw materials are relatively widely distributed and inexpensive. An important consideration in research and development programs is the possible substitution of ceramics for strategic materials such as cobalt, titanium, and manganese.[30]

Isuzu Motors, Japan, partly owned by General Motors Corp., announced that it had developed a ceramic diesel engine that reduces fuel consumption by 50%, as compared with a conventional diesel engine. Ceramics are used in headliners, head valves, and exhaust manifolds, making up about 10% of the total weight of the engine. Isuzu reported that the engine needs no cooling units.[31]

Hitachi Chemical Co. Ltd., Japan, announced development of a new ceramic, with applications in automobile engines, gas turbines, and other heat-resistant structural equipment. The new ceramic is produced by sintering silicon carbide powder with a proprietary additive. Cylinders, pistons, and piston pins of diesel engines, made of this material, were claimed to have been successfully tested.[32] Carborundum Resistant Materials Co.'s Advanced Materials Div., Niagara Falls, NY, began construction early in 1983 of a $2.7 million facility for manufacturing its sintered alpha silicon carbide. The material is a hard, strong ceramic that is resistant to abrasion, corrosion, oxidation, thermal shock, and chemical attack. It reportedly has found acceptance as a replacement for tungsten carbide wear parts, such as oil and gas drilling components, sand blast nozzle inserts, and seals; another commercial application may be in turbocharger rotors.[33] Sintered alpha silicon carbide has been tested successfully in several engine applications including an unlubricated, uncooled two-cycle diesel engine. Carborundum and Hitachi agreed to form a joint venture company to produce and market Carborundum's sintered alpha silicon carbide in Japan. The new company, Hitachi-Carborundum Co., will be equally owned by its parents.[34] W. R. Grace & Co., United States, and Feldmuehle AG, Federal Republic of Germany, announced the formation of an equal partnership, Grace-Feldmuehle Motor Ceramics Co., to study the world market for the use of ceramic materials in internal combustion engines.[35]

The Ford Motor Co. announced that it had developed a silicon nitride ceramic for cutting tools that will permit the machining of cast iron components at much higher speeds than with currently available tools. The new ceramic material, which is extremely tough and can only be cut with a diamond, has been licensed by Ford for cutting tool applications to ISCAR Metals Inc., NJ.[36] Valeron Corp.'s Valenite division planned to open a new ceramic products manufacturing facility at Madison Heights, MI. The new plant will produce high-quality ceramic cutting material and cutting inserts.[37] Dow Corning Corp., United States, signed a marketing agreement with Nippon Carbon Co. Ltd., Japan, to market silicon carbide fibers in the United States. The fibers are expected to find application in ceramic composites and aluminum-based metal matrix compounds.[38] Gorham International Inc., Gorham, ME, announced plans to study the production of advanced ceramics such as silicon carbide, silicon nitride, and sialon, by sintering, and hot isostatically pressing them.[39] NGK Insulators Ltd., Nagoya, Japan, announced plans to begin commercial production of silicon nitride rotors for turbochargers by May 1984. Rotors made of silicon nitride weigh about one-third less than those made from heat-resistant nickel alloy, and enables quicker acceleration due to reduced inertia effects. The company claimed that the ceramic rotor can be revolved at 500 meters per second at temperatures of 1,000° C.[40] Sermatech, Limerick, PA, a subsidiary of Teleflex Inc., acquired United Technologies Metal Products Inc. The purchase includes patents for Gator-Card systems used to apply ceramic coatings and other metallic coatings in the energy drilling industry.[41]

Photovoltaic cells are not yet economical in consumer power applications. However, they are cheap and reliable enough to compete in a number of high-value remote power uses such as navigational aids, telecommunications, irrigation pumps, and other remote areas without access to any grid. While single-crystal cells continue to dominate the industry, they are costly to produce, and the achieved conversion efficiency is still not high enough to compete with conventional power sources. Multijunction amorphous silicon cells, silicon concentrator cells, and single-crystal silicon ribbon are other approaches reported to have a chance of meeting the cost and efficiency thresholds needed for bulk power generation.[42] Sharp-ECD Solar Inc., Japan, started commercial production of amorphous solar cells by a continuous process in a plant in Shingo. The amorphous solar cell material is made by deposition of a double layer of amorphous silicon on stainless steel sheets. The material will be used initially in solar-powered calculators produced by Sharp Inc., Japan.[43] Arco Solar Inc., a subsidiary of Atlantic Richfield Co., began work on a 16-megawatt photovoltaic powerplant in San Luis Obispo County, CA. Pacific Gas and Electric Co. will purchase the electricity generated by the plant. The first phase of the project, about 6 megawatts of output, has been scheduled for completion by March 1984. Reflectors will track the sun on double axis trackers, reflecting the light onto higher-efficiency photovoltaic panels to increase the amount of sunlight striking the panels.[44] Standard Oil Co. of Indiana (Amoco) completed its $12 million acquisition of Solarex Corp. in September 1983. The takeover also included Solarex's subsidiary, Semix Inc., WV, which produces raw silicon that Solarex turns into solar cells. Amoco had already owned 38% of Solarex.[45]

Researchers at the University of New South Wales, Australia, reported production of a silicon cell that converts sunlight into electricity at an efficiency of 18%, a considerable improvement over that presently achieved in commercial solar cells. The new cells were claimed to last 20 years or longer and to have applications in remote areas where there is no other source of electricity available.[46] The Solar Energy Research Institute, Golden, CO, reported achieving a conversion efficiency of nearly 5% for large-area amorphous silicon solar cells. Photovoltaic modules made from thin-film amorphous silicon on a glass substrate and produced by Chronar Corp., Princeton, NJ, were used. One advantage of amorphous-silicon solar cells is the possibility of mass producing them at a much lower cost than that of single-crystal photovoltaic cells.[47]

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[1]Physical scientist, Division of Ferrous Metals.
[2]Metals Week. V. 34, No. 47, Nov. 21, 1983, p. 2.
[3]Metal Bulletin (London). No. 6840, Nov. 22, 1983, p. 15.
[4]American Metal Market. V. 91, No. 89, May 6, 1983, p. 1.
[5]———. V. 91, No. 223, Nov. 15, 1983, p. 10.
[6]Metal Bulletin (London). No. 6787, May 13, 1983, p. 15.
[7]———. No. 6823, Sept. 23, 1983, p. 15.
[8]———. No. 6828, Oct. 11, 1983, p. 23.
[9]———. No. 6831, Oct. 21, 1983, p. 15.
[10]American Metal Market. V. 91, No. 94, May 13, 1983, p. 16.
[11]European Chemical News. V. 41, No. 1105, Oct. 31, 1983, p. 19.
[12]———. V. 40, No. 1068, Feb. 7, 1983, p. 30.
[13]Industrial Minerals (London). No. 190, July 1983, p. 18.
[14]Iron and Steel Engineer. V. 60, No. 12, Dec. 1983, p. 79.
[15]Metal Bulletin Monthly. No. 155, Nov. 1983, p. 21.
[16]Metal Bulletin (London). No. 6816, Sept. 13, 1983, p. 17.
[17]———. No. 6778, Apr. 12, 1983, p. 17.
[18]American Metal Market. V. 91, No. 152, Aug. 5, 1983, p. 6.
[19]Japan Metal Journal. V. 14, No. 11, Mar. 12, 1984, p. 5.
[20]Metal Bulletin (London). No. 6781, Apr. 22, 1983, p. 15.
[21]———. No. 6798, June 24, 1983, p. 15.
[22]———. No. 6774, Mar. 25, 1983, p. 13.
[23]———. No. 6820, Sept. 13, 1983, p. 19.
[24]———. No. 6826, Oct. 4, 1983, p. 15.
[25]———. No. 6826, Oct. 4, 1983, p. 13.
[26]———. No. 6821, Sept. 16, 1983, p. 15.
[27]———. No. 6792, June 3, 1983, p. 15.
[28]Work cited in footnote 26.
[29]Metal Bulletin (London). No. 6833, Oct. 28, 1983, p. 18.
[30]High Technology. V. 3, No. 12, Dec. 1983, pp. 68-73. Fortune. V. 108, No. 2, July 25, 1983, pp. 76-79.
[31]Financial Times. No. 29, 161, Nov. 2, 1983, p. 12.
[32]American Metal Market. V. 91, No. 55, Mar. 21, 1983, p. 9.
[33]Foundry Management and Technology. V. 111, No. 2, Feb. 1983, p. 10.
[34]Industrial Minerals (London). V. 191, Aug. 1983, p. 10.
[35]Ceramic Bulletin. V. 62, No. 9, 1983, pp. 948-949.
[36]Iron Age. V. 226, No. 29, Dec. 5, 1983, p. 58.
[37]American Metal Market. V. 91, No. 1, Jan. 3, 1983, p. 21.
[38]Industrial Minerals (London). No. 184, Jan. 1983, p. 20.
[39]American Metal Market. V. 91, No. 70, Apr. 11, 1983, p. 9.
[40]———. V. 91, No. 217, Nov. 11, 1983, p. 27.
[41]———. V. 91, No. 240, Dec. 12, 1983, p. 1.
[42]Electric Power Research Institute Journal. V. 8, No. 6, July-Aug. 1983, pp. 6-15.
[43]Chemical Engineering News. V. 61, No. 7, Feb. 14, 1983, p. 32.
[44]Chemical Week. V. 132, No. 15, Apr. 13, 1983, p. 32.
[45]The Washington Post. No. 286, Sept. 17, 1983, p. D9.
[46]Chemical Week. V. 133, No. 11, Sept. 14, 1983, p. 43.
[47]———. V. 133, No. 3, July 20, 1983, p. 12.

Silver

By Robert G. Reese, Jr.[1]

In 1983, as in the past several years, the silver price was dominated more by investor interest in the metal than by industrial demand. The generally higher daily prices in 1983 encouraged exploration not only in the United States but in other countries such as Australia and Canada. Capacity expansions were completed at a number of mines, and some new operations began commercial production during the year. Higher prices and an improved economic outlook encouraged companies to reopen some facilities closed during the 1982 recession. Although 1983 was more encouraging than 1982 for silver producers, industrial silver consumers used less silver than in 1982. The lower industrial silver consumption was due in part to the higher silver price and to a lower-than-expected demand for some manufactured goods.

Domestic Data Coverage.—Domestic mine production data for silver were developed by the Bureau of Mines from four separate, voluntary surveys of U.S. operations. Typical of these surveys was the lode-mine production survey of gold, silver, copper, lead, and zinc mines. Of the 162 lode silver operations to which a survey form

Table 1.—Salient silver statistics

	1979	1980	1981	1982	1983
United States:					
Mine production thousand troy ounces	37,896	32,329	40,683	r40,248	43,415
Value thousands	$420,261	$667,278	$427,922	r$319,975	$496,671
Percentage derived from:					
Precious metals ores	51	51	54	68	76
Base metal ores	49	49	46	32	24
Placers	(1)	(1)	(1)	(1)	(1)
Refinery production:					
Domestic and foreign ores and concentrates thousand troy ounces	50,761	39,353	47,007	44,170	50,450
Secondary (old scrap) do	39,729	53,131	39,067	27,171	25,549
Exports:					
Refined do	16,332	57,206	15,131	12,876	13,658
Other do	19,231	23,645	12,772	12,594	18,294
Imports for consumption:					
Refined do	78,372	64,859	75,921	96,917	161,199
Other do	14,009	13,936	18,194	20,541	18,692
Stocks, Dec. 31:					
Industry do	16,002	17,255	20,875	r20,467	17,673
Futures exchanges do	133,129	120,798	96,511	106,182	151,232
Consumption:					
Industry and the arts do	157,258	124,694	116,670	118,840	116,291
Coinage do	168	72	179	1,846	2,128
Price, average per troy ounce[2]	$11.09	$20.63	$10.52	$7.95	$11.44
Employment[3]	1,800	2,400	3,600	2,900	2,400
World:					
Mine production thousand troy ounces	r348,120	r344,026	361,781	p383,766	e390,618
Consumption:[4]					
Industry and the arts do	r434,200	r354,500	r336,800	r348,700	348,000
Coinage do	27,800	13,700	r9,000	r12,800	18,600

eEstimated. pPreliminary. rRevised.
[1]Less than 1/2 unit.
[2]Handy & Harman.
[3]Mine Safety and Health Administration.
[4]Market economy countries only. Source: Handy & Harman.

was sent, 56% responded, representing 98.7% of the total U.S. mine production figures shown in tables 1, 2, 3, 5, 6, and 7. Production for the remaining 71 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.—The U.S. Department of the Treasury continued sales of the silver coins commemorating the 1984 Summer Olympics scheduled to be held in Los Angeles, CA. Initially, the coins dated 1983 sold for $24.95 each; however, in late January 1983, the Bureau of the Mint raised the price to $29.00 because of rising gold and silver prices. In May, Maison Lazard et Compagnie of France was chosen by the Treasury Department as sole foreign marketing agent for the coins. Blanks for the coins were supplied by Handy & Harman and Engelhard Corp. The coin was struck at the Philadelphia, Denver, and San Francisco Mints.

DOMESTIC PRODUCTION

Silver production was reported at 168 mines including 16 placer operations. Silver was produced from precious metal ores at 120 mines while 29 mines produced silver as a byproduct of the processing of copper, lead, and zinc ores. The 25 largest mines accounted for 87% of total domestic mine output. Twelve mines each produced more than 1 million ounces[2] of silver, which when aggregated, equaled 71% of the total domestic production.

Generally higher precious metal prices, along with continued low base metal prices, resulted in increased exploration for and development of precious metals properties in the United States. Most reported exploration for silver and development of new properties occurred in the Western States, primarily Idaho and Nevada. The higher silver prices also prompted the upgrading of existing facilities and the reopening of some recently closed mines. Despite the reopening of several copper mines however, the production of byproduct silver from copper operations remained low.

Alaska.—Progress continued on the development of Noranda Mining Inc.'s Greens Creek Project. In late 1983, the U.S. Forest Service accepted the Environmental Impact Statement submitted by Noranda for the project. Development of the underground mine could proceed, with the restriction that workers be housed in Juneau, 18 miles from the site. The project, located primarily in the Admiralty Island National Monument area, contains zinc, lead, silver, and gold. Anaconda Minerals Co. purchased a 33.8% interest in the project from Martin Marietta Corp. during the year. Other partners in the Greens Creek Project besides Noranda and Anaconda were Exalas Resources Corp., Texas Gas Exploration Corp., and Bristol Resources Inc.

An informal survey of Alaskan silver producers by the Alaska State Division of Geological and Geophysical Surveys indicated that over 33,000 ounces of silver was produced in Alaska during the year compared with 4,123 ounces reported to the Bureau of Mines on a voluntary basis by producers.

Arizona.—Lower copper production resulted in lower byproduct silver production for the State. Despite the depressed state of the domestic copper industry, relatively high silver prices, industry forecasts of a near-term recovery in the copper industry, and other factors encouraged some companies to reopen copper mines during the year. ASARCO Incorporated resumed limited production at the Silver Bell Mine in late 1983 to provide additional feed to Asarco's Hayden, AZ, smelter where a new oxygen flash furnace had been installed. The Silver Bell Mine had been closed since December 1981. Kennecott reopened the Ray Mine, originally closed in May 1982. Southwest Resources Inc. reopened the State of Maine Mine, a silver-gold deposit that had been inactive for over 70 years. Initial production at the State of Maine Mine in 1983 was from gob stored underground and the reject material from prior hand sorting of high-grade ore. Continental Silver Corp. began production at its Review Mine. The ultimate production target for the mine was expected to be between 220 and 330 short tons of silver-gold ore per day.

Colorado.—The Sherman Mine, closed in January 1982 because of low silver prices and limited reserves, was reactivated in January 1983 by Hecla Mining Co. Initial activities involved exploration, development, and assessment work. The mine returned to production in June, producing over 210,000 ounces of silver during the remainder of the year.[3] Homestake Mining Co. reported lower production costs at its Bulldog Mine, owing in part to the replacement of some slusher systems by load-haul-dump machines. Production at the Bulldog Mine was nearly 1.3 million ounces.[4] The Resurrection Mine, a joint venture of Asarco and Resurrection Mining Co., reported silver production of 369,000 ounces.[5]

Idaho.—The Crescent Mine, one of the assets of The Bunker Hill Corp. sold to Bunker Limited Partnership in late 1982, was reopened in late 1983. Ore from the mine was to be milled on the Crescent circuit at the Bunker Hill mill in early 1984. The first shipment of ore from the mine was received at the mill in mid-December 1983. Employment at the mine was expected to be between 70 and 80 nonunion workers.

The Clayton Mine reopened in December 1982 after being closed for several months because of low silver prices. Operations were suspended after an October 28, 1983, earthquake, which registered 6.9 on the Richter scale, struck the area, causing flooding in the lower levels of the mine through increased ground water flow. No structural damage was reported at the mine. Prior to the earthquake, Clayton Mine production reportedly had been at record-high levels. The mine remained closed through yearend while a new pumping system with increased capacity was installed. Estimated silver production was reported to be 177,500 ounces.

The Lucky Friday Mine was the largest U.S. silver producer during the year, with a reported output of nearly 5.1 million ounces. The new Silver shaft at the mine reached 6,205 feet and was dedicated in mid-August. The first ore was hoisted through the shaft in October. Hecla, owner and operator of the Lucky Friday Mine, expects that the shaft will allow continued high production from the mine and increased exploration of company holdings.

The Sunshine Mine returned to full capacity operation in February 1983 after being closed from June through December 1982 because of low silver prices. Silver production at the Sunshine Mine was nearly 4.5 million ounces.[6] The No. 12 shaft at the mine was completed to its planned depth, and horizontal development work proceeded. A number of mineralized intercepts were encountered, and a connection between the No. 12 shaft and No. 10 shaft was completed. The existing labor contract at the mine, scheduled to expire in April 1984, was extended for 3 years.

The Sunshine Mining Co. decided to expand the capabilities of its silver refinery in Idaho. The existing facilities were limited to processing doré from Sunshine Mining's Sixteen-to-One Mine in Nevada. In December 1983, a contract was let to Weyher/Livsey Constructors to expand the facilities at the refinery so that concentrates from the Sunshine Mine could also be treated. During the year, Sunshine Mining produced over 947,000 ounces of silver bullion from Sixteen-to-One doré and from custom smelting for outside sources.

Development work at the Consolidated Silver Venture proceeded with the completion of shaft development to a depth of 5,524 feet. Exploration and horizontal development work continued, but there was no commercial production recorded from the mine. Asarco reported that 2.6 million ounces and 3.8 million ounces of silver were produced at the Coeur and Galena Mines, respectively.

Montana.—Asarco and U.S. Borax Corp. continued exploration of their claims in the Cabinet Mountains Wilderness area. Both companies reported that the area had the potential to contain a deposit larger than the deposit currently being mined at the Troy Mine. Production began in Placer Development Ltd.'s Golden Sunlight Mine in early 1983. At the end of June, The Anaconda Company suspended operations at its East Berkeley Pit, reportedly because of low copper and molybdenum prices. Reported silver production at selected mines was Black Pine Mine, 1.2 million ounces; Troy Mine, 4.0 million ounces; and the Zortman Mine, 67,000 ounces.

Nevada.—The Candelaria Mine, reopened in December 1982 after being closed because of low silver prices, returned to full production in July 1983. In early 1983, NERCO Minerals Co. acquired the outstanding stock of Occidental Minerals Corp., thereby obtaining a controlling interest in the Candelaria Mine. NERCO Minerals purchased the remaining 8% interest in the mine and became the sole owner in early November. Silver King Mines Inc. began driving two 12- by 12-foot decline tunnels to develop its Ward Mountain property. At the Battle Mountain Mine, Duval Corp. began expanding mill capacity in order to handle ore from the nearby Fortitude deposit. Pacific Silver Corp. began construction of a 300-ton-per-day mill at its Buckskin property, and Belmont Resources Inc. began leaching ore at its Silver Center Mine. Sunshine Mining reported that over 902,000 ounces of silver was produced from ore mined at the Sixteen-to-One Mine.

Utah.—Sunshine Mining expanded its holdings in the Tintic mining district by acquiring HMC Mining Inc. in early June. The acquisition increased Sunshine Mining's holdings in the area from 1,387 acres to 12,751 acres. Earlier in the year, HMC purchased Kennecott's Tintic Div. with the backing of Sunshine Mining. Sunshine Mining began exploration activities at the Trixie Mine, one of the properties in the HMC acquisition. In December, Sunshine Mining entered into a contract to supply Kennecott's Garfield copper smelter with flux ore from the Trixie Mine. Initial ore shipments were made in late December. In other activity in the Tintic District, Sunshine Mining began deepening the Apex No. 2 shaft in late 1983, preparatory to conducting further exploration work on the ore reserves at the Burgin Mine.

Ranchers Exploration & Development Corp., which operated the Escalante Mine under a lease agreement, acquired ownership of the mine by a stock exchange with Escalante Silver Mines Co. Inc. in late 1983.

Other States.—Asarco decided to proceed with underground development at its West Fork Mine, located in Missouri, in October. The mine had been placed on a standby status after the mill and other surface facilities were completed in June because of conditions in the lead market. A new 400-ton-per-day flotation mill installed by Goldfield Corp. at its St. Cloud Mine, in New Mexico, began operation in September. In May, Phelps Dodge Corp. reopened the Tyrone Mine in New Mexico. Madre Mining Ltd. began commercial production at its Deer Trail Mine, in Washington, in late 1983. Hecla announced that its Knob Hill, WA, operations would probably be closed in early 1984 because of declining reserves.

CONSUMPTION AND USES

U.S. industrial consumption of silver declined because higher prices and rumors of a supply shortage encouraged silver conservation by some manufacturers. Some conservation methods included substitution or a reduction in the quantity of silver per unit. Another factor in the lower silver consumption data was a lower-than-expected demand for some electronic products, such as personal computers. End-use categories that showed an increase in silver consumption were those that provided the consumer with a "perceived store of value."

STOCKS

Refiner, fabricator, and dealer stocks declined during the first half of 1983 to 14.4 million ounces from 20.5 million ounces at yearend 1982. During the second half of 1983, industrial stocks increased to 17.7 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) increased to 106.4 million ounces by the end of February from 90.7 million ounces at yearend 1982. COMEX stocks then declined to 89.9 million ounces at the end of May before rising to over 130 million ounces in November. COMEX stocks declined slightly by yearend 1983, but remained much higher than at yearend 1982. The depository stocks held by the Chicago Board of Trade (CBT) remained at nearly the same level as at yearend 1982 during the early months of 1983. In May, CBT stocks increased 3.4 million ounces to 19 million ounces and remained near this level through September. CBT stocks rose to over 25 million ounces in November before declining slightly in December. As with the COMEX stocks, the silver depository stocks on the CBT were much higher at yearend than they had been a year earlier.

The National Defense Stockpile contained 137.5 million ounces of silver at yearend. All of the silver remained classified as excess to U.S. defense needs.

PRICES

Analysts attributed price increases early in the year to investor concerns about the potential impact on international banking of a default by one or more of the lesser developed countries with a large foreign debt. Other factors that contributed to a rising price were optimistic economic forecasts, which resulted in increased inflationary expectations, and declining U.S. interest rates, which reduced the cost of holding precious metals. Declining oil prices in February were believed to have caused the rapid decline in the silver price because of the disinflationary implications of cheaper oil and the potential impact on oil-producing nations. A subsequent agreement among Organization of Petroleum Exporting Countries' members concerning oil prices and production allocations, along with declining U.S. interest rates, were believed to have been factors in silver price increases during April and May. Analysts attributed the decline in the silver price during June to selling, owing to the belief by some investors that U.S. interest rates had stopped falling, thereby making investments such as certificates of deposit, or bonds, with a specific financial return and no storage costs, more attractive.

During the July-September period, the silver price remained stable, with price movements resulting from investor reactions to information on the U.S. money supply and changes in U.S. interest rates. The price decline that began in October was attributed by various analysts to flat industrial demand, increasing stocks of silver on the commodity exchanges, and a reduction in inflationary expectations because of a slowing in U.S. money supply growth. A strong U.S. dollar in relation to other currencies, the weak industrial demand, and declining fears of an international banking crisis were among the factors affecting the falling silver price near yearend.

Prices on the London Metal Exchange (LME) followed the same pattern as in the United States. The price increased from $11.06 per ounce at the beginning of January to $14.67 per ounce in the middle of February, then declined to $10.24 per ounce before rising to over $13.00 per ounce by the middle of May. In June, the price declined and remained in the $11.00-to-$12.00-per-ounce range through September. The price declined again in October, falling to less than $9.00 per ounce. The LME daily high and low prices for the year were $14.67 on February 15 and $8.37 on November 1, respectively. The average for the year was $11.45 per ounce.

The silver trading volume on COMEX was 32.2 billion ounces, more than double the 14.2 billion ounces traded in 1982. The trading volume at the CBT also more than doubled in 1983 with 2.8 billion ounces being traded compared with 1.2 billion ounces in 1982.

FOREIGN TRADE

Increased trading of silver on the futures exchanges and an increase in the supply of material to be refined were probably the main factors in the higher U.S. silver exports for the year.

Imports for consumption from the United Kingdom were over 500% higher than in 1982, probably because of the increased silver trading on the commodity exchanges, although local British laws may also have been a factor in the increased exports. The quantity of silver imported from Canada, Mexico, and Peru remained near past levels. Imports from Canada declined by 1.5 million ounces, while imports from Mexico and Peru increased by nearly 4.0 million ounces and 5.6 million ounces, respectively.

Most of the refined bullion entered the United States during the first 9 months of the year, when bullion imports averaged nearly 16 million ounces per month. August was the peak month for this period, with over 27.3 million ounces of refined bullion entering the United States. During the fourth quarter, refined bullion imports dropped significantly, averaging 5.8 million ounces per month.

Imports for consumption of ore and concentrates increased primarily because of increased imports from Peru. Lower shipments from Brazil accounted for most of the decrease in waste and sweepings imports, while the elimination of doré and precipitates imports from the Netherlands, along with lower doré and precipitates imports from Peru, accounted for most of the decrease in this category.

The United States was a net importer of silver. Net import reliance calculated as a percent of apparent consumption was approximately 61%.

WORLD REVIEW

The increase in world mine production of silver was due in part to the relative strength of the silver price compared with the prices for most other metals, to the need by many developing countries to earn foreign exchange for debt repayment, and to initial production and capacity expansions at various mines. Following a significant increase in mine production, Mexico regained the distinction of being the world's largest silver-producing nation.

Reported estimates of the total consumption of silver by market economy countries, excluding the United States, totaled 235.4 million ounces, a decrease of nearly 5 million ounces from the revised figures for 1982.[7] Of the 235.4 million ounces consumed, 228 million ounces was used in industrial applications, a decrease of nearly 2 million ounces from the 1982 level. The remaining 7.4 million ounces was used for coinage, a decrease of 3 million ounces from the 1982 figure.

Total consumption by all market economy countries, including the United States, exceeded their primary production by 58.6 million ounces in 1983 according to Handy & Harman estimates. The shortfall was met with silver obtained from the following sources: old scrap, 88.5 million ounces; outflow from Indian stocks, 46.8 million ounces; demonetized coins, 8 million ounces; and withdrawals from U.S. and foreign government stocks, 14.8 million ounces, which was offset by increases in privately held bullion stocks of 99.5 million ounces.

Australia.—The Electrolytic Zinc Co. of Australasia Ltd. began commercial production at its Elura Mine in New South Wales. Reserves at the mine were estimated at nearly 30 million tons of ore containing 8.3% zinc, 5.6% lead, and 4.5 ounces of silver. Design capacity of the mine was 1.1 million tons of ore per year.

MIM Holdings Ltd., 44% owned by Asarco, produced 15,956,000 ounces of silver in fiscal year 1983 compared with 14,913,000 ounces in fiscal year 1982 and 11,768,000 ounces in fiscal year 1981. The production for fiscal year 1983 represented the first full year of production following a 20% capacity expansion at the Mount Isa Mine. Development work was continued at the Hilton Mine, a potential future ore source for the Mount Isa operation. Silver production at Phelps Dodge's Woodlawn Mine declined by 327,000 ounces to 1,035,000 ounces in 1983.[8]

Canada.—Falconbridge Ltd. reopened its Corbet Mine during the second quarter of the year. The copper-zinc-silver-gold mine had been closed in June 1982 because of low metal prices. Asarco reopened the Buchans Mine, which had been closed since December 1981 because of depleted reserves, in June 1983. Mining was resumed to recover the remaining reserves on the lower levels of the mine and to process some stockpiled ore. In 1983, 54,000 ounces of silver was produced from 42,000 tons of ore at the Buchans Mine. Production was also resumed at United Keno Hill Mines Ltd.'s Elsa and Husky Mines in the Yukon Territory during the third quarter. Cominco Ltd.'s Pine Point Mine, closed in January, was reopened at midyear after the company obtained concessions from labor, Federal and Provincial governments, utilities, and others.

Heath Steele Mines Ltd., a subsidiary of Noranda Mines Ltd., closed its Little River copper-zinc-lead-silver-gold mine during the second quarter, reportedly because of low base metal prices. Although the mine remained closed for the remainder of the year, the closure was regarded as temporary pending a recovery in zinc, lead, and copper prices. Dickenson Mines Ltd. temporarily closed its Silvana Mine in British Columbia in mid-December. Among the reasons given for the closure were declining silver prices and declining ore reserves. The Baker Mine in British Columbia was closed by Du Pont Canada Inc. because of depleted ore reserves. During its 3-year life, the Baker Mine produced 36,000 ounces of gold and 700,000 ounces of silver.

Echo Bay Mines Ltd. planned to increase milling capacity at the Lupin Mine in the Northwest Territory to 1,200 tons per day. With the higher capacity, silver and gold production was expected to increase by 20% to 15,000 ounces and 140,000 ounces, respectively. Westmin Resources Ltd. approved plans to develop the H-W Mine and construct a new 3,000-ton-per-day mill on Vancouver Island. The mill would replace an existing 1,000-ton-per-day mill and be fed by ore from the H-W and two other Westmin mines. Terra Mining and Exploration Ltd. nearly doubled the capacity of its Silver Bear mill in late 1983 from 225 tons per day to 420 tons per day.

Noranda reported that mines in which it had an interest produced 11,891,000 ounces of silver, down slightly from the 12,061,000 ounces produced in 1982.[9] Refinery production of silver at Noranda Mines' CCR refinery increased to 22,446,000 ounces in 1983 from 14,226,000 ounces in 1982 when the refinery had been closed for 4 months by a strike.

Mexico.—Minerales Metálicos del Norte S.A., a subsidiary of Industria Minera México S.A., doubled the mill capacity of its Santa Bárbara unit to 4,800 tons per day. In order to meet the increased milling capacity, the San Diego, Segovedad, and Tecolotes-Hidalgo mining complexes underwent some development and mechanization, including shaft construction and rehabilitation and the introduction of load-haul-dump equipment and hydraulic drilling jumbos.

The Real de Ángeles Mine, opened in mid-1982, operated at above the mill's design capacity in 1983. An average of 11,000 tons per day of ore was treated, resulting in the production of 7,761,000 ounces of silver. The Real de Ángeles Mine was Mexico's largest silver mine in 1983.

México Desarrollo Industrial Minera S.A. (MEDIMSA) reported silver production as 17,116,000 ounces, an increase of 1 million ounces over that of 1982. MEDIMSA attributed the increase to recent facility expansions. Lacana Mining Corp. reported that its 30%-owned Torres mining complex, in Guanajuato, produced 4.1 million ounces of silver in 1983 and that its 40%-owned Encantada Mining Group, in Coahuila, produced over 1.8 million ounces of silver during the year.[10]

Peru.—Several projects were undertaken during 1983 as the country continued to develop its mining sector. Cía. de Minas Buenaventura S.A., the second-largest silver producer in 1982, received a $4 million loan from the International Finance Corp., a unit of the International Bank for Reconstruction and Development (World Bank), to cover part of the cost of modernizing and expanding facilities at its mines. The proposed project was expected to cost $22.1 million and to increase Buenaventura's annual silver production by 2.7 million ounces. Empresa Minera del Centro del Perú was expanding the mill capacity at its Casapalca operation by 2,500 tons per day to 5,500 tons per day.

The Peruvian central bank sold slightly more than 9 million ounces of its silver reserves between June and September. The sales reportedly were made to help the Government of Peru meet the currency targets established by the International Monetary Fund.

Southern Peru Copper Corp. reported silver production of 2,062,000 ounces, a decrease of nearly 200,000 ounces from that of 1982. The company's Toquepala and Cuajone Mines were closed several times during 1983 by striking workers.

Other Countries.—A new Government-owned refinery began operation in the Dominican Republic during the first quarter of 1983. The refinery could process 75 tons of doré per year and was capable of producing bullion to LME specifications. The Pueblo Viejo Mine was expected to provide the refinery with doré for at least the next 5 years.

In India, Hindustan Zinc Ltd. opened two new byproduct silver mines in 1983. The Rajpura-Dariba Mine in Rajasthan State had an annual capacity of 900,000 tons of ore per year, while the Sargipalli Mine in Orissa State was capable of processing 500 tons of ore per day.

Handy & Harman, with 50% partner King Fook Investment S.A., completed construction of a secondary precious metals refinery in Singapore in early 1983. The refinery was designed to process all types of electronic, industrial, or jewelry scrap and was expected to be capable of processing 4 million pounds of scrap annually.

TECHNOLOGY

The Bureau of Mines continued to investigate the recovery of precious metals from scrap material. The Bureau issued a report on the concentration and distribution of precious metals in mechanically processed obsolete military electronic scrap.[11] The mechanical processing consisted of shredding, air classification, wire picking, magnetic separation, and sizing of the material, followed by magnetic precleaning and eddy-current and high-tension separations. The study found that most of the precious metals were concentrated in the wire bundles and products collected by the high-tension separator and the baghouses, connected to the hammer mill and air classifier.

The Bureau of Mines also investigated hydrometallurgical procedures for removing base metals from the mechanically processed electronic scrap.[12] Aluminum was extracted from a nonmagnetic metallic concentrate produced by high-tension separation in the first-stage sodium hydroxide leach. Organic matter was then removed by incineration. A portion of the soluble nickel present in the processed scrap was extracted in the second-stage dilute sulfuric acid leach. Copper and the remainder of the soluble nickel were extracted in a third-stage concentrated sulfuric acid leach; copper was recovered from the spent leachate by cementation with an iron-base magnetic fraction. The third-stage leach residue and leachate contained essentially all of the precious metals values.

The Bureau of Mines conducted preliminary hydrometallurgical investigations on two massive sulfide samples from the Southern Juan de Fuca Ridge, North Pacific Ocean.[13] Chlorine-oxygen leaching of the samples was chosen as the procedure to be used because of the high zinc content of one sample. The bench-scale testing found that chlorine-oxygen leaching extracted more than 99% of the zinc and cadmium, 97% of the silver, and 78% of the copper.

Numerous other reports on silver-related research were summarized by the staff of the Silver Institute in its "New Silver Technology" publication, issued in January, April, July, and October 1983.[14]

[1]Physical scientist, Division of Nonferrous Metals.
[2]Ounce as used throughout this chapter refers to the troy ounce.
[3]Hecla Mining Co. 1983 Annual Report. 32 pp.
[4]Homestake Mining Co. 1983 Annual Report. 28 pp.
[5]ASARCO Incorporated. 1983 Annual Report. 36 pp.
[6]Sunshine Mining Co. 1983 Annual Report. 24 pp.
[7]Handy & Harman. The Silver Market, 1983. 68th Annual Report. 28 pp.
[8]Phelps Dodge Corp. 1983 Annual Report. 36 pp.
[9]Noranda Mines Ltd. 1983 Annual Report. 48 pp.
[10]Lacana Mining Corp. 1983 Annual Report. 22 pp.
[11]Dunning, B. W., Jr., F. Ambrose, and H. V. Makar. Distribution and Analyses of Gold and Silver in Mechanically Processed Mixed Electronic Scrap. BuMines RI 8788, 1983, 17 pp.
[12]Hilliard, H. E., B. W. Dunning, Jr., and H. V. Makar. Hydrometallurgical Treatment of Electronic Scrap Concentrates Containing Precious Metals. BuMines RI 8757, 1983, 15 pp.
[13]Sawyer, D. L., Jr., G. A. Smyres, J. J. Sjoberg, and T. G. Carnahan. Cl_2-O_2 Leaching of Massive Sulfide Samples From the Southern Juan de Fuca Ridge, North Pacific Ocean. BuMines TPR 122, 1983, 8 pp.
[14]Silver Institute. New Silver Technology. Jan.-June-July-Oct. 1983; available from the Silver Institute, 1001 Connecticut Ave., NW., Washington, DC 20036.

Table 2.—Mine production of recoverable silver in the United States, by State

(Troy ounces)

State	1979	1980	1981	1982	1983
Alaska	W	8,354	2,372	2,080	4,123
Arizona	7,478,942	6,267,588	8,055,231	r6,309,327	4,491,532
California	64,185	49,257	53,286	34,048	26,899
Colorado	2,808,934	2,987,058	3,008,994	1,934,312	2,145,616
Idaho	17,144,209	13,694,902	16,545,648	14,830,351	17,684,278
Illinois	W	W	W	W	W
Michigan	W	W	W	W	--
Missouri	2,201,112	2,357,236	1,837,011	2,241,159	2,021,343
Montana	3,301,928	2,023,893	2,988,810	6,168,711	5,707,963
Nevada	560,435	939,997	3,039,480	3,142,263	5,163,724
New Mexico	W	W	1,632,346	804,594	W
New York	10,538	20,702	28,829	r27,212	33,137
Oregon	1,572	841	7,487	--	856
South Carolina	--	--	W	--	--
South Dakota	57,973	51,257	55,792	26,241	62,314
Tennessee	W	W	W	W	W
Utah	2,454,136	2,203,289	2,882,671	4,342,333	4,566,610
Washington	W	W	67,390	W	W
Total	37,895,524	32,329,373	40,683,173	r40,248,409	43,415,267

rRevised. W Withheld to avoid disclosing company proprietary data; included in "Total."

Table 3.—Mine production of recoverable silver in the United States, by month

(Thousand troy ounces)

Month	1979	1980	1981	1982	1983
January	3,252	3,271	3,062	[r]3,643	3,198
February	3,055	3,365	3,404	[r]3,283	3,148
March	3,310	3,280	3,408	[r]4,039	3,873
April	3,228	3,335	3,314	[r]3,733	3,778
May	3,341	3,006	3,151	[r]3,713	3,772
June	3,240	3,163	3,315	[r]3,568	3,864
July	3,198	1,993	3,577	[r]3,090	3,685
August	3,482	1,741	3,408	2,987	3,852
September	2,897	1,776	3,503	3,014	3,659
October	3,057	2,074	3,795	2,889	3,505
November	2,888	2,144	3,354	[r]3,241	3,511
December	2,948	3,181	3,392	[r]3,048	3,570
Total	37,896	32,329	40,683	[r]40,248	43,415

[r]Revised.

Table 4.—Twenty-five leading silver-producing mines in the United States in 1983, in order of output

Rank	Mine	County and State	Operator	Source of silver
1	Lucky Friday	Shoshone, ID	Hecla Mining Co	Silver ore.
2	Sunshine	do	Sunshine Mining Co	Do.
3	Troy	Lincoln, MT	ASARCO Incorporated	Do.
4	Galena	Shoshone, ID	do	Do.
5	Coeur	do	do	Do.
6	Escalante	Iron, UT	Ranchers Exploration & Development Corp.	Do.
7	Utah Copper (Bingham).	Salt Lake, UT	Kennecott	Copper ore.
8	Candelaria	Mineral, NV	NERCO Metals Inc	Silver ore.
9	DeLamar	Owyhee, ID	MAPCO Minerals Corp	Gold-silver ore.
10	Bulldog	Mineral, CO	Homestake Mining Co	Silver ore.
11	Taylor	White Pine, NV	Silver King Mines Inc	Do.
12	Black Pine	Granite, MT	Black Pine Mining Co	Do.
13	Sixteen-to-One	Esmeralda, NV	Sunshine Mining Co	Do.
14	Buick	Iron, MO	AMAX Lead Co. of Missouri	Lead ore.
15	Morenci	Greenlee, AZ	Phelps Dodge Corp	Copper ore.
16	Tyrone	Grant, NM	do	Do.
17	Eisenhower	Pima, AZ	Eisenhower Mining Co	Do.
18	Sierrita	do	Duval Corp	Do.
19	St. Cloud	Sierra, NM	St. Cloud Mining Co	Silver ore.
20	Bagdad	Yavapai, AZ	Cyprus Bagdad Copper Co	Copper ore.
21	Miller's Operation	Esmeralda, NV	TW-MNR Associates	Silver tailings.
22	San Manuel	Pinal, AZ	Magma Copper Co	Copper ore.
23	Mission	Pima, AZ	ASARCO Incorporated	Do.
24	Magmont	Iron, MO	Cominco American Incorporated	Lead ore.
25	Leadville Unit	Lake, CO	ASARCO Incorporated	Lead-zinc 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		Lode: Gold-silver ore		Lode: Silver ore	
		Short tons	Troy ounces of silver	Short tons	Troy ounces of silver	Short tons	Troy ounces of silver
1979	431	4,201,963	677,819	756,221	2,152,845	1,065,591	16,766,967
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:							
Alaska	W	--	--	--	--	W	W
Arizona	--	50,000	7,000	W	W	W	W
California	W	W	W	846	1,686	1,000	1,070
Colorado	25	W	W	3,189	1,663	W	W
Idaho	--	W	W	W	W	865,536	16,221,322
Illinois	--	--	--	--	--	--	--
Missouri	--	--	--	--	--	--	--
Montana	--	5,824,421	196,859	7,872	22,706	3,393,860	5,173,136
Nevada	W	8,647,716	442,852	W	W	2,644,301	4,045,332
New Mexico	--	W	W	W	W	W	W
New York	--	--	--	--	--	--	--
Oregon	--	3,400	55	--	--	14	801
South Dakota	--	1,772,711	62,314	--	--	--	--
Tennessee	--	--	--	--	--	--	--
Utah	--	692,262	1,202	W	W	285,160	2,358,975
Washington	--	W	W	--	--	--	--
Total	4,035	18,329,722	1,146,835	1,129,756	1,794,753	7,488,153	30,063,899
Percent of total silver	(1)	XX	3	XX	4	XX	69

Year and State	Lode: Copper ore		Lode: Lead ore		Lode: Zinc ore	
	Short tons	Troy ounces of silver	Short tons	Troy ounces of silver	Short tons	Troy ounces of silver
1979	267,313,440	13,877,531	9,122,812	2,278,603	672,292	12,984
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	r9,420,220	9,407,482	2,244,737	r713,228	r27,212
1983:						
Alaska	--	--	--	--	--	--
Arizona	120,765,406	4,131,928	--	--	--	--
California	--	--	--	--	--	--
Colorado	--	--	--	--	--	--
Idaho	--	--	1	3	--	--
Illinois	--	--	--	--	--	--
Missouri	--	--	8,050,250	2,021,343	--	--
Montana	6,926,315	313,093	--	--	--	--
Nevada	--	--	--	--	--	--
New Mexico	W	W	--	--	--	--
New York	--	--	--	--	753,044	33,137
Oregon	--	--	--	--	--	--
South Dakota	--	--	--	--	--	--
Tennessee	--	--	--	--	--	--
Utah	W	W	--	--	--	--
Washington	--	--	--	--	--	--
Total	[2]171,614,767	[2]7,344,180	8,050,251	2,021,346	753,044	33,137
Percent of total silver	XX	17	XX	5	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

State	Lode: Copper-lead, lead-zinc, copper-zinc, and copper-lead-zinc ores		Lode: Old tailings, etc.		Total	
	Short tons	Troy ounces of silver	Short tons	Troy ounces of silver	Short tons	Troy ounces of silver
1979	3,103,669	2,055,561	42,493	[3]72,783	286,278,481	37,895,524
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	[r]223,115,992	[r]40,248,409
1983:						
Alaska	--	--	W	W	85	4,123
Arizona	--	--	75,513	80,717	121,034,532	4,491,532
California	--	--	--	W	343,961	26,899
Colorado	(5)	(5)	--	--	691,592	2,145,616
Idaho	--	--	--	--	2,279,641	17,684,278
Illinois	--	--	--	W	--	W
Missouri	--	--	--	--	8,050,250	2,021,343
Montana	--	--	124,181	2,169	16,276,649	5,707,963
Nevada	--	--	W	W	11,920,159	5,163,724
New Mexico	--	--	--	--	W	W
New York	--	--	--	--	753,044	33,137
Oregon	--	--	--	--	3,414	856
South Dakota	--	--	--	--	1,772,711	62,314
Tennessee	(5)	(5)	--	--	W	W
Utah	--	--	W	W	34,311,006	4,566,610
Washington	--	--	--	--	W	W
Total	(5)	(5)	[6]856,550	[3 7]1,007,082	208,222,243	43,415,267
Percent of total silver	XX	(5)	XX	2	XX	100

[r]Revised. W Withheld to avoid disclosing company proprietary data; included in "Total." XX Not applicable.
[1]Less than 1/2 unit.
[2]Includes copper-zinc ore and silver recovered from copper-zinc ore in Tennessee to avoid disclosing company proprietary data.
[3]Includes silver recovered from tungsten ore in California and silver recovered from fluorspar ore in Illinois.
[4]Includes silver recovered from molybdenum ore in Nevada.
[5]In order to avoid disclosing company proprietary data, copper-zinc ore and silver recovered from copper-zinc ore in Tennessee are included in totals for copper ore; and lead-zinc ore and silver recovered from lead-zinc ore in Colorado are included in total "Old tailings, etc."
[6]Includes lead-zinc ore in Colorado to avoid disclosing company proprietary data.
[7]Includes silver recovered from lead-zinc ore 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 cyanide leaching[1]

Year	Leaching in vats, tanks, and closed containers[2]: Ore treated (thousand short tons)	Leaching in vats, tanks, and closed containers[2]: Silver recovered (troy ounces)	Leaching in open heaps or dumps[3]: Ore treated (thousand short tons)	Leaching in open heaps or dumps[3]: Silver recovered (troy ounces)
1979	3,215,250	1,939,500	1,615,027	435,267
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	7,568,419	5,893,320	12,687,440	2,185,551

[1]May include small quantities recovered by leaching with thiourea, by bioextraction, and by proprietary processes.
[2]Including autoclaves.
[3]May include tailings and waste ore dumps.

Table 7.—Lode silver produced in the United States, by State

Year and State	Amalgamation		Cyanidation		Smelting of concentrates			Smelting of ore		Total ore processed[1] (short tons)	Total silver recovered (troy ounces)
	Ore treated (short tons)	Silver recovered (troy ounces)	Ore treated (short tons)	Silver recovered (troy ounces)	Ore concentrated (short tons)	Concentrates smelted (short tons)	Silver recovered (troy ounces)	Ore smelted (short tons)	Silver recovered (troy ounces)		
1979	7,676	170	7,674,000	2,374,767	289,134,928	r6,215,371	34,184,240	[2]643,408	1,335,916	297,460,012	37,895,093
1980	127,394	1,502	11,778,620	2,637,809	245,732,676	r6,050,679	28,643,779	[2]566,204	1,045,816	258,204,894	32,328,906
1981	186,790	6	15,899,228	4,627,666	307,536,429	r7,157,354	34,815,156	[2]486,916	1,238,506	324,109,363	40,681,334
1982	236,000	--	19,910,268	6,097,552	212,482,136	r5,256,363	r33,467,476	[2]353,088	681,369	232,981,492	r40,246,397
1983:											
Alaska	--	--	--	--	--	--	--	85	W	85	W
Arizona	--	--	50,000	7,000	128,234,846	2,251,830	4,133,840	149,777	350,692	128,434,623	4,491,532
California	W	W	W	W	W	W	W	W	W	W	W
Colorado	W	W	W	W	W	W	W	W	W	1,121,336	2,145,591
Idaho	--	--	W	W	W	W	W	123	5,041	2,319,641	17,684,278
Illinois	--	--	--	--	--	W	W	--	--	--	W
Missouri	--	--	--	--	8,050,250	743,175	2,021,343	--	--	8,050,250	2,021,343
Montana	--	--	5,807,045	192,114	10,463,178	120,214	5,475,565	6,426	40,284	16,276,649	5,707,963
Nevada	--	--	14,947,960	3,970,436	404,290	5,196	1,193,025	12	[3]263	15,352,262	[3]5,163,724
New Mexico	--	--	W	W	W	W	W	W	W	W	W
New York	--	--	--	--	753,044	115,186	33,137	--	--	753,044	33,137
Oregon	W	W	--	--	W	W	W	W	W	3,414	856
South Dakota	--	--	1,952,023	62,314	--	--	--	--	--	1,952,023	62,314
Tennessee	--	--	--	--	W	W	W	--	--	W	W
Utah	--	--	977,405	2,353,964	33,310,215	694,908	2,162,283	23,386	50,363	34,311,066	4,566,610
Washington	--	--	--	--	W	W	W	--	--	W	W
Total	137,200	50	27,211,504	8,078,821	208,320,405	4,939,057	34,503,489	284,196	[3]829,030	235,953,305	43,411,390

rRevised. W Withheld to avoid disclosing company proprietary data; included in "Total."

[1]Includes old tailings and some nonsilver-bearing ores not separable, in amounts ranging from 0.04% to 0.12% of the totals for the years listed. Excludes fluorspar, molybdenum, and tungsten ores from which silver was recovered as a byproduct and ores leached for recovery of copper.

[2]Revised to exclude copper precipitates smelted.

[3]Includes some placer production to avoid disclosing company proprietary data.

Table 8.—U.S. refinery production of silver, by raw material

(Thousand troy ounces)

Raw material	1979	1980	1981	1982	1983
Concentrates and ores:					
Domestic	38,982	36,171	44,487	43,825	50,281
Foreign	11,779	3,182	2,520	344	169
Total	50,761	39,353	47,007	[1]44,170	50,450
Old scrap	39,729	53,131	39,067	27,171	25,549
New scrap	36,714	65,642	44,738	37,812	41,839
Grand total	127,204	[1]158,127	130,812	109,153	117,838

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

Table 9.—U.S. consumption of silver, by end use

(Thousand troy ounces)

End use[1]	1979	1980	1981	1982	1983
Electroplated ware	8,065	4,350	3,904	3,254	3,154
Sterlingware	13,088	9,082	4,407	6,579	7,022
Jewelry	5,358	5,893	5,368	6,260	6,885
Photographic materials	65,978	49,825	51,025	51,769	51,826
Dental and medical supplies	2,295	2,212	1,709	1,688	1,532
Mirrors	1,850	672	581	970	970
Brazing alloys and solders	10,912	8,508	7,718	7,384	5,837
Electrical and electronic products:					
Batteries	4,583	5,976	3,803	4,167	2,637
Contacts and conductors	33,506	27,796	26,411	27,730	26,298
Bearings	332	649	297	228	170
Catalysts	5,637	3,035	3,830	[r]2,418	2,414
Coins, medallions, commemorative objects	4,676	4,693	2,622	1,832	2,979
Miscellaneous[2]	978	2,005	4,995	4,562	4,567
Total net industrial consumption[3]	157,258	124,694	116,670	118,840	116,291
Coinage	168	72	179	1,846	2,128
Total consumption	157,426	124,766	116,849	120,686	118,419

[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)

	1979	1980	1981	1982	1983
Industry	16,002	17,255	20,875	20,467	17,673
Futures exchanges	133,129	120,798	96,511	106,182	151,232
Department of the Treasury	38,990	38,890	38,732	36,768	34,565
Department of Defense	5,670	4,510	3,810	1,750	100
National Defense Stockpile	139,500	139,500	137,500	137,500	137,500

Table 11.—U.S. silver prices

(Dollars per troy ounces)

Period	Low	High	Average
1979	5.96	28.00	11.09
1980	10.80	47.60	20.63
1981	7.95	16.45	10.52
1982	4.88	11.21	7.95
1983:			
January	10.86	13.86	12.40
February	10.95	14.74	13.96
March	10.13	11.17	10.62
April	10.80	12.37	11.69
May	12.06	13.60	12.98
June	11.08	12.63	11.75
July	11.30	12.50	12.09
August	11.52	12.75	12.10
September	11.23	12.32	11.92
October	8.75	10.43	9.84
November	8.34	9.70	8.84
December	8.54	9.96	9.12
Average	8.34	14.74	11.44

Source: Handy & Harman daily quotation.

Table 12.—Value of U.S. silver trade

(Thousand dollars)

Year	Exports	Imports for consumption
1979	471,162	961,761
1980	1,909,733	1,606,010
1981	332,470	1,028,450
1982	208,748	927,079
1983	377,449	2,123,569

Table 13.—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
1979	44	237	16,981	212,323	2,206	21,060	16,332	237,542	35,563	471,162
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:										
Belgium-Luxembourg	1	9	2,255	25,872	9	80	105	1,128	2,370	27,089
Canada	53	383	1,792	20,010	196	2,024	7,156	92,168	9,197	114,585
France	--	--	1,033	11,214	12	67	15	142	1,060	11,423
Germany, Federal Republic of	10	125	798	8,284	299	1,169	1,594	20,185	2,701	29,763
Japan	--	--	1	9	106	1,338	4,354	50,662	4,461	52,009
Spain	--	--	672	8,152	--	--	--	--	672	8,152
Sweden	--	--	621	6,110	--	--	--	--	621	6,110
United Kingdom	--	--	9,991	117,774	223	2,976	10	137	10,223	120,887
Other	3	37	70	570	151	1,862	425	4,960	649	7,429
Total[1]	67	554	17,231	197,996	996	9,516	13,658	169,383	31,952	377,449

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

Table 14.—U.S. imports for consumption 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
1979	9,928	83,266	1,504	13,849	2,577	23,915	78,372	840,731	92,381	961,761
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:										
Belgium-Luxembourg	4	41	--	--	--	--	5,003	63,825	5,007	63,866
Brazil	166	1,714	92	765	9	70	173	1,998	440	4,547
Canada	1,367	14,740	416	4,695	229	3,645	33,864	396,575	35,876	419,655
Chile	672	7,276	204	2,676	1,940	22,122	465	4,910	3,281	36,984
Dominican Republic	--	--	3	36	793	8,835	239	3,154	1,035	12,025
France	--	--	--	--	--	--	1,121	13,371	1,121	13,371
Japan	11	122	2	14	--	--	2,117	23,636	2,130	23,772
Korea, Republic of	--	--	38	447	--	--	1,663	19,496	1,701	19,943
Mexico	2,168	16,885	66	591	321	1,663	27,767	320,709	30,323	339,848
Netherlands	--	--	2	29	--	--	1,396	14,194	1,398	14,223
Oman	--	--	--	--	--	--	493	6,821	493	6,821
Peru	8,504	93,767	3	34	118	1,204	15,277	173,763	23,902	268,768
Philippines	139	1,388	24	327	--	--	464	4,956	628	6,671
Switzerland	--	--	--	--	--	--	4,154	47,987	4,154	47,987
Thailand	--	--	64	793	13	143	2,836	34,620	2,913	35,556
United Kingdom	352	3,917	8	66	32	311	62,170	772,237	62,562	776,531
Uruguay	1	6	1	13	30	470	1,262	15,176	1,295	15,665
Other	527	5,558	317	2,523	55	577	732	8,674	1,631	17,332
Total[1]	13,911	145,419	1,241	13,010	3,540	39,038	161,199	1,926,102	179,891	2,123,569

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

Table 15.—Silver: World mine production, by country[1]

(Thousand troy ounces)

Country[2]	1979	1980	1981	1982[p]	1983[e]
Algeria[e]	100	100	110	110	120
Argentina	2,209	[r]2,357	2,518	2,684	[3]2,636
Australia	26,756	[r]24,654	23,906	29,156	32,150
Bolivia	5,742	6,099	6,394	5,472	5,090
Brazil[4]	1,065	737	765	748	750
Bulgaria[e]	920	930	930	930	930
Burma	340	587	450	526	[3]558
Canada	36,874	33,340	36,298	42,246	35,560
Chile	8,740	9,598	11,610	12,288	11,600
China[e]	2,000	2,500	2,500	2,500	2,500
Colombia[5]	99	152	143	126	126
Costa Rica[e]	2	2	2	2	2
Czechoslovakia[e]	1,300	1,300	1,300	1,300	1,300
Dominican Republic	2,276	1,623	2,062	[e]2,200	1,350
Ecuador	35	29	32	[e]10	32
El Salvador	152	146	137	86	60
Fiji	11	7	8	19	15
Finland	1,028	1,430	1,215	1,188	1,200
France	2,408	2,427	1,705	939	800
German Democratic Republic[e]	1,550	1,510	[r]1,450	[r]1,450	1,450
Germany, Federal Republic of	1,039	[r]1,058	1,126	1,279	1,280
Ghana	20	[e]18	[e]17	17	14
Greece	1,752	1,672	[e]1,600	[e]1,500	1,600
Greenland	763	771	720	760	750
Guatemala	10	10	8	8	8
Honduras	2,434	1,766	1,823	2,100	[3]2,500
Hungary[e]	32	(6)	(6)	(6)	--
India[5]	370	366	555	463	[3]469
Indonesia	793	701	830	1,134	1,160
Ireland	1,059	771	700	[e]700	700
Italy[5 7]	1,065	1,366	1,768	1,790	1,800
Japan	8,680	8,603	9,010	9,843	[3]9,877
Korea, North[e]	1,600	1,600	1,600	1,600	1,600
Korea, Republic of	2,278	2,292	3,061	3,237	3,000
Malaysia (Sabah)	432	437	472	[e]470	470
Mexico	[r]52,169	[r]50,052	52,916	59,175	[3]61,435
Morocco	3,283	3,154	[e]2,120	[r e]2,640	2,850
Namibia	[r]3,617	[r]3,365	3,456	2,812	[3]3,532
New Zealand	2	1	(6)	(6)	--
Nicaragua	[r]390	164	[e]150	76	[3]64
Papua New Guinea	1,428	1,180	1,363	1,385	1,500
Peru	39,248	[r]44,419	46,940	53,639	[3]55,871
Philippines	1,838	1,952	2,024	1,984	1,900
Poland	22,569	24,627	20,576	21,058	24,900
Portugal	35	20	39	24	25
Romania	965	900	850	[e]850	900
Solomon Islands	(8)	(8)	(8)	(8)	(8)
South Africa, Republic of	3,240	5,500	7,568	6,943	[3]5,559
Spain	2,294	4,526	5,347	3,787	4,000
Sweden	5,649	5,112	5,337	5,626	5,500
Taiwan	85	95	215	504	[3]345
Tunisia	231	235	84	115	[3]90
Turkey[e]	250	200	[r]200	220	220
U.S.S.R.[e 5]	46,000	46,000	46,500	46,900	47,200
United States	37,896	32,329	40,683	40,248	[3]43,415
Yugoslavia[5]	5,214	4,790	4,437	3,343	[3]3,987
Zaire	3,892	2,733	2,580	1,751	2,000
Zambia	914	764	714	887	[3]933
Zimbabwe	[r]977	[r]949	857	918	[3]935
Total	[r]348,120	[r]344,026	361,781	383,766	390,618

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

[1]Recoverable content of ores and concentrates produced unless otherwise noted. Table includes data available through June 27, 1984.

[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]Reported figure.

[4]Officially reported output, including that obtained from treatment of gold, was as follows, in troy ounces: 1979—14,725; 1980—15,657; 1981—17,072; 1982—12,057; and 1983—not available; and that recovered from treatment of lead was as follows, in troy ounces: 1979—1,050,717; 1980—721,205; 1981—747,472; 1982—747,505; and 1983—not available.

[5]Smelter and/or refinery production.

[6]Revised to zero.

[7]Includes production from imported ores.

[8]Less than 1/2 unit.

Slag—Iron and Steel

By William I. Spinrad, Jr.[1]

Domestic production of iron and steel slag increased significantly. Sales and use of iron slag decreased moderately, and sales and use of steel slag increased slightly. Air-cooled blast furnace slag continued to comprise the largest portion of total blast furnace slag sold or used. Of all iron and steel slag product shipments, 85% traveled by truck, 8% traveled by rail, and 3% traveled by waterway, with an average marketing range of 23, 247, and 540 miles, respectively. Houston Slag Materials Co. permanently closed its Houston, TX, plant because Armco Inc., Houston Slag Materials' slag supplier, permanently shut down its Houston Works blast furnace.

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. 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. Steel slag was typically used as road base and fill. The average unit value of blast furnace slag in 1983 increased 9% over that in 1982. Steel slag decreased 2% in unit value during the same period.

Domestic Data Coverage.—Sales, use, and transportation data for iron and steel slag were compiled from voluntary responses received from an annual survey of U.S. processors conducted by the Bureau of Mines. Of the 77 operations canvassed, 74, or 96%, responded, representing 93% of the total sales or use data shown in table 1. Data for the three 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 increased iron and steel production. However, sales and end use of blast furnace slag decreased moderately and that of steel slag increased only slightly compared with that of 1982. This is attributed, in part, to a combination of decreases in construction activity in certain areas of the country; decreases of available moneys for highway construction in some States; and the unavailability of slag in other areas caused by the temporary shutdown and/or limited production of blast and steel furnaces. Although sales were down as a whole, many processors showed sizable increases. Others, unable to market their slag, continued to process and stockpile it for future use.

Blast furnace slag sold or used decreased 8% in quantity and decreased slightly in value compared with that of 1982, to 13.6 million tons valued at $64.7 million. Fifty-nine percent of this was marketed in Pennsylvania, Indiana, and Ohio. Of the total blast furnace slag sold or used, 91% was air cooled. Forty plants processed iron slag, and 1 was inactive for the year. Steel slag sold or used totaled 4.8 million tons valued at $14.5 million, up 1% in quantity and down 1% in value compared with that of 1982. Forty-six plants processed steel slag, and 1 was inactive for the year. Of all iron and steel slag products shipped, 85% traveled by truck with an average marketing range of 23 miles, 8% traveled by rail with an average marketing range of 247 miles, and 3% traveled by waterway with an average marketing range of 540 miles. The remaining 4% was used at the plantsite.

Houston Slag Materials permanently closed its Houston, TX, plant because Armco, Houston Slag Materials' slag supplier, permanently shut down its Houston Works blast furnace.

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
1979	25,009	78,415	855	3,037	1,648	10,794	27,512	92,246	8,252	18,476	35,764	110,722
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

[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.

CONSUMPTION AND USES

Iron and steel slags, byproducts of ironmaking and steelmaking, were utilized mainly by the construction industry in 1983 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 1983, 42% was used as road base, 16% as fill, 11% as concrete aggregate, 10% 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 and in concrete products. Other end uses for expanded slag and for granulated blast furnace slag are not separately tabulated 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 published information, 75% to 80% of all steel slag produced is recycled to the blast furnace or used in aggregate applications.[2] Statistics developed by the Bureau of Mines indicate that 2.9 million tons of steel slag was recycled to blast furnaces in 1983. Steel slag was primarily used as road base (43%), fill (23%), railroad ballast (11%), and asphaltic concrete aggregate (10%). The remaining 13% was used for 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 in 1983 increased 9% over that of 1982 to $4.78 per ton. Air-cooled slag decreased 1% to $4.12 per ton, and expanded slag increased 9% to $9.67 per ton. Price information for granulated slag was withheld to avoid disclosing company proprietary data. Steel slag unit value was $3.01 per ton, down 2% from that of 1982. High prices in some use categories indicate that some users demanded specifications that required additional processing.

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 266 tons of basic slag valued at $16,816 was imported from Mexico, Israel, and Bahrain, and 27,380 tons valued at $698,096 was exported to Thailand and Canada, respectively.

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." Granulated blast furnace slag is imported from France and Japan for use in the production of high-grade cement, and blast furnace slag is exported to and imported from Canada periodically.

WORLD REVIEW

Estimated world production of iron-blast-furnace and steel slag was 118 million and 52 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.[3] 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 since slag is thought of as a waste product rather than a resource.

Europe.—Indicated levels of slag production were approximately the same for 1983 as for 1982 since iron and steel slag production in Europe was relatively flat in 1983 compared with that of 1982. The most current data published by the statistical office of the European Economic Community indicate that a total of 30,209,907 tons of iron-blast-furnace slag was produced in Europe in 1982.[4]

Japan.—Iron and steel production declined slightly in 1983 compared with that of 1982, but slag utilization followed the same trends as that of 1982. Based on the latest data from the Japan Iron and Steel Federation, 26 million tons of iron-blast-furnace slag and 14 million tons of steel slag were produced in 1982. Of the iron slag produced, 85% was utilized in road construction and cement and concrete manufacture. Granulated iron-blast-furnace slag and basic oxygen furnace (BOF) steel slag were increasingly used in cement manufacture and in road construction, respectively. New Japanese industrial standards have been established for air-cooled iron-blast-furnace slag aggregate for concrete, granulated blast furnace slag fine aggregate for concrete, and slag for road construction. The Public Works Research Institute of the Ministry of Construction, in conjunction with the Public Works Research Center, prepared Guidelines for Designing and Application of BOF Slag for Asphalt Pavement.[5]

TECHNOLOGY

A recently published article reviews current and potential utilization of ferrous, nonferrous, and boiler slags in the construction and maintenance of pavements. Iron-blast-furnace and steel slag production and general uses are described, as well as technical information, test data, and end-use limitations for certain types of material such as steel slag. Slag utilization patterns for North America and Europe are referred to and are supplemented in some cases with general statistics. Emphasis is given to the use of iron-blast-furnace slag in cementitious applications and the use of steel slag for asphaltic applications. These uses are considered to be the current optimal growth areas in North America. Granulated iron-blast-furnace slag is being used as a replacement for cement because of its lower cost, improved workability, chemical resistance, lower heat of hydration, and versatility in obtaining desired fineness of ground slag. Pelletized iron-blast-furnace slag has recently been used in Europe and North America for slag cement manufacture. By controlling the pelletizing process, crystalline pellets can be produced for aggregate applications and vitrified pellets for cementitious applications. Elimination of the tendency of steel slags to expand, through aging and the addition of an asphaltic cement film, has allowed the use of these slags in asphaltic mixes, such as asphaltic concrete, coated chippings, and slurry seals, which take advantage of the high stability and superior skid resistance of steel slags compared with that of blast furnace slag and traprock.[6]

Nippon Steel Corp. is conducting in-house research and joint research with the Ministry of Construction on the manufacture of steel slag and its utilization on the basis of its chemical composition and physical properties. The greatest problems to be overcome are its expansion and degradation characteristics caused by excessive amounts of free lime. Techniques have been established to overcome these problems, including injection of oxygen into molten slag; the addition of iron, silicon, and aluminum sources; and aging, an efficient and low-cost process. Research thus far has been concentrated on utilization of steel slags for road material, asphaltic concrete aggregate, road base material, ground improvement material, caisson filling material, various self-hardening materials, shot blasting material, balance weights, and reefs for aquaculture. Road uses appear to be the most promising application. Presently, 61% of all steel slag produced by Nippon is used by the company for fill, construction, recycling, and addition to stocks. The remaining 39% is sold for use in civil engineering projects, roads, cement, fertilizer, and other uses.[7]

A new anticorrosive coating for steel structures, such as tanks and bridges, was developed by Nippon Kokan K.K. (NKK) and is being marketed under the trade name NKK GANTEX. This polymer cement mortar is a mixture of granulated iron-blast-furnace slag, a Portland blast furnace slag cement, and a styrene-butadiene rubber latex. It offers better adhesion and self-hardening ability than other polymer cement mortars because of the use of iron slag instead of silica sand. Other features offered by this compound include improved abrasion resistance compared with that of conventional coating materials; high slip resistance; high anticorrosion resistance when used in submarine conditions; vibration damping and sound insulating effects; low heat conductivity and heat barrier effects; and a coating thickness unattainable with conventional coatings. This coating can also be used on buildings since it is highly adhesive to various metal and nonmetal surfaces and is further characterized by its resistance to strain-induced cracks, improved waterproofing capabilities compared with mortar and concrete, and its suitability for use as a finishing material in various textures and colors.[8]

Research is being conducted in the United Kingdom to find adequate end uses for BOF steel slag, which exhibit higher free lime contents and higher bulk densities than other steel slags. These properties cause problems with stability and covering capacity in road courses. Initial work comparing BOF slags with electric arc furnace slags and laboratory studies on the nature, structure, and stability of free lime in BOF slags indicated that BOF slags offer an excellent range of physical and mechanical properties suitable for use as a bituminously coated aggregate for wearing course applications provided their stability problems can be solved. Weathering tests have been monitored to determine optimum conditions for the production of volumetrically stable slag, and full-scale road trials have been conducted on weathered and unweathered bituminously bound BOF slag. Surfaces produced from weathered BOF slag showed better resistance to mechanical wear than the control material, and performance was directly related to the duration of weathering, with longer weathering giving better performance. A limited amount of laboratory work has also been conducted on nonbituminously bound BOF slag for use as a base course material, and the initial test results appear promising.[9]

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[1]Physical scientist, Division of Ferrous Metals.

[2]Lewis, D. W. Resource Conservation by Use of Iron and Steel Slags. Am. Soc. Test. and Mater. ASTM Spec. Tech. Publ. 774, 1982, pp. 31-42.

[3]Emery, J. J. Slag Utilization in Pavement Construction. Am. Soc. Test. and Mater. ASTM Spec. Tech. Publ. 774, 1982, pp. 95-118.

[4]Statistical Office of the European Economic Community. 1983 Iron and Steel Yearbook. P. 74.

[5]Japan Iron and Steel Federation. The Steel Industry of Japan. 1983, pp. 19, 20.

[6]Work cited in footnote 3.

[7]Nippon Steel Corp. Steelmaking. Tech. Rep. No. 21, June 1983, pp. 45-57.

[8]Clean Japan. NKK GANTEX. No. 4, Jan. 1984, pp. 1-6.

[9]Thomas, G. H. LD Research Gives Constructive Results. Iron and Steel Int., v. 56, No. 2, Apr. 1983, pp. 62-64.

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	1982				1983			
	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	4,139	13,572	W	W	4,050	12,344	W	W
Ohio	1,947	9,153	W	W	2,155	10,380	W	W
Total[2]	6,086	22,725	6,505	25,538	6,204	22,724	6,645	25,683
Middle Atlantic:								
Pennsylvania	3,270	16,413	W	W	2,891	14,226	W	W
Maryland, New York, West Virginia	1,320	5,214	W	W	1,026	4,371	W	W
Total[2]	4,590	21,627	5,306	26,852	3,917	18,598	4,651	29,375
West: Colorado, Texas, Utah	1,637	5,621	1,637	5,621	1,104	3,629	1,104	3,629
South: Alabama and Kentucky	1,006	5,881	1,006	5,881	777	4,864	777	4,864
Pacific: California	299	962	299	962	377	1,184	377	1,184
Grand total[2]	13,617	56,816	14,752	64,854	12,380	50,999	13,554	64,735

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

State, city, and company	Processing method of iron slag			Steel slag	Sources of steel slag		
	Air-cooled	Ex-panded	Granu-lated		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	2	--	--	1	--	1	--
Total	4	--	--	2	--	2	--
California:							
Fontana:							
Heckett Co	1	--	--	1	--	1	--
Colorado: Pueblo:							
Fountain Sand and Gravel Co	1	--	--	1	--	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:							
Heckett Co	--	--	--	1	--	1	1
South Chicago plant	1	1	--	--	--	--	--
Illinois Slag & Ballast Co	1	--	--	--	--	--	--
Granite City:							
International Mill Service Co	--	--	--	2	--	1	--
St. Louis Slag Products Co. Inc	1	--	--	--	--	--	--
Peoria:							
International Mill Service Co	--	--	--	1	--	--	1
Total	3	1	--	5	--	2	3
Indiana:							
Burns Harbor:							
The Levy Co. Inc	2	1	--	1	1	1	--
East Chicago:							
Heckett Co	--	--	--	1	--	1	--
Vulcan Materials Co	1	--	--	--	--	--	--
Gary:							
Indiana Slag Co	1	1	--	--	--	--	--
Total	4	2	--	2	1	2	--
Kentucky:							
Ashland:							
Heckett Co	1	--	--	--	--	--	--
Owensboro:							
Heckett Co	--	--	--	1	--	--	1
Total	1	--	--	1	--	--	1
Maryland:							
Baltimore:							
Maryland Slag Co	1	1	--	--	--	--	--
Sparrows Point:							
Atlantic Cement Co. Inc	--	--	1	--	--	--	--
Total	1	1	1	--	--	--	--

Table 3.—Locations and processing methods of iron slag and sources of steel slag —Continued

State, city, and company	Processing method of iron slag			Steel slag	Sources of steel slag		
	Air-cooled	Ex-panded	Granu-lated		Open hearth	Basic oxygen process	Elec-tric
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	--
Total	2	1	--	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:							
Stein Inc	--	--	--	1	--	--	1
United States Steel Corp	1	--	--	--	--	--	--
Lordstown:							
Standard Slag Co	--	--	1	--	--	--	--
Mansfield:							
Heckett Co	--	--	--	1	--	--	1
Middletown:							
American Materials Corp	1	--	--	--	--	--	--
McGraw Construction Co	--	--	--	1	1	1	--
Mingo Junction:							
International Mill Service Co	--	--	--	2	--	1	--
Standard Slag Co	1	--	--	--	--	--	--
Warren:							
Heckett Co	--	--	--	1	--	--	1
Standard Slag Co	1	--	--	--	--	--	--
Total	7	--	1	8	1	3	5
Oklahoma: Sand Springs:							
International Mill Service Co	--	--	--	1	--	1	--
Pennsylvania:							
Belle Vernon:							
Duquesne Slag Products Co	1	--	--	--	--	--	--
Bethlehem:							
Bethlehem Mines Corp	1	--	--	--	--	--	--
Waylite Co	--	1	--	--	--	--	--
Birdsboro:							
Birdsboro Slag Products Co	1	--	--	--	--	--	--
Burgettstown:							
Duquesne Slag Products Co	--	--	1	--	--	--	--
Butler:							
Heckett Co	--	--	--	1	--	--	1
Coatesville:							
International Mill Service Co	--	--	--	1	--	--	1
Johnstown:							
Heckett Co	--	--	--	1	--	--	1
Lebanon:							
Sheridan Corp	1	--	--	--	--	--	--

Table 3.—Locations and processing methods of iron slag and sources of steel slag —Continued

State, city, and company	Processing method of iron slag			Steel slag	Sources of steel slag		
	Air-cooled	Ex-panded	Granu-lated		Open hearth	Basic oxygen process	Elec-tric
Pennsylvania —Continued							
McKees Rocks:							
Phillips Contracting	--	--	1	--	--	--	--
Midland:							
International Mill Service Co	--	--	--	1	--	--	1
Morrisville:							
Heckett Co	--	--	--	1	1	--	1
Warner Co	1	1	--	--	--	--	--
Penn Hills:							
Gascola Slag	--	--	--	1	1	--	--
Phoenixville:							
International Mill Service Co	--	--	--	1	--	--	1
Riddlesburg:							
New Enterprise Stone & Lime Co. Inc	1	--	--	--	--	--	--
Steelton:							
Hempt Bros. Inc	1	--	--	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	11	2	2	11	4	3	6
South Carolina: Darlington:							
APAC-Carolina Inc	--	--	--	1	--	--	1
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	--	--	--	--	--	--
Midlothian:							
International Mill Service Co	--	--	--	1	--	--	1
Total	1	--	--	3	--	--	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	39	7	4	49	7	19	29

Table 4.—Shipments of iron and steel slag in the United States in 1983, by method of transportation

Method of transportation	Quantity (thousand short tons)
Truck	15,676
Rail	1,354
Waterway	597
Not transported (used at plantsite)	758
Total[1]	18,386

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

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	1982		1983	
	Quantity	Value	Quantity	Value
Concrete aggregate	1,036	4,777	1,327	6,129
Concrete products	327	1,453	412	2,085
Asphaltic concrete aggregate	1,626	7,610	1,189	6,126
Road base	6,269	23,676	5,179	20,865
Fill	1,584	6,054	1,969	5,092
Railroad ballast	1,417	4,780	867	2,894
Mineral wool	601	3,199	564	3,016
Roofing, built-up and shingles	251	1,388	264	1,421
Sewage treatment	W	W	W	W
Soil conditioning	W	W	W	W
Glass manufacture	157	2,408	139	1,810
Other[2]	348	1,470	469	1,560
Total[3]	13,617	56,816	12,380	50,999

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)

Use	1982				1983			
	Granulated		Expanded		Granulated		Expanded	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Lightweight concrete aggregate	W	W	W	W	--	--	302	3,180
Concrete products	--	--	W	W	--	--	237	1,993
Cement manufacture	W	W	W	W	(2)	(2)	W	W
Road base	W	W	W	W	(2)	(2)	W	W
Fill	W	W	--	--	--	--	--	--
Soil conditioning	W	W	W	W	(2)	(2)	W	W
Other[3]	597	3,237	539	4,800	--	--	636	8,563
Total	597	3,237	539	4,800	(2)	(2)	1,175	13,736

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	1982 Quantity	1982 Value	1983 Quantity	1983 Value
Asphaltic concrete aggregate	545	2,231	460	1,898
Road base	1,523	4,085	2,100	5,699
Fill	1,750	5,699	1,133	3,598
Railroad ballast	403	1,045	532	1,863
Other[2]	543	1,582	607	1,488
Total	4,764	[3]14,641	4,832	14,546

[1]Excludes tonnage returned to furnace for charge material. Value based on selling price at plant.
[2]Includes ice control and miscellaneous uses.
[3]Data do not add to total shown because of independent rounding.

Table 8.—Average value at the plant for iron and steel slags sold or used in the United States

(Dollars per short ton)

Year	Iron-blast-furnace slag: Air-cooled	Granulated	Expanded	Total iron slag	Steel slag	Total slag
1979	3.14	3.55	6.55	3.35	2.24	3.10
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

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 1983, by use

(Dollars per short ton)

Use	Iron-blast-furnace slag: Air-cooled Average	Air-cooled Range	Granulated Average	Granulated Range	Expanded Average	Expanded Range	Steel slag Average	Steel slag Range
Concrete aggregate	4.61	1.85-12.52	--	--	--	--	--	--
Lightweight concrete aggregate	W	W	--	--	10.52	8.50-11.98	--	--
Concrete products	5.06	2.75- 8.16	--	--	8.41	6.90-11.98	--	--
Cement manufacture	W	W	W	W	W	W	--	--
Asphaltic concrete aggregate	5.15	2.68- 7.33	--	--	--	--	4.12	1.11-8.25
Road base	4.03	1.91- 9.09	W	W	--	--	2.71	1.12-8.85
Fill	2.59	.37- 5.98	--	--	--	--	3.17	1.00-5.24
Railroad ballast	3.33	2.00- 9.96	--	--	--	--	3.50	1.50-8.00
Mineral wool	5.34	2.68-10.99	--	--	--	--	--	--
Roofing, built-up and shingles	5.37	3.31-15.24	--	--	--	--	--	--
Sewage treatment	W	W	--	--	--	--	--	--
Soil conditioning	W	W	W	W	--	--	--	--
Glass manufacture	12.99	10.00-15.69	--	--	--	--	--	--
Other	2.90	1.72- 5.71	--	--	--	--	2.45	1.39-4.65

W Withheld to avoid disclosing company proprietary data.

Sodium Compounds

By Dennis S. Kostick[1]

The U.S. soda ash industry rebounded from the 1982 decline in soda ash demand. Improvement in the world economy and lower soda ash prices contributed to increased soda ash production and exports, which rose 8% and 48%, respectively. Although soda ash usage in the glass container industry decreased an estimated 4%, domestic soda ash consumption improved in several end-use sectors so that total consumption increased slightly.

Despite improvement in certain sodium sulfate-consuming industries in the fourth quarter, production, imports, exports, and domestic consumption of natural and synthetic sodium sulfate combined declined slightly.

Domestic Data Coverage.—Domestic production data for soda ash and natural sodium sulfate were 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.

Table 1.—Salient sodium compound statistics

(Thousand short tons and thousand dollars)

	Soda ash		Sodium sulfate	
	1982	1983	1982	1983
United States:				
Production[1]	7,819	8,467	[r]864	855
Value[2]	$721,257	[e]$685,100	[r]$71,971	$79,772
Exports	1,109	1,636	111	91
Value	$140,616	$154,584	$12,162	$11,380
Imports for consumption	18	20	394	343
Value	[r]$2,419	$2,704	$28,758	$27,921
Stocks, producer	[3]324	[3]307	[4]30	[4]48
Consumption, apparent	6,667	6,868	[r]1,183	1,089
World: Production	[p]30,367	[e]31,262	[p]5,370	[e]5,229

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Includes natural and synthetic. Total production data for sodium sulfate obtained from 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.

Legislation and Government Programs.—The Bureau of Land Management (BLM) sought comments by December on a proposed concessionary leasing process for Wyoming trona. Eleven steps for conducting a lease sale were contained in the proposed process, which, if approved, would improve competition for sodium lease sales on Federal lands and streamline BLM leasing procedures.[2]

DOMESTIC PRODUCTION

The domestic soda ash industry produced a record high of 8.47 million short tons of natural and synthetic soda ash and operated at 76% of total nameplate capacity. About 19% of the quantity produced was exported to developing nations for manufacture of glass, chemicals, detergents, and miscellaneous products. The export-to-production ratio increased significantly from that of the previous 5 years, which averaged 12% annually.

Total sodium sulfate production decreased slightly to 855,000 tons, of which 423,000 tons was from natural sources and 432,000 tons was recovered as a byproduct from various rayon, dichromate, and other chemical operations.

The Soda Ash Export Trading Association, represented by three of the six domestic soda ash companies, was reorganized at yearend. The new organization was called the American Natural Soda Ash Corp. (ANSAC) and included all producers. ANSAC was formed to strengthen the soda ash export price which had been declining because of intense competition between the association and the nonassociation producers.

Texasgulf Chemicals Co. acquired 9,273 acres of sodium lease tracts adjacent to its soda ash facility in Green River, WY, from Philadelphia Quartz Corp. (PQ). A 2-year drilling and geological evaluation program by Texasgulf confirmed that large, high-grade trona resources were present on the PQ land.[3]

Anaconda Minerals Co. and Leslie Salt Co., in a joint venture, acquired the southern section of Searles Lake in California. Anaconda conducted a preliminary drilling and geological exploration program to study the subsurface structure.

At midyear, Morton Thiokol Inc. closed its Weeks Island, LA, hydrochloric acid plant, which had a byproduct sodium sulfate capacity of 120,000 tons per year. Reduced plant profitability, increased imports of salt cake, and increased usage of alternative products by the pulp industry were cited as the main reasons for the closure.[4]

A hydrochloric acid plant, commissioned in September by Climax Chemical Co., had a byproduct sodium sulfate capacity of 90,000 tons per year. The plant, near Grantsville, UT, used the Cannon fluidized process, which requires salt and sulfuric acid as raw materials.[5]

Table 2.—Producers of soda ash and natural sodium sulfate in 1983

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 & Chemical Corp	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.

Table 3.—Manufactured and natural sodium carbonates produced in the United States

(Thousand short tons and thousand dollars)

Year	Manufactured soda ash (ammonia-soda process)[1] [2]	Natural sodium carbonates[3]		Total quantity
	Quantity	Quantity	Value	
1979	W	W	[4]543,812	8,253
1980	W	W	[4]768,168	8,275
1981	W	W	[4]787,469	8,281
1982	W	W	[4]721,257	7,819
1983	W	W	[e] [4]685,100	8,467

[e]Estimated. W Withheld to avoid disclosing company proprietary data.
[1]Current Industrial Reports, Inorganic Chemicals, Bureau of the Census. Bureau of Mines responsible for data compilation after Jan. 1979.
[2]Includes quantities used to manufacture caustic soda, sodium bicarbonate, and finished light and dense soda ash.
[3]Soda ash and trona (sesquicarbonate).
[4]Includes value for synthetic soda ash.

Table 4.—Manufactured and natural sodium sulfate[1] produced in the United States

(Thousand short tons and thousand dollars)

Year	Manufactured and natural[2]			Natural	
	Lower purity[3] (99% or less)	High purity	Total[4]	Quantity	Value
1979	612	509	1,121	533	29,689
1980	676	464	1,139	583	36,389
1981	666	[r]445	[r]1,111	608	43,186
1982	[r]463	[r]401	[r]864	W	W
1983	427	427	855	423	39,425

[r]Revised. W Withheld to avoid disclosing company proprietary data.
[1]All quantities converted to 100% Na_2SO_4 basis.
[2]Current Industrial Reports, Inorganic Chemicals, Bureau of the Census.
[3]Includes Glauber's salt.
[4]Data may not add to totals shown because of independent rounding.

CONSUMPTION AND USES

Soda ash sales to glass container manufacturers were adversely affected by increased consumer preference for plastic containers. Polyethylene terephthalate (PET) bottles for soft drinks, alcoholic beverages, and certain processed foods continued to displace glass containers. Hot-fillable containers made of polyethylene with an ethylene-vinyl alcohol (EVOH) copolymer layer were test marketed for consumer acceptance. The EVOH layer is a nonpermeable oxygen barrier that prohibits spoilage.[6] Hot-fillable PET bottles that could withstand high temperatures were also introduced to compete with glass containers.[7]

The distribution of soda ash by end use was glass, 50%; chemicals, 21%; soaps and detergents, 9%; pulp and paper and water treatment, 3% each; and miscellaneous, 14%.

Despite increased output by the Kraft pulp industry, pulp-grade sodium sulfate producers lost sales because of increased substitution of inexpensive and available caustic soda and emulsified sulfur. Sales of detergent-grade sodium sulfate improved because of changes in detergent formulation that required additional sodium sulfate.

Apparent consumption of natural and synthetic sodium sulfate was 1.09 million tons. The major end uses of sodium sulfate were in pulp and paper, 47%; detergents, 40%; glass, 4%; and miscellaneous, 9%.

Table 5.—Estimated consumption of soda ash, by end use

(Thousand short tons)

End use	1982	1983
Glass:		
Bottle and container	2,500	2,400
Flat	500	575
Fiber	220	230
Other	280	245
Total	3,500	3,450
Chemicals	1,300	1,400
Soaps and detergents	500	620
Pulp and paper	275	200
Water treatment	230	230
Other[1]	862	968
Total	3,167	3,418
Grand total	6,667	6,868

[1]Includes soda ash used in petroleum and metal refining, leather tanning, enamels, etc.

STOCKS

Yearend stocks of soda ash stored on teamtracks, in terminals, in warehouses, and in plant silos decreased about 5%.

Yearend inventories of natural sodium sulfate increased 60%.

PRICES

Continuing weak domestic demand for soda ash and an excess of soda ash production capacity created intense competition among the six U.S. producers that led to inequitable pricing throughout the industry. In an attempt to restore price stability and encourage domestic soda ash sales, FMC Corp. instituted in October a temporary voluntary allowance (TVA) that reduced its f.o.b. list price of Wyoming dense bulk soda ash from $84 to $69 per ton. Other producers followed the FMC TVA, including Kerr-McGee Chemical Corp., which lowered its soda ash list price from $107.25 to $92.25 per ton.[8]

The average value of bulk natural soda ash, f.o.b. Green River, WY, and Searles Valley, CA, as reported by producers, was $76.95 per ton. The average value of bulk natural sodium sulfate, f.o.b. mine or plant, as reported by producers, was $93.30 per ton.

Table 6.—Sodium compounds yearend prices

		1982	1983
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	$112.00-118.00	120.00
Dense, bulk, carlots, works	do	88.00	69.00
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	96.00-103.00	113.00-114.00
Domestic salt cake, bulk, works[1]	do	47.00- 52.00	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. 224, No. 26, Dec. 26, 1983, pp. 35-36.

FOREIGN TRADE

Soda ash exports increased by 48% above the record high set in 1982 because of favorable rail and ocean transportation rates, improvement in the world economy, and a slight shift in global trade patterns. According to the Bureau of the Census, exports to 49 countries were distributed on a regional basis as follows: Asia, 43%; South America, 20%; North America, 19%; Africa, 9%; Oceania, 3%; Europe and the Middle East, 2% each; and Central America and the Caribbean, 1% each. Some of these Census data were revised because certain shipments to South America had been erroneously credited to Switzerland.

Responding to a complaint by Allied Canada Inc., the Canadian Department of National Revenue, Customs, and Excise ruled in 1983 that six U.S. soda ash producers were guilty of dumping dense soda ash on the Canadian market in 1982.[9] The case was referred to the Anti-Dumping Tribunal, which determined that (1) the one Canadian soda ash producer was injured because of dumping by the U.S. soda ash industry, excluding Tenneco Minerals Co., which was exempt from the ruling, and (2) all U.S. producers, including Tenneco, had the potential to cause further injury to the Canadian industry in the future. In addition, the tribunal established that the four Provinces west of the Manitoba-Ontario border were exempt from an antidumping duty; however, the eastern Provinces were subject to an antidumping duty to protect their soda ash industry. U.S. soda ash producers changed their pricing policies before the tribunal could impose the import duty. The decision on the amount of duty was pending at yearend.

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]
1980	1,094	121,945	129	12,740
1981	1,051	121,107	124	12,980
1982	1,109	140,616	111	12,162
1983	1,636	154,584	91	11,380

[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]
1980	97	4,872	133	8,370	230	13,242
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

[1]Includes Glauber's salt as follows: 1980—1,418 tons ($37,372); 1981—30 tons ($13,800); 1982—2 tons ($1,241); and 1983—3 tons ($1,648).
[2]C.i.f. U.S. port.

Source: Bureau of the Census.

Table 9.—U.S. imports for consumption of sodium carbonate

	1982[r]		1983	
	Quantity (short tons)	Value[1] (thousands)	Quantity (short tons)	Value[1] (thousands)
Sodium carbonate, calcined	18,098	$2,409	19,991	$2,703
Sodium carbonate, hydrated, and sesquicarbonate	25	10	([2])	1
Total	18,123	2,419	19,991	2,704

[r]Revised.
[1]C.i.f. U.S. port.
[2]Less than 1/2 unit.

Source: Bureau of the Census.

WORLD REVIEW

Botswana.—British Petroleum Minerals (BP) began a feasibility study to develop the brine deposits of Sua Pan in the Makgadikgadi Basin in northeastern Botswana. If results of the study proved favorable, the company intended to construct a soda ash plant with an annual capacity of about 330,000 tons. As regional demand for soda ash was estimated at only 275,000 tons per year, the BP project would compete with a proposed 330,000-ton-per-year synthetic soda ash project in the Republic of South Africa that had been announced in 1982. It appeared unlikely that both projects would be approved considering the small size of the soda ash market in southern Africa.[10]

China.—Japan agreed to help build three synthetic soda ash plants in the Provinces of Jiangsu, Shandong, and Hebei. The plants at Jiangsu and Shandong were to have a combined capacity of 660,000 tons per year and were scheduled for completion by 1986. Information on the third plant was unattainable.[11]

Turkey.—The Turkish Mining Research Institute and Etibank, the state-owned mineral company, announced plans to produce natural soda ash from a saline deposit 40 miles east of Ankara at Beypazari. Core data obtained in early development work indicated that the deposit contained 55 to 66 million tons of sodium salts.[12]

Table 10.—Sodium carbonate: World production, by country[1]

(Short tons)

Country	1979	1980	1981	1982[p]	1983[e]
Albania[e]	25,700	27,600	27,600	27,600	27,600
Australia[e]	[r]330,000	[r]330,000	[r]330,000	[r]330,000	330,000
Austria[e]	190,000	190,000	190,000	190,000	190,000
Belgium	441,197	360,376	300,931	361,170	282,600
Brazil	130,799	194,007	207,234	[e]210,000	210,000
Bulgaria	1,650,749	1,629,977	1,618,948	1,607,940	1,650,000
Canada[e]	500,000	500,000	500,000	500,000	500,000
Chad[e 2]	12,000	8,800	5,500	5,500	NA
Chile[e]	12,000	12,000	11,000	NA	NA
China	1,638,033	1,778,026	1,832,221	1,911,406	2,000,000
Colombia	146,846	137,380	137,800	[e]137,800	137,800
Czechoslovakia	131,175	135,192	130,293	117,313	117,000
Denmark[3]	3,036	148	164	[e]165	165
Egypt	[e]5,500	20,777	25,754	45,496	55,100
France	1,708,470	1,719,824	[e]1,765,000	[e]1,765,000	1,650,000
German Democratic Republic	948,519	954,880	967,859	972,684	970,000
Germany, Federal Republic of	1,544,250	1,555,481	1,310,770	1,229,604	1,323,000
Greece[e]	1,100	1,100	1,100	1,100	1,100
India	597,779	578,320	[e]676,000	646,836	760,000
Italy[e]	105,000	105,000	105,000	100,000	95,000
Japan	1,493,015	1,494,107	1,298,185	1,281,323	1,280,000
Kenya[2]	246,747	224,616	[e]275,000	179,513	165,000
Korea, Republic of	224,642	244,625	222,736	204,666	250,000
Mexico[4]	462,970	[r]447,538	442,026	429,901	440,000
Netherlands[e]	460,000	460,000	460,000	460,000	460,000
Norway[e]	29,800	29,800	29,800	29,800	29,800
Pakistan	82,958	84,878	102,267	118,157	120,000
Poland	753,980	839,960	771,617	822,323	820,000
Portugal	201,469	[e]195,000	[e]190,000	190,000	180,000
Romania	984,363	1,032,865	1,069,241	1,060,000	1,060,000
Spain[e]	550,000	550,000	550,000	550,000	550,000
Sweden[e]	1,000	1,000	1,000	1,000	1,000
Switzerland[e]	50,000	50,000	51,000	51,000	50,000
Taiwan	88,973	102,008	79,437	65,279	80,000
Turkey[e]	75,000	65,000	65,000	65,000	70,000
U.S.S.R	5,271,246	5,269,042	5,357,227	5,250,303	5,300,000
United Kingdom[e]	1,540,000	1,500,000	1,430,000	1,430,000	1,430,000
United States[4]	[r]8,252,794	[r]8,275,230	8,281,495	7,819,083	[5]8,467,118
Yugoslavia	181,200	142,274	162,212	200,488	210,000
Total	[r]31,072,310	[r]31,246,831	30,981,417	30,367,450	31,262,283

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available.
[1]Table includes data available through May 16, 1984. Synthetic unless otherwise specified.
[2]Natural only.
[3]Production for sale only; excludes output consumed by producers.
[4]Includes natural and synthetic.
[5]Reported figure.

Table 11.—Sodium sulfate: World production, by country[1]

(Thousand short tons)

Country[2]	1979	1980	1981	1982[p]	1983[e]
Natural:					
Argentina	40	42	57	47	50
Canada	489	530	590	603	490
Chile[3]	2	1	(4)	1	1
Egypt	3	3	[e]3	[e]4	3
Iran[e]	25	10	11	11	14
Mexico[5]	398	410	467	141	166
South Africa, Republic of	[e]14	14	5	3	[6]1
Spain	229	172	292	308	310
Turkey	[r]105	[r]97	73	72	77
U.S.S.R.[e 7]	375	386	386	397	397
United States	533	583	608	[8]W	[6]423
Total	[r]2,213	[r]2,248	2,492	1,587	1,932
Synthetic:					
Austria[e]	61	61	61	61	61
Belgium[e]	276	276	276	276	276
Chile[9]	76	[r]77	64	52	53
Finland[e]	50	50	50	50	50
France	168	165	[e]165	[e]165	160
German Democratic Republic	140	140	139	139	139
Germany, Federal Republic of	232	248	281	236	243
Greece[e]	8	12	12	13	14
Hungary[e]	11	11	11	11	11
Italy	[6]1,192	1,102	992	937	882
Japan	373	[r]343	314	282	280
Netherlands[e]	55	55	55	55	55
Portugal	49	58	64	[e]63	62
Spain[e 10]	193	193	193	187	187
Sweden[e]	116	116	116	116	116
U.S.S.R.[e 7]	265	276	276	276	276
United States[11]	588	556	503	[8]864	[6]432
Total	3,853	3,739	3,572	3,783	3,297
Grand Total	6,066	5,987	6,064	5,370	5,229

[e]Estimated. [p]Preliminary. [r]Revised. W Withheld to avoid disclosing company proprietary data.

[1]Table includes data available through May 16, 1984.

[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 manufactured.

[4]Less than 1/2 unit.

[5]Series revised to reflect output reported by Mexico's principal producer, Industrias Peñoles S.A. de C.V. In 1979, and probably in other years, an additional 20,000 tons (estimated) of natural sodium sulfate was produced by a smaller producer.

[6]Reported figure.

[7]Conjectural estimates based on 1968 information on natural sodium sulfate and general economic conditions.

[8]Natural sodium sulfate included with synthetic sodium sulfate production.

[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 to producers (reported under "Natural" in this table).

TECHNOLOGY

Akzo Zout Chemie Nederland BV of the Netherlands conducted a laboratory-scale trial of its vinyl chloride-soda ash process. The company had previously received a grant from the European Economic Community to help develop the process, which uses medium-pressure steam and carbon dioxide instead of costly electricity. The overall energy consumption of the new process is approximately one-half that of the conventional method for producing vinyl chloride. Soda ash is produced from the reaction of salt with a concentrated aqueous trimethylamine-carbon dioxide solution obtained downstream in the vinyl chloride process. Akzo planned to construct a pilot plant by 1985, followed by a large-scale demonstration facility.[13]

[1]Physical scientist, Division of Industrial Minerals.

[2]Federal Register. Bureau of Land Management (Dep. Interior). Wyoming; Notice of Field Test of Sodium Concessionary Leasing and Request for Comments. V. 48, No. 150, Aug. 3, 1983, pp. 35175-35176.

[3]Green River Star. Texasgulf Purchases New Mineral Rights. Sept. 28, 1983.

[4]Chemical Marketing Reporter. Saltcake, HCl Unit Slated for Closure by Morton Thiokol. V. 223, No. 21, May 23, 1983, p. 5.

[5]Industrial Minerals (London). Company News and Mineral Notes. V. 185, Feb. 1983, p. 57.

[6]Chemical Week. Rigid Plastics Are Getting a Foot in the Kitchen Door. V. 133, No. 15, Oct. 12, 1983, pp. 10-11.

[7]———. PET Curries Favor for Hot-Fillable Containers. V. 132, No. 20, May 18, 1983, pp. 12-13.

[8]Journal of Commerce. FMC Adjusts Soda Ash Pricing. Oct. 18, 1983, p. 22B.

[9]The Wall Street Journal. Soda Ash Dumping Is Ruled by Canada Against 6 U.S. Firms. Apr. 12, 1983, p. 7.

[10]European Chemical News. South Africa and Botswana Plan Rival Soda Ash Projects. V. 40, No. 1,076, Apr. 4, 1983, p. 22.

[11]Chemical Week. Japan Helps China Build Up in Fertilizers. V. 133, No. 1, July 6, 1983, p. 20.

[12]Industrial Minerals (London). Trona Process for Turkey. V. 190, July 1983, p. 11.

[13]European Chemical News. Akzo Pushes Ahead With New Vinyl Chloride/Soda Ash Process. V. 40, No. 1067, Jan. 31, 1983, p. 14.

Crushed Stone

By Valentin V. Tepordei[1]

A total of 863 million short tons of crushed stone valued at $3.3 billion, f.o.b. plant, was reported produced in the United States in 1983. This tonnage is the second lowest production reported since 1970 and 22% below the record-high production of 1979 but 9% higher than the estimated production of 1982. About three-quarters of crushed stone production continued to be limestone and dolomite, followed by granite, traprock, sandstone and quartzite, shell, calcareous marl, volcanic cinder, marble, and slate, in order of volume.

Foreign trade in crushed stone remained relatively minor. Exports increased 17% and imports increased 44%. Ninety-five percent of the exports and 60% of the imports was limestone. Apparent consumption was 863 million tons.

Table 1.—Salient U.S. crushed stone statistics

(Thousand short tons and thousand dollars)

	1979	1980	1981	1982	1983
Sold or used by producers:					
Quantity[1]	1,099,500	983,500	872,600	[e]790,030	862,700
Value[1]	$3,275,900	$3,265,800	$3,125,000	[e]$2,918,300	$3,337,000
Exports (value)	$23,000	$21,239	$25,949	$19,026	$23,021
Imports for consumption (value)	$16,000	$13,900	$13,473	$16,382	$14,813

[e]Estimated.
[1]Does not include American Samoa, Guam, Puerto Rico, and the Virgin Islands.

Domestic Data Coverage.—Domestic production data for crushed stone were developed by the Bureau of Mines from voluntary surveys of U.S. producers. Beginning with 1981, full surveys of crushed stone producers were conducted for odd-numbered years only. For 1982, a preliminary survey was conducted to collect production information on a sample basis; this was used only to estimate crushed stone production at the State level.

Starting with 1983, the stone chapter was divided into two separate chapters, dimension stone and crushed stone. Several changes in the reporting methodology have been implemented in this chapter to better reflect the diversification and the importance of the crushed stone industry.

Of the 5,178 crushed stone operations surveyed by the Bureau of Mines in 1983, 3,791 were active. Of these, 3,165 or 83%, responded representing 88% of the U.S. total crushed stone output. The nonrespondents' production was estimated using preliminary production reports, adjusted prior year production, and/or employment data. Of the 3,165 reporting operations, 173 did not indicate a breakdown by end use. Their total production as well as that of 625 nonrespondents, representing 17% of the U.S. total, is included in the sold or used tables under "Other uses." A total of 1,293 operations were idle, and for 94 operations, no information was available to estimate their production.

Legislation and Government Programs.—In September, the Environmental Protection Agency (EPA) issued proposed new Standards of Performance for Stationary Sources of Nonmetallic Mineral Operations. These standards would limit fugitive emissions from new, modified, and reconstructed crushed stone and sand and gravel plants to 10% opacity for all facilities using a capture system, and 15% for those without it. EPA proposals also recognize wet-dust suppression and baghouses as the best demonstrated emission control technology.

New regulations regarding the use of explosives in surface mining, developed by the Office of Surface Mining of the U.S. Department of the Interior, went into effect in April. The new regulations were designed to better control ground vibrations during blasting used for mining or construction work.

The impact of the Surface Transportation Assistance Act of 1982 on the demand for construction aggregates at the national and State levels over a 4-year period was analyzed in a study published by the Bureau of Mines.[2] The study estimated that a total increase in production of road construction aggregates of between 428 and 514 million tons could result from the legislative program over the 4-year period beginning in 1983.

DOMESTIC PRODUCTION

Of the total 863 million tons of crushed stone produced in the United States, 625 million tons or 72% was limestone and dolomite, 117 million tons or 14% was granite, and 74 million tons or 9% was traprock. Total quantities and values of crushed stone produced by kind of stone, as well as the number of quarries reporting producing each kind of stone, are reported for 1981 and 1983 (table 2).

The South Atlantic region continued to lead the Nation in the production of crushed stone with 25% of the U.S. total. Next was the East North Central region with 16% of the total, followed by West South Central with 14%. Of the four major geographic regions, the South continued to lead the Nation with 49% of the total, followed by the North Central with 27%, and the Northeast with 13%.

A comparison of the estimated 1982 and reported 1983 production data indicates that output increased in all regions. The largest increases were recorded in New England, 21%; South Atlantic, 16%; and Mountain, 13%.

Based on 1980 census data on population, per capita crushed stone production in 1983 was 3.8 tons. At the regional level, per capita production was 5.6 tons in the South; followed by the North Central, 4.0 tons; the Northeast, 2.4 tons; and the West, 2.2 tons.

Crushed stone was produced in every State except Delaware and North Dakota. The 10 leading States in the production of crushed stone, in order of volume, were Texas, Florida, Pennsylvania, Illinois, Georgia, Missouri, Virginia, California, North Carolina, and Kentucky. Their combined production represented 52% of the national total.

Production increased in most States, including 9 of the top 10. The increases were significant in California and Maryland. Oklahoma, Kansas, Oregon, and Tennessee were the only large producing States that showed a significant decrease in output.

Most of the crushed stone, 75%, came from 22% of the quarries with an annual output larger than 300,000 tons.

The 10 leading producers of crushed stone were, in descending order of tonnage: Vulcan Materials Co., Martin Marietta Aggregates, Koppers Co. Inc., Lone Star Industries Inc., General Dynamics Corp., Florida Rock Industries Inc., The Rogers Group Inc., Gifford-Hill & Co. Inc., Genstar Stone Products Inc., and Dravo Corp.

Between 1970 and 1981, the total production of limestone from underground mines had increased from 31 to 50 million tons. However, it had decreased to 44 million tons by 1983. By operating underground, a variety of problems usually connected with surface mining such as environmental impacts and community acceptance are significantly reduced.

In September, Martin Marietta Corp., the second largest U.S. producer of crushed stone, combined two of its major divisions, construction materials and chemicals, into a new unit called Martin Marietta Basic Products. The new division includes crushed stone, sand and gravel, and cement operations, as well as other manufactured construction materials.

Frontier Stone Inc. of Lockport, NY, a new company, bought Genstar crushed stone quarries located at Lockport and Royalton, NY. Part of the acquisition and modernization funds were provided by the New York State Job Development Authority.[3]

Genstar of Hunt Valley, MD, one of the top 10 U.S. crushed stone producers, completed construction of a new $13 million processing plant at its Frederick, MD, limestone quarry. The plant was designed to use a computerized processing control system that was expected to increase quarry production from about 450 to 1,000 tons per hour. Crushed stone produced at this quarry is used primarily as road base material and construction aggregates.[4]

Franklin Limestone Co., a division of Franklin Industries Inc. of Nashville, TN, purchased a limestone quarry from Dresser Industries Inc., Nolanville, TX. The operation produces chemical-grade limestone for the glass, paper, plastics, paint, and rubber industries.[5]

Steetley Industries Ltd., the Canadian subsidiary of the Steetley Industries Ltd. of the United Kingdom, bought J. E. Baker's Millersville, OH, dolomite quarry. The operation produces dolomitic lime and deadburned dolomite. Steetley already owns two other dolomite operations in the United States, at Woodville and Gibsonburg, OH.[6]

The executive committees of the board of directors of the National Crushed Stone Association and the National Limestone Institute announced in October plans for consolidation of the two trade associations, pending approval by the membership. If approved, the consolidation was to become effective no later than the end of 1984.

Limestone.—Starting with the 1983 survey, a new canvassing procedure was implemented, designed to collect production data on dolomite as well as limestone. A total of 84 quarries reported dolomite production, and 46 quarries produced both limestone and dolomite without indicating how much of each was quarried. Therefore, the limestone totals shown in this chapter include an undetermined amount of dolomite that was produced in addition to the dolomite reported separately. Compared with 1981, the year when the previous full survey of crushed stone producers was conducted, the 1983 output of crushed limestone, including dolomite, decreased 3% to 625 million tons and increased 5% in value to $2.3 billion. Limestone and dolomite were produced by 1,183 companies at 2,553 quarries in 46 States. Leading States, in order of tonnage, remained Texas, Florida, Illinois, Pennsylvania, and Missouri; these five States accounted for 40% of the total U.S. output. Limestone output decreased significantly in California, Florida, Michigan, North Carolina, and Oklahoma, and increased significantly in Ohio. Leading U.S. producers were, in order of volume, Vulcan Materials, Martin Marietta Aggregates, and Lone Star Industries. These three companies accounted for 11% of the total U.S. output.

Dolomite.—A total of 24 million tons of dolomite valued at $102 million was produced by 61 companies in 23 States. An additional undetermined amount of dolomite is included in the total crushed limestone data. Leading States in the production of dolomite, in order of tonnage, were New York, Pennsylvania, Michigan, Tennessee, and Virginia; these five States accounted for 67% of the total U.S. output. Leading U.S. producers were, in order of volume, Lone Star Industries, ASARCO Incorporated, and Glasgow Inc.; their combined production represented 29% of the total U.S. output of dolomite.

Marble.—Production of crushed marble increased 51% to 1.6 million tons valued at $28 million. Crushed marble was produced by 12 companies at 18 quarries in 9 States. Leading States, in order of tonnage, were Alabama, Georgia, and Pennsylvania. Alabama alone produced 42% of the U.S. total, while the three leading States together accounted for 89% of the total U.S. output. Leading producers of crushed marble, in order of tonnage, were Georgia Marble Co., D. M. Stoltzfus & Son Inc., and Standard Oil Industries; their combined production represented 84% of the total U.S. output.

Calcareous Marl.—The output of calcareous marl decreased 10% to 3.5 million tons valued at $8 million. Calcareous marl was produced by 17 companies at 20 quarries in 7 States. South Carolina accounted for 82% of the total U.S. output, followed by Texas. Leading producers, in order of tonnage, were Dundee Cement Co., Giant Portland Cement Co., and Gifford-Hill; their combined output accounted for 82% of the total U.S. production. These three leading producers of calcareous marl were also manufacturers of portland cement.

Shell.—Shell is mainly fossil reef of oyster shell. The output of crushed shell decreased 22% to 8 million tons and 33% in value to $33 million. Crushed shell was produced by 14 companies from 19 operations in 5 States. Major producing States were Louisiana with 63% of the U.S. output, and Florida. Leading producers, in order of tonnage were Dravo, Louisiana Materials Co. Inc., and Pontchartrain Dredging Corp.; their combined production represented 63% of the U.S. output.

Granite.—Output of crushed granite increased 16% to 117 million tons and 26% in value to $488 million. Crushed granite was produced by 140 companies at 509 quarries in 30 States. Leading States, in order of tonnage, were Georgia, North Carolina, Virginia, South Carolina, and California; these five States accounted for 81% of the U.S. output. Significant increases in production occurred in Georgia and North Carolina. Leading U.S. producers, in order of tonnage, were Vulcan Materials, Martin Marietta Aggregates, and Koppers; their combined production represented 48% of the U.S. total.

Traprock.—The production of crushed traprock increased 5% to 74 million tons and 9% in value to $306 million. Traprock was produced by 266 companies at 583 quarries in 23 States. Leading States, in order of tonnage, were Oregon, New Jersey, Washington, California, and Connecticut; these five States accounted for 60% of the U.S. output. A significant increase in production occurred in Wisconsin. Leading U.S. producers, in order of tonnage, were Tilcon Inc., the U.S. Forest Service, and Traprock Industries Inc.; their combined production accounted for 19% of the total U.S. output.

Sandstone and Quartzite.—Output of crushed sandstone and quartzite combined decreased 7% to 21 million tons but increased 5% in value to $88 million. Crushed sandstone was produced by 118 companies at 280 quarries in 25 States, while crushed quartzite was produced by 18 companies at 20 quarries in 13 States. Leading producing States, in order of volume, were Arkansas, Pennsylvania, and California; these three States accounted for 44% of the U.S. output. Sandstone production increased significantly in Wisconsin and decreased greatly in Virginia. Leading producers, in order of tonnage, were Weaver Construction Co., the U.S. Forest Service, and H. M. B. Construction Co.; their combined production represented 17% of the U.S. total.

Slate.—Output of crushed slate increased 37% to 713,000 tons valued at $7.6 million. Crushed slate was produced by eight companies at eight quarries in six States. Leading States, in order of tonnage, were Georgia, Virginia, and Arkansas; their combined production accounted for 94% of the U.S. output. Leading producers, in order of tonnage, were Galite Corp., Arvonia-Buckingham Slate Co., and Le Sueur-Richmond Slate Corp. The top three producers accounted for 84% of the U.S. output.

Volcanic Cinder and Scoria.—The production of volcanic cinder and scoria decreased 50% to 1.8 million tons and 32% in value to $9.1 million. Volcanic cinder and scoria were produced by 39 companies from 186 operations in 9 States. Leading States, in order of volume, were Arizona, California, New Mexico, and Hawaii; their combined production accounted for 73% of the total U.S. output. Leading producers, in order of tonnage, were the U.S. Forest Service, Peter Kiewiat and Sons, and U.S. Industries; their combined production accounted for 56% of the U.S. output.

Miscellaneous Stone.—The output of miscellaneous crushed stone decreased 20% in tonnage and 12% in value to 10 million tons and $40 million.

A new table showing stone-producing States by kind of stone was included in this chapter.

Table 2.—Crushed stone sold or used by producers in the United States, by kind

Kind	1981				1983			
	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value
Limestone	2,673	646,168	$2,227,474	$3.45	2,469	600,324	$2,227,182	$3.71
Dolomite	(1)	(1)	(1)	(1)	84	24,225	102,192	4.22
Marble	18	1,071	22,519	21.03	18	1,620	28,086	17.34
Calcareous marl	26	3,824	8,016	2.10	20	3,451	7,937	2.30
Shell	21	10,769	49,541	4.60	19	8,348	33,314	3.99
Granite	361	101,073	386,322	3.82	509	116,870	488,359	4.18
Traprock	514	r70,167	r280,997	4.00	583	74,020	305,546	4.13
Sandstone and quartzite	319	22,811	84,016	3.68	300	21,259	87,970	4.14
Slate	9	521	7,740	14.86	8	713	7,608	10.67
Volcanic cinder and scoria	199	3,667	13,400	3.65	186	1,832	9,149	4.99
Miscellaneous stone	190	12,568	45,110	3.59	181	10,077	39,913	3.96
Total[2]	XX	r872,600	r3,125,000	3.58	XX	862,700	3,337,000	3.87

rRevised. XX Not applicable.
[1]Included with limestone.
[2]Data may not add to totals shown because of independent rounding.

Table 3.—Crushed stone sold or used in the United States, by region

(Thousand short tons and thousand dollars)

Region	1982[e] Quantity	1982[e] Value	1983 Quantity	1983 Value
Northeast:				
New England	16,100	79,700	19,535	98,683
Middle Atlantic	89,800	391,500	96,155	435,352
North Central:				
East North Central	125,600	422,200	138,765	485,749
West North Central	88,400	285,800	94,616	334,686
South:				
South Atlantic	185,600	744,900	214,545	905,664
East South Central	83,500	312,600	86,186	329,099
West South Central	116,500	362,600	119,525	393,551
West:				
Mountain	23,600	96,000	26,776	99,536
Pacific	60,900	222,900	66,635	254,936
Total[1]	790,030	2,918,300	862,700	3,337,000

[e]Estimated.
[1]Data do not add to totals shown because of independent rounding.

Table 4.—Crushed stone sold or used by producers in the United States, by State

(Thousand short tons and thousand dollars)

State	1982[e] Quantity	1982[e] Value	1983 Quantity	1983 Value
Alabama	21,200	89,600	20,558	95,374
Alaska	5,100	25,200	1,981	9,460
Arizona	5,200	22,200	4,755	24,079
Arkansas	13,100	48,500	13,448	51,267
California	28,500	105,400	35,582	146,289
Colorado	6,900	27,800	6,790	22,749
Connecticut	6,100	32,700	7,692	45,890
Florida	53,100	182,300	57,282	235,700
Georgia	34,800	153,500	41,100	186,192
Hawaii	4,500	26,600	5,532	29,703
Idaho	1,200	6,000	1,935	7,480
Illinois	42,900	148,300	42,761	166,860
Indiana	20,300	65,500	24,051	82,782
Iowa	22,600	88,800	24,844	101,097
Kansas	14,400	41,100	12,192	44,540
Kentucky	29,500	104,300	33,399	117,842
Louisiana	W	W	5,758	25,702
Maine	1,200	4,000	848	2,851
Maryland	15,100	73,500	19,284	80,429
Massachusetts	6,900	33,500	7,740	36,002
Michigan	20,700	67,100	24,763	82,152
Minnesota	7,100	20,900	8,580	25,320
Mississippi	W	W	1,651	4,377
Missouri	38,600	113,300	39,454	120,700
Montana	1,400	4,700	872	2,344
Nebraska	3,100	14,300	5,641	30,047
Nevada	1,300	4,500	1,269	5,358
New Hampshire	600	3,100	946	2,853
New Jersey	10,700	57,800	12,301	70,421
New Mexico	2,800	13,700	4,730	15,121
New York	28,700	132,800	32,331	137,982
North Carolina	27,500	117,600	33,694	145,602
Ohio	30,300	105,200	32,937	114,059
Oklahoma	30,100	84,200	23,865	76,941
Oregon	14,200	41,900	13,089	39,876
Pennsylvania	50,400	200,900	51,523	226,948
Rhode Island	130	1,100	971	5,507
South Carolina	14,000	53,000	15,786	61,054
South Dakota	2,600	7,400	3,906	12,982
Tennessee	W	W	30,578	111,506
Texas	68,000	205,000	76,453	239,642
Utah	2,500	9,800	4,407	14,636
Vermont	1,200	5,300	1,339	5,579
Virginia	35,200	142,300	37,959	158,724
Washington	8,600	23,800	10,451	29,607
West Virginia	5,900	22,700	9,439	37,962
Wisconsin	11,400	36,100	14,252	39,896
Wyoming	2,300	7,300	2,019	7,769
Other	38,100	143,700	--	--
Total[1]	790,030	2,918,300	862,700	3,337,000

[e]Estimated. W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Data may not add to totals shown because of independent rounding.

Table 5.—U.S. crushed stone sold or used by producers in 1983, by size of operation

Size range	Number of operations	Quantity (thousand short tons)	Percent
0 to 25	1,067	10,594	1.2
25 to 50	556	21,170	2.5
50 to 75	283	17,226	2.0
75 to 100	206	17,976	2.1
100 to 200	534	76,579	8.9
200 to 300	308	75,258	8.7
300 to 400	201	69,391	8.0
400 to 500	147	65,447	7.6
500 to 600	109	59,557	6.9
600 to 700	77	49,869	5.8
700 to 800	65	48,795	5.7
800 to 900	42	36,440	4.2
900 to 999	36	33,936	3.9
1,000 and over	160	280,499	32.5
Total	3,791	[1]862,700	100

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

Table 6.—Crushed limestone and dolomite sold or used by producers in the United States in 1983, by State

(Thousand short tons and thousand dollars)

State	Quantity	Value
Alabama	19,691	81,010
Alaska	809	3,802
Arizona	3,611	18,050
Arkansas	5,079	16,973
California	13,725	65,951
Colorado	2,854	7,489
Connecticut	315	3,253
Florida	54,543	228,428
Georgia	4,619	18,899
Hawaii	918	5,394
Idaho	291	872
Illinois	42,761	166,860
Indiana	24,041	82,770
Iowa	24,844	101,097
Kansas	11,776	42,113
Kentucky	W	W
Maine	518	1,898
Maryland	12,656	48,844
Massachusetts	W	W
Michigan	24,669	81,977
Minnesota	6,206	18,194
Mississippi	1,651	4,377
Missouri	37,598	116,662
Montana	743	1,969
Nebraska	5,641	30,047
Nevada	1,036	4,293
New Jersey	W	W
New Mexico	2,916	8,110
New York	28,693	119,532
North Carolina	4,567	21,621
Ohio	32,874	113,857
Oklahoma	22,889	73,949
Oregon	W	W
Pennsylvania	42,358	189,644
Rhode Island	W	W
South Carolina	2,989	12,199
South Dakota	2,874	7,630
Tennessee	W	W
Texas	74,526	230,319
Utah	4,050	13,529
Vermont	1,025	4,147
Virginia	15,609	62,159
Washington	1,414	3,790
West Virginia	8,350	33,635
Wisconsin	11,165	31,055
Wyoming	1,430	5,011
Other	66,224	247,965
Total[1]	624,500	2,329,000

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Data do not add to totals shown because of independent rounding.

Table 7.—Crushed calcareous marl sold or used by producers in the United States in 1983, by State

(Thousand short tons and thousand dollars)

State	Quantity	Value
Florida	5	14
Indiana	11	12
Maine	W	W
Michigan	25	47
North Carolina	W	W
South Carolina	2,836	6,550
Texas	W	W
Other	575	1,314
Total	[1]3,451	7,937

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Data do not add to total shown because of independent rounding.

Table 8.—Crushed granite, traprock, and sandstone and quartzite sold or used by producers in the United States in 1983, by State

(Thousand short tons and thousand dollars)

State	Granite		Traprock		Sandstone and quartzite	
	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	W	W	--	--	--	--
Alaska	W	W	705	3,403	--	--
Arizona	501	1,453	--	--	118	W
Arkansas	4,367	17,047	--	--	3,923	15,642
California	7,711	31,863	7,785	26,583	2,358	6,745
Colorado	3,474	13,059	80	305	260	1,022
Connecticut	--	--	7,377	42,637	--	--
Georgia	33,898	144,666	--	--	W	W
Hawaii	--	--	4,487	23,873	--	--
Idaho	202	846	1,009	2,506	434	3,257
Kansas	--	--	--	--	403	2,401
Kentucky	--	--	--	--	W	W
Maine	--	--	W	W	W	W
Maryland	1,922	9,620	W	W	177	1,123
Massachusetts	1,317	6,742	5,924	23,523	--	--
Michigan	--	--	W	W	W	W
Minnesota	2,140	5,815	W	W	W	W
Missouri	W	W	--	--	W	W
Montana	--	--	W	W	99	278
Nevada	W	W	--	--	--	--
New Hampshire	8	22	938	2,831	--	--
New Jersey	W	W	9,925	52,596	--	--
New Mexico	W	W	W	W	W	W
New York	W	W	2,761	14,037	W	W
North Carolina	26,797	112,786	2,225	10,546	W	W
Ohio	--	--	--	--	63	203
Oklahoma	425	795	--	--	W	W
Oregon	W	W	11,282	34,627	W	W
Pennsylvania	W	W	3,693	13,012	3,147	14,975
Rhode Island	W	W	--	--	--	--
South Carolina	9,962	42,305	--	--	--	--
South Dakota	--	--	--	--	1,031	5,352
Tennessee	W	W	--	--	--	--
Texas	125	455	W	W	932	4,885
Utah	--	--	--	--	243	718
Vermont	W	W	--	--	--	--
Virginia	16,325	71,457	4,641	20,896	662	2,806
Washington	346	907	8,260	23,540	188	664
West Virginia	--	--	--	--	1,089	4,327
Wisconsin	W	W	W	W	1,980	5,422
Wyoming	W	W	--	--	--	--
Other	7,350	28,521	2,930	10,631	4,152	18,150
Total[1]	116,900	488,400	74,020	305,500	21,300	88,000

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Data do not add to totals shown because of independent rounding.

Table 9.—Volcanic cinder and scoria and miscellaneous crushed stone sold or used by producers in the United States in 1983, by State

(Thousand short tons and thousand dollars)

State	Volcanic cinder and scoria		Miscellaneous stone	
	Quantity	Value	Quantity	Value
Alabama	--	--	147	689
Arizona	447	3,120	W	W
Arkansas	--	--	W	W
California	W	W	3,589	12,227
Colorado	115	846	7	27
Hawaii	128	436	--	--
Kansas	--	--	13	26
Louisiana	--	--	493	2,452
Maryland	--	--	2,595	12,240
Massachusetts	--	--	W	W
Michigan	--	--	W	W
Nevada	W	W	W	W
New Mexico	371	1,410	--	--
New York	--	--	W	W
Oklahoma	--	--	W	W
Oregon	W	W	W	W
Pennsylvania	--	--	1,644	6,677
Rhode Island	--	--	W	W
Texas	--	--	211	903
Utah	87	333	(1)	2
Vermont	--	--	W	W
Virginia	--	--	W	W
Washington	W	W	W	W
Wyoming	--	--	W	W
Other	685	3,004	1,378	4,670
Total[2]	1,830	9,150	10,080	39,910

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Less than 1/2 unit.
[2]Data do not add to totals shown because of independent rounding.

Table 10.—Kind of crushed stone produced in the United States in 1983, by State

State	Limestone	Dolomite	Marble	Marl	Shell	Granite
Alabama	X	X	X			X
Alaska	X				X	X
Arizona	X	X	X			X
Arkansas	X	X				X
California	X	X			X	X
Colorado	X					X
Connecticut	X					
Florida	X	X		X	X	
Georgia	X	X	X			X
Hawaii	X					
Idaho	X					X
Illinois	X	X				
Indiana	X	X		X		
Iowa	X					
Kansas	X					
Kentucky	X					

State	Traprock	Sandstone	Quartzite	Slate	Volcanic cinder and scoria	Miscellaneous
Alabama						
Alaska	X					X
Arizona		X			X	X
Arkansas		X		X		X
California	X	X	X	X	X	X
Colorado	X	X			X	X
Connecticut	X					
Florida						
Georgia			X	X		
Hawaii	X				X	
Idaho	X	X	X			
Illinois						
Indiana						
Iowa						
Kansas		X	X			X
Kentucky		X				

Table 10.—Kind of crushed stone produced in the United States in 1983, by State—Continued

State	Limestone	Dolomite	Marble	Marl	Shell	Granite	Traprock	Sandstone	Quartzite	Slate	Volcanic cinder and scoria	Miscellaneous
Louisiana					X							X
Maine	X			X			X	X				
Maryland	X				X	X	X	X	X			X
Massachusetts	X					X	X					X
Michigan	X	X		X			X	X				X
Minnesota	X	X				X	X	X	X			
Mississippi	X											
Missouri	X	X	X			X		X				
Montana	X		X				X	X	X			
Nebraska	X											
Nevada	X	X				X					X	X
New Hampshire						X	X					
New Jersey	X					X	X					
New Mexico	X					X	X		X		X	
New York	X	X				X	X	X				X
North Carolina	X			X		X	X		X	X		
Ohio	X	X						X	X			
Oklahoma	X	X				X		X				X
Oregon	X					X	X	X			X	X
Pennsylvania	X	X	X			X	X	X				X
Rhode Island	X					X						X
South Carolina	X			X		X						
South Dakota	X							X	X			
Tennessee	X	X	X			X						
Texas	X	X	X	X		X	X	X				X
Utah	X	X						X	X	X	X	X
Vermont	X		X			X						X
Virginia	X	X				X	X	X		X		X
Washington	X	X				X	X	X	X		X	X
West Virginia	X							X				
Wisconsin	X	X				X	X	X				
Wyoming	X	X				X						X
Guam	X											
Puerto Rico	X		X			X	X					X
Virgin Islands							X					X

CONSUMPTION AND USES

Crushed stone production reported to the Bureau of Mines is actually material "sold or used" by the producers. Stockpiled production is not reported. Because some of the crushed stone producers did not report a breakdown by end use, their total production as well as the estimated production of nonrespondents was included this year in "Other uses." This change in reporting procedure should be taken into account when comparing 1983 data on use patterns with that of prior years.

U.S. consumption of crushed stone was 863 million tons valued at $3.3 billion, a 9% increase over the estimated consumption of 1982, and a decrease of 1% from the 1981 total. About 65% of this tonnage was used as construction aggregates, mostly for highway and road construction and maintenance, 12% for cement and lime manufacturing, 2% for agricultural purposes, 1% for metallurgical purposes, 2% for a variety of industrial uses, and 18% for other unspecified uses.

Limestone.—Of the 600 million tons of crushed limestone consumed, 59% was used as construction aggregates, 17% for cement and lime manufacturing, and 3% for agricultural purposes. No significant changes occurred in the use patterns of crushed limestone at the national level, except the large increase of the amount included in "Other uses," owing to the implementation of new reporting procedures.

Because the format of table 12 that shows the production of crushed limestone and dolomite by major uses in each State has been modified to reflect changes implemented in the survey form, a comparison of the 1981 and 1983 use pattern for construction purposes at the State level cannot be made.

U.S. consumption of crushed limestone and dolomite for lime manufacturing decreased 22% from that of 1981. At the State level, Alabama and Kentucky showed an increase, while Michigan and Texas showed a decrease in the consumption for this use. Consumption of crushed limestone and dolomite for cement manufacturing decreased 14% from that of 1981. Of the major limestone- and dolomite-producing States for cement manufacturing, Alabama, Florida, and Illinois showed increases in consumption, while California, Michigan, Missouri, New York, Pennsylvania, and Texas showed decreases.

Dolomite.—Of the 24 million tons of crushed dolomite consumed, 76% was used as construction aggregates and 13% was used for metallurgical purposes. An additional amount of dolomite consumed in a variety of uses is reported with the limestone.

Marble.—Most of the crushed marble was used as construction aggregate road material and fillers and extenders. No significant change in the end-use pattern of crushed marble occurred.

Calcareous Marl.—Of the 3.5 million tons of calcareous marl consumed, 96% was used for cement manufacturing and 3% was used in agriculture. No significant changes in use pattern occurred.

Shell.—Of the 8.3 million tons of crushed shell sold, 81% was used as construction aggregates, mostly for roads, and 8% was used for cement and lime manufacturing. No significant changes in use pattern occurred.

Granite.—Of the 117 million tons of crushed granite consumed, 77% was used as construction aggregates and 8% was used as railroad ballast. Compared with 1981, consumption of construction aggregates increased 5%, while railroad ballast decreased 25%.

Traprock.—Of the 74 million tons of crushed traprock consumed, 76% was used as construction aggregates and 4% was used as railroad ballast.

Sandstone and Quartzite.—Of the 21 million tons of crushed sandstone and quartzite sold or used, the use pattern was construction aggregates, 50%; railroad ballast, 2%; and cement and lime manufacturing, 2%. Beginning with this report, statistical data on the uses of sandstone and quartzite are shown separately.

Slate.—Of the 713,000 tons of slate sold, the partial use pattern was construction aggregates, 86%; filter stone, 3%; and roofing granules, 2%.

Volcanic Cinder and Scoria.—Of the 1.8 million tons of volcanic cinder and scoria consumed, 53% was used as construction aggregates, mainly for road construction and maintenance, and 6% was used as railroad ballast.

Miscellaneous Stone.—Of the 10 million tons of miscellaneous crushed stone consumed, 98% was used as construction aggregates, mainly for road construction and maintenance.

Table 11.—Crushed stone sold or used by producers in the United States in 1983, by use

(Thousand short tons and thousand dollars)

Use	Quantity	Value
Coarse aggregate (+1-1/2 inch):		
Macadam	16,768	58,498
Riprap and jetty stone	19,802	79,487
Filter stone	3,541	15,696
Other coarse aggregate	2,075	9,040
Coarse aggregate, graded:		
Concrete aggregate, coarse	97,000	393,840
Bituminous aggregate, coarse	60,753	259,994
Bituminous surface treatment aggregate	22,614	95,917
Railroad ballast	22,142	81,420
Other graded coarse aggregate	10,074	59,708
Fine aggregate (-3/8 inch):		
Stone sand, concrete	13,049	59,967
Stone sand, bituminous mix or seal	12,089	48,586
Screening, undesignated	13,631	49,926
Other fine aggregate	13,764	56,484
Coarse and fine aggregate:		
Graded road base or subbase	150,906	496,220
Unpaved road surfacing	54,747	197,624
Terrazzo and exposed aggregate	815	7,004
Crusher run or fill or waste	37,527	124,334
Other coarse and fine aggregate	9,827	39,144
Other construction materials[1]	147	551
Agricultural:		
Agricultural limestone	18,682	89,196
Poultry grit and mineral food	1,869	18,468
Other agricultural uses	697	2,997
Chemical and metallurgical:		
Cement manufacture	82,567	242,377
Lime manufacture	21,442	86,575
Dead-burned dolomite manufacture	1,518	6,294
Ferrosilicon	44	W
Flux stone	8,546	39,594
Chemical stone	1,148	4,909
Glass manufacture	1,516	12,085
Sulfur oxide removal	1,616	6,009
Special:		
Mine dusting or acid water treatment	905	11,700
Asphalt fillers or extenders	1,260	9,729
Whiting or whiting substitute	931	21,208
Other fillers or extenders	3,618	60,983
Lightweight aggregate	428	4,883
Roofing granules	1,457	7,973
Sugar refining	548	2,785
Other uses[2]	152,671	576,051
Total[3]	862,700	3,337,000

W Withheld to avoid disclosing company proprietary data; included with "Special: Other uses."

[1]Includes building products, drain fields, and bedding materials.

[2]Includes refractory stone, abrasives, acid neutralization, chemicals, paper manufacture, and uses not specified.

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

Table 12.—Crushed limestone and dolomite sold or used by

(Thousand short tons

State	Concrete aggregate		Bituminous aggregate		Roadstone and coverings		Riprap and railroad ballast	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	3,879	15,631	2,474	9,563	2,699	9,871	1,237	3,981
Alaska	--	--	--	--	809	3,802	--	--
Arizona	--	--	--	--	94	350	W	3,636
Arkansas	55	215	357	1,324	322	1,233	682	2,467
California	622	3,012	--	--	764	5,725	6	17
Colorado	1	5	--	--	22	85	7	33
Connecticut	--	--	--	--	--	--	--	--
Florida	20,692	92,593	7,425	47,489	12,969	33,580	499	2,777
Georgia	1,731	7,303	99	452	700	3,022	W	W
Hawaii	199	2,378	--	--	121	622	--	--
Idaho	--	--	--	--	--	--	--	--
Illinois	3,782	13,720	5,514	21,497	15,212	50,559	2,436	9,020
Indiana	1,958	6,820	5,397	18,354	4,255	14,459	1,176	3,925
Iowa	1,535	7,379	5,133	21,953	5,195	18,824	187	722
Kansas	2,018	7,835	1,707	7,203	2,910	9,371	258	958
Kentucky	W	W	W	W	W	W	W	W
Maine	W	W	W	W	W	W	W	W
Maryland	2,370	7,974	2,077	8,002	4,402	15,853	203	951
Massachusetts	--	--	W	W	W	W	--	--
Michigan	2,459	5,809	934	2,767	2,854	8,539	378	1,065
Minnesota	274	742	356	1,084	2,737	7,493	195	612
Mississippi	W	W	W	W	W	W	W	W
Missouri	2,497	8,594	2,638	9,606	8,702	25,891	3,994	9,402
Montana	--	--	--	--	--	--	5	19
Nebraska	523	2,832	362	1,627	2,145	12,548	190	998
Nevada	--	--	--	--	--	--	--	--
New Mexico	508	1,394	562	1,857	853	1,935	12	28
New York	2,178	7,906	5,462	32,771	5,650	22,343	516	2,456
North Carolina	794	3,747	W	W	1,252	5,817	5	37
Ohio	4,060	13,325	3,443	12,777	10,645	35,712	1,345	4,280
Oklahoma	4,500	17,857	2,574	10,718	4,717	11,587	885	4,027
Pennsylvania	6,450	27,932	5,778	24,936	10,065	38,062	379	1,478
Rhode Island	--	--	--	--	--	--	--	--
South Carolina	W	W	W	W	914	3,500	--	--
South Dakota	53	268	--	--	34	W	8	32
Tennessee	W	W	W	W	W	W	W	W
Texas	13,116	45,549	4,426	17,140	24,493	59,427	662	2,312
Utah	--	--	--	--	100	184	W	W
Vermont	W	W	W	W	--	W	W	W
Virginia	2,850	11,440	2,307	10,241	2,863	9,747	644	1,987
Washington	3	W	--	--	4	W	61	W
West Virginia	711	3,006	550	3,157	933	4,156	83	341
Wisconsin	726	2,304	799	2,370	5,744	13,836	127	576
Wyoming	403	1,466	W	W	130	501	W	W
Total (excluding withheld)[1]	80,949	319,036	60,374	266,888	135,309	428,637	16,180	58,137
Total withheld	12,457	45,828	11,634	45,904	17,578	60,380	4,579	12,981
Grand total[1]	93,406	364,863	72,008	312,790	152,889	489,020	20,759	71,119
Guam	160	1,134	W	W	71	439	--	--
Puerto Rico	831	3,807	29	135	W	W	W	18

W Withheld to avoid disclosing company proprietary data; included with "Total withheld" and "Other uses."
[1]Data may not add to totals shown because of independent rounding.

producers in the United States in 1983, by State and use

and thousand dollars)

Other construction uses		Cement manufacture		Agricultural uses		Lime manufacture		Other uses		Total[1]	
Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1,835	7,405	3,821	19,936	760	3,612	1,945	7,235	1,039	3,776	19,691	81,010
--	--	--	--	--	--	--	--	--	--	809	3,802
W	W	W	W	--	--	W	W	3,517	14,064	3,611	18,050
75	190	1,027	2,003	161	1,099	797	2,008	1,605	6,433	5,079	16,973
46	2,366	10,502	35,688	35	723	W	W	1,748	18,418	13,725	65,951
--	--	W	W	--	--	W	W	2,824	7,366	2,854	7,489
W	W	W	W	25	W	W	W	289	3,252	315	3,253
3,658	15,054	3,663	15,598	683	2,878	W	W	4,953	18,460	54,543	228,428
105	386	1,522	4,816	371	2,446	--	--	92	473	4,619	18,899
57	303	486	1,812	21	156	W	W	33	123	918	5,394
--	--	W	W	39	117	--	--	252	755	291	872
510	1,705	2,829	7,780	2,970	12,913	--	--	9,509	49,666	42,761	166,860
668	2,319	2,770	8,352	1,961	7,519	--	--	5,855	21,024	24,041	82,770
1,656	5,534	2,245	5,991	2,079	12,457	W	W	6,815	28,238	24,844	101,097
1,363	5,748	2,036	5,229	455	1,761	W	W	1,027	4,010	11,776	42,113
W	W	W	W	W	W	W	W	W	W	W	W
--	--	W	W	--	--	--	--	518	1,898	518	1,898
541	1,888	2,275	4,351	W	W	14	53	774	9,771	12,656	48,844
--	--	--	--	W	W	W	W	W	W	W	W
224	688	5,231	11,631	426	1,608	4,999	18,537	7,164	31,333	24,669	81,977
167	414	--	--	337	1,220	W	W	2,141	6,629	6,206	18,194
W	W	W	W	280	1,123	--	--	1,370	3,254	1,651	4,377
762	2,516	4,300	9,381	1,547	7,289	211	620	12,947	43,364	37,598	116,662
--	--	W	W	--	--	W	W	738	1,950	743	1,969
329	1,486	W	W	241	2,569	--	--	1,849	7,987	5,641	30,047
--	--	W	W	W	W	439	1,575	597	2,718	1,036	4,293
306	389	W	W	--	--	W	W	675	2,506	2,916	8,110
2,927	10,307	W	W	283	1,841	--	--	11,677	41,910	28,693	119,532
W	W	--	--	W	W	--	--	2,516	12,020	4,567	21,621
1,838	5,489	1,656	7,062	1,070	4,579	723	2,001	8,094	28,633	32,874	113,857
2,178	7,279	1,633	2,664	60	252	--	--	6,342	19,566	22,889	73,949
2,171	9,334	5,880	20,529	1,799	14,429	2,547	15,346	7,288	37,598	42,358	189,644
W	W	--	--	W	W	--	--	W	W	W	W
--	--	--	--	W	W	--	--	2,075	8,699	2,989	12,199
17	50	722	W	--	--	--	--	2,040	7,279	2,874	7,630
W	W	W	W	W	W	W	W	W	W	W	W
3,316	9,638	9,043	19,190	366	1,445	1,262	6,874	17,841	68,744	74,526	230,319
--	--	1,380	5,540	W	W	731	3,283	1,839	4,522	4,050	13,529
W	W	--	--	--	--	--	--	1,025	4,147	1,025	4,147
1,949	6,132	1,280	2,038	901	7,015	462	2,770	2,351	10,789	15,609	62,159
10	W	W	W	W	W	461	W	874	3,790	1,414	3,790
464	1,776	W	W	50	380	W	W	5,560	20,819	8,350	33,635
554	1,184	--	--	589	3,439	184	655	2,440	6,690	11,165	31,055
10	38	206	433	--	--	--	--	681	2,573	1,430	5,011
27,736	99,618	64,507	190,024	17,509	92,870	14,775	60,957	140,974	565,247	558,324	2,081,409
6,551	22,903	14,094	42,993	3,403	16,069	7,646	30,385	XX	XX	XX	XX
34,288	122,520	78,604	233,017	20,914	108,941	22,422	91,340	XX	XX	624,500	2,329,000
5	35	--	--	--	--	--	--	93	585	329	2,192
--	--	W	W	--	--	--	--	2,715	14,413	3,574	18,373

XX Not applicable.

Table 13.—Crushed limestone and dolomite sold or used by producers in the United States in 1983, by use

(Thousand short tons and thousand dollars)

Use	Limestone		Dolomite	
	Quantity	Value	Quantity	Value
Coarse aggregate (+1-1/2 inch):				
Macadam	13,118	43,735	136	480
Riprap and jetty stone	11,455	37,006	446	1,970
Filter stone	2,361	10,574	78	305
Other coarse aggregate	936	3,090	W	60
Coarse aggregate, graded:				
Concrete aggregate, coarse	70,463	270,133	3,056	11,313
Bituminous aggregate, coarse	36,643	149,533	2,701	12,824
Bituminous surface treatment aggregate	16,569	68,230	740	2,944
Railroad ballast	6,925	25,145	1,933	6,997
Other graded coarse aggregate	6,716	42,174	W	W
Fine aggregate (-3/8 inch):				
Stone sand, concrete	8,441	39,041	1,049	4,326
Stone sand, bituminous mix or seal	6,567	25,091	767	2,463
Screening, designated	6,978	24,498	399	1,481
Other fine aggregate	10,314	39,827	83	222
Coarse and fine aggregate:				
Graded road base or subbase	100,478	303,726	3,275	11,447
Unpaved road surfacing	32,991	119,657	1,935	6,825
Terrazzo and exposed aggregate	180	2,672	51	447
Crusher run or fill	16,625	53,884	1,400	4,689
Other coarse and fine aggregate	5,656	19,538	150	W
Other construction materials	90	305	--	--
Agricultural:				
Agricultural limestone	17,046	79,947	1,636	9,250
Poultry grit and mineral food	1,679	17,344	W	W
Other agricultural uses	493	1,966	W	W
Chemical and metallurgical:				
Cement manufacture	78,604	233,017	--	--
Lime manufacture	20,629	83,793	274	1,254
Dead-burned dolomite manufacture	750	4,188	768	2,106
Flux stone	5,776	25,682	2,371	10,558
Chemical stone	1,142	4,883	W	W
Glass manufacture	1,315	9,669	W	W
Sulfur oxide removal	1,616	6,009	--	--
Special:				
Mine dusting or acid water treatment	841	10,718	64	981
Asphalt fillers or extenders	980	7,140	198	1,916
Whiting or whiting substitute	685	17,157	--	--
Other fillers or extenders	2,585	40,151	93	1,378
Abrasives	W	W	--	--
Roofing granules	153	1,657	182	1,987
Sugar refining	548	2,785	--	--
Paper manufacture	W	W	--	--
Other uses	111,972	403,216	439	3,969
Total[1]	600,300	2,227,000	24,230	102,200

W Withheld to avoid disclosing company proprietary data; included with "Special: Other uses."
[1]Data do not add to totals shown because of independent rounding.

Table 14.—Crushed marble sold or used by producers in the United States in 1983, by use

(Thousand short tons and thousand dollars)

Use	Quantity	Value
Other agricultural uses	53	W
Stone sand, concrete	W	15
Terazzo and exposed aggregate	31	432
Other construction and maintenance uses[1]	313	1,647
Whiting or whiting substitute	246	4,050
Other[2]	978	21,942
Total[3]	1,620	28,090

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes concrete aggregate (coarse), graded road base or subbase, bituminous surface treatment aggregate, unpaved road surfacing, riprap and jetty stone, railroad ballast, and crusher run (select material or fill).
[2]Includes poultry grit and mineral food, stone sand, and fillers and extenders.
[3]Data do not add to totals shown because of independent rounding.

Table 15.—Crushed granite and traprock sold or used by producers in the United States in 1983, by use

(Thousand short tons and thousand dollars)

Use	Granite		Traprock	
	Quantity	Value	Quantity	Value
Coarse aggregate (+1-1/2 inch):				
Macadam	2,018	8,131	1,448	6,029
Riprap and jetty stone	3,117	17,555	2,529	10,775
Filter stone	609	2,606	342	1,512
Other coarse aggregate	118	328	862	5,177
Coarse aggregate, graded:				
Concrete aggregate, coarse	16,073	76,843	5,768	27,322
Bituminous aggregate, coarse	13,700	62,763	6,000	27,090
Bituminous surface treatment aggregate	2,564	12,702	1,881	7,933
Railroad ballast	9,707	36,047	2,866	10,212
Other graded coarse aggregate	927	3,630	2,254	13,110
Fine aggregate (-3/8 inch):				
Stone sand, concrete	2,319	9,800	811	4,028
Stone sand, bituminous mix or seal	2,993	11,934	1,037	4,210
Screening, undesignated	5,171	19,194	686	3,448
Other fine aggregate	840	3,333	1,584	8,863
Coarse and fine aggregate:				
Graded road base or subbase	23,016	91,585	14,538	53,116
Unpaved road surfacing	2,486	9,739	10,353	34,174
Terrazzo and exposed aggregate	326	1,150	11	31
Crusher run or fill	12,472	44,903	3,587	11,227
Bedding material	--	--	28	112
Other coarse and fine aggregate	1,252	4,334	2,484	13,893
Special:				
Asphalt fillers or extenders	57	604	26	69
Roofing granules	W	W	774	2,436
Agricultural uses	W	W	W	W
Other uses	17,102	71,179	14,151	60,779
Total[1]	116,900	488,400	74,020	305,500

W Withheld to avoid disclosing company proprietary data; included with "Special: Other uses."
[1]Data may not add to totals shown because of independent rounding.

Table 16.—Crushed sandstone and quartzite sold or used by producers in the United States in 1983, by use

(Thousand short tons and thousand dollars)

Use	Sandstone		Quartzite	
	Quantity	Value	Quantity	Value
Coarse aggregate (+1-1/2 inch):				
Macadam	(1)	(1)	(1)	(1)
Riprap and jetty stone	1,110	4,600	154	661
Filter stone	47	215	(1)	(1)
Other coarse aggregate	35	106	22	148
Coarse aggregate, graded:				
Concrete aggregate, coarse	1,000	4,859	(2)	(2)
Bituminous aggregate, coarse	991	4,532	303	1,381
Bituminous surface treatment aggregate	407	1,961	64	392
Railroad ballast	195	991	(2)	(2)
Other graded coarse aggregate	15	60	787	3,808
Fine aggregate (-3/8 inch):				
Stone sand, concrete	211	1,191	(3)	(3)
Stone sand, bituminous mix or seal	454	2,363	56	344
Screening, undesignated	297	764	21	125
Other fine aggregate	265	2,120	116	857
Coarse and fine aggregate:				
Graded road base or subbase	2,815	10,862	484	2,078
Unpaved road surfacing	1,740	6,186	(4)	(4)
Terrazzo and exposed aggregate	20	272	--	--
Crusher run or fill	1,874	5,799	(4)	(4)
Other coarse and fine aggregate	106	257	13	51
Chemical and metallurgical:				
Cement manufacture	201	477	183	901
Lime manufacture	(5)	(5)	--	--
Ferrosilicon	7	(5)	37	(5)
Flux stone	(5)	(5)	391	3,333
Refractory stone	--	--	(5)	(5)
Special:				
Other fillers or extenders	--	--	(5)	(5)
Other agricultural uses	--	--	(5)	(5)
Other uses	6,402	23,941	437	2,333
Total[6]	18,190	71,560	3,068	16,410

[1]Included with "Other coarse aggregate."
[2]Included with "Other graded coarse aggregate."
[3]Included with "Other fine aggregate."
[4]Included with "Other coarse and fine aggregate."
[5]Included with "Special: Other uses."
[6]Data may not add to totals shown because of independent rounding.

Table 17.—Crushed slate sold or used by producers in the United States in 1983, by use

(Thousand short tons and thousand dollars)

Use	Quantity	Value
Graded road base or subbase	9	18
Unpaved road surfacing	1	2
Other fillers or extenders	5	40
Other construction uses[1]	272	709
Other[2]	425	6,839
Total[3]	700	7,600

[1]Includes bituminous aggregate (coarse), bituminous surface treatment aggregate, riprap and jetty stone, filter stone, and crusher run (select material or fill).
[2]Includes lightweight aggregate, roofing granules, and uses not specified.
[3]Data do not add to totals shown because of independent rounding.

Table 18.—Crushed volcanic cinder sold or used by producers in the United States in 1983, by use

(Thousand short tons and thousand dollars)

Use	Quantity	Value
Coarse aggregate, large	123	321
Concrete aggregate, coarse	49	221
Railroad ballast	110	231
Coarse aggregate, graded	36	260
Fine aggregate	3	34
Graded road base or subbase	141	529
Unpaved road surfacing	420	983
Terrazzo and exposed aggregate	181	1,885
Combined coarse and fine aggregate	3	3
Other construction and maintenance uses[1]	132	848
Other fillers or extenders	40	W
Roofing granules	13	52
Other[2]	580	3,782
Total[3]	1,830	9,150

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

[1]Includes riprap and jetty stone, filter stone, bituminous aggregate (coarse), stone sand (concrete), crusher run (select material or fill), stone sand (bituminous mix or seal), and undesignated screenings.

[2]Includes other agricultural uses, cement manufacture, and lightweight aggregate.

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

Table 19.—Crushed miscellaneous stone sold or used by producers in the United States in 1983, by use

(Thousand short tons and thousand dollars)

Use	Quantity	Value
Riprap and jetty stone	688	3,972
Filter stone	47	197
Coarse aggregate, large	1	3
Concrete aggregate, coarse	70	340
Bituminous aggregate, coarse	272	1,430
Bituminous surface treatment aggregate	28	194
Stone sand, concrete	23	125
Stone sand, bituminous mix or seal	212	2,174
Screening, undesignated	65	340
Graded road base or subbase	2,504	7,834
Unpaved road surfacing	3,334	14,887
Crusher run, select natural or fill	744	2,183
Other construction and maintenance uses[1]	457	1,804
Other[2]	1,632	4,429
Total[3]	10,080	39,910

[1]Includes macadam aggregate, railroad ballast, terrazzo and other exposed aggregate, fine aggregate, and combined coarse and fine aggregate.

[2]Includes cement manufacture and roofing granules.

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

PRICES

The average price of crushed stone increased 8% to $3.87 per ton, f.o.b. quarry. By kind of stone, the average unit prices showed increases of 3% for traprock, 8% for limestone, 9% for granite, and 12% for sandstone and quartzite, and decreases of 13% for shell and 18% for marble.

TRANSPORTATION

Of the total crushed stone produced, 84% was transported by truck from the plant or quarry to the site of the first point of sale or use, 6% was transported by rail, and 5% by waterway. No information regarding the distance to which crushed stone was shipped or cost per ton per mile was available.

Table 20.—Crushed stone sold or used by producers in the United States in 1983, by method of transportation

Method of transportation	Quantity (thousand short tons)	Percent
Truck	724,463	84
Rail	53,253	6
Water	38,361	5
Other	46,660	5
Total	[1]862,700	100

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

FOREIGN TRADE

Exports.—Exports of crushed stone increased 17% to 2.4 million tons and the value increased 21% to $23 million; of this, 95% was limestone, of which 98% went to Canada.

Exports of quartzite decreased 85% to 7,000 tons valued at $1.9 million.

Imports.—Imports of crushed stone increased 44% to 2.7 million tons but decreased 10% in value to $14.8 million. About 51% of this tonnage was limestone, 97% of which came from Canada.

Imports of calcium carbonate fines increased 104% to 392,000 tons; of this, 95% came from The Bahamas.

Table 21.—Exports of crushed stone, by destination

(Thousand short tons unless otherwise specified)

Destination	Quartzite		Limestone[1]		Other		Total[2]	
	1982	1983	1982	1983	1982	1983	1982	1983
North America:								
Canada	1	3	1,867	2,244	70	77	1,937	2,324
Mexico	([3])	--	([3])	--	9	19	10	19
Other	--	--	2	--	2	--	4	--
Total[2]	1	3	1,869	2,244	82	96	1,952	2,343
South America:								
Venezuela	([3])	--	43	39	1	1	44	40
Other	([3])	--	([3])	3	([3])	4	([3])	7
Total	([3])	--	43	42	1	5	44	47
Europe:								
France	2	1	--	--	7	2	9	3
Netherlands	40	1	--	--	([3])	--	40	1
Switzerland	--	--	--	3	--	--	--	3
United Kingdom	([3])	([3])	6	--	1	6	7	6
Other	1	2	([3])	([3])	2	([3])	3	2
Total[2]	43	3	7	4	10	9	60	16
Asia	3	1	([3])	--	4	3	6	6
Oceania	([3])	--	1	1	([3])	1	2	2
Middle East and Africa	([3])	--	([3])	--	1	--	1	1
Grand total[2]	47	7	1,921	2,291	97	115	2,065	2,413
Total value thousands	$2,382	$1,884	$12,083	$14,837	$4,561	$6,300	$19,026	$23,021

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

Table 22.—U.S. imports for consumption of crushed stone and calcium carbonate fines, by type

(Thousand short tons and thousand dollars)

Type	1982		1983	
	Quantity	Customs value	Quantity	Customs value
Crushed stone and chips:				
Limestone	1,383	8,356	1,367	7,952
Marble, breccia	4	318	29	310
Quartzite	26	317	12	245
Slate	--	4	--	2
Other	250	1,575	869	2,200
Total	[1]1,664	10,570	2,277	10,709
Calcium carbonate fines:				
Chalk, natural crude	175	953	375	943
Chalk, whiting	9	1,669	9	958
Precipitated	9	3,189	8	2,203
Total	[1]192	5,811	392	4,104
Grand total	1,856	[1]16,382	2,669	14,813

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

WORLD REVIEW

In November, a National Stone Center was officially opened at Wirksworth, Derbyshire, the United Kingdom. The center is located in England's largest stone-producing county and will be developed on the site of six abandoned quarries known as the Colehill Complex. The center will be an information source for the public and all entities connected with the stone industry. It will provide a variety of services including references for technical, trade, and historical information and research facilities for studies on new technology, management, trade, planning, conservation, and safety. The center will also house the headquarters of the main trade federations associated with the stone industry. A stone trade center is also planned to be developed later.[7]

Stone production in 1982 in Canada was 59.2 million tons, valued at $263 million; about 95% of this output was crushed stone. The Province of Quebec continued to be the largest producer with 26.5 million tons valued at $111 million, followed closely by Ontario with 25 million tons valued at $102 million. Preliminary estimates for 1983 production indicated an increase of 5% to 62 million tons valued at $269 million, with the Province of Quebec accounting for about 45% of the total.

TECHNOLOGY

Three technology transfer seminars on surface mining equipment were organized by the Bureau of Mines. The purpose of these seminars was to disseminate information on recent advances in mining health and safety technology related to the use and maintenance of large mobile surface mining equipment.[8]

A new cost-effective approach to the mapping of overburden thickness using computer-assisted geophysical techniques was implemented by Dunn Geoscience Corp.[9] Although geophysical techniques had been used in mineral exploration for many years, recent technologic advances had increased speed, reduced cost, and expanded the range of geophysical mapping applications.

The National Crushed Stone Association, the American Society of Landscape Architects, and the National Sand and Gravel Association cosponsored the First Landscape Architecture Student Competition in which various methods for reclaiming crushed stone and sand and gravel sites were proposed. The first-, second-, and third-place entries were won by Michigan State University, Colorado State University, and the University of Pennsylvania, respectively.[10]

Quazite Corp. of Houston, TX, a subsidiary of Lone Star Industries and Shell Oil Corp., formed a joint venture to manufacture and market a new construction material brand named "Quazite." The product is a composite material made from selectively graded aggregates and high-performance polymers and monomers through a patented process. The material is impermeable and has high bending strength, good chemical resistance, and dielectric properties. It has a wide range of applications in construction, transportation, telecommunications, and specialty item manufacturing as a precast or cast-in-place product.[11]

A series of articles on blasting techniques that review problems facing quarry operators in today's congested areas was published by the Rock Products magazine. Problems analyzed included blasting vibrations, airblast, the importance of quarry site geology in selecting blasting methods, and the characteristics of blasting agents and their most effective use in different environments.[12]

The provisions of the 1970 Clean Air Act and the 1977 amendments that established stringent standards for sulfur oxides emissions in the atmosphere, mostly resulting from burning high-sulfur-content coals, had significantly increased the volume of research in this area. A new "dual alkali" fluegas-desulfurization process, using limestone instead of more expensive lime, was tested at Northern Indiana Public Service Co.'s Schahfer Station near Wheatfield, IN. The process had been developed by FMC Corp. The $2 million field demonstration was supported by FMC, the Electric Power Research Institute of Palo Alto, CA, and three midwestern utility companies.[13]

A $68 million, 20-megawatt atmospheric fluidized-bed combustion (AFBC) pilot plant was dedicated by the Tennessee Valley Authority at Paducah, KY. The pilot plant, operated in cooperation with the Electric Power Research Institute, was to run in a 4-year test program to determine the feasibility of the use of AFBC on a scale required by the electric utilities.[14]

Several articles on crushed stone mining and processing, underground mining, quarry automation, and use of computers were published.[15]

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[1]Physical scientist, Division of Industrial Minerals.

[2]Block, F. Estimated Impact of the Surface Transportation Assistance Act of 1982 on the Demand for Road Construction Aggregate. BuMines Minerals & Materials—A Bimonthly Survey. June-July 1983, pp. 35-43.

[3]Rock Products. Rock Newscope. V. 86, No. 10, Oct. 1983, p. 9.

[4]———. Rock Newscope. V. 86, No. 11, Nov. 1983, p. 9.

[5]Pit and Quarry. Industry News. V. 75, No. 7, Jan. 1983, p. 19.

[6]Industrial Minerals (London). World of Minerals. No. 186, Mar. 1983, p. 17.

[7]———. World of Minerals. No. 196, Jan. 1984, p. 14.

[8]U.S. Bureau of Mines. Safety in the Use and Maintenance of Large Mobile Surface Mining Equipment. Proceedings: Bureau of Mines Technology Transfer Seminars, Tucson, AZ, August 16, 1983, Denver, CO, August 18, 1983, and St. Louis, MO, August 23, 1983. BuMines IC 8947, 1983, 97 pp.

[9]Peffer, J. R., and P. G. Robelen. Affordable: Overburden Mapping Using New Geophysical Techniques. Pit & Quarry, v. 76, No. 2, Aug. 1983, pp. 70-74.

[10]Weber, K. NSGA Sponsors First Landscape Architecture Student Competition for Sand and Gravel Operators. Rock Prod., v. 86, No. 7, July 1983, pp. 32-33.

[11]Quazite Corp. Quazite. A New Class of Engineered Materials, 1983, pp. 1-10.

[12]Borg, D. G. Some Pointers on Blasting Techniques. Rock Prod., v. 86, No. 2, Feb. 1983, pp. 26-28.

[13]Chemical Engineering. V. 91, No. 11, May 28, 1984, p. 18.

[14]Robertson, J. L. Fluidized Bed Pilot Plant Starts Four-Year Test Program. Rock Prod., v. 86, No. 9, Sept. 1983, p. 22.

[15]Buckley, S. Industrial Mineral Processing-Crushing and Grinding. Ind. Miner. (London), No. 189, June 1983, pp. 55-75.

Industrial Minerals (London). Screening and Classification. No. 190, July 1983, pp. 45-55.

Dimension Stone

By Harold A. Taylor, Jr.[1]

Production of dimension stone decreased significantly, 11%, to 1.19 million short tons valued at $150 million after showing little change over the previous 5 years. One-half of the dimension stone produced was granite. Limestone, sandstone, slate, and marble were also produced.

Exports of dimension stone increased 13% in value to $21 million. The value of dimension stone imports increased 15% to $195 million, equivalent to 130% of the value of domestic production.

Domestic Data Coverage.—Domestic production data for dimension stone were developed by the Bureau of Mines from voluntary surveys of U.S. producers of rough and finished dimension stone. Of the 402 dimension stone operations surveyed, including those that were idle, 295, or 73%, responded, representing 91% of the total value shown in table 1. Production data for nonrespondents were estimated using preliminary production reports, adjusted prior years production levels, and employment data.

Table 1.—Salient U.S. dimension stone statistics

(Thousand short tons and thousand dollars)

	1979	1980	1981	1982	1983
Sold or used by producers[1]	1,350	1,315	1,331	[e]1,330	1,186
Value[1]	$122,800	$138,900	$150,463	[e]$145,113	$149,483
Exports (value)	$17,300	$15,170	$20,698	$18,678	$21,185
Imports for consumption (value)	$65,800	$88,900	$132,904	[r]$169,874	$195,378

[e]Estimated. [r]Revised.
[1]Does not include American Samoa, Guam, Puerto Rico, and the Virgin Islands.

DOMESTIC PRODUCTION

Dimension stone was produced by 217 companies at 300 quarries in 39 States. Leading States, in order of tonnage, were Georgia, Indiana, and Vermont, producing together 39% of the Nation's total. Notable was a 27% decrease in Georgia and a 41% decrease in Vermont. Of the total production, 52% was granite, 21% was limestone, 12% was sandstone, 4% was slate, and 3% was marble. Leading producer companies were Rock of Ages Corp. in Vermont and New Hampshire and Cold Spring Granite Co., principally in California, Minnesota, South Dakota, and Texas.

Granite.—Dimension granite includes all coarse-grained igneous rocks. Production decreased 9% to about 616,000 tons, and increased 13% in value to $88.9 million. Dimension granite was produced by 78 companies at 117 quarries in 22 States. Georgia continued to be the leading State producing 29% of the U.S. total, followed by Vermont and North Carolina. These three States together produced over one-half of the U.S. total. Of significance were production decreases of 29% and 46% in Georgia and New Hampshire, respectively, while North Carolina registered a 230% production increase to become the second leading State. Leading producer companies were Rock

Table 2.—Dimension stone[1] sold or used by producers in the United States, by State

State	1982[e] Quantity (short tons)	1982[e] Cubic feet (thousands)	1982[e] Value (thousands)	1983 Quantity (short tons)	1983 Cubic feet (thousands)	1983 Value (thousands)
Alabama	8,415	107	$2,341	7,385	96	$2,661
Arizona	W	W	580	45	1	1
Arkansas	4,570	57	290	9,114	114	573
California	29,148	355	1,895	20,321	245	2,839
Colorado	761	9	64	899	11	86
Connecticut	19,786	229	1,046	18,178	215	1,028
Georgia	271,104	2,809	18,510	197,864	1,898	21,672
Hawaii	432	5	4	330	4	3
Illinois	1,500	17	98	1,836	22	71
Indiana	135,217	1,840	13,337	144,478	1,866	11,015
Kansas	10,771	144	395	W	W	W
Maryland	32,477	419	1,001	12,193	149	682
Massachusetts	51,315	733	9,158	50,780	612	10,488
Michigan	4,488	55	110	4,307	53	112
Minnesota	40,091	480	11,940	27,651	337	11,365
New Hampshire	107,000	1,266	7,500	57,512	696	4,032
New Mexico	17,541	241	138	17,584	242	141
New York	21,530	252	2,293	23,552	292	4,310
North Carolina	30,491	372	2,814	86,736	1,251	8,267
Ohio	W	W	W	49,059	663	2,923
Oklahoma	17,825	215	968	9,935	124	737
Oregon	327	4	5	W	W	W
Pennsylvania	47,577	568	6,354	53,400	753	5,799
South Carolina	13,542	164	904	17,113	199	1,165
South Dakota	47,539	528	16,270	42,864	473	15,952
Tennessee	10,411	124	1,012	7,373	87	1,161
Texas	49,862	631	5,822	50,484	626	11,071
Utah	3,116	40	280	W	W	W
Vermont	202,131	2,162	29,446	118,339	1,213	19,995
Virginia	4,201	58	1,130	92,584	1,019	3,067
Washington	13,729	172	2,375	1,107	14	37
Wisconsin	36,505	456	2,644	24,218	297	2,884
Other[2]	96,374	1,257	4,389	38,603	492	5,347
Total[3]	1,329,776	15,769	145,113	1,185,844	14,065	149,483

[e]Estimated. W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes some slate used as lightweight aggregate.
[2]Includes Idaho, Iowa, Maine (1983), Missouri, Montana, New Jersey, Rhode Island, 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[e] Quantity (short tons)	1982[e] Value (thousands)	1983 Quantity (short tons)	1983 Cubic feet (thousands)	1983 Value (thousands)
California	NA	NA	5,823	71	$1,975
Connecticut	NA	NA	9,773	108	662
Georgia	249,000	$11,800	176,838	1,646	10,199
Massachusetts	49,000	8,600	49,280	597	W
Minnesota	24,500	9,500	W	W	W
New Hampshire	107,000	7,500	57,512	696	4,032
North Carolina	24,300	2,200	80,096	1,013	7,187
Oklahoma	NA	NA	5,396	65	652
South Carolina	13,500	900	17,113	199	1,165
South Dakota	47,500	16,300	42,864	473	15,952
Texas	NA	NA	39,994	482	10,663
Vermont	84,000	11,700	W	W	W
Virginia	NA	NA	20	([1])	2
Wisconsin	NA	NA	2,945	31	2,016
Other	[2]82,000	[2]10,000	[3]128,815	[3]1,370	[3]34,402
Total	680,800	78,500	616,469	6,751	88,907

[e]Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Less than 1/2 unit.
[2]Includes items indicated by symbol NA plus all other remaining States.
[3]Includes Colorado, Maine, Maryland, Missouri, New York, Pennsylvania, Rhode Island, Washington, and items indicated by symbol W.

Table 4.—Dimension limestone sold or used by producers in the United States in 1983, by State

State	Quantity (short tons)	Cubic feet (thousands)	Value (thousands)
Alabama	6,053	81	$1,555
California	1,790	22	73
Illinois	1,836	22	71
Indiana	142,682	1,839	W
Virginia	1,020	12	38
Wisconsin	21,273	266	868
Other[1]	70,430	921	16,517
Total	245,084	3,163	19,122

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes Colorado, Iowa, Kansas, Maryland, Michigan, Minnesota, New Mexico, Ohio, Texas, Washington, and item indicated by symbol W.

Table 5.—Dimension sandstone sold or used by producers in the United States in 1983, by State

State	Quantity (short tons)	Cubic feet (thousands)	Value (thousands)
Arizona	45	1	$1
Arkansas	9,114	114	573
California	213	3	8
Colorado	588	8	28
Connecticut	8,405	108	366
Indiana	1,796	27	W
Maryland	2,616	33	190
Missouri	230	3	18
New York	16,221	207	2,198
Oklahoma	4,539	58	85
Pennsylvania	35,897	541	1,444
Washington	66	1	2
Other[1]	68,336	914	4,496
Total	148,066	[2]2,015	9,409

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes Alabama, Georgia, Idaho, Michigan, New Jersey, North Carolina, Ohio, Oregon, Tennessee, Utah and item indicated by symbol W.
[2]Data do not add to total shown because of independent rounding.

Table 6.—Dimension marble sold or used by producers in the United States in 1983, by State

State	Quantity (short tons)	Cubic feet (thousands)	Value (thousands)
Idaho	3,110	40	W
Massachusetts	1,500	15	W
Other[1]	26,143	280	$18,602
Total	30,753	[2]336	18,602

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes Alabama, Georgia, Montana, New Mexico, Tennessee, Vermont, and items indicated by symbol W.
[2]Data do not add to total shown because of independent rounding.

of Ages, Cold Spring Granite, and H. E. Fletcher Co. It was estimated that the three leading companies produced 55% of U.S. output.

Nortek Inc., a Rhode Island-based conglomerate, signed a letter of intent to sell Rock of Ages, the largest producer of rough granite in Vermont, to a group led by the chairman and president of the John Swenson Granite Co. of Concord, NH. The sale was to take effect sometime after January 1, 1984.

Limestone.—Dimension limestone includes bituminous, dolomitic, and siliceous limestones. It was produced by 45 companies at 57 quarries in 16 States. Indiana continued to be the leading State, followed by Wisconsin. The top three producers, in order of value, were Indiana Limestone Co., Alabama Limestone Inc., both located within their respective States, and Biesanz Stone Co. Inc. in Minnesota.

Sandstone.—Dimension sandstone includes calcareous and siliceous-cemented sandstones or conglomerates. Quartzite, which is also included, may be described as any siliceous-cemented sandstone. It was produced by 56 companies at 72 quarries in 22 States. Leading States continued to be, in order of volume, Ohio, Pennsylvania, and New York; these three States accounted for almost two-thirds of U.S. output. Leading producers, Standard Slag Co. in Ohio, Johnston and Rhodes Bluestone Co. in New York, and Delaware Quarries Inc. in Pennsylvania, accounted for 36% of U.S. production.

Slate.—Dimension slate was produced by 22 companies at 33 quarries in 6 States. The two leading States, Vermont and Virginia, in order of volume, accounted for 67% of U.S. output. The top three producers, A. Dally and Sons Inc., Vermont Structural Slate Co. Inc., and Arvonia-Buckingham Slate Co. Inc., accounted for an estimated 37% of U.S. output.

Marble.—Dimension marble includes certain hard limestones, travertines, and any other calcareous stone that can be polished. Dimension marble was produced by 9 companies at 12 quarries in 8 States. Georgia, Vermont, and Idaho, in order of tonnage, were the three leading States, accounting for approximately 75% of U.S. output. Leading producers were Georgia Marble Co., The Marble Shop Inc., and Vermont Marble Co. The top three companies accounted for 91% of U.S. output.

Miscellaneous Stone.—Miscellaneous dimension stone, including traprock, was produced by 9 companies from 10 quarries in 6 States, and totaled 15,368 tons worth $207,000.

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 decreased slightly to 1.19 million tons valued at $149.5 million. Ashlars and partially squared, dressed pieces were 20% of total consumption by value followed by rough stone used for monumental purposes, 16%; rough blocks used for building and construction, 15%; dressed monumental stone, 15%; and dressed slabs and blocks for building and construction, 12%.

Of the total consumption of domestic granite, 26% by value was rough monumental stone; 24%, ashlars and partially squared, dressed pieces; and 18%, rough blocks for building and construction.

Consumption of domestic limestone totaled 245,100 tons valued at $19.1 million, of which 35%, by value, was ashlars and partially squared, dressed pieces; 34%, dressed slabs and blocks for building and construction; and 24%, rough blocks for building and construction.

PRICES

The average price for dimension stone increased 16% to $126 per ton.

FOREIGN TRADE

Exports.—Exports of dimension stone, about one-half of which was granite, increased 13% in value to $21 million.

Imports.—Imports of dimension stone increased 15% in value to $195 million, mostly because of increases in imports of various kinds of marble. Imports of polished marble slabs, mostly from Italy, increased 23% to

$42 million. Imports of other marble, n.s.p.f., increased 49% to $28 million, primarily because of a significant increase from Taiwan. Imports of slate decreased 32% in value to about $3 million. On a value basis, granite accounted for 46% of imports, followed by marble, 37%; travertine, 11%; and slate, 2%.

WORLD REVIEW

Some production of dimension stone occurred in most countries of the world. As usual, Italy produced about one-half of the world total. Other significant producers were Brazil, Finland, India, Norway, Portugal, Spain, Sweden, Turkey, and the United States.

Brazil.—Brazil exported 68,200 tons of rough granite in 1982, compared with 83,500 tons in 1981. The major destinations were Italy, 72%, and Japan, 20%.

Canada.—A new plant with ultramodern, Italian-designed equipment for cutting and polishing thin granite slabs came on-stream near Quebec City in 1982. Quebec Province accounted for about 90% of Canadian granite production. Sales of Quebec building granite rose to $25 million in 1982, from $9.5 million in 1979. About 25 quarries operated in Quebec, producing gray, pink, mahogany, and black granites, with most production coming from the Riviere-a-Pierre, Lac-Saint-Jean, and Guenette areas.[2]

Finland.—Finland exported 227,290 tons of rough granite in 1982, compared with 215,530 tons in 1981. The major destinations were Italy, 60%, and France, 18%.

Spain.—Spain continued to be a significant buyer and seller of dimension stone. It imported 87,800 tons of rough marble and travertine in 1982, compared with 79,200 tons in 1981. The major sources in 1982 were Italy, 55% and Portugal, 44%. Spain exported 180,300 tons of roofing slate in 1982, compared with 182,200 tons in 1981. The major destinations were France, 84%, and the Federal Republic of Germany, 9%.

Sweden.—Sweden exported 147,050 tons of rough granite in 1982, compared with 116,520 tons in 1981. The major destinations were the Federal Republic of Germany, 39%, and Denmark, 25%.

TECHNOLOGY

Shell Oil Co. and Lone Star Industries Inc. formed a joint venture, with a capitalization of $10 million, called the Quazite Corp., to manufacture thin cladding panels for buildings made of a material trade named Quazite. Quazite has the appearance of dimension stone but is a rigid synthetic material composed of a mineral aggregate and a resin, such as epoxy, acrylic, or polyester, that serves as a binder. It is reputedly nonporous and unaffected by water and deicing chemicals, expansion-contraction action resulting from freeze-thaw cycles, and airborne contaminants. The firm indicated that the material has a high modulus of elasticity and is more abrasion-resistant than, and has twice the bending strength of, granite. Quazite panels can be up to one-third the thickness of brittle materials such as granite with no loss of unit strength.

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[1]Physical scientist, Division of Industrial Minerals.

[2]Nantel, S. Dimension Stone of Quebec: Geological Aspects of Commercial Granite Deposits. Paper in 19th Forum on Geology of Industrial Minerals, Toronto, Canada, May 23-27, 1983, 22 pp.

Table 7.—Dimension stone sold or used by producers in the United States in 1983, by use

Use	Quantity (short tons)	Cubic feet (thousands)	Value (thousands)
Rough stone:			
Rough blocks for building and construction	274,710	3,393	$22,300
Irregular-shaped stone[1]	157,313	1,950	5,956
Monumental	247,254	2,578	23,413
Other[2]	13,347	177	321
Dressed stone:			
Ashlars and partially squared pieces[3]	142,343	1,766	30,619
Slabs and blocks for building and construction	60,737	790	18,157
Monumental	75,191	875	22,432
Curbing	51,937	630	8,718
Flagging	50,617	668	4,827
Roofing slate	8,861	97	4,384
Structural and sanitary	3,581	39	1,817
Flooring slate	12,114	133	3,297
Other[4]	87,839	967	3,240
Total[5]	1,185,844	14,065	149,483

[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 8.—Dimension granite sold or used by producers in the United States in 1983, by use

Use	Quantity (short tons)	Cubic feet (thousands)	Value (thousands)
Rough stone:			
Rough blocks for building and construction	132,035	1,555	$16,411
Irregular-shaped stone[1]	42,369	462	2,310
Monumental	247,254	2,416	23,413
Other[2]	180	2	16
Dressed stone:			
Ashlars and partially squared pieces	59,733	707	21,160
Slabs and blocks for building and construction	12,650	152	1,290
Monumental	64,997	763	14,987
Curbing	51,859	629	8,709
Other[3]	5,392	65	610
Total	616,469	6,751	[4]88,907

[1]Includes rubble.
[2]Includes flagging and uses not specified.
[3]Includes flagging and paving block.
[4]Data do not add to total shown because of independent rounding.

Table 9.—Dimension limestone sold or used by producers in the United States in 1983, by use

Use	Quantity (short tons)	Cubic feet (thousands)	Value (thousands)
Rough stone:			
Rough blocks for building and construction	110,564	1,429	$4,578
Irregular-shaped stone[1]	40,901	529	1,080
Other[2]	9,528	129	112
Dressed stone:			
Ashlars and partially squared pieces[3]	49,519	611	6,599
Slabs and blocks for building and construction	30,657	416	6,481
Curbing	38	([4])	2
Other[5]	3,877	48	270
Total	245,084	[6]3,163	19,122

[1]Includes rubble.
[2]Includes flagging.
[3]Includes veneer.
[4]Less than 1/2 unit.
[5]Includes flagging and uses not specified.
[6]Data do not add to total shown because of independent rounding.

Table 10.—Dimension sandstone sold or used by producers in the United States in 1983, by use

Use	Quantity (short tons)	Cubic feet (thousands)	Value (thousands)
Rough stone:			
Rough blocks for building and construction	26,385	348	$810
Irregular-shaped stone[1]	67,185	879	2,323
Other[2]	2,292	29	150
Dressed stone:			
Ashlars and partially squared pieces[3]	30,305	394	2,261
Slabs and blocks for building and construction	10,341	136	1,491
Flagging	11,088	222	1,826
Other[4]	470	6	547
Total[5]	148,066	2,015	9,409

[1]Includes rubble.
[2]Includes flagging.
[3]Includes veneer.
[4]Includes curbing and uses not specified.
[5]Data may not add to totals shown because of independent rounding.

Table 11.—Dimension slate sold or used by producers in the United States in 1983, by use

Use	Quantity (short tons)	Cubic feet (thousands)	Value (thousands)
Flagging	28,257	311	$2,150
Roofing slate	8,861	97	4,384
Structural and sanitary	3,581	39	1,817
Flooring slate	12,114	133	3,297
Other[1]	291	3	40
Total[2]	53,104	584	11,689

[1]Includes blackboards, billiard table tops, and uses not specified.
[2]Data may not add to totals shown because of independent rounding.

Table 12.—Dimension marble sold or used by producers in the United States in 1983, by use

Use	Quantity (short tons)	Cubic feet (thousands)	Value (thousands)
Rough stone: Rough blocks for building and construction	5,476	55	$495
Dressed stone: Slabs and blocks for building and construction	7,089	85	8,894
Other[1]	18,188	196	9,213
Total	30,753	336	18,602

[1]Includes rough irregular-shaped stone, dressed ashlars and partially squared pieces, monumental, flagging, and uses not specified.

Table 13.—U.S. exports of dimension stone, by type

(Thousand short tons and thousand dollars unless otherwise specified)

Type	1982		1983		Major destination in 1983, (percent[1])
	Quantity	Value	Quantity	Value	
Granite, rough	70.4	6,914	75.7	8,068	Japan 50%; Federal Republic of Germany 18%.
Granite articles	NA	1,822	NA	1,468	Canada 51%.
Limestone, crude, not for building or monumental	5.7	75	9.3	156	Chile 99%.
Limestone, dressed, for building or monumental	1.8	146	1.5	227	Canada 39%.
Limestone articles	6.0	250	30.4	584	Canada 64%.
Marble, breccia, onyx, rough or squared	10.4	811	18.6	540	Canada 70%.

See footnotes at end of table.

Table 13.—U.S. exports of dimension stone, by type —Continued

(Thousand short tons and thousand dollars unless otherwise specified)

Type	1982 Quantity	1982 Value	1983 Quantity	1983 Value	Major destination in 1983, (percent[1])
Marble, breccia, onyx articles	NA	1,867	NA	3,424	Saudi Arabia 73%.
Quartzite, rough and dressed	47.2	2,382	7.4	1,884	France 35%.
Slate building articles	NA	133	NA	385	Federal Republic of Germany 39%.
Slate building articles, other	NA	1,501	NA	967	Saudi Arabia 35%.
Stone, rough, not for building or monumental	3.4	267	3.6	331	Canada 44%.
Stone, rough, for building or monumental	9.4	1,151	13.6	1,480	Japan 52%.
Stone, other, including alabaster or jet	NA	1,359	NA	1,671	Canada 34%.
Total	NA	18,678	NA	21,185	

NA Not available.
[1]By value.

Table 14.—U.S. imports for consumption of dimension granite, by country

(Thousand cubic feet and thousand dollars)

Country	Rough[1] Quantity	Rough[1] Value	Dressed Quantity	Dressed Value	Other n.s.p.f. undecorated[2 3] (value)
1981	r312	r6,561	691	33,521	5,160
1982:					
Brazil	352	65	97	2,395	33
Canada	341	3,030	204	11,085	1,988
India	9	146	19	462	18
Ireland	--	--	2	50	756
Italy	10	62	850	55,050	1,047
Japan	--	--	8	467	2
Portugal	--	--	3	108	27
South Africa, Republic of	r53	r750	12	204	--
Spain	--	--	7	456	--
Other	6	199	26	1,360	205
Total	r771	r4,252	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
Ireland	--	--	(4)	3	505
Italy	43	72	1,357	61,422	1,077
Japan	--	--	16	85	29
Portugal	1	21	5	236	1
South Africa, Republic of	73	938	16	269	56
Spain	--	--	27	2,180	90
Other	3	77	65	1,370	101
Total	345	4,993	1,828	79,958	5,063

rRevised.
[1]Does not include nonmanufactured nonmonumental granite.
[2]Does not include granite n.s.p.f. decorated.
[3]Quantity not reported.
[4]Less than 1/2 unit.

Table 15.—U.S. imports for consumption of dimension marble and travertine, by country

Country	Marble, breccia, or onyx, polished slabs		Marble, breccia, or onyx, other n.s.p.f.[1] [2]	Travertine dressed[3]	
	Quantity (thousand square feet)	Value (thousands)	Value (thousands)	Quantity (short tons)	Value (thousands)
1981:	11,553	$29,951	$19,291	46,450	$17,554
1982:					
France	236	663	221	15	18
Germany, Federal Republic of	107	163	270	42	38
Greece	238	614	168	--	--
Italy	8,957	26,072	11,582	165,116	19,612
Mexico	308	682	1,409	1,355	964
Pakistan	23	69	394	--	--
Philippines	193	478	139	--	--
Portugal	646	2,102	354	--	--
Spain	1,044	1,957	92	151	106
Taiwan	132	270	3,626	--	--
Other	2,065	1,141	910	76	49
Total	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

[1]Does not include certain special kinds of rough marble, breccia, or onyx.
[2]Quantity not reported.
[3]Suitable for use as monumental, paving, or building stone. Does not include travertine articles.

Table 16.—U.S. imports for consumption of other dimension stone, by type

Type	1982 Quantity	1982 Value (thousands)	1983 Quantity	1983 Value (thousands)	Major source in 1983, (percent[1])
Granite, unmanufactured, nonmonumental short tons	1,102	$57	1,679	$199	Republic of South Africa 64%.
Granite, n.s.p.f. decorated	--	165	--	175	Italy 24%.
Alabaster and jet articles	--	1,120	--	1,922	Italy 91%.
Limestone, crude not for building, monumental short tons	272,770	1,359	271,291	1,349	Canada 51%.
Limestone, dressed, hewn do	16,847	414	8,883	343	Italy 52%.
Marble and breccia, rough cubic feet	58,168	162	44,336	243	Mexico 28%.
Onyx, rough do	6,585	67	1,596	32	Mexico 96%.
Marble, breccia, onyx, slab and tiles, unpolished square feet	339,599	1,227	644,351	1,432	Italy 60%.
Quartzite short tons	26,327	275	13,533	245	Canada 52%.
Slate, roofing square feet	129,267	105	298,259	82	China 44%.
Slate, other, n.s.p.f.	--	4,871	--	3,296	Italy 73%.
Travertine articles, undecorated	--	1,747	--	2,671	Italy 85%.
Travertine articles, decorated	--	468	--	715	Italy 89%.
Stone, unmanufactured short tons	13,737	267	42,357	472	Mexico 53%.
Stone, dressed, building do	811	341	2,385	405	Italy 55%.
Stone, other n.s.p.f., undecorated	--	1,401	--	1,613	Mexico 23%.
Stone, other n.s.p.f., decorated	--	1,700	--	1,357	Mexico 28%.

[1]By value.

Sulfur

By David E. Morse[1]

Domestic production of sulfur in all forms decreased 5%. Production of recovered elemental sulfur from petroleum refineries and natural gas processing plants was at an alltime high, whereas production of sulfur from Frasch mines was the lowest since 1943. Shipments of sulfur in all forms increased 13%; shipments exceeded sulfur output by 11% during 1983. Prices for all elemental sulfur decreased. Sulfur demand continued to exceed domestic production; the United States continued to be a net importer of sulfur despite a decrease of nearly 1 million metric tons in producers' stocks of elemental sulfur.

World production of sulfur in all forms declined for the third consecutive year. World demand exceeded output, requiring a drawdown of world stocks by about 3 million tons.

Table 1.—Salient sulfur statistics

(Thousand metric tons, sulfur content, and thousand dollars unless otherwise specified)

	1979	1980	1981	1982	1983
United States:					
Production:					
Frasch	6,357	6,390	6,348	4,210	3,202
Recovered[1]	4,070	4,073	4,259	4,404	4,955
Other forms	1,674	1,403	1,538	1,173	1,133
Total	12,101	11,866	12,145	9,787	9,290
Shipments:					
Frasch	7,507	7,400	5,910	3,598	4,111
Recovered[1]	4,108	4,115	4,207	4,344	5,041
Other forms	1,674	1,403	1,538	1,173	1,133
Total	13,289	12,918	11,655	9,115	10,285
Imports, elemental	2,494	2,523	2,522	1,905	1,695
Exports, elemental[2]	1,963	1,673	1,392	961	992
Consumption, apparent, all forms[3]	13,739	13,659	12,785	10,059	10,988
Stocks, Dec. 31: Producer, Frasch and recovered	4,239	3,094	3,634	4,202	3,218
Value:					
Shipments, f.o.b. mine or plant:					
Frasch	\$449,433	\$720,511	\$715,683	\$434,660	\$445,131
Recovered[1]	198,137	305,046	412,115	425,217	384,214
Other forms	89,643	84,332	140,618	122,177	116,255
Total	737,213	1,109,889	1,268,416	982,054	945,600
Imports, elemental[4]	\$94,147	\$138,852	\$209,766	\$164,885	\$129,110
Exports, elemental[5]	\$142,966	\$185,866	\$187,407	\$122,143	\$109,298
Price, elemental, dollars per metric ton, f.o.b. mine or plant	\$55.75	\$89.06	\$111.48	\$108.27	\$90.62
World: Production, all forms (including pyrites)	[r]53,227	[r]54,920	53,350	[p]50,776	[e]50,472

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Includes Puerto Rico and the Virgin Islands.
[2]Includes exports from the Virgin Islands to foreign countries in 1981-83.
[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 1981-83.

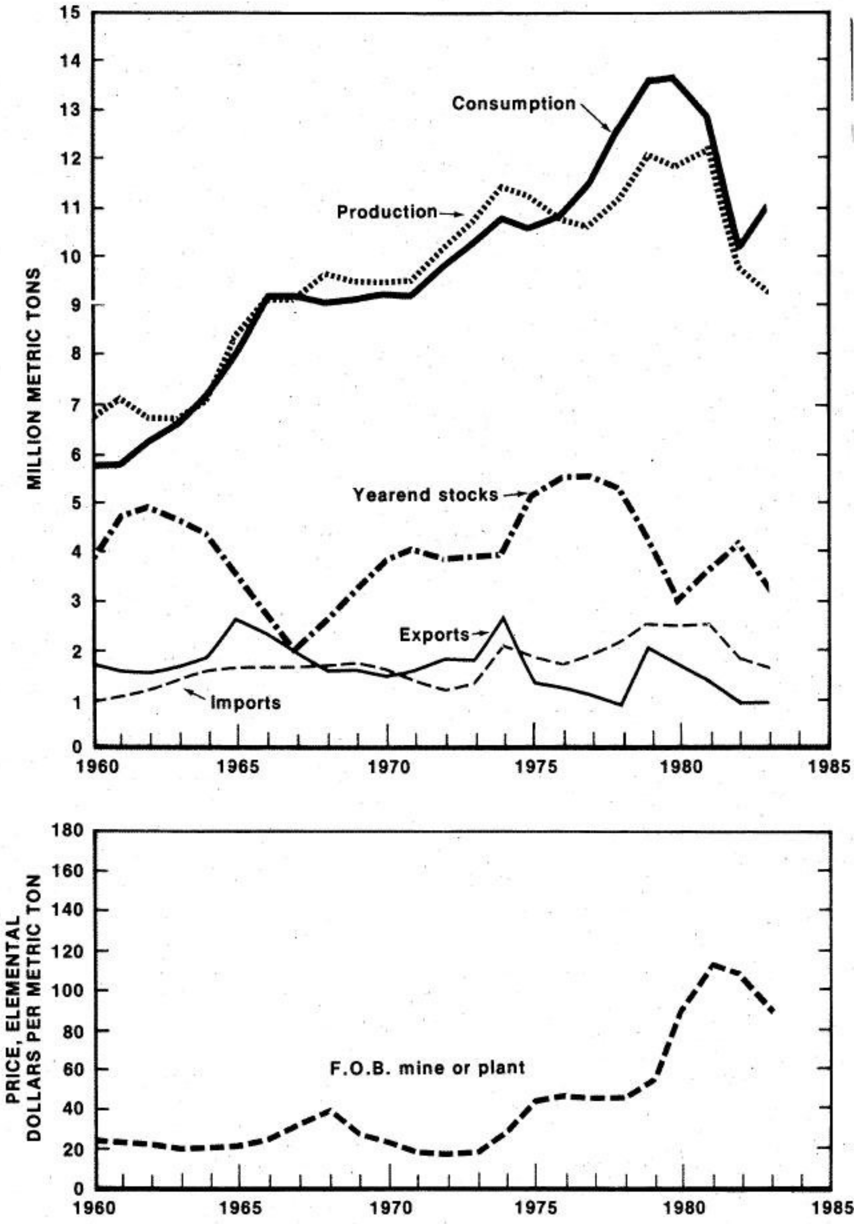

Figure 1.—Trends in the sulfur industry in the United States.

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 194 operations to which a survey request was sent, all responded, representing 100% of the total production data shown in tables 1 and 2.

DOMESTIC PRODUCTION

Frasch.—In January, seven 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 and Comanche Creek. However, the Comanche Creek Mine was closed at the end of November. At yearend, the remaining six mines were operating at an estimated 50% of capacity.

Frasch sulfur production decreased 1.01 million tons from the output in 1982. Shipments, however, increased by 0.5 million tons. Frasch sulfur accounted for about 35% of domestic production of sulfur in all forms in 1983, compared with 43% in 1982. Approximately 85% of Frasch sulfur shipments was for domestic consumption, and 15%, for export. The total value of Frasch sulfur shipments increased slightly.

Recovered.—Production of recovered elemental sulfur, a nondiscretionary byproduct from natural gas and petroleum refineries, and coking plants, accounted for 53% of the total domestic output of sulfur in all forms, compared with 45% in 1982. Production and shipments reached alltime highs in 1983 and surpassed Frasch output and shipments for the second consecutive year. This type of sulfur was produced by 58 companies at 159 plants in 27 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, 52% was produced by 43 companies at 86 refineries or satellite plants treating refinery gases and 3 coking plants, and 48% was produced by 27 companies at 68 natural gas treatment plants. The five largest recovered elemental sulfur producers were Atlantic Richfield Co., Chevron U.S.A. Inc., Exxon Co. U.S.A., Shell Oil Co., and Standard Oil Co. of Indiana. These companies' 46 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 70% of the total output; shipments from Texas accounted for 28% of total shipments. The total value of shipments of recovered elemental sulfur decreased 10%.

Table 2.—Production of sulfur and sulfur-containing raw materials in the United States

(Thousand metric tons)

	1982		1983	
	Gross weight	Sulfur content	Gross weight	Sulfur content
Frasch sulfur	4,210	4,210	3,202	3,202
Recovered sulfur[1]	4,404	4,404	4,955	4,955
Byproduct sulfuric acid (100% basis) produced at copper, lead, molybdenum, and zinc plants	2,532	828	2,541	831
Pyrites	676	265	W	W
Other forms[2]	131	80	741	302
Total	XX	9,787	XX	9,290

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	Quantity	Value[1]
1979	3,897	2,460	6,357	7,507	449,433
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	[2]3,202	4,111	445,131

[1]F.o.b. mine.
[2]Data do not add to total shown because of independent rounding.

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]
1979	1,760	2,310	4,070	4,108	198,137
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

[1]Includes Puerto Rico and the Virgin Islands.
[2]Includes a small quantity from coking operations and utility plants in 1979-82; includes only a small quantity from coking operations in 1983.
[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	1982			1983		
	Production (quantity)	Shipments		Production (quantity)	Shipments	
		Quantity	Value		Quantity	Value
Alabama	441	440	46,067	401	401	36,319
California	494	486	31,859	480	505	24,978
Florida	190	190	W	142	142	W
Illinois	214	214	21,006	224	225	20,557
Louisiana	232	232	25,247	261	261	24,122
Michigan and Minnesota	97	97	7,175	118	119	8,054
Mississippi	623	602	71,722	690	722	67,860
Missouri	W	W	W	--	--	--
New Jersey	113	103	12,040	73	73	8,029
New Mexico	62	63	5,337	60	60	3,827
New York	W	W	W	--	--	--
North Dakota	77	76	4,400	101	102	4,904
Ohio	28	27	3,106	38	39	3,837
Pennsylvania	58	57	4,818	52	53	4,507
Texas	1,298	1,297	129,454	1,394	1,407	109,061
Wisconsin	1	1	55	2	2	114
Wyoming	69	63	3,327	504	489	16,903
Other[1]	407	394	59,604	415	442	51,139
Total[2]	4,404	4,344	425,217	4,955	5,041	384,214

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes Arkansas, Colorado, Delaware, Indiana, Kansas, Kentucky, Montana, Oklahoma, Utah, Virginia, Washington, Puerto Rico, and the Virgin Islands combined to avoid disclosing company proprietary data, 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	1982 Production	1982 Shipments	1983 Production	1983 Shipments
PAD 1:				
Petroleum and coke	276	265	235	237
Natural gas	190	189	142	141
Total[1]	466	455	377	379
PAD 2:				
Petroleum and coke	440	440	498	500
Natural gas	83	81	105	107
Total[1]	523	522	604	607
PAD 3:[2]				
Petroleum	1,133	1,133	1,255	1,259
Natural gas	1,622	1,599	1,627	1,681
Total	2,755	2,732	2,882	2,940
PAD 4 and 5:				
Petroleum	593	575	594	631
Natural gas	64	57	496	481
Total[1]	657	632	1,091	1,112
Grand total[1]	4,404	4,344	4,955	5,041

[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 was 9% of the total domestic production of sulfur in all forms. Ten acid plants operated in conjunction with copper smelters, and 10 plants were accessories to lead, molybdenum, and zinc roasting and smelting operations. The five largest acid plants accounted for 58% of the output, and production in five States was 81% of the total. The five largest producers of byproduct sulfuric acid were ASARCO Incorporated, Kennecott, Magma Copper Co., Phelps Dodge Corp., and AMAX Inc. These companies' 14 plants produced 82% 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]	Lead and zinc plants[3]	Zinc plants[3]	Lead and molybdenum plants[3]	Total	Value
1979	821	346	--	--	1,167	51,815
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

[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, compared with 4% in 1982. The total sulfur content in these products was 12%

less than that of 1982. Pyrites was produced by two companies at two mines in two States; hydrogen sulfide, by two companies at three plants in three States; and sulfur dioxide, by three companies at five plants in five States. The three largest producers of these products were Shell Oil, hydrogen sulfide; Stauffer Chemical Co., sulfur dioxide; and Tennessee Chemical Co., pyrites and sulfur dioxide. These companies' one mine and five plants accounted for 95% 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
1979	400	35	72	507	37,828
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

W Withheld to avoid disclosing company proprietary data; included in "Total."

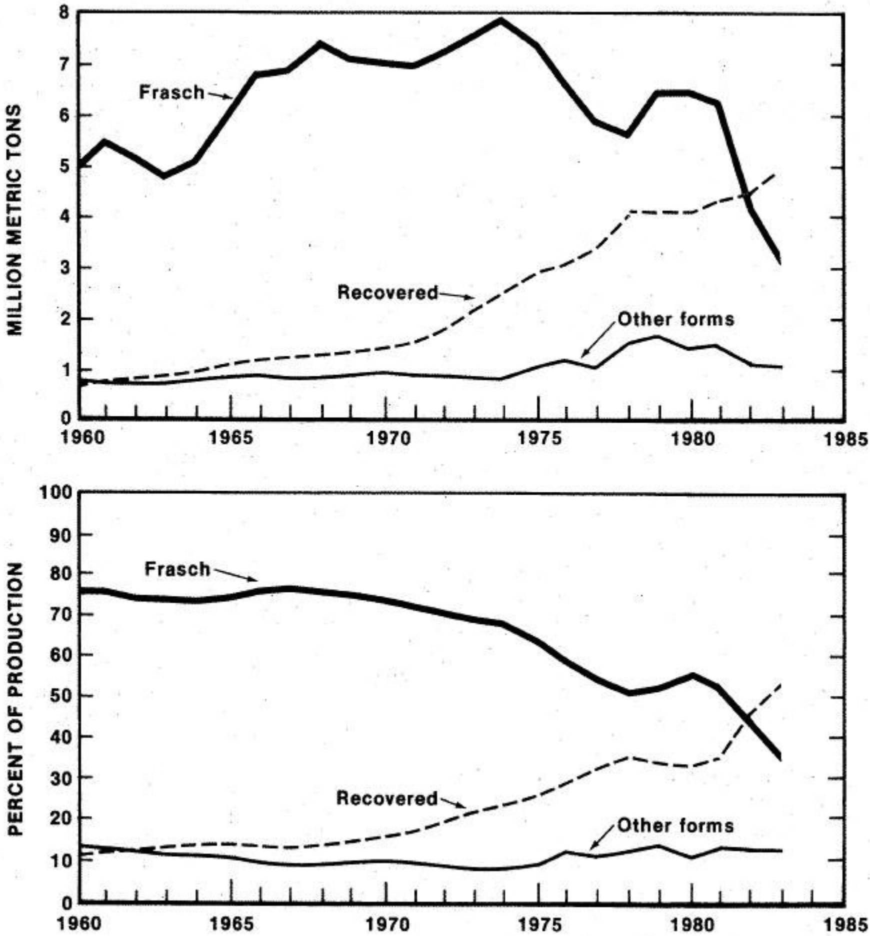

Figure 2.—Trends in the production of sulfur in the United States.

CONSUMPTION AND USES

Apparent domestic consumption of sulfur in all forms increased 9%. The sources of supply were domestic recovered elemental sulfur, 42%; domestic Frasch sulfur, 32%; and combined domestic byproduct sulfuric acid, pyrites, hydrogen sulfide, and sulfur dioxide, 11%. The remaining 15% 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 65 companies, and shipments by end use of sulfuric acid were reported by 67 companies. Twelve companies reported shipments of both elemental sulfur and sulfuric acid.

The largest sulfur end use, sulfuric acid production, represented 81% 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."

Table 9.—Apparent consumption of sulfur[1] in the United States

(Thousand metric tons)

	1979	1980	1981	1982	1983
Frasch:					
Shipments	7,507	7,400	5,910	3,598	4,111
Imports	1,229	990	856	690	604
Exports	1,963	1,673	1,216	731	601
Total	6,773	6,717	5,550	3,557	4,114
Recovered:					
Shipments[2]	4,108	4,115	4,207	4,344	5,041
Imports	1,265	1,533	1,666	1,215	1,091
Exports	81	109	176	230	391
Total	5,292	5,539	5,697	5,329	5,741
Pyrites, shipments	400	322	307	265	W
Byproduct sulfuric acid, shipments	1,167	1,003	1,159	828	831
Other forms, shipments[3]	107	78	72	80	302
Total, all forms	13,739	13,659	12,785	10,059	10,988

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 and 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	1982	1983
20	Food and kindred products	W	W
26, 261	Pulp and paper products	20	14
282, 2822, 2823	Synthetic rubber, cellulose fibers, other plastic products[1]	W	34
287	Agricultural chemicals	376	563
28, 285, 286	Paints and allied products, industrial organic chemicals, other chemical products	64	115
284	Soaps and detergents	45	23
29, 291	Petroleum refining and petroleum and coal products	180	142
295	Paving and roofing materials	W	---
281	Other industrial inorganic chemicals	80	250
30	Rubber and miscellaneous plastic products	W	W
	Sulfuric acid:		
	Domestic sulfur	5,906	6,558
	Imported sulfur	1,071	1,675
	Total	6,977	8,233
	Unidentified	677	801
	Total domestic uses	8,419	10,175
	Exports	657	645
	Grand total	9,076	10,820

W Withheld to avoid disclosing company proprietary data; included with "Unidentified."
[1]Includes cellulosic fibers in 1983.

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 1982	Quantity 1983
102	Copper ores	776	534
1094	Uranium and vanadium ores	369	250
10	Other ores	158	138
261	Pulpmills	661	607
26	Other paper products	96	152
285, 2816	Inorganic pigments and paints and allied products	539	382
281	Other inorganic chemicals	774	965
282, 2822	Synthetic rubber and other plastic materials and synthetics	661	965
2823	Cellulosic fibers including rayon	263	294
283	Drugs	43	87
284	Soaps and detergents	295	320
286	Industrial organic chemicals	1,003	1,124
2873	Nitrogenous fertilizers	231	160
2874	Phosphatic fertilizers	19,624	21,759
2879	Pesticides	127	84
287	Other agricultural chemicals	224	184
2892	Explosives	46	62
2899	Water-treating compounds	443	398
28	Other chemical products	225	204
29, 291	Petroleum refining and other petroleum and coal products	2,311	2,071
30	Rubber and miscellaneous plastic products	17	96
331	Steel pickling	262	288
333	Nonferrous metals	50	32
33	Other primary metals	16	19
3691	Storage batteries (acid)	161	177
	Unidentified	1,023	1,305
	Total domestic	30,398	32,657
	Exports	239	169
	Grand total	30,637	32,826

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] 1982	Elemental sulfur[1] 1983	Sulfuric acid (sulfur equivalent) 1982	Sulfuric acid (sulfur equivalent) 1983	Total 1982	Total 1983
102	Copper ores	--	--	254	175	254	175
1094	Uranium and vanadium ores	--	--	121	82	121	82
10	Other ores	--	--	52	45	52	45
20	Food and kindred products	W	W	--	--	W	W
26, 261	Pulpmills and paper products	20	14	247	248	267	262
28, 285, 286, 2816	Inorganic pigments, paints and allied products, industrial organic chemicals, other chemical products	64	115	176	125	240	240
281	Other inorganic chemicals	80	250	253	316	333	566
282, 2822	Synthetic rubber and other plastic materials and synthetics	W	[2]34	216	315	216	[2]349
2823	Cellulosic fibers including rayon	--	([3])	86	96	86	96
283	Drugs	--	--	14	28	14	28
284	Soaps and detergents	45	23	97	104	142	127
286	Industrial organic chemicals	--	--	328	367	328	367
2873	Nitrogenous fertilizers	--	--	75	52	75	52
2874	Phosphatic fertilizers	--	--	6,415	7,113	6,415	7,113
2879	Pesticides	--	--	42	28	42	28
287	Other agricultural chemicals	376	563	73	60	449	623
2892	Explosives	--	--	15	20	15	20
2899	Water-treating compounds	--	--	145	130	145	130
28	Other chemical products	--	--	73	67	73	67
29, 291	Petroleum refining and other petroleum and coal products	180	142	755	677	935	819
295	Paving and roofing materials	W	--	--	--	W	--
30	Rubber and miscellaneous plastic products	W	W	6	31	6	31
331	Steel pickling	--	--	86	94	86	94
333	Nonferrous metals	--	--	16	11	16	11
33	Other primary metals	--	--	5	6	5	6
3691	Storage batteries (acid)	--	--	53	58	53	58
	Exported sulfuric acid	--	--	78	55	78	55
	Total identified	765	1,141	9,681	10,303	10,446	11,444
	Unidentified	677	801	334	427	1,011	1,228
	Grand total	1,442	1,942	10,015	10,730	11,457	12,672

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 in 1983.
[3]Included with "Synthetic rubber and other plastic materials and synthetics."

Shipments of 100% sulfuric acid increased 7%. Shipments of sulfuric acid for phosphatic fertilizer production, the largest end use, increased 11%. Shipments of sulfuric acid for petroleum refining and other petroleum and coal products, the second largest end use, declined 10%. Usage of sulfuric acid for copper ore leaching decreased 31%.

According to the 1983 canvass reports, company receipts of spent sulfuric acid for reclaiming totaled 2.4 million tons. The largest source of spent acid, from petroleum refining and coal products, accounted for 65% of the total returned. The petroleum refining industry was a net user of about 500,000 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, explosives, steel, industrial organic chemicals, other agricultural chemicals, storage batteries, other chemical products, and some unidentified sources.

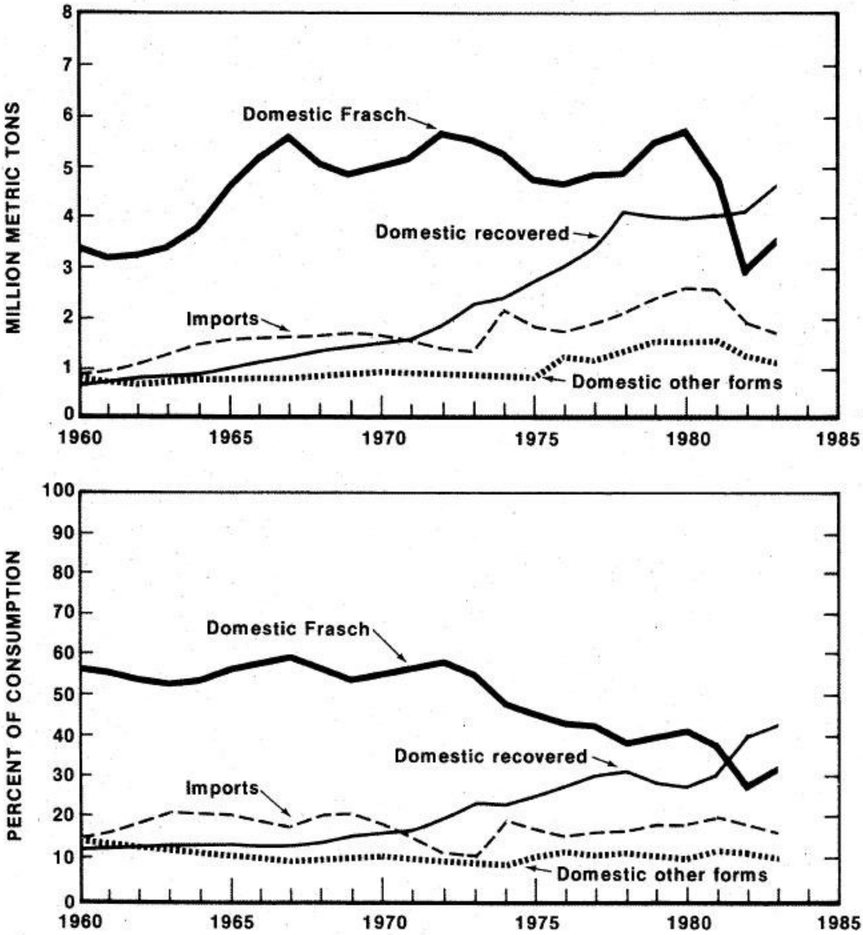

Figure 3.—Trends in the consumption of sulfur in the United States.

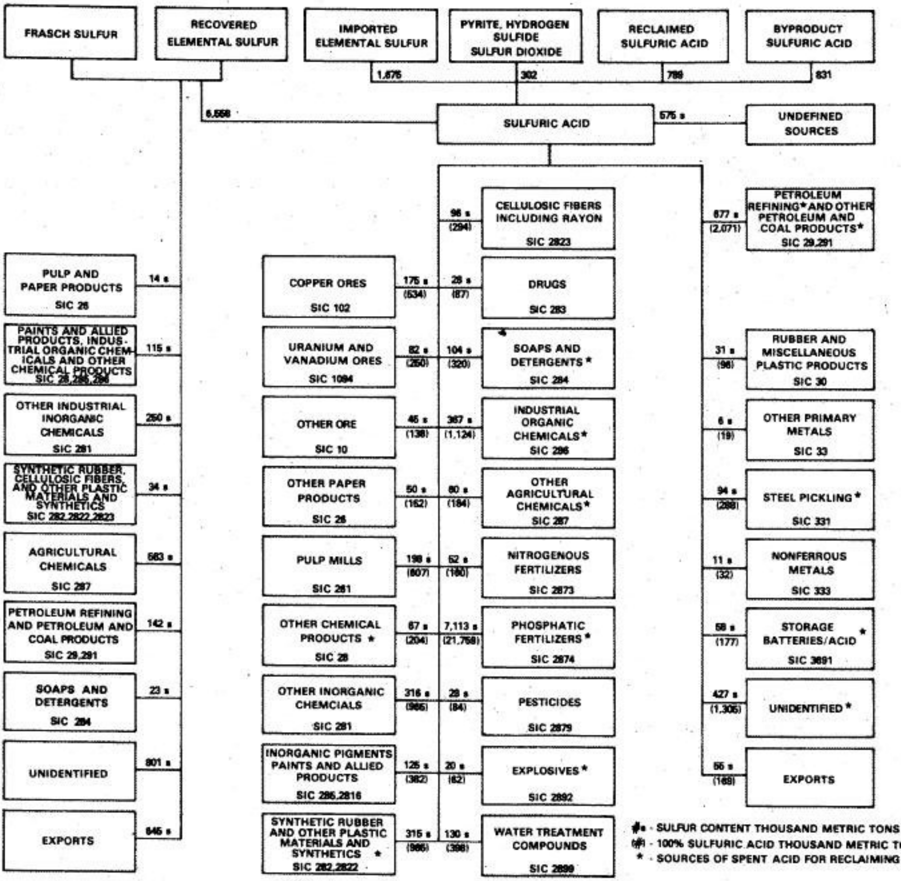

Figure 4.—Sulfur-sulfuric acid supply and end-use relationship in 1983.

STOCKS

Inventories of Frasch sulfur were reduced by 23%. Combined yearend stocks amounted to approximately a 4-month supply, compared with a 6-month supply in 1982, 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
1979	4,058	181	4,239
1980	2,954	140	3,094
1981	3,442	192	3,634
1982	3,964	238	4,202
1983	3,065	153	3,218

PRICES

In April, the posted price for liquid sulfur ex-terminal Tampa, FL, was reduced from \$132.90 to \$130.41 per metric ton and remained unchanged thereafter. Price discounting from the posted price was widespread from April through yearend.

On the basis of total shipments and value reported to the Bureau of Mines, the average value of shipments of Frasch sulfur, f.o.b. mine, for domestic consumption and exports combined decreased 10%. 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 the midcontinent, and near the values for Frasch sulfur in the East and South. Although reported values for recovered elemental sulfur were generally lower throughout the Nation, the disproportionately low value for Wyoming distorts the average value calculation for all recovered elemental shipments in 1983.

Table 14.—Reported sales values of shipments of sulfur, f.o.b. mine or plant

(Dollars per metric ton)

Year	Frasch	Recovered	Average
1979	59.87	48.23	55.75
1980	97.36	74.13	89.06
1981	121.11	97.97	111.48
1982	120.79	97.89	108.27
1983	108.28	76.22	90.62

FOREIGN TRADE

Exports of elemental sulfur from the United States, including the Virgin Islands, increased 3% in quantity but decreased 11% in value. For the first time, elemental sulfur exports from the west coast exceeded 300,000 tons and represented 31.5% of all elemental sulfur 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 declined 11% in quantity and 22% in value.

The United States also had significant international trade in sulfuric acid. Canada, Japan, and Mexico were the United States' most important sulfuric acid trade partners.

Table 15.—U.S. exports[1] of elemental sulfur, by country

(Thousand metric tons and thousand dollars)

Country	1982 Quantity	1982 Value	1983 Quantity	1983 Value
Algeria	21	2,263	--	--
Argentina	8	1,235	1	334
Australia	1	434	(2)	339
Belgium-Luxembourg	375	52,760	337	44,072
Brazil	80	10,646	99	11,810
Bulgaria	11	1,229	--	--
Canada	7	493	6	380
Chile	2	606	(2)	84
Egypt	42	4,640	69	7,544
Germany, Federal Republic of	2	1,584	2	1,319
Greece	29	3,621	(2)	2
India	71	6,098	46	3,707
Italy	39	4,702	44	3,974
Mexico	51	2,819	43	2,339
Morocco	52	6,043	24	2,505
Nigeria	--	--	5	415
Romania	50	7,336	31	3,819
Senegal	--	--	29	2,272
Sweden	--	--	5	433
Taiwan	1	323	80	7,041
Thailand	(2)	8	6	469
Tunisia	68	7,349	132	11,948
Turkey	14	2,169	--	--
U.S.S.R.	28	3,523	--	--
United Kingdom	1	74	16	1,388
Uruguay	3	398	(2)	3
Other	r5	r1,791	18	3,104
Total[3]	961	122,143	992	109,298

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 16.—U.S. exports of sulfuric acid (100% H_2SO_4), by country

Country	1982 Quantity (metric tons)	1982 Value (thousands)	1983 Quantity (metric tons)	1983 Value (thousands)
Canada	68,297	$2,989	105,835	$5,270
Colombia	1,366	110	772	199
Ecuador	142	42	2,218	98
Honduras	1,672	7	721	23
Jamaica	1,954	159	122	9
Korea, Republic of	290	224	1,422	188
Mexico	116,787	5,024	25,077	950
Netherlands	187	37	6,407	173
Netherlands Antilles	9,059	667	15,184	1,017
Panama	1,381	60	1,249	96
Saudi Arabia	1,317	144	1,239	691
Venezuela	21,181	1,779	389	51
Other	r12,986	r2,124	10,367	1,324
Total	236,619	13,366	171,002	10,089

rRevised.

Table 17.—U.S. imports of elemental sulfur, by country

(Thousand metric tons and thousand dollars)

Country	1982 Quantity	1982 Value[1]	1983 Quantity	1983 Value[1]
Canada	1,215	77,357	1,091	62,505
Germany, Federal Republic of	(2)	18	(2)	34
Mexico	690	87,494	604	66,556
Other[3]	(2)	16	(2)	15
Total	1,905	164,885	1,695	129,110

[1]Declared customs valuation.
[2]Less than 1/2 unit.
[3]Includes Taiwan and the United Kingdom in 1982 and France and Japan in 1983.

Table 18.—U.S. imports of sulfuric acid (100% H_2SO_4), by country

Country	1982 Quantity (metric tons)	1982 Value[1] (thousands)	1983 Quantity (metric tons)	1983 Value[1] (thousands)
Canada	307,375	$8,722	300,342	$9,261
Germany, Federal Republic of	10,918	492	35	21
Japan	81,931	3,699	110,786	4,853
Mexico	1,990	124	665	52
Norway	19,692	1,254	13,967	494
Peru	6,130	229	--	--
Spain	--	--	10,424	573
Sweden	2	11	8,340	310
United Kingdom	91	87	900	152
Other	r3	r44	8	19
Total	428,132	14,662	445,467	15,735

rRevised.
[1]Declared c.i.f. valuation.

WORLD REVIEW

World production of sulfur in all forms declined for the third consecutive year. World consumption of elemental sulfur exceeded output; the United States and Saudi Arabia each shipped nearly 1 million tons from inventories, Canada shipped over 800,000 tons from stocks, Mexico reduced stocks by about 350,000 tons, and the Federal Republic of Germany and Iraq both appeared to have reduced stocks by about

100,000 tons. About 200,000 tons was added to sulfur stocks at Lacq, France.

Brazil.—Brazil attempted to increase reliance on domestic sulfur sources to supply feedstock for sulfuric acid production. A 300-ton-per-day Frasch process pilot plant began operation at Castanhal, Sergipe. Recovered elemental sulfur capacity at petroleum refineries was increased in October to 192,000 tons per year when a 60,000-ton-per-year unit began operation at Beltim. Annual sulfuric acid capacity based on domestic pyrites was 425,000 tons. Smelter-based sulfuric acid capacity was increased dramatically after the 617,000-ton-per-year acid plant at the Camacari metallurgical complex near Salvador began operation in November 1982.

Canada.—Shipments of sulfur in all forms were about 7.2 million tons, 8% less than shipments in 1982. Recovered elemental sulfur was produced at 52 sour natural gas processing plants and 14 petroleum refineries. Byproduct production from smelter gases increased 16% to approximately 730,000 tons of contained sulfur.

Canadian sulfur exports declined 8% to 5.7 million tons. Sulfur exported through the Port of Vancouver, British Columbia, declined 5% to 4.6 million tons.

In Alberta Province, sulfur production increased 175,000 tons to 5.48 million tons, of which 331,000 tons was from tar sands. Sulfur shipments from Alberta were 6.2 million tons, with 4.4 million tons shipped to overseas markets, 1.09 million tons exported to the United States, and 700,000 tons shipped to domestic consumers. Alberta producers' stocks were reduced from 15.09 to 14.5 million tons during the year.

Germany, Federal Republic of.—Recovered elemental sulfur output from natural gas decreased by approximately 250,000 tons because of technical problems at the 2,100-ton-per-day processing plant at Grossenkneten. Recovered elemental sulfur output from West German oil refineries also decreased because of reduced refinery throughput.

Iraq.—Production of sulfur from the Misraq Frasch operation continued at a reduced rate. After a hiatus of nearly 2 years, caused by the ongoing war with neighboring Iran, Iraqi sulfur reappeared on the world market. Iraqi sulfur was transported by rail and truck to ports in both Kuwait and Turkey for shipment to overseas consumers. Because of the war, the quantity of sulfur consumed by domestic consumers, especially at the new large fertilizer complex at Al-Qain, was unknown.

Mexico.—Frasch sulfur output declined for the fourth consecutive year; recovered elemental sulfur production from Petróleos Mexicanos operations was relatively stable. Shipments to domestic and export markets exceeded production by approximately 350,000 tons, thereby reducing stocks to an extremely low level.

Poland.—Sulfur exports from Poland increased to 4.03 million tons from 3.97 million tons in 1982. Exports to Western Europe declined 12% to 1.04 million tons; exports to Eastern Europe declined slightly to 1.93 million tons, of which 863,000 tons was shipped to the Soviet Union. Morocco and Tunisia were supplied with a total of 510,000 tons, and Brazil received 364,000 tons.

Saudi Arabia.—Sulfur exports of 1.71 million tons exceeded estimated production by 1 million tons. Stocks at yearend were estimated to be 750,000 to 800,000 tons.

Table 19.—Sulfur: World production (all forms), by country and source[1]

(Thousand metric tons)

Country[2] and source[3]	1979	1980	1981	1982[p]	1983[e]
Algeria: Byproduct, petroleum and natural gas	15	14	15	[e]10	10
Argentina:[e]					
Native (from caliche)	--	--	10	(4)	--
Byproduct, all sources	20	NA	NA	--	--
Total	20	NA	10	(4)	--
Australia:					
Pyrites	29	(4)	(4)	(4)	(4)
Byproduct:					
Metallurgy[e]	140	140	[r]130	[r]130	130
Petroleum	[r]16	[r]13	13	14	14
Total	[r]185	[r]153	143	144	144
Austria:					
Byproduct:					
Metallurgy	10	9	9	10	9
Petroleum and natural gas	24	19	28	38	35
Gypsum	27	24	25	27	27
Total	61	52	62	75	71
Bahamas: Byproduct, petroleum[e]	5	5	5	5	5
Bahrain: Byproduct, petroleum	25	33	36	34	[5]49
Belgium: Byproduct, all sources[e]	270	270	270	[r]250	250
Bolivia: Native	[6]15	11	10	6	4
Brazil:					
Frasch	--	--	--	--	1
Pyrites	33	25	44	54	55
Byproduct:					
Metallurgy	--	--	17	30	150
Petroleum	92	131	102	100	110
Total	125	156	163	184	316
Bulgaria:[e]					
Pyrites	315	300	[r]200	[r]200	200
Byproduct, all sources	75	70	70	70	70
Total	390	370	[r]270	[r]270	270
Canada:					
Pyrites[7]	12	12	10	9	5
Byproduct:					
Metallurgy	667	903	783	627	730
Natural gas	5,935	5,899	5,599	5,226	5,390
Petroleum[e]	200	160	160	160	170
Tar sands	213	286	247	259	330
Total	7,027	7,260	6,799	6,281	6,625
Chile:					
Native:					
Refined	12	14	5	7	7
From caliche	65	74	110	98	100
Byproduct, metallurgy	27	27	[e]28	32	32
Total	104	115	143	137	139
China:[e]					
Native	200	200	200	200	200
Pyrites	1,500	1,700	1,800	1,800	2,100
Byproduct, all sources	300	300	300	300	300
Total	2,000	2,200	2,300	2,300	2,600
Colombia:					
Native	16	26	26	[e]26	26
Byproduct, petroleum	2	1	2	2	3
Total	18	27	28	28	29
Cuba:					
Pyrites	12	22	14	[e]20	20
Byproduct, petroleum[e]	8	8	8	8	8
Total[e]	20	30	[r]22	28	28

See footnotes at end of table.

Table 19.—Sulfur: World production (all forms), by country and source[1] —Continued

(Thousand metric tons)

Country[2] and source[3]	1979	1980	1981	1982[p]	1983[e]
Cyprus:[8] Pyrites	21	25	7	5	5
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	8	6	[e]6	6
Ecuador:[e]					
Native	5	5	4	5	5
Byproduct:					
Natural gas	5	5	5	5	5
Petroleum	5	5	5	5	5
Total	15	15	14	15	15
Egypt: Byproduct, petroleum and natural gas	3	3	2	2	4
Finland:					
Pyrites	151	144	184	177	180
Byproduct:					
Metallurgy	263	247	234	270	270
Petroleum[e]	30	30	30	[r]10	10
Total[e]	444	421	448	[r]457	460
France:					
Byproduct:					
Natural gas	1,940	1,840	1,701	1,668	1,693
Petroleum	188	226	221	[e]283	250
Unspecified[e]	160	150	120	[r]110	120
Total	2,288	2,216	2,042	2,061	2,063
German Democratic Republic:[e]					
Pyrites	10	10	10	([4])	--
Byproduct, all sources	350	350	350	[r]360	360
Total	360	360	360	360	360
Germany, Federal Republic of:					
Pyrites	203	222	213	229	200
Byproduct:					
Metallurgy[9]	450	450	400	[e]400	400
Natural gas	690	814	834	872	650
Petroleum	[r]213	220	[r e]190	220	195
Unspecified[e]	[5]93	93	95	100	95
Total	[r]1,649	1,799	1,732	1,821	1,540
Greece:					
Pyrites	63	61	[e]60	[e]60	60
Byproduct:					
Natural gas	--	--	4	97	115
Petroleum[e]	3	4	7	8	10
Total[e]	66	65	[r]71	[r]165	185
Hungary:					
Pyrites[e]	3	3	3	3	3
Byproduct, all sources	9	9	[e]9	[e]9	9
Total[e]	12	12	12	12	12
India:					
Pyrites	27	34	23	22	25
Byproduct:					
Metallurgy[e]	115	115	92	100	110
Petroleum	4	5	4	13	15
Total[e]	146	154	119	[r]135	150
Indonesia:[8] Native	([10])	([10])	1	1	1

See footnotes at end of table.

Table 19.—Sulfur: World production (all forms), by country and source[1] —Continued

(Thousand metric tons)

Country[2] and source[3]	1979	1980	1981	1982[p]	1983[e]
Iran:[e]					
Native	75	70	50	50	50
Byproduct, petroleum and natural gas	200	150	6	10	15
Total	275	220	56	60	65
Iraq:[e]					
Frasch	550	700	[r]200	[r]300	300
Byproduct, petroleum and natural gas	40	40	40	40	40
Total	590	740	[r]240	[r]340	340
Ireland: Pyrites	13	11	11	11	11
Israel: Byproduct, petroleum and natural gas[e]	10	10	10	10	10
Italy:					
Native	19	23	20	10	8
Pyrites	302	331	261	269	240
Byproduct, all sources[e 11]	250	250	[r]230	[r]210	210
Total	571	604	511	489	458
Japan:					
Pyrites	300	311	293	276	300
Byproduct:					
Metallurgy	1,350	1,300	1,236	1,268	1,270
Petroleum	1,241	1,173	1,080	1,051	1,075
Total	2,891	2,784	2,609	2,595	2,645
Korea, North:[e]					
Pyrites	255	250	225	200	200
Byproduct, metallurgy	[r]30	[r]30	[r]30	[r]30	30
Total	[r]285	[r]280	[r]255	[r]230	230
Korea, Republic of:[e]					
Byproduct:					
Metallurgy	54	54	54	54	54
Petroleum	36	36	36	36	36
Total	90	90	90	90	90
Kuwait: Byproduct, petroleum and natural gas[e]	100	120	[r]97	[r]141	145
Libya: Byproduct, petroleum and natural gas[e]	20	22	16	20	20
Mexico:					
Frasch	1,773	1,700	1,652	1,391	1,104
Byproduct:					
Metallurgy[e]	100	115	100	100	100
Petroleum and natural gas	252	402	426	425	429
Total[e]	2,125	2,217	2,178	1,916	1,633
Morocco: Pyrites	63	36	38	(4)	--
Namibia: Pyrites	4	4	8	58	[5]81
Netherlands:[e]					
Byproduct:					
Metallurgy	88	90	90	[r]100	100
Petroleum	70	52	55	[r]65	75
Total	158	142	145	[r]165	175
Netherlands Antilles: Byproduct, petroleum[e]	91	91	90	90	90
New Zealand: Byproduct, all sources[e]	1	(10)	(10)	(10)	(10)
Norway:					
Pyrites	119	193	200	195	198
Byproduct:[e]					
Metallurgy	40	40	40	40	40
Petroleum	6	6	6	6	10
Total[e]	165	239	[r]246	[r]241	248
Pakistan:					
Native	1	1	(10)	1	1
Byproduct, all sources[e]	14	14	15	[r]19	20
Total	15	15	15	20	21

See footnotes at end of table.

Table 19.—Sulfur: World production (all forms), by country and source[1] —Continued

(Thousand metric tons)

Country[2] and source[3]	1979	1980	1981	1982[p]	1983[e]
Peru:					
Native	([10])	--	--	--	--
Byproduct, all sources[e]	20	20	20	[r]58	65
Total	20	20	20	[r]58	65
Philippines:					
Pyrites	41	54	46	30	80
Byproduct, metallurgy	--	--	--	--	40
Total	41	54	46	30	120
Poland:[12]					
Frasch[e]	4,310	4,667	4,295	[r]4,441	4,400
Native[e]	520	518	478	[r]494	490
Byproduct:					
Metallurgy	310	300	300	300	300
Petroleum	35	30	30	30	30
Gypsum[e]	20	20	20	20	20
Total	5,195	5,535	5,123	5,285	5,240
Portugal:					
Pyrites	151	155	135	116	110
Byproduct, all sources	1	2	2	2	5
Total	152	157	137	118	115
Romania:[e]					
Pyrites	400	[r]350	[r]300	[r]200	200
Byproduct, all sources	130	140	150	150	150
Total	530	[r]490	[r]450	[r]350	350
Saudi Arabia:[e]					
Native	1	1	NA	--	--
Byproduct, petroleum and natural gas	125	460	600	[r]900	800
Total	126	461	600	[r]900	800
Singapore: Byproduct, petroleum[e]	20	20	10	10	10
South Africa, Republic of:					
Pyrites	243	493	502	465	[5]474
Byproduct:[e]					
Metallurgy	100	100	100	[r]135	[5]125
Petroleum	25	25	27	[r]25	32
Total	368	618	629	625	631
Spain:					
Pyrites	1,091	1,096	1,118	1,029	1,000
Byproduct:					
Coal (lignite) gasification[e]	3	3	3	3	3
Metallurgy	120	125	135	[e]125	120
Petroleum	10	12	12	[e]10	8
Total[e]	1,224	1,236	1,268	[r]1,167	1,131
Sweden:					
Pyrites	282	[r]202	204	206	208
Byproduct:					
Metallurgy[e]	130	130	130	130	130
Unspecified	36	[r]37	38	40	40
Total	448	[r]369	372	376	378
Switzerland: Byproduct, petroleum	3	3	3	3	3
Syria: Byproduct, petroleum and natural gas	[r]4	5	6	22	30
Taiwan:					
Pyrites	([10])	([10])	([10])	([4])	--
Byproduct, all sources	9	8	10	[e]20	27
Total	9	8	10	[e]20	27
Trinidad and Tobago: Byproduct, petroleum	77	57	44	[r e]10	20

See footnotes at end of table.

Table 19.—Sulfur: World production (all forms), by country and source[1] —Continued

(Thousand metric tons)

Country[2] and source[3]	1979	1980	1981	1982[p]	1983[e]
Turkey:					
Native	r21	r23	28	29	31
Pyrites	r16	r33	29	30	25
Byproduct, all sources[e]	70	70	r120	r126	[5]124
Total[e]	r107	r126	r177	r185	180
U.S.S.R.:[e]					
Frasch	800	800	800	800	800
Native	1,900	2,000	r2,000	r1,900	1,800
Pyrites	3,500	3,550	3,600	r3,600	3,600
Byproduct:					
Coal	40	40	40	40	40
Metallurgy	1,700	1,800	r1,800	r1,800	1,800
Natural gas	1,100	1,200	1,250	1,300	1,350
Petroleum	200	200	200	200	200
Total	9,240	9,590	r9,690	r9,640	9,590
United Kingdom:					
Byproduct:					
Metallurgy[e]	[5]56	50	50	50	50
Of petroleum refinery	53	e80	75	e85	60
Spent oxides	4	4	4	4	4
Total	113	e134	e129	e139	114
United States:					
Frasch	6,357	6,390	6,348	4,210	[5]3,202
Pyrites	400	322	307	265	W
Byproduct:					
Metallurgy	1,167	1,008	1,159	828	[5]831
Natural gas	1,760	1,757	1,971	1,960	[5]2,371
Petroleum	2,310	2,316	2,288	2,444	[5]2,584
Unspecified	107	78	72	80	[5]302
Total	12,101	11,866	12,145	9,787	[5]9,290
Uruguay: Byproduct, petroleum[e]	2	2	2	2	2
Venezuela: Byproduct, petroleum and natural gas[e]	[5]85	85	85	85	85
Yugoslavia:					
Pyrites	190	r252	274	r e277	270
Byproduct:[e]					
Metallurgy	200	200	r200	r200	180
Petroleum	5	5	4	r4	3
Total	395	r457	478	r e481	453
Zaire: Byproduct, metallurgy[e]	r25	r25	r25	r25	35
Zambia:					
Pyrites	1	r2	1	1	[5]11
Byproduct, all sources	74	92	90	84	84
Total	75	r94	91	85	95
Zimbabwe:[e]					
Pyrites	28	29	25	25	25
Byproduct, all sources	5	5	5	5	5
Total	33	34	30	30	30
Grand total	r53,227	r54,920	53,350	50,776	50,472

See footnotes at end of table.

Table 19.—Sulfur: World production (all forms), by country and source[1] —Continued

(Thousand metric tons)

Country[2] and source[3]	1979	1980	1981	1982[p]	1983[e]
Grand total—Continued					
Of which:					
Frasch	13,790	14,257	13,295	11,142	9,807
Native	[r]2,855	[r]2,971	2,947	2,832	2,728
Pyrites	[r]9,838	[r]10,292	10,205	9,892	9,946
Byproduct:					
Coal and coal gasification	43	43	43	43	43
Metallurgy	[r]7,142	[r]7,253	7,142	6,784	7,036
Natural gas	11,430	11,515	11,364	11,128	11,574
Petroleum	[r]4,983	[r]4,957	4,751	4,939	5,088
Petroleum and natural gas, undifferentiated	[r]878	1,330	1,331	1,703	1,623
Spent oxides	4	4	4	4	4
Tar sands	213	286	247	259	330
Other	2,004	[r]1,968	1,976	2,003	2,246
Gypsum	47	44	45	47	47

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available. W Withheld to avoid disclosing company proprietary data; included with "Byproduct: Unspecified."

[1]Table includes data available through May 23, 1984.

[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 is credited to the nation where the recovery takes place, which in some instances is not the original source country of the crude product from which the sulfur is extracted.

[4]Revised to zero.

[5]Reported figure.

[6]Exports; regarded as tantamount to production owing to minimal domestic consumption levels.

[7]Byproduct pyrite and pyrrhotite from the processing of metallic sulfide ores.

[8]In addition, may produce limited quantities of byproduct sulfur from oil refining.

[9]Includes only the elemental sulfur equivalent of sulfuric acid produced as a byproduct from metallurgical furnaces; additional output may be included under "Byproduct: Unspecified."

[10]Less than 1/2 unit.

[11]Includes recovery from gypsum, if any.

[12]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

The Bureau of Mines developed a sulfur concrete technology over the past several years. Sulfur concrete materials were tested under actual operating conditions in 50 corrosive process environments at 40 commercial plants. After 4 years of testing, these materials essentially showed no evidence of material degradation or loss of strength. However, conventional concrete materials were attacked and in some cases completely destroyed under the same conditions.[2]

[1]Physical scientist, Division of Industrial Minerals.

[2]McBee, W. C., T. A. Sullivan, and B. W. Jong. Industrial Evaluation of Sulfur Concrete in Corrosive Environments. BuMines RI 8786, 1983, 15 pp.

Talc and Pyrophyllite

By Robert A. Clifton[1]

Although the combined total domestic production of talc and pyrophyllite declined 6% in 1983, sales increased 13% because of increased demand. Exports decreased 6%.

Domestic Data Coverage.—Domestic production data for talc and pyrophyllite were developed by the Bureau of Mines from a voluntary survey of 33 known operating mines. All 33 mines responded, representing 100% of U.S. production data shown in table 1.

Table 1.—Salient talc and pyrophyllite statistics

(Thousand short tons and thousand dollars)

	1979	1980	1981	1982	1983
United States:					
Mine production, crude:					
Talc	1,268	1,127	1,236	1,049	980
Pyrophyllite	185	113	107	87	87
Total[1]	1,453	1,240	1,343	1,135	1,066
Value:					
Talc	$19,365	[r]$18,600	[r]$21,600	[r]$19,540	$18,998
Pyrophyllite	998	837	[r]1,016	1,131	1,282
Total[1]	20,364	[r]19,437	[r]22,616	[r]20,671	20,280
Sold by producers, crude and processed:					
Talc	1,119	1,173	1,115	915	1,038
Pyrophyllite	195	158	106	110	125
Total	1,314	1,331	1,221	1,025	1,163
Value:					
Talc	$80,529	$84,523	$95,354	$82,104	$104,739
Pyrophyllite	4,413	4,254	3,454	3,557	4,057
Total	84,942	88,777	98,808	85,661	108,796
Exports[2] (talc)	316	275	311	232	218
Value	$15,210	$14,963	$15,095	$12,957	$12,916
Imports for consumption (talc)	22	21	[3]27	[3]27	44
Value	$2,822	$3,720	[r 3]$5,834	[r 3]$6,264	$7,691
Apparent consumption	1,020	1,077	937	820	989
World: Production	[r]7,568	[r]8,306	7,965	[p]7,539	[e]7,553

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

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

[2]Excludes powders—talcum (in package), face, and compact.

[3]Does not include imported pyrophyllite.

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, 4.2% ad valorem; cut, sawed, or in blanks, crayons, cubes, disks, or other forms, 0.1 cent per pound; and other not specifically provided for, 4.8% ad valorem.

DOMESTIC PRODUCTION

Talc.—U.S. mine production of crude talc decreased about 7% in tonnage and 3% in value. Talc, including soapstone, was produced at 26 mines in 11 States. California led all States in the number of producing mines with six. Montana, New York, Texas, and Vermont accounted for 90% of domestic talc production. Montana continued to lead all States in the value of talc produced.

The Vermont Talc Co. changed its operation from an underground mine to open pit.[2] The company also opened a new open pit mine and completed engineering work on a new froth flotation plant. Cyprus Industrial Minerals Co. was evaluating a deposit on "lease land" technically owned by the city of Chester; Englehard Corp.'s Eastern Magnesia Talc Co., a large producer, permanently closed its mine in November.

The seven largest domestic producers of talc, listed alphabetically, remained Cyprus Industrial Minerals, with mines in California, Montana, and Texas; Eastern Magnesia Talc, in Vermont; Pfizer Inc., Minerals, Pigments & Metals Div., 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.

Pyrophyllite.—Pyrophyllite was produced by four companies operating seven mines in North Carolina and California. Total production remained at about the same level as that of 1982.

Table 2.—Crude talc and pyrophyllite produced in the United States, by State

(Thousand short tons and thousand dollars)

State	1982 Quantity	1982 Value	1983 Quantity	1983 Value
California	85	1,699	71	1,289
Georgia (talc)	20	141	14	101
North Carolina	83	1,266	89	1,452
Texas (talc)	205	3,024	250	3,933
Other[1] (talc)	742	r14,541	642	13,505
Total	1,135	r20,671	1,066	20,280

rRevised.
[1]Includes Arkansas, Montana, New York, Oregon, Vermont, Virginia, and Washington.

CONSUMPTION AND USES

Apparent domestic consumption of crude and processed talc and pyrophyllite increased 20%. Sales of talc and pyrophyllite increased 13% in tonnage and 27% in value.

End-use distribution of ground talc was ceramics, 35%; paint, 18%; roofing, 11%; paper, 9%; plastics, 6%; cosmetics, 5%; rubber, 3%; insecticides, 1%; and the remainder went to a variety of miscellaneous uses.

The largest portion, 32%, of domestically produced ground pyrophyllite was used in ceramics, 27% in refractories, 14% in insecticides, 8% in roofing, and the remainder in other uses. A significant fraction of imported pyrophyllite was ground for use in the ceramics industry.

Table 3.—End uses for ground talc and pyrophyllite

(Thousand short tons)

Use	1982 Talc	1982 Pyrophyllite	1982 Total	1983 Talc	1983 Pyrophyllite	1983 Total
Ceramics	292	20	312	319	27	346
Cosmetics[1]	45	--	45	50	--	50
Insecticides	7	19	26	5	12	17
Paint	170	1	171	166	1	167
Paper	79	--	79	81	--	81
Plastics	54	1	55	57	1	58
Refractories	2	22	24	2	23	25
Roofing	94	10	104	98	7	105
Rubber	21	1	22	28	--	28
Other[2]	83	11	94	95	13	108
Total	847	85	932	901	84	985

[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 other uses not specified.

PRICES

Talc prices varied depending on the quality and degree and method of processing. In general, prices remained steady except for minor increases and foreign exchange fluctuation. Prices, quoted by the Engineering and Mining Journal, December 1983, 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	40.00
99% through 325 mesh	50.00
100% through 325 mesh, fluid-energy ground	100.00

American Paint & Coatings Journal, December 26, 1983, 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, f.o.b. mill	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 1983, for steatite talc, c.i.f. main European ports, were as follows:

Australian, cosmetic (ex store)	\$105-\$180
Norwegian:	
Ground (ex store)	113- 120
Micronized (ex store)	150- 210
French, fine-ground	134- 191
Italian, cosmetic-grade	248
Chinese, normal (ex store):	
UK 200 mesh	180- 183
UK 300 mesh	188- 195

FOREIGN TRADE

Exports.—Talc exports decreased 6% while the average price of these exports increased 6% to \$59 per ton. These prices varied from between \$33 per ton for material shipped to Mexico to about \$500 per ton for material sent to several smaller countries.

Mexico remained the major importer of U.S. talc, accounting for 39% of the tonnage shipped, followed by Canada, 34%; Japan, 7%; and Belgium-Luxembourg, less than 1%. Canada, however, continued to lead in value of imports with 36% of the total compared with Mexico's 22%. A total of 53 countries were recipients of U.S. talc.

Imports.—U.S. imports of talc increased 63% because of increased crude from Australia and ground material from Canada. Australia became a new significant supplier to the United States. Imports from Canada increased by 71%. Canada, which supplied 41% of total imports, remained the leading source of imported talc, followed by Australia with 25%.

Table 4.—U.S. exports of talc[1]

(Thousand short tons and thousand dollars)

Year	Belgium-Luxembourg		Canada[2]		Japan		Mexico		Other		Total	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1979	18	1,043	60	4,485	19	1,145	164	3,539	55	4,998	316	15,210
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

[1]Excludes powders—talcum (in package), face, and compact.
[2]Probably includes shipments in transit through Canadian ports.

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)
1981	10,393	$1,254	15,154	$1,818	1,456	$1,490	$1,272	27,003	r$5,834
1982:									
Australia	37	4	3,653	314	--	--	--	3,690	318
Brazil	--	--	42	7	464	181	71	506	259
Canada	22	5	10,374	1,508	131	187	9	10,527	r1,709
China	--	--	--	--	195	165	393	195	558
India	NA	1	--	--	5	4	427	5	432
Italy	9,039	1,722	139	43	2	3	--	9,180	1,768
Korea, Republic of	--	--	1,426	312	164	94	--	1,590	406
Other[1]	5	2	535	311	270	352	149	810	814
Total	9,103	1,734	16,169	2,495	1,231	986	1,049	26,503	r6,264
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[2]	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

rRevised. NA Not available.
[1]Includes 13 countries.
[2]Includes 23 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 detailed discussion of the pyrophyllite industry in Australia and the Far East was reported in the literature.[3] Using primarily 1981 data, the article examined each country's share of the world's pyrophyllite production. Of the 1.8 million tons produced, Japan accounted for 57%, followed by the Republic of Korea, 25%; the United States, 6%; Brazil, 5%; Canada and India, 3% each; and Australia, 1%. Argentina and the Republic of South Africa accounted for less than 1% each.

Australia.—A description of the Pambula pyrophyllite mine of Steetley Industries Ltd., including location and geological setting, reserves, mining, processing, products, and pyrophyllite markets, was published.[4]

Canada.—Bakertalc Inc. enjoyed its best year ever in 1982, producing 15,000 tons.[5] At that production rate, reserves were determined to be adequate for 26 years.

Japan.—A study was published of the Japanese pyrophyllite industry, including complex geology of deposits and processing methods used. A detailed summary of each company's markets was provided. Of particular significance was the loss of large portions of the paper, rubber, and other markets to imported kaolin and talc.[6]

Korea, Republic of.—A report was published describing deposits of pyrophyllite in the Republic of Korea and its markets. The Republic of Korea, which ranked second in world production of pyrophyllite, continued to retain its centuries-old market in ornamental stone for carving and sculpture. Newer markets, such as raw material for refractories, had emerged during World War I and continued to consume the majority of South Korean pyrophyllite. Chinaware and tiles were also major pyrophyllite consumers.[7]

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[1]Physical scientist, Division of Industrial Minerals.
[2]Bixby, P. H. Talc. Min. Eng., v. 35, No. 5, May 1983, pp. 513-514.
[3]Industrial Minerals (London). No. 194, Nov. 1983, pp. 21-36.
[4]Nichol, D. Pyrophyllite Operations at Pambula, Australia. Ind. Miner. (London), No. 194, Nov. 1983, pp. 31-36.
[5]The Northern Miner (Toronto). Bakertalc Has Record in Sales, Earnings. V. 69, No. 19, July 14, 1983, p. 3.
[6]Fujii, N. The Present Position of Japanese Pyrophyllite. Ind. Miner. (London), No. 194, Nov. 1983, pp. 21-27.
[7]Sang, K. N. Pyrophyllite Clay Deposits in the Republic of Korea. Ind. Miner. (London), No. 194, Nov. 1983, pp. 30-31.

Table 6.—Talc and pyrophyllite: World production, by country[1]

(Thousand short tons)

Country[2]	1979	1980	1981	1982[p]	1983[e]
Argentina (talc, steatite, pyrophyllite)	38	36	40	32	32
Australia	174	188	100	[r] [e]103	103
Austria (unground talc)	128	129	128	129	128
Brazil (talc and pyrophyllite)[3]	403	455	555	[e]423	550
Canada (shipments)	100	96	98	[e]79	107
China[e]	165	1,010	990	990	990
Finland	295	350	339	358	330
France (ground talc)	333	332	341	305	305
Germany, Federal Republic of (marketable)	17	17	17	17	17
Hungary[e]	19	19	19	19	19
India	426	407	405	[r] [e]370	355
Italy (talc and steatite)	173	183	180	181	180
Japan[4]	1,884	1,928	1,703	1,645	[5]1,614
Korea, North[e]	175	185	185	185	185
Korea, Republic of (talc and pyrophyllite)	858	793	622	652	660
Mexico	9	11	15	14	13
Norway	96	97	37	[r] [e]36	40
Pakistan (pyrophyllite)	30	33	28	25	28
Peru (talc and pyrophyllite)	[r]7	[r]9	[r] [e]10	[r] [e]10	10
Romania[e]	66	66	66	66	66
South Africa, Republic of[6]	17	16	17	15	[5]8
Spain (steatite)	78	82	76	69	70
Taiwan	12	11	27	34	30
Thailand (talc and pyrophyllite)	15	13	13	24	24
U.S.S.R.[e]	530	540	550	560	560
United Kingdom	18	19	20	21	20
United States (talc and pyrophyllite)	1,453	1,240	1,343	1,135	[5]1,066
Other[7]	49	41	41	42	43
Total	[r]7,568	[r]8,306	7,965	7,539	7,553

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through May 9, 1984.
[2]In addition to the countries listed, Czechoslovakia produced talc, but available information was inadequate to make reliable estimates of output levels.
[3]Total of beneficiated and salable direct shipping production of talc and pyrophyllite.
[4]Includes talc, pyrophyllite, and pyrophyllite clay.
[5]Reported figure.
[6]Includes talc and wonderstone.
[7]Category represents the combined totals of Afghanistan, Botswana, Burma, Chile, Colombia, Egypt, Greece (steatite), Nepal, Paraguay, Philippines, Portugal, Sweden, Uruguay, Zambia, and Zimbabwe.

Thorium

By James B. Hedrick[1]

Domestic mine production of monazite, the principal source of thorium, increased in 1983. Associated Minerals Ltd. Inc. was the only domestic monazite producer. Thorium products used by the domestic industry during the year were imported or produced in the United States from either imported materials or from existing company and Government 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 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 request was sent responded, representing an estimated 100% of total production. The production data are withheld to avoid disclosing company proprietary data.

Table 1.—Salient U.S. thorium statistics

(Metric tons of ThO_2, unless otherwise specified)

	1979	1980	1981	1982	1983
Exports: Ores, metals	6	2	6	4	4
Imports: Metals, alloys, and compounds	27	24	33	23	46
Shipments from Government stockpile excesses	9	3	3	--	--
Apparent consumption, nonenergy applications[e 1]	30	25	30	19	42
Prices, yearend, dollars per kilogram, ThO_2:					
Nitrate, mantle-grade	$7.06	$8.40	$9.50	$10.60	$10.60
Oxide, 99%, grade	$15.45	$16.00	$21.20	$24.50	$31.00

[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.—Government stocks of thorium nitrate in the National Defense Stockpile were 3,234,936 kilograms, (equivalent to 1,547,043 kilograms of thorium oxide), compared with the stockpile goal of 272,155 kilograms (equivalent to 130,153 kilograms of thorium oxide).

DOMESTIC PRODUCTION

Monazite was produced as a byproduct of minerals sands mining for titanium and zirconium minerals at Green Cove Springs, FL, by Associated Minerals, a subsidiary of the Australian-owned firm Associated Minerals Consolidated Ltd. Associated Minerals was the only minerals sands operation in the United States to produce monazite during the year.

W. R. Grace's Davison Chemical Div. and Rhône-Poulenc were the only domestic processors of monazite or intermediate concentrates of monazite. Other firms processed imported and domestic finished compounds, metals, and alloys.

W. R. Grace processed monazite at its Chattanooga, TN, facilities to produce rare-earth catalysts and compounds. Although thorium was extracted from monazite, no thorium compounds were produced for sale. W. R. Grace's stored thorium residues contained a revised 3,200 metric tons[2] of thorium oxide equivalent at yearend.

Rhône-Poulenc separated rare earth-thorium hydroxides at its Freeport, TX, plant to produce rare-earth products. Thorium nitrate was produced as a byproduct.

Marathon Gold Corp. announced that it would recover monazite as a byproduct of its placer gold mining operations near Craig, CO, starting in 1985. The minerals sands reportedly contain from 7.5 to 20 kilograms of heavy minerals per ton, of which 5% to 21% is monazite. Marathon was reportedly negotiating with domestic rare-earth and thorium processors interested in purchasing its monazite concentrates.

Williams Strategic Metals Inc. (WSM), a subsidiary of Williams Resources Inc., announced plans to recover rare-earth and thorium-bearing apatite from 16 million tons of iron ore tailings near Mineville, NY. The Mineville Mine and facilities were purchased from Republic Steel Corp., which operated the iron mine until 1971. WSM reportedly expects to begin processing in 1985 at a rate of 90,000 tons of iron ore tailings per year. It was estimated that the company could produce 12 tons of byproduct thorium annually if there were sufficient demand. WSM would produce magnetite and yttrium, including rare earths, as coproducts and phosphoric acid as a byproduct.

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.

CONSUMPTION AND USES

Domestic thorium processors consumed an estimated 47 tons of thorium oxide equivalent in 1983 in energy and nonenergy uses.

The distribution of nonenergy uses for thorium was estimated as follows: refractory applications and associated research, 57%; aerospace alloys, 10%; lamp mantles, 18%; welding rods, 4%; and other applications and research, 11%.

Thorium used in metallurgical applications was primarily alloyed with magnesium. The addition of thorium to magnesium imparts high strength and excellent creep resistance at elevated temperatures, properties that are useful in aircraft and aerospace applications. Small quantities were used in dispersion-hardened alloys for high-strength, high-temperature applications.

Thorium oxide (thoria) has the highest melting point of all the oxides, 3,300° C, and is used in several refractory applications, including high-technology ceramics, investment molds, crucibles, and experimental stage core-retention beds for nuclear reactors.

Mantles for incandescent "camping" lanterns are coated with thorium nitrate. The nitrate is converted to an oxide when burned and produces an intense white light when heated in a gas flame.

Thorium nitrate was also used to produce thoriated tungsten welding electrodes. The addition of thorium improves the flow of electrons through the welding rod.

Other nonenergy uses for thorium were in electron tubes, special-use lighting, catalysts, and high-refractive glass.

An energy-related use for thorium is as a nuclear fuel using the thorium-232/uranium-233 fuel cycle. In the reactor process, fission of uranium-233 releases neutrons that are absorbed by thorium-232 creating additional uranium-233. If more uranium-233 exists after operation of the reactor than was initially loaded, the reactor has functioned as a breeder reactor.

STOCKS

The U.S. Department of Energy's inventory at yearend contained 1,237,270 kilograms of thorium oxide equivalent contained in various forms.

PRICES

The average declared value of imported monazite decreased significantly during 1983 to \$377 per ton, \$49 per ton less than the 1982 value. The price of Australian monazite (concentrate minimum 55% rare-earth oxide including thoria, f.o.b.-f.i.d.),[3] as quoted in Metal Bulletin (London), increased from \$A400 to \$A440 (US\$392 to US\$432)[4] per ton at yearend 1982 to \$A410 to \$A450 (US\$369 to US\$405)[5] per ton at yearend 1983. Although the Australian yearend quoted price for monazite increased, fluctuations in the foreign exchange rate caused the U.S. dollar price to decrease.

The yearend price for monazite based on a thorium oxide content of 7% was approximately \$5.27 to \$5.78 per kilogram of thorium oxide contained.

Rhône-Poulenc quoted thorium product prices, per kilogram, net 30 days, f.o.b. New Brunswick, NJ, or duty paid at point of entry, effective January 1, 1983, as follows: thorium oxide—99% purity, \$31; 99.99% purity, \$51. Thorium nitrate at 99.5% purity (mantle-grade) was quoted at \$10.60 per kilogram of thorium oxide equivalent.

FOREIGN TRADE

For the fourth consecutive year, France was the destination of all of the domestic exports of thorium ore, including monazite. It was believed that Rhône-Poulenc's rare-earth and thorium processing plant at La Rochelle, France, received the ore shipments.

Table 3.—U.S. foreign trade in thorium and thorium-bearing materials

(Quantity in kilograms unless otherwise specified)

	1981		1982		1983		Principal sources and destinations, 1983
	Quantity	Value	Quantity	Value	Quantity	Value	
EXPORTS							
Thorium ore, monazite	129,403	$146,421	91,508	$103,356	57,139	$51,678	France 57,139.
Metals[1]	195	10,639	301	17,690	937	48,882	United Kingdom 843; Japan 49; France 45.
IMPORTS							
Ore and concentrate:							
Thorium ore, monazite ___ metric tons	7,469	3,158,167	7,203	3,070,006	4,028	1,517,299	Australia 3,726; Malaysia 302.
ThO_2 content	522,830	XX	510,240	XX	284,980	XX	
Compounds:							
Nitrate	28,192	258,327	15,202	160,243	17,438	191,871	France 15,378; Canada 2,050; United Kingdom 10.
Oxide	18,348	377,164	13,787	307,058	35,844	825,393	France 31,412; Netherlands 2,898; Other 1,534.
Oxide equivalent, in gas mantles[e 2]	1,200	556,894	1,846	731,233	1,193	505,589	Malta 939; China 109; Brazil 91; Other 54.
Other	302	106,538	326	75,593	428	100,793	United Kingdom 351; the Federal Republic of Germany 48; Switzerland 29.
Metals and alloys	2,135	225,888	[r]4,780	NA	2,310	NA	United Kingdom 2,310.

[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 source of the world's thorium is monazite, a rare-earth phosphate mineral. Monazite was recovered as a byproduct of minerals sands mined for titanium and zirconium in many countries and as a byproduct of tin mining in Malaysia and Thailand. Monazite production quantities fail to reflect world demand for thorium because monazite is processed almost entirely for its rare-earth content. 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 located throughout the world.

Australia.—Allied Eneabba Ltd. produced 10,429 tons of monazite in 1983, an increase over the 5,693 tons produced in 1982. During the year, Allied acquired the assets of its mining contractor, Astek Pty. Ltd., through its wholly owned subsidiary, Indoon Resources Pty. Ltd., to improve mine production and reduce costs. Additional improvements were a major equipment refurbishing program that has enabled the company to shorten its workweek from 7 to 5 days, and the purchase of a single machine that can mine and load raw sand directly to haulage units.

Brazil.—According to Anuário Mineral Brasileiro 1983, measured reserves of monazite in Brazil were about 25,000 tons. The largest reserves, about 18,000 tons, are located in the São João de Barra region in the State of Rio de Janeiro.

China.—Exports of monazite from China increased to 11,520 tons valued at $719,000 in 1982, compared with 1,000 tons valued at $75,000 in 1981. France received all of the reported monazite exports. Monazite was reportedly being produced in Jiangxi and Guangdong Provinces. Strict Chinese national standards for radioactive materials has made the handling of monazite increasingly difficult. As a result, Chinese monazite is often converted to rare-earth chloride and the radioactive thorium is extracted.[6]

France.—In 1983, Rhône-Poulenc S.A. produced various thorium compounds from imported monazite, mainly for export worldwide, principally to the United States and the United Kingdom. Thorium oxide and nitrate were produced at its plant in La Rochelle, France. Thorium-bearing rare-earth hydroxide, an intermediate compound produced from monazite, was also shipped by Rhône-Poulenc.

India.—Monazite was produced by Indian Rare Earths Ltd. (IREL) and Kerala Minerals and Metals Ltd. IREL produced about 92% of the total.[7] Construction work at IREL's new Orissa Sands Complex near Chatrapur, in the State of Orissa, was in an advanced stage, and the complex was scheduled to begin production in the first half of 1984. Annual monazite capacity at Orissa will reportedly be 4,000 tons, from which 340 tons of thorium oxide could be produced. Orissa's reserves reportedly contained an estimated 130,000 tons of thorium oxide.

Sri Lanka.—Reserves at Pulmoddai, Ceylon Mineral Sands Corp.'s center of operation, were reported at 4 million tons grading 0.3% monazite. Other deposits in Sri Lanka were located at Kaikawela, Polkotuwa, Kudremela Point, and between Mullaitivu and Nilaveli including Pulmoddai.[8]

Thailand.—Monazite was produced entirely as a byproduct of tin mining. Production in 1983 came almost entirely from Ranong in the southern region.

Table 4.—Monazite concentrate: World production, by country[1]

(Metric tons)

Country[2]	1979	1980	1981	1982[p]	1983[e]
Australia	16,340	14,079	13,251	9,433	14,500
Brazil	1,900	2,532	2,100	[e]1,768	2,000
India[3]	3,254	3,395	3,704	[e]4,000	4,000
Malaysia (exports)	542	347	320	[e]450	340
Sri Lanka	213	63	[e]60	304	300
Thailand	32	152	107	162	140
United States	W	W	W	W	W
Zaire	90	51	50	[e]50	50
Total	22,371	20,619	19,592	16,167	21,330

[e]Estimated. [p]Preliminary. W Withheld to avoid disclosing company proprietary data; not included in "Total."
[1]Table includes data available through Apr. 27, 1984.
[2]In addition to the countries listed, China, Indonesia, Nigeria, the Republic of Korea, and North Korea 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

A report on the uranium and thorium resources of New Mexico was prepared by the New Mexico Bureau of Mines and Mineral Resources as part of the National Uranium Resource Evaluation. The report lists more than 1,300 deposits.[9]

A preliminary map of the thorium provinces in the conterminous United States was published by the U.S. Geological Survey. The map gives the location, type of deposit, a preliminary estimate of resource potential, and status of geologic resource information and sources.[10]

Significant concentrations of heavy-mineral sands, including monazite, were reported in surficial U.S. Atlantic Continental Shelf sediments. Comparisons of offshore sediments from Virginia, South Carolina, and northeastern Florida indicated monazite enrichment was highest off the coast of Virginia, with an average grade of 0.01%.[11]

[1]Physical scientist, Division of Nonferrous Metals.

[2]All measurements are in metric units unless otherwise specified.

[3]Free on board-free into container depot.

[4]Values have been converted from Australian dollars ($A) to U.S. dollars (US$) at the rate of $A1.019 = US$1.00 based on yearend 1982 foreign exchange rates from the Wall Street Journal.

[5]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.

[6]Roskill's Letter From China. China's Rare Earth Deposits. No. 5, Spring 1982, p. 2.

[7]Indian Rare Earths Ltd. 32d Annual Report 1981-82, p. 15.

[8]Industrial Minerals (Sri Lanka). Mineral Sands-Looking to Expansion. Oct. 1983, p. 63-64.

[9]McLemore, V. T. Uranium and Thorium Occurrences in New Mexico: Distribution, Geology, Production, and Resources, with Selected Bibliography. NM Bureau of Mines and Miner. Resour. Open File Rep., 1983, 950 pp. Available from the NM Bureau of Mines and Miner. Resour., Socorro, NM (photocopy), and from the Dep. of Energy, Bendix Field Engineering Corp., Grand Junction, CO (microfiche DOE OFR GJBX-11(83).

[10]Staatz, M. H., and T. J. Armbrustmacher. Preliminary Map of the Thorium Provinces in the Conterminous United States. U.S. Geol. Surv. OFR 79-576U, 1982, 1 p. Available from the U.S. Geol. Surv., Branch of Distribution, Denver, CO.

[11]Grosz, A. E., and E. C. Escowitz. Economic Heavy Minerals of the U.S. Atlantic Continental Shelf. Pub. in 6th Symp. on Coastal Sedimentology in connection with the Southeastern Geol. Soc. Am. meeting, Mar. 1983, 12 pp.

Tin

By James F. Carlin, Jr.[1]

For the third consecutive year, the world tin supply exceeded demand, although world mine production declined and world consumption rose slightly 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 were developed by the Bureau of Mines from a voluntary survey of U.S. mines. All three mines to which a survey request was sent responded.

Table 1.—Salient tin statistics

(Metric tons unless otherwise specified)

	1979	1980	1981	1982	1983
United States:					
Production:					
Mine	W	W	W	W	W
Smelter	4,600	3,000	2,000	3,500	2,500
Secondary	21,493	18,638	15,438	r14,293	14,822
Exports[1]	569	595	2,361	5,769	1,340
Imports for consumption:					
Metal	48,355	45,982	45,874	27,939	34,048
Ore (tin content)	4,529	840	232	1,961	969
Consumption:					
Primary	49,496	44,342	40,229	r33,019	34,301
Secondary	12,969	12,020	14,144	13,276	11,246
Stocks, yearend U.S. industry	r10,704	r12,101	r11,131	r10,251	9,859
Prices, average cents per pound:					
New York market	711.45	773.44	648.40	586.85	601.28
New York composite	753.89	846.00	733.05	653.91	654.78
London	700.93	761.99	649.53	580.50	589.19
Penang	672.33	745.56	637.85	587.29	590.78
World production:					
Mine	r245,294	r247,300	253,113	p237,176	e211,620
Smelter	r249,337	r249,236	247,832	p239,213	e222,035

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 throughout 1983. A total of 2,865 metric tons was sold in 1983. In response to continuing assertions that GSA stockpile sales were harming the economies of major tin producing countries, the U.S. Department of State, GSA, and the Association of Southeast Asian Nations signed a memorandum of understanding on December 13, limiting GSA tin disposals to 6,000 tons during the period January 1, 1983, through December 31, 1984.

At yearend 1983, the National Defense Stockpile inventory was 190,623 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.—Only one mine, operating in Alaska, 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 and Minerals Corp., decreased tin metal output to an estimated 2,500 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

	1982	1983
Tinplate scrap treated ---- metric tons--	[r]464,560	486,543
Tin recovered in the form of:		
Metal ---- do----	810	928
Compounds (tin content) ---- do----	[r]447	182
Total[1] ---- do----	[r]1,257	1,110
Weight of tin compounds produced ---- do----	1,754	1,284
Average quantity of tin recovered per metric ton of tinplate scrap used ---- kilograms--	[r]2.37	1.98
Average delivered cost of tinplate scrap ---- per metric ton--	[r]$56.16	$60.60

[r]Revised.
[1]Recovery from tinplate scrap treated only. In addition, detinners recovered 242 metric tons (244 metric tons in 1982) of tin as metal and in compounds from tin-base scrap and residues in 1983.

Table 3.—Tin recovered from scrap processed in the United States, by form of recovery

(Metric tons)

Form of recovery	1982	1983
Tin metal:		
At detinning plants	1,054	1,170
At other plants	13	10
Total	1,067	1,180
Bronze and brass:		
From copper-base scrap	6,897	6,596
From lead- and tin-base scrap	74	88
Total	6,971	6,684
Solder	2,723	3,072
Type metal	222	172
Babbitt	237	185
Antimonial lead	1,015	803
Chemical compounds	[r]447	182
Miscellaneous[1]	[r]101	94
Total	[r]4,745	4,508
Grand total	[r]12,783	12,372
Value (thousands)	[r]$165,384	$164,002

[r]Revised.
[1]Includes foil and terne metal.

Table 4.—U.S. stocks, receipts, and consumption of new and old scrap and tin recovered in 1983, 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)	2,505	60,935	59	59,837	59,896	3,544	2	2,573	2,575
Brass, composition or red	2,970	37,381	8,449	29,259	37,708	2,643	285	1,056	1,341
Brass, low (silicon bronze)	163	1,545	594	764	1,358	350	--	--	--
Brass, yellow	4,081	44,509	12,178	32,731	44,909	3,681	2	188	190
Bronze	2,092	15,879	2,373	14,063	16,436	1,535	186	1,106	1,292
Low-grade scrap and residues	9,133	82,991	69,153	18,592	87,745	4,379	5	--	5
Nickel silver	650	2,816	198	2,636	2,834	632	2	23	25
Railroad-car boxes	68	714	--	674	674	108	--	32	32
Total	21,662	246,770	93,004	158,556	251,560	16,872	482	4,978	5,460
Brass mills:[1]									
Brass, low (silicon bronze)	3,120	14,019	14,095	--	14,095	3,044	--	--	--
Brass, yellow	18,416	277,006	279,226	--	279,226	16,196	--	--	--
Bronze	882	4,251	3,955	--	3,955	1,178	188	--	188
Nickel silver	4,182	20,209	19,963	--	19,963	4,428	--	--	--
Total	26,600	315,485	317,239	--	317,239	24,846	188	--	188
Foundries and other plants:[2]									
Automobile radiators (unsweated)	1,213	4,790	W	4,918	4,918	1,085	--	221	221
Brass, composition or red	559	15,166	2,060	13,044	15,104	621	98	620	718
Brass, low (silicon bronze)	69	1,227	848	392	1,240	56	--	--	--
Brass, yellow	200	5,161	1,418	3,393	4,811	550	4	16	20
Bronze	826	586	277	281	558	854	21	22	43
Low-grade scrap and residues	--	--	--	--	--	--	--	--	--
Nickel silver	22	116	W	115	115	23	--	--	--
Railroad-car boxes	691	3,845	--	3,791	3,791	745	--	180	180
Total	3,580	30,891	4,603	25,934	30,537	3,934	123	1,059	1,182
Total tin from copper-base scrap	XX	XX	XX	XX	XX	XX	793	6,037	6,830
Lead-base scrap:									
Smelters, refiners, others:									
Babbitt	135	2,725	--	2,730	2,730	130	--	146	146
Battery lead plates	27,874	578,965	--	564,428	564,428	42,411	--	1,288	1,288
Drosses and residues	11,700	63,965	69,959	--	69,959	5,706	2,025	--	2,025
Solder and tinny lead	233	17,356	--	16,592	16,592	997	--	2,927	2,927
Type metal	1,230	4,693	--	5,332	5,332	591	--	251	251
Total	41,172	667,704	69,959	589,082	659,041	49,835	2,025	4,612	6,637
Tin-base scrap:									
Smelters, refiners, others:									
Babbitt	10	45	--	52	52	3	--	44	44
Block-tin pipe	5	78	--	74	74	9	--	73	73
Drosses and residues	17	439	444	--	444	12	34	--	34
Pewter	--	1	--	--	--	1	--	--	--
Total	32	563	444	126	570	25	34	117	151
Tinplate and other scrap:									
Detinning plants	--	--	478,109	--	478,109	--	1,204	--	1,204
Grand total	XX	XX	XX	XX	XX	XX	4,056	10,766	14,822

[e]Estimated; tin recovered new and old from copper-base scrap, brass mills, and foundries. W Withheld to avoid disclosing company proprietary data. 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 slightly but was well below the level of 1979. Solder was the largest application of primary tin, with tinplate following closely.

Tinplate continued to lose ground to aluminum in the container market. Out of 92.4 billion metal cans shipped, tinplated steel and tin-free steel accounted for 37% and aluminum accounted for 63%, compared with 89.3 billion metal cans shipped in 1982 when steel accounted for 41% and aluminum for 59%.[2]

Brass mills consumed 565 tons of primary tin and 300 tons of secondary tin, compared with 475 and 220 tons, respectively, in 1982.

Table 5.—U.S. consumption of primary and secondary tin

(Metric tons)

	1979	1980	1981	1982	1983
Stocks, Jan. 1[1]	13,584	r7,075	r8,835	r8,717	7,549
Net receipts during year:					
Primary	50,126	43,545	41,162	35,843	36,494
Secondary	2,636	2,461	5,692	6,507	5,412
Scrap	10,659	7,709	8,050	7,830	7,435
Total receipts	63,421	53,715	54,904	50,180	49,341
Total available	77,005	r60,790	r63,739	r58,897	56,890
Tin consumed in manufactured products:					
Primary	49,496	44,342	40,229	r33,019	34,301
Secondary	12,969	12,020	14,144	13,276	11,246
Total	62,465	56,362	54,373	r46,295	45,547
Intercompany transactions in scrap	1,602	835	726	274	245
Total processed	64,067	57,197	55,099	r46,569	45,792
Stocks, Dec. 31 (total available less total processed)	12,938	r3,593	r8,640	r12,328	11,098

rRevised.
[1]Includes tin in transit in the United States.

Table 6.—Tin content of tinplate produced in the United States

(Metric tons)

Year	Tinplate waste (waste, strips, cobbles, etc., gross weight)	Tinplate (all forms)		
		Gross weight	Tin content[1]	Tin per metric ton of plate (kilograms)
1979	360,852	4,236,578	17,929	4.2
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	r10,936	4.0
1983	166,186	2,586,810	9,328	3.6

rRevised.
[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	1982			1983		
	Primary	Secondary	Total	Primary	Secondary	Total
Alloys (miscellaneous)	W	W	W	W	W	W
Babbitt	1,088	827	1,915	2,563	318	2,881
Bar tin	509	W	509	654	W	654
Bronze and brass	1,466	2,934	4,400	1,395	3,188	4,583
Chemicals	W	W	W	W	W	W
Collapsible tubes and foil	W	W	W	W	W	W
Solder	9,250	3,892	13,142	10,087	4,033	14,120
Terne metal	(1)	(1)	(1)	(1)	(1)	(1)
Tinning	1,887	W	1,887	1,759	W	1,759
Tinplate[2]	10,969	165	11,134	9,328	134	9,462
Tin powder	906	W	906	793	W	793
Type metal	W	W	W	W	W	W
White metal[3]	1,054	123	1,177	856	81	937
Other	5,890	5,335	11,225	6,866	3,492	10,358
Total	r33,019	13,276	r46,295	34,301	11,246	45,547

rRevised. W Withheld to avoid disclosing company proprietary data; included with "Other."
1Included with "Alloys (miscellaneous)."
2Includes secondary pig tin and tin acquired in chemicals.
3Includes pewter, britannia metal, and jewelers' metal.

Table 8.—U.S. industry yearend tin stocks

(Metric tons)

	1979	1980	1981	1982	1983
Plant raw materials:					
Pig tin:					
Virgin[1]	r5,727	r7,359	r6,857	r6,269	6,326
Secondary	r181	r229	r411	r265	732
In process[2]	r1,167	r1,247	r1,449	r1,015	682
Total	r7,075	r8,835	r8,717	r7,549	7,740
Additional pig tin:					
Jobbers-importers	258	564	1,943	r1,386	608
Afloat to United States	3,371	2,702	471	r1,316	1,511
Total	3,629	3,266	2,414	2,702	2,119
Grand total	r10,704	r12,101	r11,131	r10,251	9,859

rRevised.
1Includes tin in transit in the United States.
2Tin content, including scrap. In 1980-83, data represent scrap only.

PRICES

The price of tin metal showed unusual stability throughout 1983. The average tin price was almost identical to that for 1982.

Table 9.—Monthly composite price of Straits tin for delivery in New York

(Cents per pound)

Month	1982 High	1982 Low	1982 Average	1983 High	1983 Low	1983 Average
January	786.82	770.16	775.90	633.16	618.40	624.43
February	773.54	657.16	745.19	661.65	634.10	650.69
March	679.41	654.76	669.17	677.84	654.54	667.72
April	666.66	651.09	655.99	698.69	676.45	687.59
May	671.46	646.86	662.84	686.77	673.49	680.00
June	640.85	565.61	608.25	677.72	658.85	667.07
July	627.97	595.19	612.55	671.20	648.68	659.68
August	647.84	608.17	625.49	653.19	642.94	648.38
September	664.08	620.99	639.04	653.22	638.05	645.10
October	632.00	621.35	624.74	653.31	634.25	646.83
November	625.45	601.73	613.47	652.75	646.49	649.02
December	619.57	608.54	614.33	645.40	620.30	630.80
Average	XX	XX	653.91	XX	XX	654.78

XX Not applicable.

Source: Metals Week.

FOREIGN TRADE

Imports of tin concentrates in 1983 fell to one-half the level of the prior year and remained well below the levels reached in 1973. Thailand remained the major source of tin metal, followed by Indonesia, Bolivia, and Brazil.

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 manufactures: Imports: Tinfoil, tin powder, flitters, metallics, tin and manufactures, n.s.p.f. Value (thousands)	Imports: Dross, skimmings, scrap, residues, and tin alloys, n.s.p.f. Quantity (metric tons)	Imports: Dross, skimmings, scrap, residues, and 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)
1981	$8,666	2,583	$3,387	$16,357	170	$2,098
1982	12,288	3,068	4,364	13,566	321	2,667
1983	10,728	1,193	1,219	8,972	642	4,120

Table 11.—U.S. exports and imports for consumption of tin, tinplate, and terneplate in various forms

Year	Ingots, pigs, and bars: Exports Quantity (metric tons)	Ingots, pigs, and 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)
1981	2,361	$31,053	r345,716	$220,993	r261,644	r$180,390	5,080	r$413
1982	5,769	84,454	r217,840	118,870	r198,123	r134,718	5,530	454
1983	1,340	17,305	171,121	83,827	266,548	168,413	2,144	188

r Revised.

[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	1982 Quantity (metric tons)	1982 Value (thousands)	1983 Quantity (metric tons)	1983 Value (thousands)
Concentrates (tin content):				
Bolivia	192	$1,817	257	$2,812
Canada	187	845	--	--
Peru	1,416	17,473	341	3,474
Singapore	--	--	101	887
South Africa, Republic of	144	1,183	270	2,376
Zaire	22	226	--	--
Total	1,961	21,544	969	9,549
Metal:[1]				
Australia	334	4,083	390	4,879
Belgium-Luxembourg	10	119	45	592
Bolivia	4,340	54,388	5,739	73,798
Brazil	2,409	31,675	5,604	70,885
Burma	--	--	56	754
Canada	2	49	2	41
Chile	116	1,589	71	905
China	2,632	35,495	1,938	23,617
Germany, Federal Republic of	(2)	14	181	2,335
Hong Kong	5	75	--	--
India	20	309	--	--
Indonesia	5,744	75,278	6,004	77,354
Malaysia	2,364	30,981	4,704	62,396
Mauritania	--	--	18	223
Netherlands	--	--	9	117
Nigeria	124	1,383	265	3,529
Singapore	600	7,848	1,029	13,701
South Africa, Republic of	38	473	18	228
Taiwan	--	--	135	1,705
Thailand	9,116	118,463	7,436	95,768
United Kingdom	55	737	18	268
Zaire	--	--	10	126
Zimbabwe	30	370	376	4,931
Total	27,939	363,329	34,048	[3]438,154

[1]Bars, blocks, pigs, or granulated.
[2]Less than 1/2 unit.
[3]Data do not add to total shown because of independent rounding.

WORLD REVIEW

International Tin Agreement (ITA).— The Sixth ITA, which commenced July 1, 1982, continued in effect throughout 1983. 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 preexport control levels and continued into the second quarter of 1983. The export cutback rate was tightened further to 39.6% in the third quarter, and remained at that level through the remainder of 1983. Some sources estimated the world tin surplus at about 80,000 tons.

Tin smuggling became a major factor in international trade and became the focus of ITC attention. Collaborative efforts by major tin producing members to eliminate illicit trade were increased and reportedly showed positive results.

The ITC buffer stock manager continued with tin price support actions on the London Metal Exchange and on the Penang physical tin market in Malaysia during most of the year. The ITC retained the same buffer stock price floor and ceiling ranges that were in effect since October 17, 1981. The ITC buffer stock price range was as follows:

	Malaysian dollars per kilogram
Floor price	29.15
Lower sector	29.15-32.06
Middle sector	32.06-34.98
Upper sector	34.98-37.89
Ceiling price	37.89

On August 16, 1983, an agreement establishing the Association of Tin Producing

Countries (ATPC) came into force. The five charter members were Bolivia, Indonesia, Malaysia, Thailand, and Zaire. Nigeria joined later in the year. The stated objectives of the ATPC were to obtain fair returns for tin producers and adequate and stable supplies for tin consumers at reasonable prices, to facilitate cooperation in the marketing of tin, and to enhance the growth of tin usage. Members stated that they viewed the ATPC as complementing and supporting the activities of the ITA.

Argentina.—Sociedad Minera Pirquitas Picchetti y Cía. S.A. operated the only tin mine, the Pirquitas Mine. In operation since 1936, located in the Jujuy Province, the underground mine produced both tin and silver. The ore grade was reportedly about 1.3% tin. The firm also operated the only tin smelter, located in Buenos Aires.

Australia.—Tasmania remained the source of about two-thirds of tin production, and the large Renison Ltd. underground tin mine in western Tasmania accounted for about 40% of the total tin output. Of the reported 78 tin mines, only about a dozen had significant production. Some of the smaller mines closed down during the year, but all the larger mines continued operating. About one-fourth of tin production was consumed domestically.

Associated Tin Smelters Pty. Ltd., in Sydney, which was the larger of the two Australian smelters, utilized raw materials from producers in eastern Australia, including many of the small operators in Queensland and New South Wales. The other smelter was operated by Greenbushes Tin NL, in Western Australia, which mined its own tin deposit adjacent to the smelter site.

Mungana Mines Ltd. entered a joint venture with Amoco Minerals Co. (Australia) for exploration of the Harpers base metals prospect in Queensland; tin was reported to be only one of several metals sought there.

Tin production began at Pacific Copper Mines Ltd.'s Kangaroo Creek property near Cairns, Queensland, with an initial ore throughput of 2,000 tons per day. Reserves were reportedly 3.7 million tons, grading 0.55 kilogram of tin per ton; property life was projected at 6 years.

Otter Exploration Ltd. further explored its Windermere tin prospect in Queensland and reported finding a zone that averaged 0.95% tin.

A joint venture led by Metals Exploration Ltd. reported near-surface tin mineralization in New South Wales, at the Midway 3KEL prospect, of about 1.8 million tons of material grading 0.7% tin, in a strike length believed to be about 16 kilometers.

Great Northern Mining Corp. Ltd. acquired the assets of Loloma Ltd. in the Herberton-Irvine Bank area of North Queensland. Both firms were tin producers.

Renison Goldfields Consolidated Ltd. announced exploration prospects at St. Dizier and at St. Helens, both in Tasmania.

Bolivia.—With a work force of over 26,000 people, the Corporación Minera de Bolivia (COMIBOL) was the country's largest tin producer. 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. COMIBOL began a rehabilitation study of its mine and milling equipment, with the assistance of two foreign consulting firms. A significant proportion of mine output was from medium-sized mines. There were also many small mines and a number of mining cooperatives.

Smelting was mainly done by the state-owned Empresa Nacional de Fundiciones (ENAF). ENAF reportedly was short of its tin production targets because of labor difficulties, raw material shortages, and lack of foreign exchange revenue to purchase needed foreign equipment to keep the firm's facilities operating.

Brazil.—Not a member of the ITA, the Brazilian Government encouraged the growth of its tin mining industry. Brazil announced plans to increase tin output by 25% and exports by 35% in 1984. The Government encouraged domestic tin smelters to export metal in order to bring in foreign exchange to help offset the country's balance-of-payment problems and prohibited the export of tin concentrates.

The three largest private tin mining companies—the Paranapanema S.A. Mineração, Indústria e Construção; Brascan Ltd.; and Mineração Brumadinho S.A.—announced plans to sharply increase output.

Paranapanema, Brazil's major tin producer, announced the startup of its new mine in Pitinga in Amazonas State. The property was estimated to contain some 60,000 tons of tin ore.

St. Joe Minerals Corp. neared completion of a feasibility study at its Mocambo tin project, an alluvial deposit situated near São Felix in the Xingu River area of Pará State. A small plant was set up to determine the metallurgical characteristics of the deposit. If the deposit should prove to be an economical venture, production of about 1,000 tons per year of tin by 1985 was considered possible. This was the first major investment in a metal mining venture by Mineração San Jose Ltd., St. Joe's mining subsidiary in Brazil.

Brazil's smelting capacity was rated at 24,000 tons per year, and only about 50% was utilized. Industry sources identified at least nine smelters. The largest were the Mamore smelter and the Cesbra smelter, each in the 7,000- to 8,000-ton-per-year-capacity range.

Canada.—Rio Algom Ltd. announced plans to develop a substantial open pit mine at its tin prospect in the East Kemptville area of Nova Scotia. Startup was planned for 1985. The operation was expected to produce about 4,500 tons per year of tin concentrates and to cost $150 million. The company announced minable ore resources of 56 million tons at 0.17% tin, and the property was expected to have a life of 17 years.

Indonesia.—In this important tin producing country, more than 60% of deposits were located offshore. P.T. Tambang Timah, the national mining organization, remained the dominant producer.

P.T. Koba Tin ranked as the country's second largest tin producer. Its low-cost mine on Banyka Island yielded a reported 5,000 tons of tin production for the year. Koba was jointly owned by Kajaura Mining Corp. (Pty.) Ltd., an Australian company, and by P.T. Tambang Timah.

P.T. Broken Hill Proprietary Indonesia was offered for sale by its parent company in Australia. The firm operated the Kelapa Kampit Mine on Belitung Island. In the past, this was the only Indonesian tin mine to export its concentrates, usually to Malaysia or the United Kingdom.

Planning progressed for the new $96 million electrolytic tinning line to be built adjacent to the P.T. Krakatau Steel complex in Cilegon, West Java. The new facility was to be operated by a newly formed firm, P.T. Pelat Timah Nusantara, a joint venture of P.T. Tambang Timah, P.T. Krakatau Steel, and P.T. Nusantara Ampera Bakti. It was expected that the tinning line, with an annual capacity of 130,000 tons, would soon make the country self-sufficient in tinplate.

Malaysia.—Following the pattern of recent years, the number of active mines declined. There were 547 mines in 1983, compared with 936 mines in 1978. The number of dredges declined to 38, the number of gravel pump mines declined to 430, and the total tin industry labor force declined about 10% to 25,600 people.

Namibia.—The majority of tin production came from the Uis tin mine, in the Brandberg area, about 193 kilometers north of Swakopmund. The Uis tin 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. They provided a large part of Iscor's tin needs for use in the making of electrolytic tinplate.

Nigeria.—The Government was studying a plan to bring the five major tin mining firms under a new Government-funded holding company, the Nigerian Tin Mining Co. The five firms were 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. Makeri Smelting Co. Ltd. continued to treat all Nigerian tin concentrates.

Nigerian tin mine production declined rather steadily over recent years, from a figure of almost 8,000 tons in 1970 to about 1,000 tons in 1983. The Government reported that existing alluvial deposits were depleted and that mining firms on the central plateau had not reinvested in prospecting and new mine development.

Singapore.—According to ITC estimates, about 7,000 tons of tin concentrates were smuggled to Singapore, a non-ITC member, for smelting. Malaysia was reported to be the main source of the material, with Indonesia and Thailand also important sources. The smuggled tin constituted a double burden on tin producing countries; first, it was out of the ITC's control and thus represented an unwanted surplus, which tended to further depress the world price; second, since the smugglers did not pay export taxes or royalties on the tin, the Government was deprived of an important source of revenue.

Reportedly, delegations from major Asian tin producing countries implored Singapore to ban the importation of tin concentrates that appeared to be smuggled.

The Kimetal Ltd. smelter, with a capacity of about 7,200 tons per year, reportedly operated only at a 1,000-ton-per-year level owing to depressed tin demand.

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.

Rooiberg reported declining tin grades and announced a $3.4 million program of shaft-sinking projects designed to increase proven reserves at its existing mines. Union reported that its mine was nearing the end of its working life and would probably close by 1984 or 1985.

Thailand.—The drop in tin production in 1983 was reportedly caused by mounting operating costs, relatively low tin prices, environmental conflicts, smuggling, and the ITC export controls. Industry sources especially pointed to relatively high tin royalties paid by miners as a major disincentive. Near yearend, the Government reduced the royalty from the equivalent of about $1.50 per pound to about $1.15 per pound.

The Thaisarco smelter at Phuket, with a capacity of 38,000 tons per year, operated at only about one-half of capacity. The Thai Pioneer smelter, with a 3,600-ton-per-year capacity, remained closed owing to financial problems and a lack of feed; the Jootee Group and the Nganthawee Group, both large tin mining organizations, expressed interest in acquiring it.

Tongkah Harbour Ltd. announced plans to increase the capacity of its 50-year-old dredge located near Phuket by about 50%.

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

(Metric tons)

Country	1979	1980	1981	1982[p]	1983[e]
Argentina	386	351	413	304	[2]338
Australia	12,571	11,588	12,267	12,126	9,700
Bolivia	27,648	27,291	29,830	26,773	24,400
Brazil	7,005	6,930	8,297	[e]9,500	12,000
Burma	1,233	1,290	1,438	1,681	[2]1,642
Burundi	8	--	--	--	--
Cameroon	8	[r]15	19	[e]14	14
Canada	337	264	239	135	[2]141
China[e]	14,000	14,600	15,000	15,000	15,000
Czechoslovakia[e]	[3]180	322	433	[r]443	400
German Democratic Republic[e]	1,600	1,800	[r]1,600	[r]1,700	1,700
Indonesia	[r]29,535	[r]32,527	35,392	33,806	27,000
Japan	660	549	561	529	[2]599
Korea, Republic of	31	8	--	--	--
Laos[e]	[r]170	[r]290	[r]200	[r]225	200
Malaysia	62,995	61,404	59,938	52,330	42,000
Mexico	23	60	28	27	25
Namibia	1,042	1,070	1,228	1,326	1,400
Niger	[r]89	[r]64	55	36	40
Nigeria	2,750	2,569	2,300	1,240	1,060
Peru	870	1,077	1,519	1,672	[2]2,368
Portugal	225	274	506	410	400
Rwanda	1,910	2,069	1,790	1,655	[2]1,520
South Africa, Republic of	2,697	2,913	2,811	3,035	[2]2,668
Spain	496	437	564	518	500
Tanzania	10	12	11	[e]10	10
Thailand	33,962	33,685	31,474	26,109	[2]19,943
Uganda	60	30	30	30	30
U.S.S.R.[e]	35,000	36,000	36,000	37,000	37,000
United Kingdom	2,373	2,982	3,869	4,208	4,100
United States	W	W	W	W	W
Vietnam	[e]200	370	380	[e]580	550
Zaire	3,879	3,159	3,321	3,144	3,200
Zambia[e]	1	([4])	--	10	[2]22
Zimbabwe[e]	1,340	1,300	1,600	[r]1,600	1,650
Total	[r]245,294	[r]247,300	253,113	237,176	211,620

[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 6, 1984.

[2]Reported figure.

[3]Estimate by the International Tin Council.

[4]Less than 1/2 unit.

The dredge was producing at the rate of about 470 tons per year of tin concentrates.

Sea Minerals Ltd. claimed discovery of a major tin deposit near Phuket. The firm was completing a second barge and expected to increase its prospecting.

U.S.S.R.—The U.S.S.R. continued to rank as an important tin producer. The major Soviet tin mining regions were the Soviet Far East, Yakutia, and Transbaykal.

United Kingdom.—Tin mining was centered in the Cornwall area. Marine Mining Consortium Ltd. continued construction of a tin recovery plant at Gwithian on St. Ives Bay. By 1985, the firm planned to start a dredging operation that would cover the area from St. Ives Bay to Cligga Head, with the dredge penetrating the mining waste that for centuries had flowed to the sea in streams and rivers from Cornwall tin mining. The company expected to obtain 1 kilogram of pure tin for every 2 tons of waste dredged from the seabed. It determined that no suitable harbors existed for landing the dredged waste. It was planned that the firm's dredge vessel would bring the material to a floating buoy 700 meters from the shore at Gwithian. From there a pipeline would transport it to the plant, which Marine Mining estimated would operate until the material was exhausted about 20 years later.

Geevor Tin Mines Ltd. announced a $3 million project to deepen the shaft at its mine and installed new concentration equipment designed to increase throughput capacity to 250,000 tons per year.

The privately owned Wheal Concord lode mine near Truro was placed into receivership and operations were closed owing to financial problems.

Table 14.—Tin: World smelter production, by country[1]

(Metric tons)

Country	1979	1980	1981	1982[p]	1983[e]
Argentina[e]	100	300	[r]200	[r]200	150
Australia	5,423	4,819	4,286	3,105	[2]2,913
Belgium	2,240	2,822	65	--	--
Bolivia	14,950	18,191	20,005	19,032	15,525
Brazil	10,133	8,792	7,639	9,298	13,000
China[e]	14,000	14,600	15,000	15,000	15,000
German Democratic Republic[e]	2,000	2,200	2,300	[r]2,400	2,400
Germany, Federal Republic of	4,096	2,262	1,815	608	500
Indonesia	27,790	30,465	32,429	29,755	29,300
Japan	1,251	1,319	1,315	1,296	1,260
Malaysia[3]	73,068	71,318	70,326	69,000	65,000
Mexico[4]	1,268	[r]1,322	838	944	925
Netherlands	[r]1,700	[r]1,100	2,700	2,700	2,750
Nigeria	2,858	2,678	2,486	2,754	2,340
Portugal	1,121	938	900	[e]400	[2]200
South Africa, Republic of	819	1,100	2,056	[e]2,800	2,400
Spain	4,412	4,100	4,400	3,700	[2]2,200
Thailand	33,058	34,689	32,626	25,497	[2]18,467
U.S.S.R.[e]	35,000	36,000	36,000	37,000	37,000
United Kingdom	8,025	5,829	6,839	8,200	6,300
United States[5]	4,600	3,000	2,000	3,500	2,500
Vietnam[e]	(6)	(6)	(6)	[r]475	520
Zaire	458	458	450	352	150
Zimbabwe	967	934	1,157	1,197	[2]1,235
Total	[r]249,337	[r]249,236	247,832	239,213	222,035

[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 unless otherwise specified. Table includes data available through June 6, 1984.

[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: 1979—23; 1980—60; 1981—28; 1982—27; and 1983—25 (estimated).

[5]Includes tin content of alloys made directly from ores.

[6]Revised to zero.

TECHNOLOGY

Thermo Electron Corp. announced a new method for reclaiming tin from tin smelter dust without the necessity to preagglomerate the tin dust particles. Dust containing tin oxide was directed into the tail flame of a plasma reactor, where the tin oxides were reduced to liquid tin using hydrogen or hydrocarbon gases. Tin was removed from a collection vessel at the bottom of the plasma reactor. The tin could also have been allowed to solidify and then remelted to separate tin from slag in the tin product. The plasma recovery process reportedly achieved yields of 95% in metal containing 99% tin.[3]

The Geological Research Corp. developed a process for concentrating tin oxide material having a particle size less than 10 micrometers. The method consisted of subjecting an aqueous slurry of ore containing fine tin oxide materials to a high-intensity wet magnetic separator at a field strength of about 10,000 gauss. The process separated the slurry into a nonmagnetic product and a magnetic product. Successive separation products were later combined to form a concentrate containing the major proportion of the tin oxide materials originally present in the slurry.[4]

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[1]Physical scientist, Division of Nonferrous Metals.

[2]Can Manufacturers Institute. Metal Can Shipments Report 1983. Washington, DC, 1983, p. 5.

[3]Thermo Electron Corp. Plasma Recovery of Tin From Smelter Dust. U.S. Pat. 4,410,358, Oct. 10, 1983.

[4]Geological Research Corp. Recovery of Tin, Magnetic Separating of Tin Oxide Minerals in a Slurry. U.S. Pat. 4,382,856, May 10, 1983.

Titanium

By Langtry E. Lynd[1] and Ruth A. Hough[2]

Domestic consumption of titanium concentrates and titanium dioxide (TiO_2) pigments increased, mainly because of recovery in the homebuilding industry. Production of rutile increased, but output of ilmenite was about the same as in 1982. Demand for titanium metal declined somewhat further as hopes for an early recovery in the commercial aircraft market failed to materialize.

Rutile prices dropped in the first half of the year, but were in a strong uptrend at yearend as demand for TiO_2 pigments improved. The price of high-TiO_2 slag was raised early in the year and that of ilmenite increased slightly by yearend. Titanium sponge metal published prices were unchanged, but discounting from list prices was prevalent. Titanium dioxide pigment sales prices strengthened, but was still appreciably below 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. Out of 40 operations to which a survey request was sent, 92% responded, representing an estimated 95% of the consumption of rutile, ilmenite, and titanium slag shown in tables 1 and 7. Consumption for the three nonrespondents was estimated using reported prior-year consumption levels.

Table 1.—Salient titanium statistics

(Short tons unless otherwise specified)

	1979	1980	1981	1982	1983
United States:					
Ilmenite concentrate:					
Mine shipments	646,399	593,704	523,681	233,063	W
Value thousands	$32,965	$32,041	$37,013	$19,093	W
Imports for consumption	184,478	357,488	236,217	348,366	259,328
Consumption	791,063	848,607	856,116	583,250	730,578
Titanium slag:					
Imports for consumption	111,210	194,994	268,825	247,845	138,708
Consumption	144,708	181,582	252,826	225,541	166,401
Rutile concentrate, natural and synthetic:					
Imports for consumption	283,479	281,605	202,373	163,325	111,578
Consumption	313,761	297,582	285,371	238,937	265,558
Sponge metal:					
Imports for consumption	2,488	4,777	6,490	1,354	1,199
Consumption	23,937	26,943	e31,599	e17,328	e16,072
Price, Dec. 31, per pound	$3.98	$7.02	$7.65	$5.55	$5.55
Titanium dioxide pigments:					
Production	742,081	727,245	761,190	r657,362	757,341
Imports for consumption	104,968	97,590	124,906	138,922	174,857
Consumption, apparent	837,042	753,480	806,040	r738,717	849,964
Price, Dec. 31, cents per pound:					
Anatase	53.0	57.0	69.0	69.0	69.0
Rutile	59.0	63.0	75.0	75.0	75.0
World: Production:					
Ilmenite concentrate	r3,909,537	r4,106,830	4,017,591	p3,346,221	e 1 2,876,302
Rutile concentrate, natural[1]	r389,992	r480,472	398,673	p374,437	e358,987
Titaniferous slag	r842,033	r1,343,202	1,244,864	p1,157,000	e1,095,000

eEstimated. pPreliminary. rRevised. W Withheld to avoid disclosing company proprietary data.
[1]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 short tons. The Government stockpile in December contained 21,465 tons of specification sponge metal and 10,866 tons of nonspecification material.

The General Services Administration (GSA) on October 28 announced contract awards for the purchase of 4,500 tons[3] of primary titanium for the stockpile, 3,500 tons of which was awarded to Japanese and United Kingdom producers. These purchases were delayed following a complaint by RMI Co. that foreign producers were awarded contracts despite the possibility that they might be guilty of dumping and despite questions as to whether the awards contradict the Buy-America provisions of the Stockpile Act. At yearend, an antidumping charge brought by RMI against imports from Japan and the United Kingdom was being investigated by the U.S. International Trade Commission.

The Government stockpile goal for rutile was unchanged at 106,000 tons. The total rutile stockpile inventory at yearend was 39,186 tons.

DOMESTIC PRODUCTION

Concentrates.—U.S. producers of ilmenite in 1983, with a total production capacity of about 600,000 tons per year, were Associated Minerals (U.S.A.) Ltd. Inc. (AMU) at Green Cove Springs, FL; E. I. du Pont de Nemours & Co. Inc. at Starke and Highland, FL; and NL Industries Inc. at Tahawus, NY. Production was increased somewhat in Florida, but decreased greatly at Tahawus following the 1982 closure of the NL Industries pigment plant at Sayreville, NJ, which had utilized the Tahawus concentrate.

As in 1982, AMU was the only U.S. producer of natural rutile concentrate. Kerr-McGee Chemical Corp. continued production of synthetic rutile at its 110,000-ton-per-year Mobile, AL, plant.

Ferrotitanium.—Ferrotitanium was produced by A. Johnson & Co. Inc., Lionville, PA; Reactive Metals and Alloys Corp., West Pittsburgh, PA; and Shieldalloy Corp., Newfield, NJ. Most of the production of ferrotitanium consisted of the 70% titanium grades.

Metal.—Domestic production and consumption of titanium sponge metal each dropped about 6%. Sponge production capacity remained about the same as in 1982.

The low level of titanium production and demand in 1983 was attributed mainly to the depressed state of the commercial aircraft industry. Several companies, including RMI and Oregon Metallurgical Corp., reportedly were making plans for increased participation in the smaller but faster-growing nonaerospace part of the titanium market. Viking Metallurgical Corp., Verdi, NV, a major producer of titanium forgings, reportedly had long-range plans geared toward becoming a major producer of titanium mill products for industrial applications. Viking added a 3,500-ton-per-year electron beam (e.b.) furnace, bringing its total melting capacity to 5,000 tons per year. Other companies that have been developing the capability of producing commercially pure (c.p.) mill products for industrial applications included Cabot Corp., Kokomo, IN, producing primarily flat-rolled products, and A. Johnson, which licensed e.b. technology from Viking. A major part of A. Johnson's activities was scheduled to be devoted to casting c.p. slab directly from titanium melted in its new e.b. furnace at Morgantown, PA, eliminating the step of remelting ingot and forging it into slab.

RMI made an agreement with Kobe Steel Ltd. to ship c.p. titanium ingot and other c.p. titanium products to Kobe in Japan for processing to tube and pipe and possibly sheet and strip. These products will then be shipped back to the United States and sold by RMI. ALS Metals Co., the Allegheny Ludlum Steel Corp.-Sumitomo Group partnership formed in late 1982, planned to initially manufacture and market c.p. titanium sheet, strip, plate, and welded tubing in the United States and Canada.

RMI began operations in its new melt shop at Niles, OH, in July. The melt shop reportedly can produce ingots up to 48 inches in diameter, weighing over 20 tons. In August, RMI announced the purchase of Micron Metals Inc., Salt Lake City, UT. Micron Metals is a major processor of titanium and other metal powders.

Albany Titanium Inc. (ALTi) began construction of its laboratory and office complex and scheduled for completion by late 1984 a pilot plant capable of producing 500 tons of titanium per year. ALTi has exclusive rights to two issued and five pending patents on a low-cost process that was developed by Occidental Petroleum Corp. The process was claimed to have lower raw material and processing costs than existing commercial processes and was said to be continuous, with energy costs only 25% of those of current producers. The plant was to be expanded to produce 5,000 tons per year by early 1986.

Teledyne Allvac, Monroe, NC, in 1983 began operation of a new $20 million forging facility to form bars and other shapes from titanium ingot that the company produces at Monroe. The addition of this forging capability was part of an $80 million, 7-year modernization program.

Wyman-Gordon Co. completed installation of two vacuum-arc furnaces at its new aerospace alloys center in Millbury, MA, with melting capacity of 1,500 tons per year. Ingots up to 36 inches in diameter weighing 10 tons can reportedly be produced.

Suisman Titanium Corp.'s ST-2001 tungsten-carbide-free titanium turnings were qualified by Pratt & Whitney Aircraft Group, General Electric Co., and McDonnell Douglas Corp. as an approved raw material for the production of premium- and rotor-grade titanium ingots. These qualifications should greatly expand the use of titanium turnings to produce ingot.

The charter meeting of the Titanium Development Association was held in New York, NY, on December 8. The stated purposes of the association were to promote the common interests of producers, processors, and consumers of titanium metal; to encourage the highest professional and ethical standards in the business practices and general conduct of the titanium industry; and to cooperate with other industries, organizations, Government entities, and international trade associations to improve and expand the use of titanium.

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)	TiO_2 content (short tons)	Value (thousands)
1979	639,292	646,399	389,535	$32,965
1980	[r]556,646	593,704	358,181	32,041
1981	[r]542,357	523,681	310,854	37,013
1982	[r]263,391	233,063	145,725	19,093
1983	W	W	W	W

[r]Revised. 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 1983

Company	Ownership	Plant location	Capacity (short tons)	
			Sponge	Ingot
A. Johnson & Co. Inc	Axel Johnson Group of Stockholm, Sweden.	Lionville, PA	--	[1]1,500
Howmet Corp., Alloy Div	Pechiney Ugine Kuhlmann, 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	--
Lawrence Aviation Industries Inc.	Self	Port Jefferson, NY	--	1,000
Martin Marietta Aluminum Inc	do	Torrance, CA	--	4,000
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	59,000

[1]Single melt only, commercially pure ingot and slab.

Pigment.—Production of TiO_2 pigment was 15% higher than in 1982, reflecting improvement in economic conditions. Two producing companies were expanding capacity, and one company ceased production.

Kerr-McGee announced it will spend $4 million to expand its 56,000-ton-per-year chloride process TiO_2 pigment plant at Hamilton, MS, by about 13% to 63,500 tons per year. The expansion project was scheduled to be completed by the third quarter of 1984. The company said that production in 1982 exceeded nominal capacity by about 4,000 tons per year.

SCM Corp. in 1983 purchased a 35,000-ton-per-year chloride-process TiO_2 and titanium tetrachloride plant at Ashtabula, OH, from Gulf + Western Industries Inc. following a decision by the Federal Trade Commission not to oppose the acquisition.

Gulf + Western reportedly withdrew from the TiO_2 industry, and shut down its 44,000-ton-per-year sulfate-process plant at Gloucester City, NJ, in November.

Table 4.—Components of U.S. titanium metal supply and demand

(Short tons)

Component	1979	1980	1981	1982	1983
Production:					
Sponge	[1]21,100	[1]22,500	[1]26,400	[1]15,600	13,966
Ingot	37,414	42,864	[r]46,236	[r]26,536	26,439
Exports:					
Sponge	180	113	58	36	39
Other unwrought	155	344	257	173	258
Scrap	4,967	3,300	3,280	4,287	5,379
Ingot, slab, sheet bar, etc	1,984	3,278	4,203	2,196	1,371
Other wrought	1,316	1,845	1,846	1,404	783
Total	8,602	8,880	9,644	8,096	7,830
Imports:					
Sponge	2,488	4,777	6,490	1,354	1,199
Scrap	6,140	4,138	3,787	1,277	1,572
Ingot and billet	338	191	244	212	81
Mill products	942	946	1,116	870	935
Total	9,908	10,052	11,637	3,713	[2]3,788
Stocks, end of period:					
Government: Sponge (total inventory)	32,331	32,331	32,331	32,331	32,331
Industry:					
Sponge	2,155	2,381	[e]3,720	[e]3,350	[e]3,136
Scrap	6,733	8,641	[e]10,484	[e]11,073	[e]12,635
Ingot	2,366	1,860	3,592	[r]2,534	3,218
Other	200	2	7	3	22
Total industry	11,454	12,884	17,803	16,960	19,011
Reported consumption:					
Sponge	23,937	26,943	[e]31,599	[e]17,328	[e]16,072
Scrap	13,986	15,406	[e]14,795	[e]8,528	[e]10,467
Ingot	37,868	43,360	43,592	27,580	26,231
Mill products (net shipments)[3]	23,113	27,133	25,492	18,281	15,949
Castings (shipments)[3]	186	191	209	[r]260	240

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

[3]U.S. Bureau of the Census, Current Industrial Reports, Ser. ITA-991.

Table 5.—Capacities of U.S. titanium dioxide pigment plants on December 31, 1983

Company and plant location	Pigment capacity (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	--	56,000
SCM Corp., Glidden Pigments Group:		
Ashtabula, OH	--	77,000
Baltimore, MD	66,000	42,000
Total	130,000	744,000

Table 6.—Components of U.S. titanium dioxide pigment supply and demand

(Short tons)

Component	1979 (gross weight)	1980 (gross weight)	1981		1982		1983	
			Gross weight	TiO_2 content	Gross weight	TiO_2 content	Gross weight	TiO_2 content
Production	742,081	727,245	761,190	700,648	[r]657,362	607,113	757,341	669,841
Shipments:[1]								
Quantity	756,941	731,546	778,116	727,854	707,075	662,487	813,958	762,818
Value (thousands)	$720,265	$795,734	$947,881	$947,881	$927,517	$927,517	$950,515	$950,515
Exports	49,369	42,126	61,104	57,440	72,823	66,280	91,702	86,096
Imports for consumption	104,968	97,590	124,906	[e]117,412	138,922	[e]130,309	174,857	[e]164,191
Stocks, end of period	54,008	83,237	102,189	96,058	86,933	81,543	77,465	72,740
Consumption, apparent[2]	837,042	753,480	806,040	742,080	[r]738,717	685,657	849,964	756,739

[e]Estimated. [r]Revised.
[1]Includes interplant transfers.
[2]Apparent consumption equals production plus imports minus exports minus stock increase.

Sources: Bureau of the Census and Bureau of Mines. 1980 is the 1st year for which actual TiO_2 content data are available for total production.

CONSUMPTION AND USES

Concentrates.—The total amount of titanium in concentrates consumed domestically increased 14%, mainly because of higher TiO_2 pigment production. Most of the increase in consumption was in the form of ilmenite.

Metal.—Demand for titanium sponge, ingot, and mill products declined in all market sectors except military aircraft. Mill product shipments were 48% in the form of billet; 39% sheet, strip, plate, tubing, pipe, extrusions, and other; and 13% rod and bar. As in previous years, bar and billet were the major forms used for aerospace gas turbine engines and airframe forgings, while the other forms were used mainly for nonaerospace industrial applications. Mill product usage was estimated to be about 75% for aerospace and 25% for other industrial uses.

The largest uses of titanium were for compressor blades and wheels, stator blades, rotors, and other parts in aircraft gas turbine engines, and in airframe structures of both military and commercial aircraft, such as wing-support structures, landing gears, ducting, and structures where resistance to heat is required. The most rapid growth in titanium use has been for those industrial uses requiring superior resistance to corrosion, such as surface condensers in powerplants, heat exchangers, and chemical industry equipment.

Pigment.—Consumption of TiO_2 pigments rose to a new peak, mainly because of increased demand from the homebuilding industry.

Ferrotitanium.—Consumption of ferrotitanium and titanium metal 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]
1979	791,063	487,228	144,708	106,346	313,761	292,912
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:						
Alloys and carbide	(3)	(3)	(4)	(4)	--	--
Pigments	574,634	345,618	225,541	168,433	[2]194,994	[2]184,403
Welding-rod coatings and fluxes	(3)	(3)	--	--	5,607	5,275
Miscellaneous[5]	8,616	6,775	--	--	38,336	35,435
Total	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	[2]265,558	[2]250,418

[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	1979	1980	1981	1982	1983
Paints, varnishes, lacquers	47.4	44.1	43.4	43.3	43.3
Paper	21.8	24.3	23.8	24.6	24.2
Plastics (except floor covering and vinyl-coated fabrics and textiles)	11.8	10.6	11.4	11.4	11.7
Rubber	2.9	2.1	2.2	2.3	1.6
Printing ink	1.9	2.8	1.3	.9	1.0
Ceramics	1.9	1.7	1.4	1.1	1.0
Other	7.1	8.2	8.6	6.4	5.9
Exports	5.2	6.2	7.9	10.0	11.3
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)

	1979	1980	1981	1982	1983
Carbon steel	529	423	641	420	744
Stainless and heat-resisting steel	2,368	1,620	1,552	1,289	1,748
Other alloy steel (includes HSLA)	959	848	903	664	749
Tool steel	W	W	W	W	W
Total steel[2]	3,856	2,891	3,096	2,373	3,241
Cast irons	129	102	63	47	38
Superalloys	1,197	1,053	645	409	535
Alloys, other than above	234	272	254	200	252
Miscellaneous and unspecified	9	13	26	10	12
Total consumption	5,425	4,331	4,084	3,039	4,078

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 stocks of concentrates decreased 35% mainly because of a 273,000-ton reduction in ilmenite stocks. The high usage from stocks reflected increased consumption along with lower production and imports.

Table 10.—Stocks of titanium concentrates and pigment in the United States, December 31

(Short tons)

	Gross weight	TiO_2 content[e]
Ilmenite:[1]		
1981[r]	854,444	543,114
1982[r]	742,644	470,776
1983	469,342	299,260
Titanium slag:[1]		
1981	203,692	150,706
1982	135,765	103,667
1983	78,378	61,026
Rutile:[1]		
1981	163,054	153,770
1982	176,079	165,762
1983	130,034	122,188
Titanium pigment:[2]		
1981	NA	102,189
1982	NA	86,933
1983	NA	77,465

[e]Estimated. [r]Revised. NA Not available.
[1]Producer, consumer, and dealer stocks.
[2]U.S. Bureau of the Census. Producer stocks only.

PRICES

Concentrates.—The published prices of titanium concentrates were generally higher by yearend.

Metal.—Titanium metal published prices were unchanged, but sales were reported at discounted prices, including purchases of sponge metal for the Government stockpile at prices in the \$2.92 to \$3.97 range.

Pigment.—In the fourth quarter, U.S. TiO_2 pigment producers reportedly increased their pigment sales prices about 5 cents per pound above the previous discount levels of 60 cents per pound for rutile grades and 58 to 59 cents per pound for anatase grades.

Table 11.—Published prices of titanium concentrates and products

	1982[1]	1983[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	28.00- 31.00	30.00- 34.00
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	450.00-475.00	400.00-430.00
Rutile, bagged, f.o.b. Australian ports do	240.00-250.00	267.00-284.00
Rutile, bulk, f.o.b. Australian ports do	231.00-240.00	259.00-275.00
Rutile, large lots, bulk, f.o.b. Titen, FL do	310.00	310.00
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	150.00	162.00
Titanium slag, 85% TiO_2, f.o.b. Richards Bay, Republic of South Africa[e] do	170.00-180.00	170.00-180.00
Metal:		
Sponge, domestic, f.o.b. plant per pound	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	6.50- 7.00	No quotation.
Mill products:		
Bar do	18.00	18.00
Billet do	15.00	13.00
Plate do	17.00	16.00
Sheet do	[r]18.00	18.00
Strip do	[r]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.
[1]Yearend.
[2]Slag contained 72% and 74% TiO_2 in 1982, and 74% and 80% TiO_2 in 1983. Price is for 74% TiO_2 product.

FOREIGN TRADE

Since 1980, the main trends in exports and imports of titanium materials have been increases in TiO_2 pigment exports and imports, and decreases in imports of titanium metal, slag, natural rutile, and synthetic rutile.

Table 12.—U.S. exports of titanium products, by class

Class	1981		1982		1983	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Concentrates:						
Ilmenite	NA	NA	19,230	\$618	865	\$26
Rutile	7,297	\$2,099	2,452	661	3,526	980
Total	7,297	2,099	21,682	[1]1,280	4,391	1,006
Metal:						
Sponge	58	451	36	256	39	203
Other unwrought	257	2,244	173	1,218	258	1,896
Scrap	3,280	6,811	4,287	6,718	5,379	7,074
Ingots, billets, slabs, etc	4,203	105,647	2,196	60,240	1,371	29,232
Other wrought	1,846	53,807	1,404	40,368	783	22,965
Total	9,644	168,960	8,096	108,800	7,830	61,370
Pigment and oxides:						
Titanium dioxide pigments	61,104	63,398	72,823	77,657	91,702	86,900
Titanium compounds, except pigment-grade	1,328	3,004	1,299	4,411	1,819	5,232
Total	62,432	66,402	74,122	82,068	93,521	92,132

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

Table 13.—U.S. imports for consumption[1] of titanium concentrates, by country

Concentrate and country	1981 Quantity (short tons)	1981 Value (thousands)	1982 Quantity (short tons)	1982 Value (thousands)	1983 Quantity (short tons)	1983 Value (thousands)
Ilmenite:						
Australia	234,562	$5,791	342,279	$8,671	259,328	$9,262
Germany, Federal Republic of[2]	--	--	24	2	--	--
Norway	1,656	96	--	--	--	--
Sri Lanka	--	--	6,063	92	--	--
Total[3]	236,217	5,887	348,366	8,765	259,328	9,262
Titanium slag:						
Canada	246,137	27,326	201,168	24,908	127,691	18,533
South Africa, Republic of	22,685	3,001	45,685	7,348	11,016	1,628
Other	3	2	992	609	--	--
Total[3]	268,825	30,328	247,845	32,865	138,708	20,161
Rutile, natural:						
Australia	88,345	28,887	74,501	20,498	80,096	16,450
Malaysia	11	187	--	--	--	--
Sierra Leone	25,236	6,983	53,308	13,200	--	--
South Africa, Republic of	47,406	11,723	11,320	2,431	10,817	3,365
Other	25	9	2	2	79	21
Total[3]	161,022	47,790	139,131	36,131	90,992	19,836
Rutile, synthetic:						
Australia	39,708	8,854	22,744	2,876	11,118	1,767
France	--	--	--	--	127	111
India	440	1,886	--	--	--	--
Japan	1,200	492	1,450	603	617	235
Taiwan	--	--	--	--	8,723	1,583
Other	3	2	--	--	--	--
Total[3]	41,351	11,234	24,194	3,479	20,586	3,696
Titaniferous iron ore:[4]						
Canada	12,271	509	6,996	336	2,124	107

[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	1981 Quantity (short tons)	1981 Value (thousands)	1982 Quantity (short tons)	1982 Value (thousands)	1983 Quantity (short tons)	1983 Value (thousands)
Australia	5,341	$5,129	4,712	$4,850	5,591	$5,824
Belgium-Luxembourg	4,860	4,525	4,731	4,902	14,456	11,287
Canada	15,710	17,288	21,912	25,135	25,563	27,396
Finland	5,196	5,262	4,026	4,176	4,829	4,678
France	22,663	24,029	20,862	22,726	31,195	30,032
Germany, Federal Republic of	38,482	39,229	37,506	37,432	36,659	35,804
Italy	56	57	297	318	1,223	1,082
Japan	4,724	4,936	5,266	6,084	4,888	4,870
Netherlands	2,635	1,893	--	--	254	211
Norway	4,992	4,583	7,312	7,125	6,428	5,638
Spain	13,017	13,061	19,234	19,614	23,006	18,784
United Kingdom	7,011	7,200	12,014	13,266	19,761	19,135
Yugoslavia	112	106	506	494	155	115
Other[1]	r106	r96	r544	r446	848	638
Total[2]	124,906	127,396	138,922	146,569	174,857	165,495

rRevised.
[1]Includes China, Gibraltar, Hong Kong, India, the Republic of Korea, Mexico, 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	1981 Quantity (short tons)	1981 Value (thousands)	1982 Quantity (short tons)	1982 Value (thousands)	1983 Quantity (short tons)	1983 Value (thousands)
Unwrought: Sponge						
Canada[1]	--	--	3	$32	--	--
China	633	$9,947	24	287	1	$4
Japan	5,747	81,822	1,283	16,753	976	6,761
U.S.S.R	110	1,746	44	160	193	913
United Kingdom	--	--	--	--	30	177
Total[2]	6,490	93,515	1,354	17,232	1,199	7,856
Ingot and billet:						
Austria	58	792	20	194	--	--
Canada	([3])	3	35	634	7	102
China	80	2,150	([3])	1	--	--
Germany, Federal Republic of	48	988	6	134	19	405
Japan	38	678	66	1,154	44	546
U.S.S.R	--	--	13	182	4	38
United Kingdom	20	526	71	1,260	6	133
Other	--	--	([3])	2	([3])	4
Total[2]	244	5,139	212	3,560	81	1,228
Waste and scrap:						
Austria	30	83	--	--	39	55
Belgium	39	78	63	62	66	89
Canada	1,483	5,436	195	698	451	2,240
China	74	812	17	88	22	19
Finland	127	511	--	--	--	--
France	103	1,054	31	106	62	95
Germany, Federal Republic of	213	1,267	72	261	166	365
Japan	251	1,820	48	191	44	130
Sweden	98	599	69	197	90	168
Switzerland	--	--	--	--	117	184
U.S.S.R	406	1,053	280	516	--	--
United Kingdom	876	6,128	475	1,489	463	1,036
Other	86	733	26	41	52	80
Total[2]	3,787	19,574	1,277	3,648	1,572	4,461
Wrought titanium:						
Canada	610	4,617	469	7,549	317	5,219
China	--	--	5	279	--	--
Germany, Federal Republic of	55	1,863	([3])	24	([3])	2
Japan	377	11,810	367	7,495	605	8,842
United Kingdom	55	2,708	16	695	8	258
Other	19	575	12	199	5	33
Total[2]	1,116	21,573	870	16,240	935	14,354

[1]Country of transshipment rather than country of production.
[2]Data may not add to totals shown because of independent rounding.
[3]Less than 1/2 unit.

WORLD REVIEW

World production of titanium concentrates decreased somewhat despite reports of generally increased TiO_2 pigment production and demand, resulting in a reduction in stocks of concentrates and a consequent firming of prices, particularly for rutile.

World demand for titanium sponge metal remained well below world capacity, and capacity utilization was below 50%.

Australia.—Australia continued to be the largest producer of titanium minerals, with exports of ilmenite to Brazil, Japan, Spain, the United Kingdom, the United States, and the U.S.S.R., and exports of rutile mainly to Japan, the United Kingdom, and the United States.

Belgium.—Titech Europe SA dedicated a new titanium foundry in May at Charleroi. Titech Europe was jointly owned by Titech International Inc. of Pomona, CA, and a Government of Belgium regional investment group. The plant was scheduled to produce premium-grade titanium castings to meet the growing needs of Europe's aerospace, petrochemical, marine, and nuclear industries.

Brazil.—In October, Cia. Vale do Rio Doce (CVRD) started up its pilot plant for processing anatase ore from the Tapira and Salitre carbonatite complexes in Minas Gerais State. Anatase, like rutile, is a crystalline form of titanium dioxide. The process is the result of a 10-year research program by CVRD, and involves grinding, reduction, and magnetic and electrostatic separation to yield a 90% TiO_2 concentrate suitable for chloride-process titanium dioxide pigment or metal manufacture. The Tapira and Salitre anatase deposits represented a very large potential source of titanium, with a reserve base estimated at over 50 million tons of TiO_2.

Canada.—QIT-Fer et Titane Inc. completed ahead of schedule its $8.1 million ore-upgrading plant to allow production of 80% TiO_2 slag instead of the 74% TiO_2 grade it produced since late 1982, and the 72% grade it made in prior years. The Sorel smelter was fully converted to produce the 80% TiO_2 slag by October 31, 1983.

Finland.—The Otanmaki Mine, the sole producer of ilmenite in 1983, was expected to close within the next year or two because of unprofitability.

Germany, Federal Republic of.—NL Chemicals, a division of NL Industries Inc., announced a major expansion of its Kronos Titan AG chloride-process TiO_2 plant at Leverkusen, from 40,000 tons per year to 88,000 tons per year, to be completed by mid-1985. The company planned to shut down an equivalent capacity of its sulfate-process plant also at Leverkusen, reducing considerably the quantity of waste generated at the site. The project was said to be a result of pressure from environmental groups in the Federal Republic of Germany and the Netherlands to halt the disposal of TiO_2 plant waste in the North Sea. The Federal Republic of Germany has reportedly decided to ban all disposal in the North Sea of titanium dioxide plant wastes by the end of 1989.

India.—Indian Rare Earths Ltd.'s Orissa sands project was reportedly well advanced toward startup by May 1984 of its 110,000-ton-per-year synthetic rutile plant. In addition to annual production of 240,000 tons of ilmenite, for conversion to synthetic rutile, the mine was expected to produce 11,000 tons of natural rutile, 33,000 tons of sillimanite, 4,000 tons of monazite, and 4,000 tons of zircon. An acid regeneration plant was expected to yield up to 88,000 tons of iron oxide.[4]

Japan.—In November, Showa Titanium Co. Ltd., a joint venture of Showa Denko K.K. and Ishizuka Research Inc., started trial operation of its new 2,200-ton-per-year titanium sponge plant in Toyama City. Commercial operation was to begin in January 1984 at about 50% of capacity. The new plant is based on an improved process developed by Ishizuka that was expected to have a power consumption rate about 25% less than in currently employed processes.

Production of titanium sponge in Japan was 11,600 tons, 37% less than in 1982. Japan's titanium sponge production capacity, including the new Showa plant, was about 37,500 tons per year.

Sierra Leone.—Production of rutile by Sierra Rutile Ltd., owned by Nord Resources Corp., Dayton, OH, was resumed in January 1983 following a 3-month shutdown.

U.S.S.R.—Production of titanium sponge metal was estimated to be 45,000 tons, and annual production capacity was estimated to be about 50,000 tons.

United Kingdom.—Deeside Titanium Ltd. was believed to be producing titanium granules at about 30% of its 5,500-ton-per-year capacity. Deeside's largest sale through December was the 500 tons sold to the U.S. General Services Administration for the Government stockpile.

IMI Titanium Ltd. completed construction at its Birmingham plant of a new melting furnace capable of producing 10-ton titanium ingots. The furnace uses a molten sodium-potassium eutectic for crucible cooling, rather than water, to avoid the explosion hazard of a water-cooled crucible.

Table 16.—Titanium: World production of concentrates (ilmenite, leucoxene, rutile, and titaniferous slag), by concentrate type and country[1]

(Short tons)

Concentrate type and country	1979	1980	1981	1982[p]	1983[e]
Ilmenite and leucoxene:[2]					
Australia:					
Ilmenite	[r]1,301,839	[r]1,526,218	1,456,303	1,266,788	965,000
Leucoxene	[r]24,769	26,393	21,232	22,198	19,800
Brazil	14,541	18,562	16,631	[e]17,000	17,000
China[e]	NA	NA	150,000	150,000	154,000
Finland	131,947	175,267	178,023	184,968	[3]176,370
India[4]	161,867	185,078	179,141	168,500	165,000
Malaysia[5]	220,262	208,470	190,432	114,571	209,000
Norway	903,690	912,508	724,907	608,215	[3]599,657
Portugal	295	258	368	322	330
Sri Lanka	61,035	37,430	88,197	75,268	[3]90,145
U.S.S.R.[e]	450,000	460,000	470,000	475,000	480,000
United States[6]	639,292	[r]556,646	542,357	263,391	W
Total	[r]3,909,537	[r]4,106,830	4,017,591	3,346,221	2,876,302
Rutile:					
Australia	[r]302,620	[r]343,639	254,432	243,277	190,000
Brazil	484	472	190	[e]220	220
India[4]	5,445	5,908	7,397	7,400	7,700
Sierra Leone	8,267	52,356	55,992	52,590	[3]79,146
South Africa, Republic of[e]	46,000	53,000	55,000	52,000	62,000
Sri Lanka	16,176	14,097	14,662	7,950	[3]8,921
U.S.S.R.[e]	[r]11,000	[r]11,000	[r]11,000	[r]11,000	11,000
United States	W	W	W	W	W
Total	[r]389,992	[r]480,472	398,673	374,437	358,987
Titaniferous slag:					
Canada[7]	[r]525,835	[r]964,202	836,864	[r] [e]737,000	675,000
Japan[7]	198	NA	NA	NA	NA
South Africa, Republic of[e] [8]	316,000	379,000	408,000	420,000	420,000
Total	[r]842,033	[r]1,343,202	1,244,864	1,157,000	1,095,000

[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: 1979—8,127,413; 1980—not available; 1981—3,208,185; 1982—3,136,054; and 1983—not available. This material reportedly contains 20% TiO_2. The table includes data available through June 13, 1984.

[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]Reported figure.

[4]Data are for fiscal year beginning Apr. 1 of year stated.

[5]Exports.

[6]Includes a mixed product containing ilmenite, leucoxene, and rutile.

[7]Contains 70% to 74% TiO_2.

[8]Contains 85% TiO_2.

TECHNOLOGY

The Bureau of Mines assessed the feasibility of prereduction of domestic ilmenites and titaniferous magnetite with coal char to improve melting operations and subsequent electric furnace processing to yield iron metal and titanium-enriched slags. Prereduction decreased electrode consumption during furnace operation and also conserved expensive electrical energy that otherwise must be used to reduce and melt the entire titaniferous materials charge.[5]

In another Bureau of Mines study, the heat capacity of titanium disulfide (TiS_2) was determined from 5.87° to 300.7° Kelvin by adiabatic calorimetry.[6]

A U.S. patent was issued covering an Occidental Research Corp. process for making titanium metal from titanium ore, including ilmenite. Albany Titanium Co. obtained the rights to the process, which involves fluorinating the ore with a fluosilicate melt such as sodium fluosilicate and reducing the titanium fluorides to metal. The reduction may be carried out by contacting the molten titanium fluorides with a molten alloy of zinc and aluminum, forming a titanium-zinc alloy and fluorides of aluminum. The titanium-zinc alloy is separated from the aluminum fluorides and the zinc is distilled from the alloy to leave behind titanium sponge metal.[7]

The three major processes for producing titanium metal sponge were reviewed: The Kroll process, which uses magnesium to reduce titanium tetrachloride ($TiCl_4$) to titanium metal; the Hunter process, which uses sodium for the reduction; and electrowinning, which is a direct reduction from titanium salts dissolved in a fused salt bath using electrical energy. The review also discussed $TiCl_4$ production from ore, sponge purification methods, costs, production capabilities, and projected usages.[8]

The properties and use of a new cold-formable alloy, developed primarily by the U.S. Air Force, were described. The new alloy, Ti-15V-3Cr-3Al-3Sn (Ti-15-3) is a metastable beta strip alloy, and was developed with the objective of reducing manufacturing costs by being cold-formable rather than requiring hot rolling like the established alpha-beta alloys.[9]

The effects of various methods of rapid solidification processing (RSP) of titanium alloys on alloy composition, microstructures, and properties were investigated. The results indicated that the primary benefits of RSP in titanium alloys will result from the development of novel alloy compositions rather than by improvements in the properties of conventional compositions. Several novel titanium alloys expected to produce unique combinations of microstructure and properties upon RSP were identified.[10] Companies involved in RSP work on titanium alloys included McDonnell Douglas Corp., Pratt & Whitney Aircraft Group, the Boeing Co., General Electric Co., and other firms.[11]

The advantages of applying titanium nitride (TiN) and other ultrahard coatings to cutting tools by physical vapor deposition (PVD) were described. Not only was the life between regrinds reportedly increased by 2 to 10 times, but less power was used at the same speed and feed, and heavier cuts at higher speeds were said to be practical and recommended. TiN was one of the least difficult coatings that could be applied by PVD and was reported to be one of the best.[12]

Titanium powder metallurgy (p/m) technology was experiencing growth and acceptance in orthopedic and hip implant devices and in the electroplating and chemical fixture industries. However, the use of titanium p/m for aircraft application was still described as minimal. Powder metallurgy parts best suited to aerospace applications include landing gears, impellers, and structural airframe components.[13]

New advances in powder metallurgy and castings that reportedly resulted in premium-quality materials that were directly competitive with conventional wrought-ingot metallurgy products, were described. These advances reportedly overcame the problem of reduced fatigue performance that previously prevented use of powder metallurgy in high-integrity applications.[14]

The use of superplastic forming of titanium into built-up, low-cost advanced titanium structures (BLATS) that result in substantial weight and cost savings was described. The BLATS technology, developed by Rockwell International's Metal and Process Laboratory in the early 1970's, was being applied in 1983 to make 92 parts for the F-15, the F-18, and the AV8B Harrier, products from McDonnell Douglas, and retrofit parts of the Northrop T-38 jet trainer. For the B-1B bomber, to be made by Rockwell, two parts were identified for production by the BLATS method, with another 20 as possible candidates for such production.[15]

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[1]Physical scientist, Division of Nonferrous Metals.
[2]Statistical assistant, Division of Nonferrous Metals.
[3]Weight units used in this chapter are short tons unless otherwise specified.
[4]Clarke, G. M. The Industrial Minerals of India. Ind. Miner. (London), No. 191, Aug. 1983, pp. 21-36.
[5]Nafziger, R. H., and R. R. Jordan. Prereduction and Melting of Domestic Titaniferous Materials. Metall. Trans. Bull., v. 14B, No. 1, Mar. 1983, pp. 55-62.
[6]Beyer, R. P. Heat Capacities of Titanium Disulfide From 5.87 to 300.7° K. J. Chem. and Eng. Data, July 1983, pp. 347-348.
[7]Hard, R. A., and M. A. Prieto. Process for Making Titanium Metal From Titanium Ore. U.S. Pat. 4,390,365, June 28, 1983, 10 pp.
[8]Poulsen, E. R., and J. A. Hall. Extractive Metallurgy of Titanium: A Review of the State of the Art and Evolving Production Techniques. J. Met., v. 35, No. 6, June 1983, pp. 60-65.
[9]Rosenburg, H. W. Ti-15-3: A New Cold-Formable Sheet Titanium Alloy. J. Met., v. 35, No. 11, Nov. 1983, pp. 30-34.
[10]Sastry, S. M. L., T. C. Peng, P. J. Meschter, and J. E. O'Neal. Rapid Solidification Processing of Titanium Alloys. J. Met., v. 35, No. 9, Sept. 1983, pp. 21-28.
[11]American Metal Market. Companies Push Research on RST Titanium Alloys. V. 91, No. 177, Sept. 12, 1983, p. 14.
[12]Boston, M. E. Titanium Nitride and Other Ultra-Hard Coatings—by PVD. Metallurgia, v. 50, No. 6, June 1983, pp. 248-253.
[13]Sfiligoj, M. Aero's Use of Titanium P/M Could Increase 30% by 1990. Am. Met. Mark., v. 91, No. 195, May 16, 1983, p. 24.
[14]Froes, F. H., and D. Eylon. Near Net Shape Methods Gain. Titanium Supplement to Am. Met. Mark., June 24, 1983.
[15]Jones, S. L. Advanced Techniques for Fabricating Titanium Are Seen Gaining New Uses. Am. Met. Mark., v. 91, No. 1, Jan. 3, 1983, pp. 7-8, 11.

Tungsten

By Philip T. Stafford[1]

Consumption of tungsten increased slightly compared with that of 1982, but remained at its lowest level since 1975, and imports were at their lowest level since 1976. Mine production decreased 36% from that of 1982, to the lowest level since 1934. Tungsten prices fell 24% to the lowest prices since 1973.

During 1983, more than 95% of domestic production came from two mining operations in California. Most mines, mills, and ammonium paratungstate (APT) plants were closed all or part of the year.

The 20-year deadlock between tungsten producing and consuming countries continued, as no agreement was reached during 1983 at the 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 49 operations to which surveys were sent, 100% responded, and the data are reported in table 1.

Table 1.—Salient tungsten statistics

(Metric tons unless otherwise specified)

	1979	1980	1981	1982	1983
United States:					
Concentrate:					
Mine production	3,013	2,754	3,605	1,521	980
Mine shipments	3,014	2,738	3,545	1,575	1,016
Value thousands	$55,785	$50,575	$62,231	$22,062	$10,528
Consumption	9,793	9,268	9,839	4,506	5,181
Shipments from Government stocks	2,351	1,703	958	344	259
Exports	875	920	79	305	1
Imports for consumption	5,149	5,158	5,331	3,528	2,861
Stocks, Dec. 31:					
Producer	38	48	108	54	47
Consumer	698	601	671	r1,765	1,085
Ammonium paratungstate:					
Production	8,055	7,664	8,855	4,914	5,021
Consumption	8,491	8,430	9,165	5,873	5,655
Stocks, Dec. 31: Producer and consumer	399	438	699	748	970
Primary products:					
Production	9,606	9,134	9,960	6,441	6,020
Consumption	9,268	9,163	9,613	6,349	6,523
Stocks, Dec. 31:					
Producer	1,535	1,598	1,472	1,477	1,433
Consumer	1,153	1,075	936	933	1,446
World: Concentrate:					
Production	r48,593	r51,897	49,011	p45,305	e38,882
Consumption	48,487	r47,625	47,854	p41,084	e38,925

eEstimated. pPreliminary. rRevised.

Legislation and Government Programs.—The General Services Administration (GSA) Office of Stockpile Transactions continued to sell excess stockpiled tungsten concentrate on the basis of monthly sealed bids. Regular offerings of excess concentrate were made at the disposal rate of 136,078 kilograms of contained tungsten 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. Actual shipments of excess concentrate from the stockpile totaled 259,220 kilograms of contained tungsten 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 contained tungsten)

Material	Goals	Inventory by program, Dec. 31, 1983		
		National stockpile	DPA[1] inventory	Total
Tungsten concentrate:				
Stockpile grade	25,152	25,488	72	25,560
Nonstockpile grade	--	13,261	83	13,344
Total	25,152	38,749	155	38,904
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 each fell 36% compared with that of 1982. Production totaled 980 metric tons of contained tungsten in 1983, and shipments totaled 1,016 metric tons, the smallest amounts since 1934. Although five mines in two Western States reported production, two mines provided more than 95% of the domestic tungsten production. No mine operated continuously, although 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 and spring, when it was closed owing to weather conditions.

Normally the largest producer, the Pine Creek Mine and APT plant of the Metals Div., Union Carbide Corp. (UCC), located near Bishop, CA, in Inyo County, was closed or operated at a reduced capacity at various times during the year. The following major operations were closed throughout the year: Emerson Mine and mill of UCC, at Tempiute, NV, in Lincoln County; the Climax Mine and mill of Climax Molybdenum Co., a division of AMAX Inc., at Climax, CO, in Lake County, principally a molybdenum producer; 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
1979	380,147	3,014	\$55,785	\$146.75	\$18.50
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

[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 1983

Company	Location of mine, mill, or processing plant
Producers of tungsten concentrate:	
Teledyne Tungsten	North Fork, CA.
Union Carbide Corp., Metals Div	Bishop, CA.
Processors of tungsten:	
AMAX Inc., AMAX Tungsten Div	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 3%, but remained at its lowest level since 1975. 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, 24%; specialty steels, 4%; superalloys, 3%; hard-facing rods and materials, 2%; chemicals, 1%; and miscellaneous, 3%.

Consumption of tungsten products used directly to make end-use items was distributed as follows: tungsten carbide, 65%; tungsten metal powder, 25%; tungsten scrap, 3%; scheelite, 3%; ferrotungsten, 2%; and other, 2%.

Table 5.—Production, disposition, and stocks of tungsten products in the United States

(Metric tons of contained tungsten)

	Hydrogen-reduced metal powder	Tungsten carbide powder		Chemicals	Other[1]	Total
		Made from metal powder	Crushed and crystalline			
1982						
Gross production during year	6,089	3,396	754	2,637	83	12,959
Used to make other products listed here	3,980	20	189	2,305	24	6,518
Net production	2,109	3,376	565	332	59	6,441
Disposition:						
To other processors	177	743	106	74	1	1,101
To end-use consumers	2,309	2,145	129	183	52	4,818
To make products not listed in this table	890	645	428	6	4	1,973
Producer stocks, Dec. 31	761	259	298	120	39	1,477

See footnotes at end of table.

Table 5.—Production, disposition, and stocks of tungsten products in the United States —Continued

(Metric tons of contained tungsten)

	Hydrogen-reduced metal powder	Tungsten carbide powder		Chemicals	Other[1]	Total
		Made from metal powder	Crushed and crystal-line			
1983						
Gross production during year	5,480	3,475	677	1,887	45	11,564
Used to make other products listed here	3,728	16	167	1,632	1	5,544
Net production	1,752	3,459	510	255	44	6,020
Disposition:						
To other processors	670	667	127	35	2	1,501
To end-use consumers	2,069	1,665	98	170	64	4,066
To make products not listed in this table	714	389	404	7	--	1,514
Producer stocks, Dec. 31	708	299	271	138	17	1,433

[1]Includes ferrotungsten, scheelite (produced from scrap), nickel-tungsten, and self-reducing oxide pellets.

Table 6.—U.S. consumption and stocks of tungsten products in 1983, by end use

(Metric tons of contained tungsten)

End use	Ferro-tungsten	Tung-sten metal powder	Tung-sten carbide powder	Scheelite (natural, synthetic)	Tung-sten scrap[1]	Other tungsten materi-als[2]	Total
Steel:							
Stainless and heat-resisting	24	--	--	22	--	--	46
Alloy	W	--	--	10	--	2	12
Tool	51	--	--	142	--	3	196
Superalloys	W	59	W	W	154	2	215
Alloys (excludes steels and superalloys):							
Cutting and wear-resistant materials	--	19	4,077	--	--	1	4,097
Other alloys[3]	5	21	79	--	7	1	113
Mill products made from metal powder	--	1,553	W	--	--	--	1,553
Chemical and ceramic uses	--	--	--	--	--	71	71
Miscellaneous and unspecified	26	--	83	44	65	2	220
Total	106	1,652	4,239	218	226	82	6,523
Consumer stocks, Dec. 31, 1983	32	24	1,217	36	59	78	1,446

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

In 1983, the average value of tungsten concentrate shipped from domestic mines and mills, as reported to the Bureau of Mines, decreased 26% to $82.17 per metric ton unit of WO_3, compared with the 1982 value. Excess tungsten concentrate was purchased from GSA during the year at prices ranging from $68.00 to $82.50 per metric ton unit for domestic use and from $75.52 to $82.33 per metric ton unit for export.

The 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 prices showed similar trends and similar monthly and annual averages. The price of concentrate was unusually stable from 1978 until October 1981, when it began a drop that extended through 1983. For the year, prices fell 24%, compared with those of 1982.

The price of hydrogen-reduced tungsten metal powder, 99% purity, f.o.b. shipping point, as quoted in Metals Week, remained stable throughout the year in the price range of $5.94 to $6.22 per kilogram. Within these ranges, the price was primarily dependent upon the particle size of the tungsten powder.

Prices for the other intermediate products of APT, ferrotungsten, and tungsten carbide powder were not reported because of the competitiveness of these products.

Table 7.—Monthly price quotations of tungsten concentrate in 1983

Month	Metal Bulletin (London), wolframite, European market, 65% WO_3 basis[1]				Metals Week, U.S. spot quotations, 65% WO_3 basis, c.i.f. U.S. ports[2]				International Tungsten Indicator, weighted average price,[3] 60% to 79% WO_3	
	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	Dollars per metric ton unit	Dollars per short ton unit
January	76.00	83.72	79.86	72.45	72.00	77.00	74.50	82.12	83.47	75.72
February	77.75	82.13	79.94	72.52	72.00	79.00	75.63	83.36	81.23	73.69
March	84.67	87.44	86.06	78.07	74.00	84.00	77.50	85.43	81.87	74.27
April	88.00	91.00	89.50	81.19	80.00	85.00	82.80	91.27	83.54	75.79
May	87.50	90.50	89.00	80.74	80.00	86.00	83.38	91.91	84.88	77.00
June	83.63	86.63	85.13	77.22	76.00	85.00	81.63	89.98	83.00	75.30
July	79.44	82.67	81.05	73.53	76.00	82.00	79.00	87.08	84.32	76.49
August	73.00	78.00	75.50	68.49	76.00	82.00	79.00	87.08	77.76	70.54
September	77.44	81.22	79.33	71.97	73.00	83.00	77.60	85.54	78.48	71.20
October	78.38	81.63	80.00	72.57	73.00	75.00	74.00	81.57	80.08	72.65
November	70.11	74.78	72.44	65.72	64.00	76.00	71.00	78.26	77.09	69.93
December	68.25	72.88	70.56	64.01	63.00	74.00	68.60	75.62	73.84	66.99

[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 \$80.67 for 1983. The average equivalent price per short ton unit of WO_3 was \$73.18 for 1983.

[2]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 \$77.05 for 1983. The average equivalent price per metric ton unit of WO_3 was \$84.93 for 1983.

[3]Weighted average price per metric ton unit of WO_3 was \$80.19 for 1983. The equivalent weighted average price per short ton unit of WO_3 was \$72.75 for 1983.

FOREIGN TRADE

Exports of tungsten in concentrate and primary products decreased 53% from 2,018 tons in 1982 to 953 tons in 1983. Imports decreased 24% from 5,372 tons in 1982 to 4,091 tons in 1983.

Table 8.—U.S. exports of tungsten ore and concentrate, by country

Country	1982		1983	
	Tungsten content (metric tons)	Value (thousands)	Tungsten content (metric tons)	Value (thousands)
Belgium-Luxembourg	39	\$325	--	--
Bolivia	1	9	--	--
Canada	5	72	(1)	\$3
Germany, Federal Republic of	225	2,672	1	7
Netherlands	35	300	--	--
Saudi Arabia	--	--	(1)	1
Sweden	(1)	6	--	--
Venezuela	(1)	3	--	--
Total	305	3,387	1	11

[1]Less than 1/2 unit.

Table 9.—U.S. exports of ammonium paratungstate, by country

Country	1982			1983		
	Gross weight (metric tons)	Tungsten content[1] (metric tons)	Value (thousands)	Gross weight (metric tons)	Tungsten content[1] (metric tons)	Value (thousands)
Australia	(2)	(2)	$1	(2)	(2)	(2)
Belgium-Luxembourg	--	--	--	(2)	(2)	$2
France	2	1	8	2	2	12
Germany, Federal Republic of	(2)	(2)	7	6	4	44
Israel	(2)	(2)	1	--	--	--
Korea, Republic of	--	--	--	(2)	(2)	3
Total	2	1	17	8	6	61

[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	1982		1983	
	Tungsten content (metric tons)	Value (thousands)	Tungsten content (metric tons)	Value (thousands)
Argentina	15	$477	5	$143
Australia	1	26	(1)	2
Austria	23	513	19	505
Belgium-Luxembourg	1	60	4	146
Brazil	5	239	10	258
Canada	78	2,303	113	2,771
Finland	(1)	1	5	63
France	(1)	20	5	126
Germany, Federal Republic of	197	3,336	33	798
India	1	92	3	167
Ireland	--	--	2	491
Israel	8	58	(1)	1
Italy	20	906	19	796
Japan	79	1,860	16	504
Mexico	20	906	9	378
Netherlands	6	409	7	402
Peru	(1)	4	2	30
Romania	30	618	--	--
Singapore	7	203	3	47
South Africa, Republic of	2	91	2	37
Sweden	1	16	2	41
United Kingdom	55	1,801	67	1,432
Venezuela	1	32	2	56
Other	1	88	2	83
Total	551	14,059	330	9,277

[1]Less than 1/2 unit.

Table 11.—U.S. exports of tungsten and tungsten alloy powder, by country

Country	1982			1983		
	Gross weight (metric tons)	Tungsten content[1] (metric tons)	Value (thousands)	Gross weight (metric tons)	Tungsten content[1] (metric tons)	Value (thousands)
Brazil	1	1	$33	1	1	$29
Canada	13	10	402	20	16	417
Finland	10	8	239	11	8	194
France	(2)	(2)	1	2	1	49
Germany, Federal Republic of	79	63	2,176	53	42	1,526
Israel	496	396	11,258	94	75	2,010
Italy	(2)	(2)	2	2	2	41
Japan	27	22	840	12	10	414
Korea, Republic of	4	3	137	(2)	(2)	6
Mexico	14	11	305	2	2	57
Netherlands	91	73	1,544	229	183	2,426
Singapore	1	1	10	(2)	(2)	17
Sweden	(2)	(2)	12	5	4	120
Switzerland	1	1	47	7	6	179
Turkey	--	--	--	3	2	87
United Kingdom	14	12	194	2	2	65
Other	1	1	39	2	2	55
Total	752	602	17,239	445	356	7,692

[1]Tungsten content estimated by multiplying gross weight by 0.80.
[2]Less than 1/2 unit.

Table 12.—U.S. exports of miscellaneous tungsten-bearing materials

Product and country	1982		1983	
	Gross weight (metric tons)	Value (thousands)	Gross weight (metric tons)	Value (thousands)
Tungsten and tungsten alloy wire:				
Brazil	9	$1,548	6	$1,083
Canada	18	2,590	19	3,510
France	2	372	2	375
Germany, Federal Republic of	4	1,481	4	1,302
India	2	189	1	101
Italy	2	420	3	496
Japan	6	984	6	1,071
Korea, Republic of	(1)	82	1	223
Mexico	4	940	4	497
Poland	(1)	9	2	172
U.S.S.R.	4	375	4	279
United Kingdom	2	459	3	661
Venezuela	(1)	104	1	582
Other	3	1,148	4	1,509
Total	56	10,701	60	11,861
Unwrought tungsten and alloy in crude form, waste, and scrap:				
Austria	21	144	9	46
Belgium-Luxembourg	6	32	--	--
Brazil	--	--	1	51
Canada	22	314	22	368
Germany, Federal Republic of	167	1,378	206	1,640
Italy	3	72	1	19
Japan	11	94	14	140
Mexico	1	21	--	--
South Africa, Republic of	4	88	13	147
Sweden	41	357	5	58
United Kingdom	30	315	7	72
Other	3	64	1	29
Total	309	2,879	279	2,570

See footnotes at end of table.

Table 12.—U.S. exports of miscellaneous tungsten-bearing materials —Continued

Product and country	1982 Gross weight (metric tons)	1982 Value (thousands)	1983 Gross weight (metric tons)	1983 Value (thousands)
Other tungsten metal:				
Australia	2	$240	1	$90
Austria	5	65	--	--
Canada	21	1,571	24	1,236
France	5	537	3	403
Germany, Federal Republic of	43	1,549	18	749
Italy	5	353	4	298
Japan	r8	r1,132	11	1,447
Mexico	12	614	5	326
Singapore	r(1)	r23	(1)	4
Sweden	2	49	--	--
Switzerland	8	458	5	288
United Kingdom	31	1,882	9	848
Other	17	889	8	721
Total	159	9,357	88	6,360
Other tungsten compounds:				
Australia	1	22	1	11
Austria	2	33	--	--
Belgium-Luxembourg	(1)	3	21	196
Brazil	2	109	12	141
Canada	78	791	7	264
France	4	114	3	101
Germany, Federal Republic of	27	758	7	175
Hong Kong	(1)	1	1	15
Ireland	1	31	1	26
Israel	20	384	11	492
Italy	1	88	1	50
Japan	8	259	11	188
Korea, Republic of	(1)	14	6	27
Mexico	7	209	6	182
Netherlands	35	350	1	49
Singapore	4	108	10	360
Sweden	1	18	(1)	18
United Kingdom	219	320	104	319
Other	2	74	2	84
Total	407	3,686	205	2,698

rRevised.
[1]Less than 1/2 unit.

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

Country	1982 Tungsten content (metric tons)	1982 Value (thousands)	1983 Tungsten content (metric tons)	1983 Value (thousands)
Argentina	--	--	5	$39
Australia	16	$235	28	198
Austria	7	113	--	--
Bolivia	643	8,511	662	6,299
Brazil	247	3,516	78	658
Burma	58	635	201	1,401
Canada	1,259	15,003	649	6,286
Chile	3	40	12	89
China	425	7,343	62	654
France	27	342	40	353
Germany, Federal Republic of	7	47	--	--
Italy	11	155	--	--
Korea, Republic of	9	167	117	846
Malaysia	33	386	6	50
Mexico	246	2,340	215	1,698
Peru	114	1,618	199	1,610
Portugal	239	3,534	339	3,524
Sweden	--	--	26	179
Thailand	134	2,037	142	1,197
Turkey	3	47	53	426
United Kingdom	12	185	27	210
Zaire	35	495	--	--
Total	3,528	[1]46,748	2,861	25,717

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

Table 14.—U.S. imports for consumption of ammonium paratungstate, by country

Country	1982		1983	
	Tungsten content (metric tons)	Value (thousands)	Tungsten content (metric tons)	Value (thousands)
Australia	26	$422	73	$942
Austria	--	--	12	136
China	427	7,109	174	2,524
Germany, Federal Republic of	87	1,873	52	921
Korea, Republic of	219	3,929	431	5,011
South Africa, Republic of	--	--	17	252
United Kingdom	--	--	3	18
Total	759	13,333	762	9,804

Table 15.—U.S. imports for consumption of ferrotungsten, by country

Country	1982		1983	
	Tungsten content (metric tons)	Value (thousands)	Tungsten content (metric tons)	Value (thousands)
Austria	11	$193	25	$295
Brazil	7	135	--	--
Germany, Federal Republic of	3	77	--	--
Portugal	43	747	19	257
Sweden	--	--	4	52
United Kingdom	5	70	--	--
Total	69	1,222	48	604

Table 16.—U.S. imports for consumption of miscellaneous tungsten-bearing materials

Product and country	1982		1983	
	Tungsten content (metric tons)	Value (thousands)	Tungsten content (metric tons)	Value (thousands)
Other metal-bearing materials in chief value of tungsten:				
Canada	--	--	(1)	$3
France	2	$17	--	--
United Kingdom	--	--	6	23
Total	2	17	6	26
Waste and scrap containing not over 50% tungsten:				
United Kingdom	--	--	1	26
Other	1	15	(1)	4
Total	1	15	1	30
Waste and scrap containing over 50% tungsten:				
Australia	2	20	--	--
Belgium-Luxembourg	4	62	--	--
Canada	28	314	19	167
China	8	174	--	--
Finland	--	--	1	32
France	7	119	7	49
Germany, Federal Republic of	47	772	26	284
Israel	298	3,831	218	2,791
Italy	11	178	--	--
Japan	135	2,254	18	254
Korea, Republic of	15	321	--	--
Mexico	1	7	5	44
Netherlands	58	645	157	994
Singapore	36	789	31	696
Sweden	5	73	22	168
United Kingdom	108	1,566	89	766
Yugoslavia	2	29	--	--
Total	765	11,154	593	6,245

See footnotes at end of table.

Table 16.—U.S. imports for consumption of miscellaneous tungsten-bearing materials —Continued

Product and country	1982 Tungsten content (metric tons)	1982 Value (thousands)	1983 Tungsten content (metric tons)	1983 Value (thousands)
Unwrought tungsten, except alloys, in lumps, grains, and powders:				
China	r(1)	r$8	3	$70
Germany, Federal Republic of	60	1,341	9	240
Korea, Republic of	162	3,868	25	485
Other	5	135	3	92
Total	227	r5,352	40	887
Unwrought tungsten, ingots, and shot	(1)	1	(1)	1
Unwrought tungsten, other:[2]				
China	9	331	--	--
Other	(1)	5	(1)	3
Total	9	336	(1)	3
Unwrought tungsten, alloys:				
Canada	1	14	4	134
China	32	810	30	679
Germany, Federal Republic of	(1)	1	11	246
Other	1	76	3	121
Total	34	901	48	1,180
Wrought tungsten:[2]				
Austria	7	484	6	424
Canada	5	66	(1)	1
China	--	--	(1)	18
Germany, Federal Republic of	1	32	2	146
Japan	6	1,318	9	1,174
Netherlands	2	192	(1)	95
Singapore	(1)	(1)	--	--
Switzerland	(1)	2	1	29
United Kingdom	1	72	1	62
Other	(1)	89	3	124
Total	22	2,255	22	2,073
Tungstic acid	(1)	11	(1)	7
Calcium tungstate:				
Germany, Federal Republic of	12	622	6	269
United Kingdom	(1)	1	--	--
Total	12	623	6	269
Potassium tungstate	(1)	17	--	--
Sodium tungstate:				
China	7	109	(1)	3
Other	--	--	1	7
Total	7	109	1	10
Tungsten carbide:				
Austria	(1)	5	2	45
Belgium-Luxembourg	17	575	23	715
Canada	1	32	2	62
China	28	642	3	76
Germany, Federal Republic of	279	7,150	177	3,356
Korea, Republic of	30	768	15	274
Mexico	1	42	7	111
Taiwan	3	67	--	--
Other	3	109	2	45
Total	362	9,390	231	4,684
Other tungsten compounds:				
China	332	4,597	64	544
Other	2	57	2	44
Total	334	4,654	66	588
Mixtures, organic compounds, chief value in tungsten:				
France	5	137	--	--
Other	r2	r66	1	17
Total	7	203	1	17

rRevised.
[1]Less than 1/2 unit.
[2]Estimated from reported gross weight.

Table 17.—U.S. import duties on tungsten

TSUS No.	Item	Rate of duty effective Jan. 1, 1983	
		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	8.2% ad valorem	35% ad valorem.
629.25	Waste and scrap containing by weight not over 50% tungsten.	6.3% 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.	9 cents per pound on tungsten content and 12.5% ad valorem.	58% ad valorem.
629.29	Unwrought tungsten, ingots, and shot	9% ad valorem	50% ad valorem.
629.30	Unwrought tungsten, other	10.5% ad valorem	60% ad valorem.
629.32	Unwrought tungsten, alloys, containing by weight not over 50% tungsten.	5.9% ad valorem	35.5% ad valorem.
629.33	Unwrought tungsten, alloys, containing by weight over 50% tungsten.	10.5% ad valorem	60% ad valorem.
629.35	Wrought tungsten	9.5% ad valorem	Do.
416.40	Tungstic acid	12.8% ad valorem	55% ad valorem.
417.40	Ammonium tungstate	11.7% ad valorem	49.5% ad valorem.
418.30	Calcium tungstate	10.7% ad valorem	43.5% ad valorem.
420.32	Potassium tungstate	17.5% ad valorem	50.5% ad valorem.
421.56	Sodium tungstate	11.4% ad valorem	46.5% ad valorem.
422.40	Tungsten carbide	12.5% ad valorem	55.5% ad valorem.
422.42	Other tungsten compounds	11% ad valorem	45.5% ad valorem.
423.92	Mixtures of two or more inorganic compounds in chief value of tungsten.	do	Do.

WORLD REVIEW

A meeting was held in Geneva, Switzerland, during December by the Committee on Tungsten (COT) of the United Nations Conference on Trade and Development (UNCTAD) in an effort to resolve a 20-year deadlock between producing and consuming countries concerning the stabilization of the world tungsten market. No agreement was reached by COT, but it recommended that another meeting be convened in 1984 and requested the UNCTAD Secretariat to prepare papers concerning the establishment of a proposed sessional working group, and expansion and improvement of the quarterly bulletin, Tungsten Statistics.

Bolivia.—The Anschutz Mining Corp. through its subsidiary, Churquini Enterprises Inc., was developing a major mine in a large tungsten deposit, the El Chicote Grande, about 240 kilometers southeast of La Paz. The only production at this site in 1983 was from a small rehabilitated vintage mill with a capacity of about 20 tons of concentrate per month. By yearend, further development of the mine and a new 1,000-ton-per-day mill had been discontinued until world tungsten market prices improve.

Canada.—The mine and mill operated by Canada Tungsten Mining Corp. Ltd. at Tungsten, Northwest Territories, normally the largest tungsten mine in the market economy countries, produced 280 tons of tungsten, a decrease of 90% from that of 1982. The mine was closed from mid-January through mid-November, and when operating it produced at a reduced rate. Recovery was 81.7% from 36,000 tons of ore, grading 1.19% WO_3. At yearend, ore reserves were reported by the company to contain 27,000 tons of tungsten.[2]

Limited concentrate production began in late 1983 at the Mount Pleasant tungsten-molybdenum mine, in Charlotte County, New Brunswick, and full production was expected to begin in early 1984. The joint venture between Billiton Canada Ltd. and Brunswick Tin Mines Ltd. was expected 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., delayed development of the MacTung tungsten deposit near MacMillan Pass along the Yukon-Northwest Territories boundary until world tungsten market conditions improved. The target date for production from a 900-ton-per-day mine-mill complex was late in 1987 or later. 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.

United Kingdom.—AMAX Exploration of U.K. Inc. and Hemerdon Mining and Smelting (U.K.) Ltd. planned to construct a tungsten-tin mine and mill near Plymouth, Devon County. The expected annual capacity was 2,000 tons of tungsten in concentrate and 400 tons of tin. The opening date was delayed beyond 1987 and was dependent on Government approval and favorable economic conditions. Minable ore reserves were placed at 60,000 tons of tungsten.

[1]Physical scientist, Division of Ferrous Metals.
[2]Canada Tungsten Mining Corp. Ltd. 1983 Annual Report. 16 pp.

Table 18.—Tungsten: World concentrate production, by country[1]

(Metric tons of contained tungsten)[2]

Country	1979	1980	1981	1982[p]	1983[e]
Argentina	[r]74	[r]44	12	17	17
Australia	3,193	[r]3,575	3,517	2,618	[3]2,060
Austria	1,496	[r]2,150	1,435	1,714	[3]1,117
Bolivia	2,470	2,732	2,779	2,534	2,400
Brazil	933	876	1,248	[e]1,100	1,200
Burma	692	823	825	844	[3]930
Canada	2,597	3,179	1,993	2,842	[3]327
China[e]	13,100	15,000	13,500	12,500	12,500
Czechoslovakia[e]	80	80	50	50	50
France	590	577	591	727	700
India	18	22	18	25	20
Japan	746	668	667	640	[3]488
Korea, North[e]	2,150	2,200	2,200	2,200	500
Korea, Republic of	2,713	2,737	2,739	2,420	[3]2,293
Malaysia	27	14	35	43	31
Mexico	252	266	263	99	90
Namibia[e]	165	150	--	--	--
New Zealand	85	4	10	7	5
Peru	564	549	521	688	720
Portugal	[r]1,377	1,568	1,395	1,358	1,360
Rwanda	505	431	354	409	[3]292
Spain	394	446	437	545	550
Sweden	371	327	371	275	300
Thailand	1,826	1,615	1,209	855	[3]562
Turkey	56	96	153	[e]150	170
Uganda[e]	20	20	20	20	20
U.S.S.R.[e]	8,700	8,700	8,850	9,000	9,100
United Kingdom[e]	66	70	70	([4])	--
United States	3,013	2,754	3,605	1,521	[3]980
Zaire	[r]210	[r]134	89	74	75
Zimbabwe[e]	110	90	55	30	25
Total	[r]48,593	[r]51,897	49,011	45,305	38,882

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through June 27, 1984.
[2]Conversion factors: WO_3 to W, multiply by 0.7931; 60% WO_3 to W, multiply by 0.4758.
[3]Reported figure.
[4]Revised to zero.

Table 19.—Tungsten: World concentrate consumption, by country[1]

(Metric tons of contained tungsten)

Country[2]	1980	1981	1982[p]	1983[e 3]
Reported consumption:				
Australia	76	100	145	140
Austria	2,597	2,321	1,850	1,304
Canada[e]	300	300	300	300
France	841	684	647	560
Japan	2,931	2,238	1,826	1,500
Korea, Republic of	1,434	1,793	1,560	1,555
Mexico[e]	40	40	40	23
Portugal	206	227	183	180
Sweden	2,155	1,432	994	800
United Kingdom	1,462	879	367	300
United States	9,268	9,839	4,506	5,181
Apparent consumption:[4]				
Argentina	19	20	29	40
Belgium-Luxembourg	[e]100	9	9	9
Brazil	556	480	454	300
China[e 3]	4,500	4,800	4,500	4,500
Czechoslovakia[e 3]	1,300	1,300	1,300	1,300
German Democratic Republic[e]	270	270	270	270
Germany, Federal Republic of	1,499	1,348	1,541	1,500
Hungary[e]	600	600	600	600
India[e]	299	[r]459	400	400
Italy[e]	90	40	40	40
Korea, North[e 3]	1,600	1,600	1,600	500
Netherlands[e]	400	400	300	300
Poland	895	427	1,312	1,073
South Africa, Republic of[e]	250	250	250	250
Spain	137	98	161	100
U.S.S.R.[e 3]	13,800	15,900	15,900	15,900
Total	[r]47,625	47,854	41,084	38,925

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

[1]Source, unless otherwise specified, is the Quarterly Bulletin of the UNCTAD Committee on Tungsten: Tungsten Statistics. V. 18, No. 1, Jan. 1984.

[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 U.S. Bureau of Mines.

[4]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 in 1983 emained depressed for the second year in a row. Consumption of vanadium was extremely weak during the first half of the year as a result of the general world recession but showed signs of improvement during the second half. Producers of vanadium oxides in the Republic of South Africa and the United States were forced to cut back production, lay off workers, and place some processing plants on standby. Production of vanadium oxides and slags by the market economy countries was the lowest since 1970. At conversion plants in Western Europe and North America, stocks of ferrovanadium and related vanadium-carbon ferroalloys, built to excessive levels between 1980 and 1982, gradually began to diminish in the fourth quarter. Stocks of ferrovanadium held by steel plants, foundries, and other consumers were kept at dangerously low levels in order to conserve cash.

In the United States, ferrovanadium consumption was the lowest since 1963 because of continuing sluggishness in the automotive, machinery, and construction industries during the first half of 1983. However, consumption began to improve during the fourth quarter as production of automobiles and appliances increased. Excess stocks of line pipe and oil country tubular goods, in which vanadium is an alloying element, continued to dampen sales of ferrovanadium to several steel plants. Although raw steel production in the United States was 13% greater than that of 1982, production of high strength, low alloy (HSLA) and full alloy steels, the major uses of vanadium,

Table 1.—Salient vanadium statistics

(Short tons of contained vanadium unless otherwise specified)

	1979	1980	1981	1982	1983
United States:					
Production:					
Ore and concentrate:					
Recoverable vanadium[1]	5,520	4,806	5,126	4,098	2,171
Value thousands	$73,892	$64,370	$71,496	$52,577	$30,675
Vanadium oxides recovered from ore[2]	5,758	5,506	6,368	4,867	2,433
Vanadium oxides recovered from petroleum residue[3]	1,617	1,520	1,900	1,513	893
Consumption	6,719	6,139	6,863	3,496	3,277
Exports:					
Ferrovanadium (gross weight)	880	803	435	326	775
Ore and concentrate	101	46	56	57	59
Vanadium pentoxide, anhydride (gross weight)	630	724	346	1,582	2,648
Other compounds (gross weight)	316	190	61	361	95
Imports (general):					
Ferrovanadium (gross weight)	738	328	1,236	855	846
Ores, slags, residues	2,442	1,786	2,435	1,112	58
Vanadium pentoxide, anhydride	907	856	354	129	408
World: Production from ores, concentrates, slags	37,311	38,281	38,778	[p]35,898	[e]30,087

[e]Estimated. [p]Preliminary.

[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.

remained severely depressed. Continuing weak orders for commercial aircraft and industrial equipment fabricated from titanium alloys led to a stagnant market for vanadium-aluminum master alloys.

Vanadium oxide producers in the United States curtailed byproduct extraction operations in an attempt to draw down excessive oxide stocks built up in 1980 and 1981. At yearend 1983, six of the nine domestic facilities that had recovered vanadium oxides in 1981 were shut down. The remaining three were operating at less than 50% of capacity.

Vanadium extraction operations in the Republic of South Africa were sharply curtailed in May, and production remained at a low level for the rest of the year because of the depressed spot price of vanadium pentoxide (V_2O_5). Mining and extraction operations in Finland continued at a loss, forcing management to consider phasing out the industry in that country.

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 20 of the plants or mills canvassed in 1983 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). More than 55 mines in the United States reported production or shipments of vanadium-bearing ores in 1982.

Legislation and Government Programs.—For the first time in 23 years, the General Services Administration (GSA) took steps to upgrade and increase the stocks of vanadium materials held in the National Defense Stockpile. The National Defense Stockpile goals of 1,000 short tons of vanadium contained in ferrovanadium and 7,700 tons of vanadium contained in vanadium pentoxide remained in effect throughout the year. These goals were established by GSA on May 1, 1980. As of December 31, 1983, U.S. Government inventories consisted of 541 tons of contained vanadium in the form of vanadium pentoxide and 2 tons of vanadium metal.

On September 21, Gulf Chemical & Metallurgical Co. was awarded a contract to supply GSA with 362,000 pounds of vanadium pentoxide in material 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%. The vanadium pentoxide was to be stockpiled in 55-gallon steel drums at the Somerville Depot near Royce, NJ. Gulf Chemical & Metallurgical, a subsidiary of Associated Metals & Minerals Corp., won the award with a low bid of $2.32 per pound of V_2O_5. The company operated a plant at Freeport, TX, that reportedly could recover more than 1,500 tons of vanadium pentoxide per year from spent catalysts.

The Grand Junction Area Office of DOE has responsibility for the long-term stabilization of uranium mill tailings sites and the administration of Government-leased uranium-vanadium properties on the Colorado Plateau. On July 31, the Grand Junction office underwent a major reduction in force. The personnel cutbacks were the result of completion of the National Uranium Resource Evaluation (NURE) archiving program and reduced Federal funding for uranium resource assessment. Bendix Field Engineering Corp., the operating contractor for the Grand Junction facility, gave termination notices to 130 employees involved in the NURE program. Approximately 180 employees were retained to support ongoing DOE functions.

On October 7, the Environmental Protection Agency (EPA) published new rules dealing with the stabilization and long-term control of mill tailings at uranium-vanadium processing sites.[2] The new rules, which took effect on December 6, are expected to influence future operations at all four of the currently licensed uranium-vanadium mills on the Colorado Plateau. In some cases, mill operators will be required to install plastic liners or other protective barriers under their tailings piles in order to prevent uranium, its radioactive daughter products, and nonradioactive toxic substances such as selenium from contaminating underground water sources. Each tailings pile will be required to have an earthen cover to minimize radon emissions and prevent erosion of the sand-like wastes by wind and rain. The rules would also limit radon release from the surface of the pile to 20 picocuries per square meter per second.

On October 19, DOE announced that it would move the radioactive tailings at the site of the old Vitro Corp. of America uranium-vanadium mill in South Salt Lake, UT, to a remote area in western Tooele County. The tailings were produced between 1951 and 1964 when Vitro processed

1.7 million tons of uranium ore for the Atomic Energy Commission. The removal cost is expected to be in excess of $60 million. At least 19 other mill sites in the Western United States will eventually require similar remedial action.

For 7 years the Bureau of Mines has been conducting uranium-vanadium tailings stabilization studies at Union Carbide Corp.'s mill at Uravan, CO. The research project has involved testing the ability of different plant species to control surface erosion on a tailings pile protected by a covering of mine waste rock.[3]

DOMESTIC PRODUCTION

Domestic production, expressed in terms of recoverable vanadium, was at its lowest level since 1951 because of depressed demand for ferrovanadium by the hard-pressed U.S. and Canadian steel industries. Colorado was the leading producing State, followed by Utah and Idaho. In Colorado and Utah, vanadium was obtained as a coproduct from the mining of uraniferous sandstones on the Colorado Plateau. Most of these coproduct mining and milling operations were unprofitable in 1983 because of the continuing weak price for yellowcake (U_3O_8). In Idaho, vanadium pentoxide was produced from vanadium-bearing ferrophosphorus by Kerr-McGee Chemical Corp. at Soda Springs. The ferrophosphorus was a byproduct of nearby elemental phosphorus plants.

In January, Energy Fuels Nuclear Inc. suspended processing operations at its White Mesa uranium-vanadium mill near Blanding, UT, because of weak demand for both uranium and vanadium. A month later, Energy Fuels and Union Carbide signed a preliminary agreement that eventually led to joint ownership. The $40 million mill, which remained on standby for the rest of the year, normally employs about 150 workers and is one of the newer and more efficient uranium and vanadium extraction facilities in the United States.

The vanadium mine and mill complex operated by Union Carbide at Hot Springs, AR, remained closed throughout the year. The company's other operations in Colorado and Utah were operated intermittently to meet commitments for yellowcake made under long-term contracts with utilities. The Uravan mill in Montrose County, CO, operated at reduced capacity between July and November. About 140 employees are needed when the mill is in operation. Vanadium pentoxide production at the company's Rifle plant in Garfield County followed the Uravan schedule because the bulk of its liquor feedstock comes from Uravan. The work force at Rifle was reduced from 30 to 17 when production was halted on October 31. At yearend, Union Carbide laid off about 100 employees at its mines near Uravan and Egnar, CO, and in the La Sal area of Utah. The company retained about 20 employees to operate its Deremo-Snyder Mine west of Egnar.

Atlas Corp. continued to recover vanadium and uranium at its Moab mill in Grand County, UT. Ore for the mill was obtained from three of the company's mines in San Juan County—the Pandora, the Velvet, and the Rim Columbus. The company's Snow and Probe Mines in Emery County were kept on standby throughout the year. Atlas was also considering developing a new uranium-vanadium mine on the Bullfrog Claims, 10 miles north of Ticaboo in Garfield County. The deposit is located on Federal land along the southern flank of the Henry Mountains. The property was acquired from Exxon Minerals Co. in August 1982 and is now known as the Edward R. Farley, Jr. Project. Mine construction could begin in late 1984 if the feasibility study is positive and the necessary permits are granted in a timely manner. The Atlas claims are contiguous to those of Plateau Resources Ltd. Plateau Resources completed construction of a 750-ton-per-day uranium mill at Ticaboo in April 1982 and has two mines under development in nearby Shootaring Canyon.

The MiVida uranium-vanadium mine in San Juan County was reopened by Rio Algom Corp. in late October 1983. The underground mine, located in the Monticello district, is leased from Minerals West Inc. and owned by the county. Rio Algom has been trucking about 200 tons of ore per day to its Lisbon mill near La Sal. Only the uranium will be recovered because the Lisbon mill does not have a vanadium solvent extraction circuit.

Cotter Corp. kept the vanadium recovery circuit at its Canon City mill in Fremont County, CO, closed throughout 1983 but continued to ship vanadium pentoxide from stocks. Vanadium-poor uraninite ore from the company's Schwartzwalder Mine in Jefferson County was being used as feed for the uranium circuit. In Mesa County, Rajah Ventures Ltd. operated both the Packrat Mine on Beaver Mesa and the October Mine in John Brown Canyon south of Gateway.

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. However, imports of these materials plummeted in 1983. For the first time in 16 years there were no imports of vanadiferous slag. U.S. production from petroliferous materials totaled 893 tons of contained vanadium, 41% less than the 1,513 tons for 1982.

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. recovered high-grade ash containing 794 tons of vanadium pentoxide in 1983, compared with 773 tons in 1982. The New York utility operated two oil-fired power stations in Suffolk County, one at Northport and the other at Port Jefferson.

In December 1983, Phibro-Salomon Inc. agreed to sell its idle vanadium pentoxide extraction plant at Bartlesville, OK, to an investment group headed by the then current president of Phibro Resources Corp. Somex Ltd., a subsidiary of Phibro-Salomon, built the plant in 1979 to recover vanadium of petroleum origin from boiler ash, refinery residues, and spent refinery catalysts. The plant, which reportedly has an annual production capacity of 1,100 tons of contained vanadium, had been closed since late 1982 because of technological problems and plummeting demand for the strategic metal.

The near-depression conditions in the steel industry since 1981 have had a particularly adverse effect on all six U.S. producers of ferrovanadium and proprietary vanadium-iron-carbon additives. The domestic ferrovanadium industry was seriously affected in 1983 and underwent complete restructuring. Engelhard Corp., for example, halted operations at its ferrovanadium plant at Strasburg, VA. The company put both the conversion plant and the adjacent lime plant up for sale. The Strasburg plant, built in 1979, had been producing both 50% and 80% grades of ferrovanadium by aluminothermic reduction.

In February, The Pesses Co., a specialty ferroalloys producer and scrap broker, was the subject of a petition by three of its creditors seeking involuntary liquidation of Pesses under Chapter 7 of the Federal Bankruptcy Code. Ashland Chemical Co. of Columbus, OH, was considering purchasing a portion of Pesses production facilities. In 1982, Ashland expanded its foundry products lines to include specialty metals and alloys. The company, a subsidiary of the Ashland Oil Co., installed a reduction furnace at its foundry products plant in Cleveland. The new furnace was capable of producing ferrovanadium, high-purity ferrocolumbium, and several other specialty ferroalloys. Several executives of Pesses joined Ashland to help market the new products.

The market for vanadium chemicals remained weak despite the relatively strong recovery shown by the U.S. chemical industry in the second half of 1983. Producers of primary vanadium chemicals included Foote Mineral Co., Cambridge, OH; Stauffer Chemical Co., Weston, MI; and Union Carbide, Niagara Falls, NY.

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]
1979	5,841	5,520
1980	5,832	4,806
1981	5,852	5,126
1982	4,093	4,098
1983	W	2,171

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.—Production of vanadium oxides in the United States[1]

(Short tons)

Year	Gross weight	Oxide content[2]
1979	10,338	10,279
1980	10,048	9,829
1981	11,366	11,367
1982	8,850	8,689
1983	4,590	4,344

[1]Produced directly from all domestic ores and ferrophosphorus; includes metavanadates.

[2]Expressed as equivalent V_2O_5.

CONSUMPTION, USES, STOCKS

Reported domestic consumption of vanadium declined 6% in 1983 compared with that of 1982 and was lower than that of any year since 1963. The primary cause of the decline was a prolonged cutback in U.S. production of HSLA and full alloy steels. The steel industry as a whole showed an overall gain of 13% in raw steel output from the abysmal level of 1982, but the alloy sector continued to experience heavy import pressure and extremely weak demand.

Approximately 84% of the vanadium was consumed by the iron and steel industry as ferrovanadium or related vanadium-carbon ferroalloys. This dependence on the struggling iron and steel industry continued to create a difficult marketing situation for the six domestic ferrovanadium producers. Fortunately, there was a deceleration in the sharp decline in consumption that occurred after 1981. Shipments of sheet steel and strip to the automotive industry and other consumer goods sectors were up 24.6%. However, increased demand for ferrovanadium by producers of sheet steel, tool steel, and rails was more than offset by reduced consumption in line pipe and oil country goods. The temporary world oil surplus discouraged the petroleum industry from developing new high-cost oilfields, modernizing existing refineries, and proceeding with expensive synfuels projects. Excess stocks of line pipe and oil country tubular goods further dampened sales of ferrovanadium.

During the year, the U.S. steel industry underwent a major restructuring in order to be more efficient and competitive with imported steel. United States Steel Corp., Bethlehem Steel Corp., and others embarked on major plant closure programs to reduce overcapacity. In the third quarter, Republic Steel Corp. and Jones & Laughlin Steel Corp. agreed to merge their facilities pending Government approval. Electroslag remelting furnaces and rotary forge facilities were placed in operation as part of the program to modernize the specialty steel sector. These changes were expected to have a positive effect on the long-term outlook for vanadium.

Demand for vanadium in titanium alloys was slightly higher than that of 1982 owing to increased sales of military aircraft. The commercial aircraft market remained stagnant because of the recession, airline competition, and a significant surplus of used aircraft. According to the Aerospace Industries Association, the Boeing Co., Lockheed Corp., and McDonnell Douglas Corp. together shipped a total of 257 civil jet transport aircraft in 1983, compared with only 236 in 1982 and 388 in 1981. Titanium-aluminum-vanadium alloy (Ti-6Al-4V), 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 1983. Two newer alloys, titanium-vanadium-iron-aluminum (Ti-10V-2Fe-3Al) and titanium-vanadium-chromium-aluminum-tin (Ti-15V-3Cr-3Al-3Sn), were being extensively evaluated for the next generation of commercial airlines. Forgings of Ti-10V-2Fe-3Al have already been used in some components of the new Boeing 757 and 737-300 jetliners. Because of the gloomy near-term outlook for sales to the aerospace industry, North American titanium alloy producers met in December to develop a program aimed at promoting the sale of their products to the chemical processing industry and other potential consumers. Valves, tubing, tanks, and other components fabricated from titanium alloys are appealing because of their anticorrosion properties.

Consumption of ammonium metavanadate, granular pentoxide, and other vanadium chemicals for catalysts remained weak but showed signs of improvement during the second half of the year when production of sulfuric acid, adipic acid, and maleic anhydride began to rebound.

In addition to the consumers' stocks, producers' stocks of vanadium as fused oxide, precipitated oxide, vanadates, metal, alloys, and chemicals totaled 4,463 tons of contained vanadium at yearend 1983, compared with 5,222 tons at yearend 1982.

Table 4.—Producers of vanadium alloys or metal in the United States in 1983

Producer	Plant location	Product[1]
Affiliated Metals and Minerals Inc	New Castle, PA	FeV.
Cabot Corp., Engineered Products Group	Henderson, KY	VAl and ZrVAl.
Do	Wenatchee, WA	Do.
Engelhard Corp., Minerals & Chemicals Div	Strasburg, VA	FeV.
Foote Mineral Co., Ferroalloys Div	Cambridge, OH	FeV and Ferovan.[2]
Metallurg Inc., Shieldalloy Corp	Newfield, NJ	FeV.
Pesses Co., The	Pulaski, PA	FeV and VAl.
Reading Alloys Inc	Robesonia, PA	Do.
Teledyne Inc., Teledyne Wah Chang Albany Div	Albany, OR	V.
Union Carbide Corp., Metals Div	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	1982		1983	
	Consumption	Ending stocks	Consumption	Ending stocks
Ferrovanadium[1]	2,995	280	2,741	313
Oxide	29	14	24	10
Ammonium metavanadate	6	1	3	1
Other[2]	466	31	509	50
Total	3,496	326	3,277	374

[1]Includes other vanadium-iron-carbon alloys.
[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, by end use

(Short tons of contained vanadium)

End use	1983
Steel:	
Carbon	577
Stainless and heat-resisting	14
Full alloy	716
High-strength, low-alloy	966
Tool	426
Unspecified	--
Total	2,699
Cast irons	10
Superalloys	14
Alloys (excluding steels and superalloys):	
Cutting and wear-resistant materials	1
Welding and alloy hard-facing rods and materials	9
Nonferrous alloys	505
Other alloys[1]	12
Chemicals and ceramics:	
Catalysts	19
Other[2]	W
Miscellaneous and unspecified	8
Grand total	3,277

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 1983 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 1983. However, considerable discounting of metallurgical-grade material occurred throughout the year because of the continuing slump in the production of HSLA and full alloy steels.

On July 14, Highveld Steel and Vanadium Corp. Ltd. decided to lower its list price from \$2.40 to \$2.30 per pound V_2O_5 c.i.f. for 98% minimum fused pentoxide from the Republic of South Africa. In Western Europe, the spot price for metallurgical-grade pentoxide gradually increased during the first half of the year from \$1.20-\$1.40 per pound to \$2.00-\$2.10, a price level that was still below the cost of production for most producers. Vanadium pentoxide prices eventually stabilized at \$2.00 to \$2.05 in the fourth quarter of 1983 when China withdrew from the Western market.

The Metals Week price spread for technical air-dried vanadium pentoxide (chemical-grade) of \$4.10 to \$4.94 per pound was set on April 1, 1982, and remained unchanged throughout 1983.

Domestic producers were forced to suspend their list prices for the common grades of ferrovanadium in mid-January because of stiff competition from importers and continuing cutbacks in consumption by steelmakers. The average U.S. Customs value for ferrovanadium in January was only \$4.31 per pound of contained vanadium, compared with \$6.63 per pound at the beginning of 1982. U.S. producer quotations for the common grades of ferrovanadium ranged from \$7.36 to \$7.50 per pound immediately prior to the suspension.

In mid-June, Foote Mineral, Shieldalloy Corp., and Union Carbide reinstated published prices for their ordinary grades of ferrovanadium in response to strengthening demand from the U.S. and Canadian steel industries. On June 21, "Ferovan," "Standard Ferrovanadium," and "Carvan" were all listed at \$5.50 per pound of contained vanadium. In related action, Union Carbide introduced its new "UCAR" grade of ferrovanadium. The new product was priced at \$5.80 of contained vanadium, f.o.b. Niagara Falls, NY. The "UCAR" grade has a minimum vanadium content of 77%, a maximum carbon content of 1%, and is recommended for low-carbon HSLA steels as a grain refiner. On October 1, Union Carbide raised the price of its "UCAR" grade to \$6 per pound. Two weeks later, Foote Mineral followed suit and matched Union Carbide's price for its equivalent 70% to 80% grade.

FOREIGN TRADE

U.S. exports of ferrovanadium more than doubled in 1983, halting a 4-year decline. Exports of ferrovanadium totaled 775 tons (gross weight), compared with 326 tons for 1982. The average declared value for the ferrovanadium was \$3.96 per pound of alloy, a 25% decrease from the \$5.27 value for 1982. Continued cutbacks in U.S. ferrovanadium production forced domestic pentoxide producers to cultivate new customers in developing countries and to compete more aggressively in traditional overseas markets such as Japan. Exports of vanadium pentoxide (anhydride) totaled 2,648 tons (gross weight), a 67% increase over the 1,582 tons of 1982.

A dramatic change in the vanadium import pattern occurred during 1983. Imports of vanadium pentoxide more than doubled, while imports of vanadium-bearing feed materials plummeted. Imports of ferrovanadium, averaging 80.4% vanadium, were slightly less than those of 1982 but gained a greater share of an already depressed market. Canada regained its position as the leading supplier of ferrovanadium and accounted for 62% of the imports in terms of contained weight. Finland was the principal source of imported pentoxide, with the Republic of South Africa a distant second. Vanadium pentoxide shipments from the Republic of South Africa have declined more than tenfold since 1978.

Imports of vanadium contained in petroleum residues totaled only 58 tons, compared with 559 tons in 1982. All of the material came from refinery operations in the Netherlands Antilles. For the first time in 16 years there were no imports of vanadiferous iron slag from Highveld's Witbank steelworks in the Transvaal. The closure of the Phibro vanadium extraction plant in

Oklahoma and an oversupply of petroleum residues, utility ashes, and spent catalysts along the Atlantic seaboard discouraged the importation of vanadium-bearing petroleum coke from Venezuela.

Potassium vanadate imports amounted to 118 tons (gross weight), of which 58 tons came from the Federal Republic of Germany and 38 tons came from the Republic of South Africa. In addition, 20 tons of ammonium vanadate was received from the United Kingdom. Imports classified as "Other vanadium compounds" totaled 54 tons (gross weight), of which 53 tons came from the United Kingdom.

Table 7.—U.S. exports of vanadium in 1983, by country

(Thousand pounds and thousand dollars)

Country	Ferrovanadium (gross weight)		Vanadium ore and concentrate (vanadium content)		Vanadium compounds (gross weight)			
					Pentoxide (anhydride)		Other[1]	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Argentina	88	335	--	--	154	278	--	--
Australia	--	--	--	--	96	224	(2)	2
Austria	--	--	--	--	220	281	--	--
Belgium-Luxembourg	--	--	--	--	1,109	1,470	(2)	1
Brazil	--	--	--	--	158	438	(2)	1
Canada	237	1,276	--	--	567	532	17	45
Chile	(2)	1	--	--	17	34	84	158
Colombia	--	--	--	--	9	17	--	--
Costa Rica	--	--	--	--	--	--	(2)	5
Cyprus	9	40	--	--	--	--	--	--
Denmark	--	--	--	--	--	--	1	1
Egypt	10	30	--	--	--	--	--	--
France	--	--	--	--	--	--	23	123
Germany, Federal Republic of	--	--	61	114	563	560	(2)	2
Guatemala	--	--	--	--	1	2	--	--
Indonesia	13	45	--	--	26	185	--	--
Israel	15	62	--	--	--	--	--	--
Italy	--	--	--	--	(2)	1	--	--
Japan	--	--	--	--	706	1,321	(2)	2
Korea, Republic of	40	103	--	--	72	158	--	--
Malaysia	3	10	--	--	--	--	1	3
Mexico	16	54	--	--	132	265	16	45
Netherlands	--	--	56	159	560	780	15	42
Netherlands Antilles	--	--	--	--	40	54	--	--
New Zealand	--	--	--	--	30	71	--	--
Philippines	4	16	--	--	2	12	--	--
Saudi Arabia	--	--	--	--	--	--	27	31
Singapore	--	--	--	--	9	19	(2)	1
South Africa, Republic of	1	5	--	--	69	112	6	8
Spain	--	--	--	--	89	154	--	--
Sweden	146	592	--	--	--	--	(2)	2
Switzerland	111	485	--	--	--	--	--	--
Taiwan	--	--	--	--	143	189	--	--
Tunisia	--	--	--	--	410	587	--	--
United Kingdom	(2)	1	--	--	115	125	1	16
Uruguay	--	--	--	--	(2)	1	--	--
Venezuela	857	3,091	--	--	(2)	1	--	--
Total	1,550	[3]6,144	117	273	5,297	7,871	191	488

[1]Excludes vanadates.
[2]Less than 1/2 unit.
[3]Data do not add to total shown because of independent rounding.

Table 8.—U.S. imports of ferrovanadium, by country

(Thousand pounds and thousand dollars)

Country	1982 Gross weight	1982 Vanadium content	1982 Value	1983 Gross weight	1983 Vanadium content	1983 Value
General imports:						
Austria	112	87	512	282	230	947
Belgium-Luxembourg	712	547	3,185	223	178	823
Brazil	--	--	--	[1]4	3	18
Canada	499	400	2,531	1,042	838	3,970
France	26	21	126	--	--	--
Germany, Federal Republic of	214	170	1,032	116	91	424
United Kingdom	146	120	708	26	21	77
Total[2]	1,710	1,344	8,094	1,693	1,362	6,259
Imports for consumption:						
Austria	112	87	512	282	230	947
Belgium-Luxembourg	712	547	3,185	223	178	823
Brazil	--	--	--	[1]4	3	18
Canada	499	400	2,531	1,042	838	3,970
France	26	21	126	--	--	--
Germany, Federal Republic of	214	170	1,032	116	91	424
United Kingdom	140	115	679	26	21	77
Total[2]	1,704	1,339	8,065	1,693	1,362	6,259

[1]Bureau of Mines interpretation of revised Census data.
[2]Data may not add to totals shown because of independent rounding.

Table 9.—U.S. imports of vanadium pentoxide (anhydride), by country

Country	1982 Gross weight (pounds)	1982 Vanadium content (pounds)	1982 Value	1983 Gross weight (pounds)	1983 Vanadium content (pounds)	1983 Value
General imports:						
China	99	55	$267	--	--	--
Finland	79,366	44,458	211,896	1,232,651	690,489	$2,070,043
Germany, Federal Republic of	6,614	3,705	22,895	400	224	1,833
South Africa, Republic of	338,141	189,415	827,582	224,868	125,963	523,956
United Kingdom	37,483	20,997	97,205	3	2	1,583
Total	461,703	258,630	1,159,845	1,457,922	816,678	2,597,415
Imports for consumption:						
China	99	55	267	--	--	--
Finland	79,366	44,458	211,896	1,232,651	690,489	2,070,043
Germany, Federal Republic of	6,614	3,705	22,895	400	224	1,833
South Africa, Republic of	300,662	168,421	730,682	112,434	62,982	289,147
United Kingdom	37,483	20,997	97,205	3	2	1,583
Total	424,224	237,636	1,062,945	1,345,488	753,697	2,362,606

WORLD REVIEW

Ferrovanadium consumption continued to weaken in Western Europe and Japan as a result of cutbacks in the production of structural steels, pipe, tubing, and steel components for making machinery and heavy equipment. Vanadium producers in market economy countries were particularly affected by the worldwide oil surplus, which continued to discourage sales of high-strength seamless tubes and other oil country goods that contain vanadium to strengthen the steel. Several low-cost producers of vanadium oxides and slags slashed production in an attempt to reduce the existing imbalance between supply and demand. Even the more efficient oxide producers operated near the break-even point or at a loss.

Australia.—Operations at the new Wundowie mine and mill complex in Western Australia remain suspended. Agnew Clough Ltd., the owner, continued to conduct process improvement studies at the mill in anticipation of a recovery in demand for vanadium pentoxide and a subsequent increase in price. In 1981, the company processed 30,720 tons of "caprock" ore, averaging 1.13% V_2O_5.[4]

Western Mining Corp. Ltd. halted development of its Yeelirrie uranium-vanadium project in Western Australia following a controversial decision by the Australian Federal Government to revoke most negotiating licenses with potential foreign buyers of yellowcake. A large segment of the ruling party reportedly favored the phasing out of all uranium mining activities on the continent as part of the party's antinuclear policies. Development of the Yeelirrie deposit had already been slowed by the withdrawal of Esso Exploration and Production Australia Inc. from the project partnership in May 1982.

Belgium-Luxembourg.—Société Anonyme d'Application de Chemie Industrielle, a division of SADACEM NV, made several technological improvements at its Langerbruggekaai plant near Ghent, Belgium. The company produced more than 1,300 tons (gross weight) of an 80% grade of ferrovanadium in 1982, the last year of available data. This was a 69% increase over the 770 tons reported for 1981. U.S. imports of ferrovanadium from the Belgium-Luxembourg Economic Union totaled 112 tons (gross weight) in 1983.

Canada.—Renzy Mines Ltd. studied the feasibility of recovering vanadium from Athabasca tar sands fly ash.[5] The company planned to build an extraction unit that will process fly ash generated from the oil sands operations of Suncor Inc., which are located north of Fort McMurray, Alberta. Suncor's 58,000-barrel-per-day mining, extraction, and upgrading complex produces about 33,000 tons per year of ash containing 4.5% V_2O_5 as well as smaller amounts of gallium and other rare metals. The vanadiferous fly ash is generated at the upgrading plant when the residual bitumen coke is burned as fuel.

China.—Vanadium pentoxide was reported to have been produced at five different locations in China during 1983: the Emei ferroalloy plant in Sichuan Province, Chengde in Hebei Province, Jinzhou in Liaoning Province, Nanjing in Jiangsu Province, and the Shanghai metallurgical works in the city of Shanghai. Four of the five plants also had facilities for converting the oxide to ferrovanadium. In most cases titaniferous iron slag containing 12% to 20% V_2O_5 was used as feed material. However, the Nanjing plant apparently used vanadiferous residues from oil shale operations. China sold an estimated 2,200 tons of vanadium pentoxide to market economy countries during the year. The bulk of the ferrovanadium was consumed internally.[6]

Finland.—Rautaruukki Oy announced that it had begun phasing out mining operations at both Otanmäki and Mustavaara because of continuing low prices for vanadium pentoxide and iron ore concentrate. The company was able to maintain production of vanadium pentoxide at its 1982 level despite weakening market conditions and rising operational costs. In 1983, the company recovered 3,072 tons of vanadium pentoxide, 181,000 tons of ilmenite concentrate, and 366,000 tons of magnetite concentrate from 1,381,000 tons of ore mined underground at Otanmäki. Mustavaara in contrast is an open pit operation and produced only vanadium pentoxide. Vanadium pentoxide production at Mustavaara declined slightly from 3,290 tons in 1982 to 3,204 tons in 1983. Vanadium extraction costs had risen dramatically at both mines since 1973 as a result of the sharp increase in the price of crude oil. Large quantities of increasingly expensive fuel oil were needed to heat the pellet roasting furnaces. Rautaruukki had already begun retraining part of its mine work force and planned to manufacture railway freight cars and other heavy equipment at new fabricating plants near the two mine sites.[7]

Japan.—The four producers of ferrovanadium in Japan faced stiff competition from imports in 1983. The industry produced only 3,110 tons of ferrovanadium during the year, compared with 4,922 tons in 1982.[8] This 37% decline in production resulted in a corresponding 39% decline in imports of vanadium pentoxide, which decreased from 5,342 tons in 1982 to 3,260 tons in 1983. The Republic of South Africa was the principal vanadium pentoxide supplier to Japan and accounted for 60% of the total gross weight. Imports of ferrovanadium rose from 769 to 817 tons gross weight. The bulk of the imported ferrovanadium came from Austria and the European Communities. Nearly all of the 185 tons of ferrovanadium exported went to North Korea.[9]

New Zealand.—New Zealand Steel Ltd. was expanding its iron and steel complex at Glenbrook on the North Island. Four new prereduction kilns and two electric pig iron furnaces were being added to the iron reduction plant. Commissioning of its new ironmaking units was expected to take place in 1985. The company expected to recover vanadiferous slag from the new submerged arc furnaces. The iron sand concentrates from the company's Taharoa and Waikato North Head operations contain 8% TiO_2 and 0.6% V_2O_5.[10]

South Africa, Republic of.—In May 1983, Highveld Steel and Vanadium Corp. Ltd. temporarily discontinued production of vanadium pentoxide at its Vantra division in the Transvaal because of continuing weak demand in Western Europe and Japan. Four rotary kilns and four multiple-hearth roasters were normally used to extract the vanadium directly from Bushveld magnetite mined at Mapochs. Vanadiferous slag production was also reduced at the company's Witbank iron plant for the first time since its commissioning in 1968. Highveld produced 39,490 tons (gross weight) of slag during the calendar year, a decrease of about 37% from that of 1982.[11]

United Kingdom.—Brandeis Intsel Ltd. procured 937 tons of vanadium pentoxide and slightly less than 55 tons of ferrovanadium for the United Kingdom strategic stockpile at Sheffield. Most of the vanadium pentoxide came from stocks held in Finland and Sweden. The ferrovanadium was supplied by a ferroalloy producer in the Federal Republic of Germany.[12]

Venezuela.—The Venezuelan Government announced that it would delay large-scale development of the Orinoco Oil Belt because of the current low level of world oil consumption relative to 1973.[13] The Orinoco Belt has potential reserves of at least 1.5 trillion barrels of heavy crude oil, containing 150 to 500 parts per million vanadium. Petróleos de Venezuela S.A., the state oil monopoly, had planned to build a $5.5 billion facility at Cerro Negro that would have demetallized and upgraded 170,000 barrels per day of 8° to 10° API crude, with startup in 1988. Earlier in the year, Petróleos de Venezuela signed an agreement with Veba AG to process Venezuelan crudes and heavy crudes in the Federal Republic of Germany. Ruhroel GmbH, a joint venture of the two companies, was to process 5 million tons per year of Venezuelan heavy crudes at its Gelsenkirchen refining complex in the Ruhr.[14]

Union Carbide planned to buy vanadium-bearing petroleum coke from Lagoven S.A., a subsidiary of Petróleos de Venezuela, on a long-term basis. The petroleum coke was to be shipped to Union Carbide's Hot Springs mill in Garland County, AR, where the vanadium will be recovered in the form of a modified oxide. Lagoven operated a refinery at Amuay Bay with a crude processing capacity of 630,000 barrels per day. The bulk of its feed was piped from fields on the northeastern shore of Lake Maracaibo. The Venezuelan company reportedly had a new flexicoker producing almost 3,000 tons per year of vanadium pentoxide contained in coke.[15]

Table 10.—Vanadium: World production from ores and concentrates, by country[1]

(Short tons of contained vanadium)

Country	1979	1980	1981	1982[p]	1983[e]
Production from ores, concentrates, slags:[2]					
Australia (in vanadium pentoxide product)[e]	--	--	[3]101	110	--
Chile[e 4]	510	300	140	--	--
China (in vanadiferous slag product)[e]	4,000	5,000	5,000	5,000	5,000
Finland (in vanadium pentoxide product)	3,051	3,135	3,431	3,470	[5]3,516
Norway[e]	630	540	[r]380	120	--
South Africa, Republic of:[e 6]					
Content of pentoxide and vanadate product	4,300	4,500	4,200	[r]3,700	3,300
Content of vanadiferous slag product	9,300	9,500	9,900	[r]8,900	5,600
Subtotal	13,600	14,000	14,100	[r]12,600	8,900
U.S.S.R.[e]	10,000	10,500	10,500	10,500	10,500
United States (recoverable vanadium)	5,520	4,806	5,126	4,098	[5]2,171
Total	37,311	38,281	38,778	35,898	30,087
Production from petroleum residues, ashes, and spent catalysts:[7]					
Japan (in vanadium pentoxide product)	[e]720	710	687	754	770
United States (in vanadium pentoxide and ferrovanadium products)	1,617	1,520	1,900	1,513	[5]893
Total	2,337	2,230	2,587	2,267	1,663
Grand total	39,648	40,511	41,365	38,165	31,750

[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 20, 1984.

[2]Production in this section is credited to the country that was the origin of the vanadiferous raw material.

[3]Reported preliminary Australian exports.

[4]Based on U.S. imports of vanadium-bearing slag.

[5]Reported figure.

[6]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% vanadium.

[7]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

The U.S. Naval Research Laboratory in Washington, DC, successfully completed a program begun in 1976 to develop V_3Ga multifilament wire for superconducting magnets. Superconducting magnets of this type were being evaluated for use in advanced electrical ship propulsion systems. Considerable research and some production of V_3Ga wire was also being carried out in Japan. The Japanese National Research Institute for Metals in Tokyo was operating a hybrid magnet using a Nb_3Sn tape conductor with a V_3Ga core that was capable of producing fields up to 17.5 tesla.[16]

Teledyne Wah Chang Albany cast a record-setting 1,655-pound ingot of vanadium metal at its plant in Oregon. The cylindrical ingot, which measured 10.5 inches in diameter and 90 inches in length, was believed to be the largest vanadium ingot ever produced.[17]

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[1]Physical scientist, Division of Ferrous Metals.

[2]U.S. Code of Federal Regulations. Title 40—Protection of Environment; Chapter I—Environmental Protection Agency; Part 192—Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings; July 1, 1984.

[3]Froisland, L. J., P. L. Placek, and M. B. Shirts. Restoration of Surface Vegetation on Uranium Wastes at Uravan, Colo. BuMines RI 8653, 1982, 13 pp.

[4]Pratt, R. Vanadium. Ch. in Australian Mineral Industry Annual Review for 1981. Canberra, Australia, 1984, pp. 272-273.

[5]The Northern Miner. Recovery of Vanadium From Oil Sands Plant; First in Canada. V. 70, No. 1, Mar. 15, 1984, pp. 1-2.

[6]The TEX Report Co. Ltd. 1983 Ferro Alloy Manual. Tokyo, Japan, pp. 282-292.

[7]Rautaruukki Oy (Helsinki, Finland). 1983 Annual Report, pp. 5, 35.

[8]Japan Metal Journal (Tokyo). V. 14, No. 15, Apr. 9, 1984, p. 8.

[9]Japan Tariff Association. Japan Exports and Imports. V. 12, 1983, pp. 124, 307, 433.

[10]Mining Magazine. New Zealand: Ironsand to Steel. V. 148, No. 5, May 1983, pp. 346-353.

[11]Highveld Steel and Vanadium Corp. Ltd. (Witbank, Rep. of South Africa). 1983 Annual Report, pp. 3-20.

[12]Metal Bulletin. (London). UK Stockpile Purchases Complete. No. 6772, Mar. 18, 1983, p. 15.

[13]Financial Times (London). Venezuela Shelves Ambitious Oil Plans. No. 28983, Jan. 12, 1983, p. 4.

[14]European Chemical News. Hüls Shifts Oil-Based Ammonia Production to Veba Oel. V. 41, No. 1107, Nov. 14, 1983, pp. 8, 27.

[15]American Metal Market. UC to Buy Venezuelan Firm's Vanadium-Bearing Petro Coke. V. 91, No. 241, Dec. 13, 1983, p. 7.

[16]Gubser, D. U., T. L. Francavilla, and D. G. Howe. Processing of High Transition Temperature Superconductors—V_3Ga Multifilament Wire Development. Naval Res. Lab. Memorandum Rept. 5024, 1983, 63 pp.

[17]Metal Progress. V. 124, No. 4, Sept. 1983, p. 3.

Vermiculite

By Arthur C. Meisinger[1]

Vermiculite concentrate sold and used declined for the fourth consecutive year to 282,000 short tons valued at $27.2 million. Exfoliated vermiculite sales from 43 plants declined for the third consecutive year to 224,000 tons valued at $52.2 million.

W. R. Grace & Co., the largest domestic producer with mines in Montana and South Carolina, produced exfoliated vermiculite at 28 plants in 24 States, compared with 30 plants in 1982.

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 year production levels adjusted by trends in employment and other guidelines. Of the 46 exfoliating plants to which a request was sent, 42 plants responded, representing 87% of the total exfoliated vermiculite sold and used shown in table 1. Plant data for the nonrespondents were estimated using reported previous year production levels adjusted by trends in employment and other guidelines.

Table 1.—Salient vermiculite statistics

(Thousand short tons and thousand dollars unless otherwise specified)

	1979	1980	1981	1982	1983
United States:					
Sold and used by producers:					
Concentrate	346	337	320	316	282
Value	$22,000	$23,500	$26,200	$28,500	$27,200
Average value[1] dollars per ton	$63.58	$69.73	$81.88	$90.19	$96.45
Exfoliated	278	281	274	235	224
Value	$51,300	$54,500	$58,600	$55,500	$52,200
Average value[1] dollars per ton	$184.53	$193.95	$213.87	$236.17	$233.04
Exports to Canada	33	30	31	22	19
Imports for consumption[e]	27	26	27	21	24
World: Production[2]	595	593	577	[p]562	[e]495

[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 was 282,000 tons valued at $27.2 million, a decrease of 11% in quantity and 5% in value from those of 1982.

The principal vermiculite mining and beneficiating operations continued to be those of W. R. Grace at Libby, MT, and Enoree, SC. Vermiculite was also mined and processed during the year by Patterson Vermiculite Co. near Enoree, SC, and by Virginia Vermiculite Ltd., in Louisa County, VA.

Production of exfoliated vermiculite in 1983 decreased 5% in quantity sold and used and 6% in value to 224,000 tons and $52.2 million, respectively. Production came from 43 plants in 29 States compared with 46 plants in 30 States in 1982. The three idled plants were in North Dakota, South Carolina, and Wisconsin.

In descending order of exfoliated vermiculite output, the principal producing States were Ohio, Texas, California, Florida, New Jersey, and South Carolina.

CONSUMPTION AND USES

Use of vermiculite as aggregate material in concretes, plasters, and premixes decreased 11% despite the increase in construction activity; however, its use as thermal insulation increased 11% after a significant decrease in 1982. Agricultural use declined 13%.

Table 2.—Exfoliated vermiculite sold and used in the United States, by end use

(Short tons)

End use	1982	1983
Aggregates:		
Concrete	51,300	46,600
Plaster	3,800	3,300
Premixes[1]	56,500	49,500
Total	111,600	[2]99,500
Insulation:		
Loose-fill	23,300	25,400
Block	30,600	33,800
Other[3]	3,300	4,200
Total	57,200	63,400
Agricultural:		
Horticultural	[r]17,000	22,400
Soil conditioning	[r]14,700	7,800
Fertilizer carrier	33,500	26,800
Total	65,200	57,000
Other[4]	800	3,900
Grand total[2]	235,000	224,000

[r]Revised.
[1]Includes acoustic, fireproofing, and texturizing uses.
[2]Data may not add to totals shown because of independent rounding.
[3]Includes high-temperature and packing insulation and sealants.
[4]Includes various industrial uses not specified.

Table 3.—Active vermiculite exfoliating plants in the United States in 1983

Company	County	State
A-Tops Corp	Beaver	Pennsylvania.
Brouk Co	St. Louis	Missouri.
Cleveland Gypsum Co., a division of Cleveland Builders Supply Co	Cuyahoga	Ohio.
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	South Carolina.
	Davidson	Tennessee.
	Bexar	Texas.
	Dallas	Do.

Table 3.—Active vermiculite exfoliating plants in the United States in 1983 —Continued

Company	County	State
International Vermiculite Co	Macoupin	Illinois.
Koos Inc	Kenosha	Wisconsin.
Patterson Vermiculite Co	Laurens	South Carolina.
Robinson Insulation Co	Cascade	Montana.
The Schundler Co	Middlesex	New Jersey.
O. M. Scott & Sons	Union	Ohio.
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.

PRICES

The average value of vermiculite concentrate sold and used by U.S. producers increased 7% to $96.45 per ton, f.o.b. plant. The average value of exfoliated vermiculite, f.o.b. plant, decreased from $236 per ton to $233 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, $75 to $128; 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 and Brazil totaled 24,000 tons. Exports to Canada were 19,000 tons and represented 7% of total sales.

WORLD REVIEW

Estimated world production decreased 12%, the fifth consecutive year of decline. The United States and the Republic of South Africa, together, accounted for 91% of the total production. Production of vermiculite concentrates in the Republic of South Africa declined 16%, and exports accounted for 74% of production.

[1]Industry economist, Division of Industrial Minerals.

Table 4.—Vermiculite: World production, by country[1]

(Short tons)

Country	1979	1980	1981	1982[p]	1983[e]
Argentina	6,478	10,920	3,557	3,697	[2]3,748
Brazil	8,137	13,427	15,771	15,497	15,400
Egypt	770	800	800	309	330
India	3,376	4,054	3,995	2,280	2,800
Japan[e]	17,000	19,000	19,000	19,000	19,000
Kenya	2,491	2,819	[e]2,900	[e]2,900	2,900
Mexico	---	[3]601	657	575	550
South Africa, Republic of	211,173	204,698	210,101	201,327	[2]168,691
Tanzania[e]	20	20	20	20	20
United States (sold and used by producers)	346,000	337,000	320,000	316,000	[2]282,000
Total	595,445	[r]593,339	576,801	561,605	495,439

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Excludes production by centrally planned economy countries. Table includes data available through July 3, 1984.
[2]Reported figure.
[3]First year production registered.

Zinc

By James H. Jolly[1]

The domestic zinc mining and smelting industry continued to operate at the depressed levels of 1982 despite significant increases in U.S. zinc consumption in 1983. Imports of slab zinc were the third highest in history and supplied the greater part of U.S. requirements. Both mine production and smelter output were at their second lowest levels in 50 years. Three mines closed, one permanently. One mine that closed in 1982 reopened after negotiating a more favorable labor contract. Only four of six domestic primary zinc smelters operated during the year, and as a result, imports of concentrate were at their lowest level since 1939. U.S. producers' zinc prices stayed within a narrow range in the first half of 1983, but rose rapidly in the second half because of increasing demand and shortages of Special High Grade (SHG) zinc metal. Slab zinc stocks were marginally lower at yearend; however, consumer stocks of slab zinc were higher in anticipation of continued strong demand.

Table 1.—Salient zinc statistics

(Metric tons unless otherwise specified)

	1979	1980	1981	1982	1983
United States:					
Production:					
Domestic ores, recoverable content	267,341	317,103	312,418	r303,160	275,294
Value thousands	$219,841	$261,671	$306,879	r$257,116	$251,204
Slab zinc:					
From domestic ores	255,344	231,850	259,835	193,284	210,315
From foreign ores	217,137	108,606	86,728	34,892	25,379
From scrap	53,212	29,396	50,192	74,288	69,390
Total	525,693	369,852	396,755	302,464	305,084
Secondary zinc[1]	316,818	274,967	290,658	210,681	279,237
Exports of slab zinc	279	302	323	341	427
Imports for consumption:					
Ores and concentrates (zinc content)	87,499	182,370	245,710	66,809	63,156
Slab zinc	524,130	410,163	612,007	456,233	617,679
Stocks of slab zinc, Dec. 31:					
Producer and consumer	151,661	92,151	126,581	r111,777	112,940
Merchant	NA	33,650	68,773	47,397	35,199
Government stockpile	345,684	342,380	340,581	340,578	340,577
Consumption:					
Slab zinc	1,000,606	811,146	840,875	709,491	805,891
All classes	1,394,314	1,142,409	1,189,369	953,111	1,120,548
Price: Prime Western, cents per pound (delivered)	37.30	[2]37.43	[2]44.56	[2]38.47	[2]41.39
World:					
Production:					
Mine thousand metric tons	r5,985	r5,962	5,848	p6,238	e6,246
Smelter do	r6,260	r6,049	6,079	p5,865	e6,175
Price: Prime Western, London, cents per pound	33.59	34.47	38.34	33.74	34.73

eEstimated. pPreliminary. rRevised. NA Not available.

[1]Excludes redistilled slab zinc.

[2]Based on U.S. High Grade, cents per pound.

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 473 operations to which the survey request was sent, 352 responded, representing an estimated 81% of the total slab zinc consumption shown in tables 1, 15, 16, and 17 and an estimated 58% of total consumption shown in tables 1 and 15. Consumption for the remaining 121 nonrespondents was estimated using prior year consumption levels, trends in consumption, or other guidelines.

Legislation and Government Programs.—The National Defense Stockpile goal for zinc was 1,292,739 metric tons, unchanged since May 1980. The total zinc inventory held by the Government at yearend 1983 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 slab zinc, 121,750 tons of Prime Western slab zinc, and 35,690 tons of other slab zinc grades.

Promulgation of final Clean Water Act effluent discharge regulations for zinc and a variety of nonferrous metals and powder forming operations were delayed in August to give the Environmental Protection Agency an additional 10 months to establish the regulations. When finally implemented, affected companies were expected to be in compliance in 3 years.

DOMESTIC PRODUCTION

MINE PRODUCTION

The drop in mine production of recoverable zinc was due to mine closures in Missouri, Tennessee, and Pennsylvania. Mine output in 1983 was the second lowest production year, after 1979, in the last 50 years. Tennessee was the principal zinc-producing State, a position the State has held 23 times in the last 26 years. Missouri and New York were the second and third leading States in zinc mine output. The leading U.S. zinc producers were ASARCO Incorporated, St. Joe Minerals Corp., and Gulf + Western Industries Inc. (G+W). Before the end of 1983, however, G+W, except for its 60% interest in The Jersey Minière Zinc Co., was essentially out of the U.S. zinc mining industry, having either sold or permanently closed all of its zinc mines.

The 25 leading U.S. zinc-producing mines accounted for 98% of the recoverable domestic zinc mined in 1983, and the 10 leading mines accounted for 80% of total production.

In Tennessee, zinc was produced from zinc ores at seven underground mines and from iron-sulfur-copper-zinc ores at Copperhill. Asarco operated four Tennessee zinc mines—Young, New Market, Immel, and Coy. According to the company's annual report, Asarco milled 2.45 million tons of ore, producing 59,900 tons of zinc in concentrate, slightly less than that produced in 1982. Ore reserves at the four mines were 6.54 million tons grading 3.34% zinc at yearend.

Jersey Minière Zinc completed its first full year of operation of the combined Elmwood-Gordonsville Mine and new mill, which came on-stream in April 1982. The operation was the single largest domestic zinc producer in 1983. All zinc concentrates were shipped to the company's zinc refinery in Clarksville, TN, for processing. Yearend ore reserves at the Elmwood-Gordonsville Mine were about 25.5 million tons grading 3.7% zinc.

United States Steel Corp. reopened its zinc mine at Jefferson City, TN, in September after negotiating a better labor contract and arranging contracts to supply concentrates to two domestic zinc smelters. The mine was closed in October 1982 because of depressed zinc markets, low zinc prices, and a second rejection by union workers of company-sought concessions.

The New Jersey Zinc Co., owned by G+W, closed down the Beaver Creek Mine and its Jefferson City, TN, mill at the end of January, citing the depressed zinc market. This mine and mill, New Jersey's Jefferson City and Idol Mines, and several other company mineral properties in eastern Tennessee were sold to Inspiration Resources Corp. in July. In December, Inspiration announced that it was planning to reopen the Beaver Creek Mine and Jefferson City mill in January 1984.

Zinc produced in Missouri was a coproduct from eight underground lead mines. Mine output fell in 1983 owing mainly to reduced production at the Buick Mine and to the March closing of Ozark Lead Co.'s Milliken Mine for economic reasons. Zinc production at the Buick Mine, owned jointly by AMAX Lead Co. of Missouri and Homestake Mining Co., fell about 16% from that of 1982 owing to the milling of ore lower in zinc content. At the Buick Mine, 1.93 million tons of ore grading 7.9% lead and 1.8% zinc was milled in 1983, yielding about 29,500 tons of zinc in zinc concentrate. Yearend ore reserves at the Buick Mine were 35.5 million tons grading 5.7% lead and 1.4% zinc.

St. Joe Lead Co., a unit of Fluor Corp., produced zinc at four Missouri lead-zinc mines. A small amount of zinc was also produced from development ore at the company's new Viburnum No. 35 Mine near Bixby. The nearby Viburnum mill was expanded and modernized to accommodate the increased production of 3,600 tons per day from the new mine. The Viburnum No. 35 Mine, anticipated to come on-stream in early 1984, was expected to produce 41,000 tons of lead and 5,000 tons of zinc annually.

The Magmont lead-zinc-copper mine at Bixby, MO, operated by Cominco American Inc. under a joint venture arrangement with Dresser Industries Inc., produced 11,917 tons of zinc in concentrate, 42% higher than in 1982. Cominco American milled 1.04 million tons of ore grading 7.2% lead, 1.4% zinc, and 0.2% copper in 1983, compared with 1 million tons of ore milled grading 6.5% lead, 1.0% zinc, and 0.3% copper in 1982. A new drift driven 2 miles from the Magmont shaft to open up the Magmont West area was completed. Magmont ore reserves at yearend were 6.2 million tons averaging 8.0% lead, 1.0% zinc, and 0.4 ounce of silver per ton.

Asarco completed construction of the mill and other surface facilities at its West Fork, MO, lead mine in June; however, it was not decided until October that underground mine development, suspended in July 1982, would continue. Production was expected to begin in 1985. The mill was designed to process 3,450 tons of ore per day, with an expected yield of 46,000 tons of lead, 7,000 tons of zinc, and 125,000 ounces of silver in concentrates. Ore reserves in the West Fork ore body were estimated at 14 million tons averaging 5.5% lead and 1.2% zinc, with some copper and silver.

In New York, St. Joe Resources Co., a unit of Fluor Corp., operated the Balmat, Hyatt, and Pierrepont Mines. All ore was milled at the company's Balmat mill. The concentrates were either shipped to St. Joe Resources' Monaca, PA, zinc smelter or exported to Europe and Canada. In April, St. Joe Resources arranged to have some of its concentrates toll refined at Noranda Mines Ltd.'s Valleyfield, Quebec, Canada, zinc refinery.

In Colorado, zinc production came largely from the Leadville Mine, managed by Asarco but owned jointly with Resurrection Mining Co., a Newmont Mining Co. subsidiary. Asarco milled 193,000 tons of ore, the same as in 1982, but zinc output rose 10% to 12,519 tons owing to the milling of higher grade ore. Yearend ore reserves were 1.3 million tons averaging 9.37% zinc, 4.22% lead, and 2.72 ounces of silver per ton, as well as some copper and gold. Standard Metal Corp. increased production of zinc concentrates at its Sunnyside gold mine in 1983. Ore production rose sharply because of the employment of new vertical crater retreat mining methods in certain sections of the mine. The zinc concentrates were shipped to Cominco Ltd.'s zinc smelter at Trail, British Columbia, Canada.

Hecla Mining Co. produced 1,944 tons of zinc in concentrate at its Lucky Friday silver mine in Idaho. Output increased slightly over that of 1982 despite a 2-month strike in the first half of 1983. The new silver shaft reached its initial objective of 1,891 meters in April, and the first ore was hoisted in October. An ultimate depth of 2,286 meters was planned. Ore reserves increased moderately because development work was resumed. At yearend, the ore reserves were 470,000 tons grading 17.1 ounces of silver per ton, 12.2% lead, and 1.2% zinc.

G+W, as part of its withdrawal from the zinc industry, closed the company's Friedensville, PA, zinc mine in October after failing to find a buyer for the property. Despite the presence of substantial ore reserves, the mine, Pennsylvania's only zinc operation, was expected to remain permanently closed owing to severe water problems underground.

In Alaska, two projects, Red Dog and Greens Creek, progressed toward development. Most of the environmental and State permitting for both deposits was approved and decisions to begin development were expected in 1984. The Greens Creek polymetallic deposit, owned by Anaconda Minerals Co., 33.8%; Noranda, 33.8%; Texas Gas & Exploration Co., 12.3%; Bristol Bay Resources, 11.2%; and Exalas Resources Corp., 8.9%, was tentatively scheduled for startup in 1987. Noranda, the operating company, has estimated ore reserves at Greens Creek to be 3.1 million tons averaging 12.8 ounces of silver per ton, 7.5% zinc, 2.5% lead, 0.4% copper, and 0.1 ounce of gold per ton. A proposed 750-ton-per-day mining rate was planned, which would yield about 22,000 tons of zinc per year.

Cominco and the NANA Regional Corp. Inc. were expected to complete engineering and feasibility studies on their Red Dog deposit in 1984. Cominco, the operating company, was tentatively planning to begin mine construction in 1985 with startup of the operation and first shipments of concentrates in 1988. A two-stage development and production plan was proposed with an initial annual ore production of 0.9 million tons yielding about 390,000 tons of lead and zinc concentrates. By the sixth year of operation, production was to be doubled. The Red Dog ore reserves were estimated at 77 million tons averaging 17.1% zinc, 5% lead, and 2.4 ounces of silver per ton.

SMELTER AND REFINERY PRODUCTION

Only four primary zinc smelters, with annual capacities totaling 300,000 tons, operated in the United States in 1983; two others, Corpus Christi, TX, and Bunker Hill, ID, with annual capacities totaling 207,000 tons, were idle. At yearend, companies owning the idle smelters were studying the feasibility of reopening them, but were experiencing problems with labor costs, power, and/or feed materials. St. Joe Resources increased the annual capacity of its Monaca, PA, electrothermic zinc smelter from 77,000 tons to 91,000 tons. St. Joe Resources boosted capacity and productivity by installing a fourth Larvik furnace and by modernizing other facilities. The four Larvik furnaces, which are used mainly to process secondary material, have a combined capacity of about 12,000 tons. The capacity of the smelter's five electrothermic furnaces, which can process both concentrate and high-grade secondary material, was about 79,000 tons. With the smelter changes, the company was capable of devoting all of its capacity to metal or up to 50% to 55% of the capacity to zinc oxide.

In December, the National Zinc Co. and its 51,000-ton-per-year Bartlesville, OK, zinc smelter were sold by Phibro Resources Corp. to Continental Resources & Development Inc. Because the smelter depends entirely on purchased feed material, the new company was exploring the possibility of acquiring a stake in an existing zinc mining operation.

Zinc Oxide.—The sources of domestic zinc oxide production were about 33% from ores and concentrate, about 35% from slab zinc, and about 32% from secondary material. French-process zinc oxide was about 67% of the total produced, compared with 62% in 1982. Lead-free zinc oxide was produced at 11 plants and leaded zinc oxide was produced at 1 plant. Two companies produced oxide from ores and concentrates. Asarco, Pacific Smelting Co., St. Joe Resources, and New Jersey Zinc were the largest domestic producers of zinc oxide in 1983.

Output of zinc oxide at Asarco's two plants, located in Columbus, OH, and Hillsboro, IL, was 32,500 tons, an increase of about 25% over the depressed level of 1982. However, the combined operating rate of both plants was only about 60% of capacity. Southern Zinc Co. purchased the Chicago, IL, zinc oxide manufacturing assets of Sipi Metals Corp. The facility will be operated by Midwest Zinc Corp., a newly formed subsidiary of Southern, itself a subsidiary of Gulf Metals Industries Inc.

Zinc Salts.—Zinc sulfate was produced by about 12 companies from secondary material and concentrate. Zinc chloride production from five companies was derived entirely from secondary material.

Slag-Fuming Plants.—No slag-fuming plants operated in 1983; however, substantial quantities of zinc-bearing lead blast furnace slags and residues were stockpiled by Asarco at its lead smelters in East Helena, MT, and EL Paso, TX.

Byproduct Sulfur.—Production of sulfur in byproduct sulfuric acid from four primary zinc plants and one zinc oxide plant was 125,500 tons, up from the 112,000 tons produced in 1982. More zinc concentrates were processed in 1983 even though the Corpus Christi zinc plant was closed all year.

CONSUMPTION AND USES

Zinc consumption for most end-use categories improved, paralleling growth in domestic economic activity, especially in the housing and automobile industries. The construction industry accounted for an estimated 45% of zinc consumption, followed by transportation, 20%; machinery, 12%; electrical, 8%; and chemical and other indusries, 15%.

Galvanizing continued to be the principal use of slab zinc, consuming about 46%, followed by zinc-based alloys, 26%; brass and bronze, 13%; rolled zinc, 7%; and other uses, 8%. SHG accounted for one-half of the slab zinc consumed and was mainly used for production of die-cast alloys. The Bureau of the Mint purchased 34,020 tons of SHG slab zinc to manufacture pennies; production for the year was 14.2 billion pennies. Prime Western was the second largest grade of slab zinc consumed, and was used mainly for galvanizing.

The apparent consumption of zinc oxide was about 162,000 tons, up from 152,000 tons in 1982. Reported shipments of zinc oxide to user industries increased in 1983 with the largest tonnage increase posted by the rubber industry. Reported zinc sulfate shipments decreased about 10% compared with those of 1982. Agricultural uses, which accounted for 84% of zinc sulfate uses in 1983, fell only marginally; whereas, other uses decreased by more than one-third. Zinc chloride and other zinc chemical usage generally increased.

Zinc Institute Inc. (ZI) studies on zinc coatings in the automotive industry[2] revealed a trend toward more zinc protection of steel parts for automobiles made in model year 1983. Although the amount of steel protected by Zincrometal reportedly fell about 10%, the quantities of one- and two-sided galvanized steel increased. The net total zinc content in coatings for the typical U.S. automobile in 1983 was 6.70 pounds, compared with 6.59 pounds in 1982. The total included 1.5 pounds of zinc in paints. If waste from stamping of zinc-coated steel is included, the zinc content in coatings required per typical automobile in 1983 was 9.63 pounds, compared with 9.47 pounds in 1982.

Another ZI study reported that the weight of zinc diecastings for the average 1983 model year automobile was 23.00 pounds, down from 23.12 pounds and 39.53 pounds reported for average automobiles in 1982 and 1977, respectively.[3] The declining use of zinc was attributed to substitution, elimination of parts, and increased use of thin-wall zinc diecastings. The ZI study also indicated that aftermarket diecastings accounted for 3 to 5 pounds of zinc per automobile and 15 to 20 pounds of zinc per truck.

STOCKS

Slab zinc stocks held by domestic producers, consumers, and merchants were marginally lower at the end of 1983 than at the start of the year. Annual data collected by the Bureau of Mines showed that producer and merchant stocks of slab zinc were down 28%; whereas, consumer stocks were up 15%. The lower producer and merchant stock position reflected, in part, the strong zinc demand; whereas, the consumer stock increase indicated concern for adequate zinc supply and possible price increases.

Stocks of slab zinc on the London Metal Exchange (LME) ended 1983 at 96,700 tons, up 5,000 tons from that at the start of the year. Despite increased LME zinc stock levels, High Grade zinc stocks fell 72% to 5,925 tons at yearend; whereas, good ordinary brand stocks increased 20,250 tons during the year to 90,775 tons. The LME stock changes reflected a world trend toward increased demand for higher purity zinc metal in 1983.

PRICES

Domestic prices for benchmark High Grade slab zinc in the first half of 1983 were relatively stable, ranging from 38 to 40 cents per pound. In mid-July, the producer price was raised 3 cents per pound to 43 cents, the highest price posted by producers since February 1982. The price increase was attributed to a number of factors, mainly improved demand in the United States, heavy Chinese purchases on Western markets, and a tightening in the supply of SHG zinc on world markets. At the end of August, the domestic price of High Grade jumped another 3 cents to 46 cents owing to favorable demand outlook, several price increases by European zinc producers, and large purchases of SHG zinc by the U.S. Mint for penny production. SHG was in such short supply that some consumers reportedly were paying several times the usual 0.5-cent premium over High Grade to obtain the metal. The High Grade price rose another 3 cents per pound to 49 cents in late October prompted by the tight SHG market, which was indicated by relatively high bid prices for SHG and small quantities of metal offered to the U.S. Mint in mid-October. Despite continuing strong zinc demand, additional zinc price increases in Europe, and an announcement by the U.S. Mint that its November zinc purchases would be increased, the 49-cent-per-pound price held to yearend 1983.

American- and French-process lead-free zinc oxide at the beginning of the year were quoted at 44.5 to 46.5 cents and 46 to 48 cents per pound, respectively. Prices for both remained the same until August at which time they were increased, generally paralleling the rise in zinc metal prices. Their respective quoted prices at yearend were 53 to 53.5 cents and 55 cents per pound. The price of photoconductive-grade zinc oxide was quoted at or marginally higher than the price of French-process zinc oxide.

The quoted price of zinc sulfate, granular monohydrate industrial grade, 36% zinc, in 100-pound bags, ranged from $26.50 to $29 in 1983. Agricultural zinc sulfate, 36% zinc in carload lots, was $20 per 100 pounds. Technical-grade zinc chloride, 50% solution, in tanks, was priced all year at $12.25 to $18.20 per 100 pounds. Standard pigment-grade zinc dust types 1 and 2, in drums, were quoted at 59 to 69.5 cents per pound.

FOREIGN TRADE

Domestic concentrate exports mainly came from G+W's Friedensville, PA, mine, which closed late in the year, and from the New York mines of St. Joe Resources, which had some of its concentrate toll processed in Canada. Exports of concentrates almost equaled the quantity imported. Imports of concentrates were the lowest since 1939, owing principally to the fact that only four of six domestic primary zinc smelters operated in 1983. Slab zinc imports for consumption in 1983 were the third highest in history.

Import duties on unwrought zinc and other zinc materials continued to be reduced in line with the Tokyo round of multilateral trade negotiations completed in 1979. Duties on zinc ores, concentrates, and zinc-bearing materials continued to be suspended during 1983.

Table 2.—U.S. import duties for zinc materials, January 1, 1983

Item	TSUS No.	Most favored nation (MFN)	Non-MFN
Ores and concentrates[1]	602.20	0.48 cent per pound on zinc content.	1.67 cents per pound on zinc content.
Fume	603.50	do	Do.
Unwrought, other than alloys	626.02	1.8% ad valorem	1.75 cents per pound.
Alloys	626.04	19% ad valorem	45% ad valorem.
Waste and scrap[1]	626.10	3.7% ad valorem	11% ad valorem.

[1]Duty on zinc ores, concentrates, and zinc-bearing materials suspended until June 30, 1984, as provided by Public Law 96-467.

WORLD REVIEW

World consumption of zinc rose significantly over the depressed levels consumed in 1982. According to the International Lead and Zinc Study Group (ILZSG), zinc metal consumption in the market economy countries in 1983 was 4.5 million tons, the highest level recorded since 1979. The largest increases in consumption occurred in the United States, Japan, the Federal Republic of Germany, and Belgium. On a regional basis, consumption in the Americas, Asia, and Europe increased; whereas, it declined in Africa and Oceania. China became a large importer of zinc metal from the market economy countries in the last 2 years, importing 229,000 tons in 1983 and 102,000 tons in 1982.[4]

World zinc metal stocks fell during the first 10 months of 1983, but increased slightly in the last 2 months, ending the year at 641,000 tons or 23% less than at the beginning of the year. LME stocks were 96,700 tons at the end of 1983, 5,600 tons more than at the end of 1982.

World mine production, according to the Bureau of Mines, was slightly above the record high 1982 output despite a 150,000-ton decrease in North American production. Smelter production in the market economy countries was at the highest level since

1979.

The European Commission-approved plan for zinc smelter capacity reduction in Western Europe was placed on standby status in November when no candidates for closure were nominated. Under the plan, a company that closed its smelter capacity permanently would have been reimbursed $220 by the other zinc producers for each ton closed.

At its annual October session, ILZSG projected that world zinc mine and smelter production and world zinc consumption would be higher in 1984 than in 1983.

Australia.—Mine production was a record high in 1983 mainly owing to increased production at the Mount Isa Mine in Queensland and initial production at the new Elura Mine in New South Wales. Several other mines had marginally higher output; however, production at Broken Hill in New South Wales was lower.

Mine and mill production at the Mount Isa Mine, owned by MIM Holdings Ltd., rose substantially owing to mine and mill capacity expansions completed in 1982. Ore output reached record high levels in 1983 with the introduction of open-stoping mining methods in some ore bodies replacing less productive cut-and-fill methods. Startup of the new 800-ton-per-hour heavy-medium separation plant, which was designed to reject about 35% of the mill feed as waste material, resulted in record high output of zinc in concentrate. Because of the separation plant and other mill improvements, the zinc capacity of the mill jumped 65,000 tons to 175,000 tons per year. Zinc production in concentrate for the fiscal year ended June 30, 1983, was a record high 170,300 tons. Zinc-lead ore reserves at the end of the fiscal year were 53 million tons averaging 6.66% zinc, 6.05% lead, and 4.8 ounces of silver per ton. At MIM's Hilton Mine, 12 miles north of Mount Isa, construction of the main cage winder was well advanced and was expected to be completed in early 1984. Trial stoping at the Hilton Mine was scheduled to start in 1985. Hilton ore was expected to be necessary to maintain future production levels at the Mount Isa complex. Hilton ore reserves at the end of the fiscal year were 45 million tons averaging 9.6% zinc, 6.6% lead, and 4.8 ounces of silver per ton.

In March, EZ Industries Ltd. (EZI) officially opened its new silver-zinc-lead Elura Mine, 47 kilometers northwest of Cobar in New South Wales. The mine, which was developed at a cost of $180 million, had an expected mine life of at least 16 years. Plans called for the mining of 1.1 million tons of ore annually, resulting in production of about 130,000 tons of zinc concentrate and 100,000 tons of silver-lead concentrate per year. Estimated ore reserves were 28.6 million tons averaging 8.1% zinc, 5.3% lead, and 4.3 ounces of silver per ton. For the fiscal year ended June 30, 1983, EZI milled 299,600 tons of Elura ore producing 30,000 tons of zinc concentrate averaging 44.9% zinc, 3.8% lead, and 5.9 ounces of silver per ton, and 15,800 tons of silver-lead concentrate averaging 4.9% zinc, 45.5% lead, and 45.5 ounces of silver per ton.

In 1983, Conzinc Riotinto of Australia Ltd. (CRA), through its subsidiaries, Zinc Corp. Ltd. (ZC) and North Broken Hill Consolidated Ltd. (NBHC), processed 2.25 million tons of ore and dump residues at its Broken Hill lead-zinc operations. Concentrate production was 395,000 tons containing 204,000 tons of zinc, which was about 15,000 tons of zinc less than the record high output achieved in 1982. At yearend 1983, ZC ore reserves were 10.6 million tons averaging 9.5% lead, 9.0% zinc, and 2.9 ounces of silver per ton; NBHC ore reserves were 18.9 million tons grading 11.5% zinc, 7.5% lead, and 1.9 ounces of silver per ton.

Cobar Mines Pty. Ltd., a CRA subsidiary, produced 7,900 tons of zinc at its CSA Mine at Cobar, New South Wales. Zinc output was down 15% in 1983 compared with that of 1982 despite a substantial increase in ore milled. Cobar continued its expansion program to raise ore capacity above 800,000 tons annually by 1985. At yearend 1983, ore reserves at the CSA Mine were 2.3 million tons averaging 4.6% zinc, 1.6% lead, and 1.6% copper. In addition, 1.9 million tons of probable ore containing 2% copper, but less lead and zinc, have been identified.

Zinc production at Woodlawn Mines Ltd., a joint venture of St. Joe, Phelps Dodge Exploration Ltd., and NBHC, fell about 14% because the mine was closed for the month of January as a cost saving measure because of low metal prices. In 1983, Woodlawn milled 610,000 tons of zinc-lead-copper ore producing 114,000 tons of zinc concentrate containing about 54,000 tons of zinc. Opencut mining was expected to end in 1987 when recoverable ore reserves within the design limits of the open pit were exhausted. The feasibility of underground development of deep extensions of the main ore zone was under consideration.

Australia slab zinc production increased marginally in 1983. Increased output at the Cockle Creek and Port Pirie smelters of CRA offset a small decrease in production at EZI's Risdon, Tasmania, smelter. Risdon zinc production fell 4% to 184,178 tons, owing largely to limited electric power at economic prices. At Risdon, the first shipments of zinc concentrates from Elura were received in late February. A new plant to remove the higher arsenic impurity in Elura zinc concentrates was commissioned.

Canada.—Although zinc mine production declined by about 120,000 tons in 1983, Canada remained the leading world producer, accounting for about one-sixth of world output. The production decrease was largely attributable to the closure of Cominco's Pine Point Mine in the Northwest Territories for the first half of 1983 and to the shutdown at the end of April of Noranda's Little River Mine in New Brunswick. Together, zinc output from these two mines was about 108,000 tons less than they produced in 1982. The principal Canadian zinc producers in 1983 were Noranda, Cominco, and Kidd Creek Mines Ltd. The major producing mines, which accounted for about one-half of Canadian production, were Noranda's Brunswick Mining and Smelting Corp. Ltd. (BMS) No. 12 Mine in New Brunswick, Kidd Creek's Timmins Mine in Ontario, and Cominco's Polaris Mine in the Northwest Territories.

Government loans and other Government concessions were used to encourage several zinc mines to resume operations or to continue production. Cyprus Anvil Mining Corp., a subsidiary of Dome Petroleum Ltd., began a Government-supported 2-year mine reopening program in May at its Faro Mine in the Yukon. The mine, which produced 107,200 tons of zinc in 1981, was closed for economic reasons in June 1982. The project, which consists largely of overburden removal, was expected to cost about $40 million, one-half of which was to be interest-free Government financing. Pine Point Mines Ltd., 69% owned by Cominco, reopened its Pine Point Mine in mid-June after a 5-1/2-month shutdown owing to depressed metal prices and high operating costs. The reopening was made possible through cost reductions via labor concessions, reduced smelter charges, Government-supported rate reductions in power and rail transport, and Government provisions to allow unemployment insurance payments to be applied toward a portion of the wages paid to employees engaged in exploration and preproduction work. Zinc production at Pine Point totaled 72,800 tons in 1983 compared with 149,200 tons in 1982.

Difficult ice conditions slowed initial shipments of zinc concentrate early in the Arctic shipping season from Canada's two most northerly zinc mines, the Polaris Mine on Little Cornwallis Island and the Nanisivik Mine on Baffin Island; however, all planned shipments were made before the season ended. In 1983, Cominco completed its first full year of production at the Polaris Mine. The company milled 829,000 tons of ore, producing 132,000 tons of zinc in concentrate, most of which was shipped to Europe. Ore reserves at yearend were 16.9 million tons averaging 14.8% zinc and 4.1% lead.

Cominco's Sullivan zinc-lead-silver mine at Kimberley, British Columbia, celebrated its 75th year of production in 1983. Ore milled fell 200,000 tons to 2.02 million tons because of an 8-day strike; however, zinc output in concentrates was 60,830 tons, up from 58,690 tons in 1982, owing to improved zinc grades. At yearend 1983, the ore reserves at the Sullivan Mine were 42.6 million tons averaging 6.2% zinc, 4.4% lead, and 1.1 ounces of silver per ton.

BMS, 64.1% owned by Noranda, treated 3.4 million tons of ore, slightly less than the 3.6 million tons milled in 1982. Zinc output totaled 245,000 tons or almost 23% of Canadian production in 1983. Ore reserves at yearend were 103 million tons grading 9.81% zinc, 3.68% lead, 0.33% copper, and 3.1 ounces of silver per ton.

Sherritt Gordon Mines Ltd., operators of the Fox and Ruttan copper-zinc mines near Lynn Lake, Manitoba, announced that the Fox Mine would close in 1986 owing to exhaustion of ore and that the Ruttan operation would close in June 1984 for economic reasons. Late in 1983, Sherritt Gordon was seeking both Government and private loans to develop deeper ore reserves at Ruttan necessary to ensure continuation of operations. At yearend, the ore reserves at the Ruttan Mine were 21.7 million tons averaging 1.47% copper and 1.23% zinc. In 1983, Sherritt Gordon's Lynn Lake operations produced 12,400 tons of zinc in concentrate.

The Buchans Mine, 51% owned by Abitibi-Price Inc. and 49% by Asarco, was reopened in June after a 1-1/2-year shutdown to mine remaining ore reserves and to process stockpiled ore. Although some additional reserves were found, a permanent closure of the mine was expected in mid-1984. In 1983, Buchans' production was about 2,000 tons of zinc in concentrate.

Westmin Resources Ltd. continued development of its H-W base metal deposit near Myra Falls on Vancouver Island. Reportedly, Westmin has committed \$152 million to bring the deposit into production in late 1984. Plans called for construction of a 2,700-ton-per-day mill designed to process ore from the H-W Mine and two other nearby mines, the Lynx and Myra Creek, also owned by Westmin. An annual production of 30,000 tons of zinc in concentrate was expected. H-W ore reserves were estimated to be 13.8 million tons grading 5.3% zinc, 2.2% copper, 1.3% lead with 1.2 ounces of silver and 0.08 ounce of gold per ton.

In October, Cominco officially opened its highly automated 272,000-ton-per-year zinc electrolytic and melting plant at Trail, British Columbia. The new \$175 million plant, which has the largest capacity of any zinc plant in the world, replaced an older, labor-intensive, 245,000-ton-per-year electrolytic plant. The old plant required 550 operating and supervisory personnel; whereas, the new plant, because of automation and computer-controlled operation, was designed to employ only 230 people but with 10% more output.

Canadian Electrolytic Zinc Ltd. (CEZ), a Noranda subsidiary, officially opened its new \$47 million roaster-acid plant complex at the company's Valleyfield, Quebec, zinc refinery. The new roaster not only allowed CEZ to roast all of its concentrate at the refinery but also, together with other facility changes, increased the annual zinc refining capacity at Valleyfield by 9,000 tons to 227,000 tons. Kidd Creek completed a 19,000-ton expansion of annual capacity to 127,000 tons at its zinc refinery at Hoyle, Ontario, by adding an \$8 million zinc pressure-leach facility similar to that commissioned by Cominco at Trail, British Columbia, in 1982. The new facility, only the second of its kind in the world, replaced the need for additional roaster-acid capacity.

Chile.—The \$30 million El Torque zinc-lead mine project in southern Chile was officially inaugurated in November. The project, which is operated by Sociedad Contractual Minera "El Torque" Ltda., was the southernmost metalliferous mining operation in the world, about 1,000 miles south of Santiago. The project involved development of two underground mines, Zuniga and San Antonio, and construction of a 750-ton-per-day mill. Because the deposit occurs in one of the most desolate areas of Chile, a considerable investment in infrastructure was also required. Plans called for an annual production of 42,000 tons of zinc concentrate grading 54% zinc, 13,000 tons of lead concentrate grading 76% lead with about 35 ounces per ton of silver, and a small tonnage of copper-gold concentrate. Initial shipments of concentrates were expected in January 1984. Estimated ore reserves were 2.2 million tons averaging 11% zinc and 5% lead with significant amounts of cadmium, copper, gold, and silver.

Ireland.—Bula Ltd., 49% owned by the Irish Government, received permission to develop an underground mine at its lead-zinc deposit near Navan. Bula planned to begin mine development in 1984 with a startup in 1985. Plans called for an annual production of 80,000 tons of zinc in concentrate and 15,000 tons of lead in concentrate. Ore reserves were estimated at 14 million tons averaging 6.7% zinc and 1.3% lead.

Tara Mines Ltd. treated a record high 2.4 million tons of ore from its Navan Mine in 1983, producing 185,700 tons of zinc and 33,500 tons of lead in concentrates. At yearend, ore reserves were 53.5 million tons grading 9.31% zinc and 2.6% lead.

Peru.—Zinc exports, valued at \$289 million, accounted for 9.7% of the total value of Peruvian exports in 1983. Mine production was at a record high, 9% higher than in 1982. Centromin Perú S.A., a Government-owned company, was the principal zinc producer in 1983 with a production of 190,700 tons. Centromin's seven concentrators processed 6.8 million tons of ore, including some from local private mines, and produced 220,500 tons of zinc in concentrate. San Ignacio de Morococha S.A. (SIMSA), operators of the San Vincente Mine at San Ramon, continued to be the largest private zinc producer in Peru. SIMSA processed 570,000 tons of zinc ore, producing a record high 51,100 tons of zinc in concentrate. Proven and probable reserves at the San Vincente Mine were 4.6 million tons averaging 12.1% zinc and 1.1% lead. Cía Minera Milpo S.A. operated the second largest private zinc-producing mine, the lead-zinc-silver El Porvenir Mine. The company processed 634,000 tons of ore, producing a record high 31,400 tons of zinc in concentrate, 24% more than in 1982. Milpo continued its expansion and improvement program to raise ore capacity from 1,800 tons per day to 3,100 tons per day in 1986.

Plans called for a \$17.5 million additional investment in the 1984-86 period.

Capacity expansions, totaling 18,000 tons of zinc at three mines—Quiruvilca, Cecilia, and Carahuracra—were completed in 1983. A number of expansions in zinc mine capacity were expected to be completed in 1984 and 1985. Centromin planned to increase zinc capacity 8,000 tons and 16,000 tons, respectively, at its Casapalca and Andaychagua Mines in 1984. Sociedad Minera Gran Bretana S.A. was investing \$14 million to develop new ore reserves at the Contonga Mine. Plans called for construction of a 500-ton-per-day concentrator to be in production in July 1984 producing 7,800 tons of zinc concentrate containing 52% zinc and 3,400 tons of lead-silver concentrate. Gran Bretana was planning a further \$15 million expansion in 1985 to increase output to 1,000 tons per day. Gran Bretana ore reserves were estimated to exceed 2.5 million tons averaging 5.5% zinc, 3.2% lead, 0.4% copper, and 4.7 ounces of silver per ton.

In 1983, production at the 100,000-ton-per-year-capacity Cajamarquilla zinc refinery, owned by Empresa Minera del Perú (Minero Perú), was 89,762 tons, lower than expected owing to sabotage of electric powerlines and minor furnace accidents. The refinery continued to be a major fiscal burden on Minero Perú owing to the high financing charges for the project, \$25.5 million in 1983, equivalent to \$0.12 per pound of refined zinc. An average cost of \$0.50 per pound was thought to be the break-even cost of the refinery.[5]

South Africa, Republic of.—Prieska Copper Mines (Pty.) Ltd. expected zinc-copper ore reserves at its Prieska Mine in northeast Cape Province to be exhausted in 1985. For the fiscal year ended June 30, 1983, ore milled totaled 2.96 million tons yielding 158,500 tons of zinc concentrate, up 18.9% over that of 1982, and 94,800 tons of copper concentrate. Ore reserves at the end of the fiscal year were 6.3 million tons.

Black Mountain Mineral Development Co. (Pty.) Ltd., owned 51% by Gold Fields of South Africa Ltd. and 49% by Phelps Dodge Corp., produced a record high 22,400 tons of zinc in concentrate in 1983 at its Black Mountain lead-zinc mine in Cape Province. At yearend, Black Mountain ore reserves were 33.6 million tons averaging 6.0% lead, 2.9% zinc, 0.4% copper, and 2.3 ounces of silver per ton.

Thailand.—Padaeng Industry Co., a joint venture owned 67% by Thai Government and private interests, 30% by Union Minière SA of Belgium, and 3% by Mitsui Mining and Smelting Co. Ltd. of Japan, continued development of the Mae Sod zinc deposit and construction of a 60,000-ton-per-year electrolytic zinc refining plant at Tak near the Burmese border. The Mae Sod deposit, which contains about 4.5 million tons of direct-shipping ore grading 26% zinc occurring as silicates and oxides, was being developed as an open pit operation. Mining costs were expected to be very low because of low labor cost and shallowness of the ore. Because of the nature of the ore, roasting would not be required to extract the zinc. Padaeng planned to leach the zinc directly from the ore followed by electrowinning. Technology to overcome problems associated with silicate leaching, mainly silica-gel formation was incorporated in the zinc refinery design. The refinery was expected to be operational in October 1984. A mine life of 16 years was projected.

TECHNOLOGY

The genesis, geochemistry, and geology of Mississippi Valley-type lead-zinc deposits, the principal production sources of both lead and zinc in the United States, were reviewed.[6] New data presented were expected to lead to reassessments of known deposits and to aid the search for new deposits. An assessment of U.S. lead and zinc resources was published.[7] Data indicated the United States had substantial zinc resources, but the average cost of recovery for 90% of these resources was about the highest 1983 zinc price for High Grade.

The Bureau of Mines investigated the processing of seafloor samples of massive zinc-copper-iron sulfides from the southern Juan de Fuca Ridge.[8] Zinc sulfide mineralization comprised 55% and 80% of the two samples tested. Aqueous chlorine-oxygen leaching procedures were effective in extracting 99% of the zinc and 97% of the silver.

Technological trends in recovery of lead and zinc from scrap materials were discussed at a special scrap meeting held by ILZSG.[9] Discussions on zinc dealt with zinc recovery from shredding cars, recycling of zinc scrap, improved zinc recovery systems, and recovery of zinc from steel plant flue dusts.

The Bureau of Mines carried out a characterization study of electric furnace steelmaking dust (EFD) to provide a basis for decisions concerning resource recovery, recycling, and waste disposal.[10] Most dust samples were found to be environmentally hazardous; they ranged from less than 1% zinc to 28% and averaged about 10%. Domestic EFD was virtually all disposed of in landfills. The total EFD generated annually was estimated to contain about 50,000 tons of zinc. Recycling was suggested as a means not only to recover the zinc and other valuable metals, but also to make the material environmentally safe.

Modernization and improved operations at a number of electrolytic zinc plants were reported.[11] Modernization of St. Joe Resources' Monaca electrothermic smelter was described.[12] Although capacity was halved, changes at the Monaca smelter made it cost competitive with the world's large electrolytic zinc producers. Flexibility in the choice of feed was considered to be one of the smelter's most important attributes.

Comprehensive coverage of zinc-related investigations and an extensive review of current world literature on the extraction and uses of zinc and its products are contained in quarterly issues of "Zinc Abstracts" published by the Zinc Development Association, London, United Kingdom.[13]

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[1]Physical scientist, Division of Nonferrous Metals.
[2]Zinc Institute Inc. U.S. Automotive Market for Zinc Coatings, 1983. 1983, 3 pp.
[3]———. U.S. Automotive Market for Zinc Die Castings, 1977-1983. 1983, 2 pp.
[4]International Lead and Zinc Study Group (London). Lead and Zinc Statistics. V. 24, No. 5, May 1984, p. 46.
[5]Metal Bulletin (London). Debt Problems for Cajamarquilla. No. 6806, July 22, 1983, p. 5.
[6]Kisvarsanyi, G., S. K. Grant, W. P. Pratt, and J. W. Koenig (eds.). International Conference on Mississippi Valley Type Lead-Zinc Deposits, Proceedings Volume. Univ. MO, Rolla, MO, 1983, 603 pp.
[7]Kilgore, C. C., S. J. Arbelbide, and A. A. Soja. Availability of Lead and Zinc—Domestic. A Minerals Availability Program Appraisal. BuMines IC 8962, 1983, 30 pp.
[8]Sawyer, D. L., Jr., G. A. Smyres, J. J. Sjoberg, and T. G. Carnahan. Cl_2–O_2 Leaching of Massive Sulfide Samples From the Southern Juan de Fuca Ridge, North Pacific Ocean. BuMines TPR 122, 1983, 8 pp.
[9]International Lead and Zinc Study Group (London). Secondary Lead and Zinc, Special Meeting of the Scrap Sub-Committee. Final Report, Sept. 1983, 326 pp.
[10]Law, S. L., W. F. Lowry, J. G. Snyder, and G. W. Kramer. Characterization of Steelmaking Dusts From Electric Arc Furnaces. BuMines RI 8750, 1983, 26 pp.
[11]Osseo-Asare, K., and J. D. Miller (eds.). Hydrometallurgy: Research, Development and Plant Practice. Metall. Soc. AIME, Warrendale, PA, 1983, pp. 587-969.
[12]Bounds, C. O. Modernization of the Monaca Electrothermic Zinc Smelter. J. Met., v. 35, No. 8, Aug. 1983, pp. 30-36.
[13]Zinc Development Association. Zinc Abstracts. V. 41, Nos. 1-4, 1983, 299 pp.

Table 3.—Mine production of recoverable zinc in the United States, by month

(Metric tons)

Month	1982[r]	1983
January	24,295	25,190
February	24,660	23,046
March	26,289	25,631
April	23,355	23,054
May	25,569	22,474
June	27,016	21,137
July	21,337	20,163
August	27,438	24,043
September	26,108	23,072
October	27,843	23,938
November	25,923	21,853
December	23,327	21,693
Total	303,160	275,294

[r]Revised.

Table 4.—Mine production of recoverable zinc in the United States, by State

(Metric tons)

State	1979	1980	1981	1982	1983
Arizona	W	W	138	--	--
California	W	--	W	--	--
Colorado	9,910	13,823	W	W	W
Idaho	29,660	27,722	W	W	W
Illinois	W	W	W	W	W
Kentucky	--	--	W	W	W
Missouri	61,682	62,886	52,904	63,680	57,044
Montana	104	71	25	W	--
Nevada	W	2	W	--	--
New Jersey	31,118	28,859	16,198	16,800	16,475
New Mexico	W	W	W	--	--
New York	12,133	33,629	36,889	[r]52,237	56,748
Pennsylvania	21,447	22,556	24,732	24,762	16,792
Tennessee	85,119	111,754	117,684	121,306	109,958
Utah	W	W	1,576	--	--
Virginia	11,406	12,038	9,731	--	--
Wisconsin	W	W	--	--	--
Total	267,341	317,103	312,418	[r]303,160	275,294

[r]Revised. W Withheld to avoid disclosing company proprietary data; included in "Total."

Table 5.—Production of zinc and lead in the United States in 1983, by State and class of ore, from old tailings, etc., in terms of recoverable metals

(Metric tons unless otherwise specified)

State	Zinc ore: Gross weight (dry basis)	Zinc ore: Zinc	Zinc ore: Lead	Lead ore: Gross weight (dry basis)	Lead ore: Zinc	Lead ore: Lead	Zinc-lead ore: Gross weight (dry basis)	Zinc-lead ore: Zinc	Zinc-lead ore: Lead
Alaska	--	--	--	--	--	--	--	--	--
Arizona	--	--	--	--	--	--	--	--	--
California	--	--	--	--	--	--	--	--	--
Colorado	--	--	--	--	--	--	W	W	W
Idaho	--	--	--	1	--	1	--	--	--
Illinois	--	--	--	--	--	--	--	--	--
Kentucky	W	W	--	--	--	--	--	--	--
Missouri	--	--	--	7,303,066	57,044	409,280	--	--	--
Montana	--	--	--	--	--	--	--	--	--
Nevada	--	--	--	--	--	--	--	--	--
New Jersey	87,761	16,475	--	--	--	--	--	--	--
New Mexico	--	--	--	--	--	--	--	--	--
New York	683,150	56,748	1,299	--	--	--	--	--	--
Oregon	--	--	--	--	--	--	--	--	--
Pennsylvania	338,531	16,792	--	--	--	--	--	--	--
Tennessee	4,019,432	108,352	--	--	--	--	--	--	--
Total	[1]5,128,874	[1]198,367	1,299	7,303,067	57,044	409,281	([2])	([2])	([2])
Percent of total zinc and lead	XX	72	([3])	XX	21	91	XX	([2])	([2])

State	Copper-zinc, copper-lead, copper-zinc-lead ores: Gross weight (dry basis)	Copper-zinc, copper-lead, copper-zinc-lead ores: Zinc	Copper-zinc, copper-lead, copper-zinc-lead ores: Lead	All other sources[4]: Gross weight (dry basis)	All other sources[4]: Zinc	All other sources[4]: Lead	Total: Gross weight (dry basis)	Total: Zinc	Total: Lead
Alaska	--	--	--	W	--	W	W	--	W
Arizona	--	--	--	7,264,776	--	144	7,264,776	--	144
California	--	--	--	W	--	W	W	--	W
Colorado	--	--	--	W	W	W	W	W	W
Idaho	--	--	--	601,597	W	25,725	601,598	W	25,726
Illinois	--	--	--	([5])	W	W	([5])	W	W
Kentucky	--	--	--	--	--	--	W	W	--
Missouri	--	--	--	--	--	--	7,303,066	57,044	409,280
Montana	--	--	--	9,473,890	--	1,163	9,473,890	--	1,163
Nevada	--	--	--	7,014	--	14	7,014	--	14
New Jersey	--	--	--	--	--	--	87,761	16,475	--
New Mexico	--	--	--	89,581	--	258	89,581	--	258
New York	--	--	--	--	--	--	683,150	56,748	1,299
Oregon	--	--	--	W	--	W	W	--	W
Pennsylvania	--	--	--	--	--	--	338,531	16,792	--
Tennessee	1,822,270	1,605	--	--	--	--	5,841,702	109,958	--
Total	1,822,270	1,605	--	17,948,423	18,278	38,458	32,202,634	275,294	449,038
Percent of total zinc and lead	XX	1	--	XX	7	9	XX	100	100

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

[1]Zinc ore and zinc recovered from zinc ore in Kentucky included with "All other sources" to avoid disclosing company proprietary data.

[2]Included with "All other sources" to avoid disclosing company proprietary data.

[3]Less than 1/2 unit.

[4]Includes zinc recovered from zinc ore in Kentucky and lead and zinc recovered from lead-zinc ore in Colorado 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.

[5]Excludes tonnages of fluorspar from which lead and zinc were recovered as byproducts.

Table 6.—Twenty-five leading zinc-producing mines in the United States in 1983 in order of output

Rank	Mine	County and State	Operator	Source of zinc
1	Elmwood-Gordonsville	Smith, TN	Jersey Minière Zinc Co	Zinc ore.
2	Balmat	St. Lawrence, NY	St. Joe Resources Co	Do.
3	Buick	Iron, MO	AMAX Lead Co. of Missouri	Lead ore.
4	Young	Jefferson, TN	ASARCO Incorporated	Zinc ore.
5	Sterling	Sussex, NJ	The New Jersey Zinc Co	Do.
6	Immel	Knox, TN	ASARCO Incorporated	Do.
7	Friedensville	Lehigh, PA	The New Jersey Zinc Co	Do.
8	Pierrepont	St. Lawrence, NY	St. Joe Resources Co	Do.
9	New Market	Jefferson, TN	ASARCO Incorporated	Do.
10	Magmont	Iron, MO	Cominco American Inc	Lead ore.
11	Leadville	Lake, CO	ASARCO Incorporated	Lead-zinc ore.
12	Brushy Creek	Reynolds, MO	St. Joe Lead Co	Lead ore.
13	Coy	Jefferson, TN	ASARCO Incorporated	Zinc ore.
14	Zinc Mine Works	do	United States Steel Corp	Do.
15	Sunnyside	San Juan, CO	Standard Metals Co	Gold ore.
16	Fletcher	Reynolds, MO	St. Joe Lead Co	Lead ore.
17	Viburnum No. 28	Iron, MO	do	Do.
18	Viburnum No. 29	Washington, MO	do	Do.
19	Mission	Pima, AZ	ASARCO Incorporated	Copper ore.
20	Eisenhower	do	Eisenhower Mining Co	Do.
21	Lucky Friday	Shoshone, ID	Hecla Mining Co	Silver ore.
22	Copperhill	Polk, TN	Tennessee Chemical Co	Copper-zinc ore.
23	Hyatt	St. Lawrence, NY	St. Joe Resources Co	Zinc ore.
24	San Xavier	Pima, AZ	ASARCO Incorporated	Copper ore.
25	Rosiclare mill	Hardin & Pope, IL	Ozark-Mahoning Co	Fluorspar.

Table 7.—Primary and redistilled secondary slab zinc produced in the United States

(Metric tons)

	1979	1980	1981	1982	1983
Primary:					
From domestic ores	255,344	231,850	259,835	193,284	210,315
From foreign ores	217,137	108,606	86,728	34,892	25,379
Total	472,481	340,456	346,563	228,176	235,694
Redistilled secondary:					
At primary smelters	40,343	13,113	14,438	42,418	40,545
At secondary smelters	12,868	16,283	35,754	31,870	28,845
Total	[1]53,212	29,396	50,192	74,288	69,390
Grand total (excludes zinc recovered by remelting)	525,693	369,852	396,755	302,464	305,084

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

Table 8.—Distilled and electrolytic zinc, primary and secondary, produced in the United States, by grade

(Metric tons)

Grade	1979	1980	1981	1982	1983
Special High	173,082	148,384	137,210	112,648	95,395
High	39,247	24,552	51,990	31,076	78,511
Continuous Galvanizing	62,683	45,275	55,008	57,739	50,661
Controlled Lead	40,319	18,650	38,660	7,612	10,231
Prime Western	210,362	132,991	113,887	93,389	70,286
Total	525,693	369,852	396,755	302,464	305,084

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) 1982	1983
Electrolytic:			
AMAX Zinc Co. Inc	Sauget, IL	76,000	76,000
ASARCO Incorporated	Corpus Christi, TX	[1]104,000	[1]104,000
The Bunker Hill Co	Kellogg, ID	[2]103,000	[2]103,000
Jersey Minière Zinc Co	Clarksville, TN	82,000	82,000
National Zinc Co	Bartlesville, OK	51,000	51,000
Electrothermic:			
St. Joe Resources Co	Monaca, PA	77,000	91,000

[1]Zinc plant closed in Oct. 1982.
[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) 1982	1983
Arco Alloys Corp	Detroit, MI		
W. J. Bullock Inc	Fairfield, AL		
T. L. Diamond & Co. Inc	Spelter, WV		
Hugo Neu-Proler Co	Terminal Island, CA		
Huron Valley Steel Corp	Belleville, MI		
Interamerican Zinc Co	Adrian, MI	[r]95,000	95,000
The New Jersey Zinc Co	Palmerton, PA		
Pacific Smelting Co	Torrance, CA		
Do	Memphis, TN		
Prolerized Schiabo Neu Co	Jersey City, NJ		

[r]Revised.

Table 11.—U.S. stocks and consumption of new and old zinc scrap in 1983, 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	21	995	993	--	993	23
Old zinc	699	1,101	--	1,520	1,520	280
Remelt zinc	9	8,107	7,981	--	7,981	135
Engravers' plates	63	575	--	585	585	53
Rod and die scrap	974	2,405	--	2,387	2,387	992
Diecastings	1,535	11,639	--	11,554	11,554	1,620
Fragmentized diecastings	3,009	27,108	--	27,017	27,017	3,100
Remelt die-cast slab	642	8,739	--	8,739	8,739	642
Skimmings and ashes	48,022	62,441	72,920	--	72,920	37,543
Sal skimmings	14	134	127	--	127	21
Die-cast skimmings	2,280	5,707	6,185	--	6,185	1,802
Galvanizers' dross	11,807	35,148	34,197	--	34,197	12,758
Flue dust	3,154	3,509	3,509	--	3,509	3,154
Chemical residues	295	3,157	3,157	--	3,157	295
Other	76	2,689	2,702	--	2,702	63
Total	72,600	173,454	131,771	51,802	183,573	62,481
Chemical plant, foundries, other manufacturers:						
Old zinc	10	23	--	23	23	10
Rod and die scrap	10	33	--	43	43	--
Diecastings	18	268	--	268	268	18
Skimmings and ashes	1,579	3,266	3,236	--	3,236	1,609
Sal skimmings	3,378	4,956	5,717	--	5,717	2,617
Galvanizers' dross	2	100	100	--	100	2
Flue dust	475	6,155	6,133	--	6,133	497
Chemical residues	3,749	1,415	5,155	--	5,155	9
Other	1	818	818	--	818	1
Total	9,222	17,034	21,159	334	21,493	4,763

Table 11.—U.S. stocks and consumption of new and old zinc scrap in 1983, 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: New scrap	Consumption: Old scrap	Consumption: Total	Stocks, Dec. 31
All classes of consumers:						
New clippings	21	995	993	--	993	23
Old zinc	709	1,124	--	1,543	1,543	290
Remelt zinc	9	8,107	7,981	--	7,981	135
Engravers' plates	63	575	--	585	585	53
Rod and die scrap	984	2,438	--	2,430	2,430	992
Diecastings	1,553	11,907	--	11,822	11,822	1,638
Fragmentized diecasting	3,009	27,108	--	27,017	27,017	3,100
Remelt die-cast slab	642	8,739	--	8,739	8,739	642
Skimmings and ashes	49,601	65,707	76,156	--	76,156	39,152
Sal skimmings	3,392	5,090	5,844	--	5,844	2,638
Die-cast skimmings	2,280	5,707	6,185	--	6,185	1,802
Galvanizers' dross	11,809	35,248	34,297	--	34,297	12,760
Flue dust	3,629	9,664	9,642	--	9,642	3,651
Chemical residues	4,044	4,572	8,312	--	8,312	304
Other	77	3,507	3,520	--	3,520	64
Total	81,822	190,488	152,930	52,136	205,066	67,244

Table 12.—Production of zinc products from zinc-base scrap in the United States

(Metric tons)

Product	1979	1980	1981	1982	1983
Redistilled slab zinc	53,212	29,396	50,192	74,288	69,390
Zinc dust	34,141	35,557	39,626	25,296	42,938
Remelt zinc	89	229	195	69	66
Remelt die-cast slab	3,911	3,568	6,722	3,905	3,109
Zinc-die and diecasting alloys	6,328	4,146	6,902	5,366	6,535
Galvanizing stocks	2,731	2,461	2,612	2,507	2,801
Secondary zinc in chemical products	59,148	55,890	62,557	61,827	59,085

Table 13.—Zinc recovered from scrap processed in the United States, by kind of scrap and form of recovery

(Metric tons)

	1982	1983
KIND OF SCRAP		
New scrap:		
Zinc-base	127,651	152,653
Copper-base	94,891	119,590
Magnesium-base	113	131
Total	222,655	272,374
Old scrap:		
Zinc-base	42,334	51,255
Copper-base	19,385	24,431
Aluminum-base	376	349
Magnesium-base	219	218
Total	62,314	76,253
Grand total	284,969	348,627
FORM OF RECOVERY		
As metal:		
By distillation:		
Slab zinc[1]	74,288	69,390
Zinc dust	25,296	42,938
By remelting	2,576	2,867
Total	102,160	115,195

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)

	1982	1983
FORM OF RECOVERY —Continued		
In zinc-base alloys	9,271	9,64
In brass and bronze	111,003	163,90
In aluminum-base alloys	376	45
In magnesium-base alloys	332	34
In chemical products:		
Zinc oxide (lead free)	35,969	33,19
Zinc sulfate	16,079	14,97
Zinc chloride	9,490	10,20
Miscellaneous	289	70
Total	182,809	233,432
Grand total	284,969	348,62

[1]Includes zinc content of redistilled slab made from remelt die-cast slab.

Table 14.—Zinc dust produced in the United States

Year	Quantity (metric tons)	Value	
		Total (thousands)	Average per pound
1979	36,186	$36,075	$0.452
1980	42,640	41,202	.438
1981	43,734	[r]53,801	[r].558
1982	37,516	[r]49,327	[r].596
1983	48,672	55,090	.513

[r]Revised.

Table 15.—U.S. consumption of zinc

(Metric tons)

	1979	1980	1981	1982	1983
Slab zinc	1,000,606	811,146	840,875	709,491	805,891
Ores and concentrates (zinc content)[1]	79,710	58,986	60,643	35,515	38,287
Secondary (zinc content)[2]	313,998	272,277	287,851	208,105	276,370
Total	1,394,314	1,142,409	1,189,369	953,111	1,120,548

[1]Includes ore used directly in galvanizing.
[2]Excludes redistilled slab and remelt zinc.

Table 16.—U.S. consumption of slab zinc, by industry and product

(Metric tons)

Industry and product	1979	1980	1981	1982	1983
Galvanizing:					
Sheet and strip	267,825	220,744	248,006	204,519	230,541
Wire and wire rope	23,557	22,748	22,119	17,180	18,328
Tubes and pipe	45,643	37,075	39,418	34,322	34,907
Fittings (for tubes and pipe)	8,231	7,394	6,369	5,707	5,990
Tanks and containers	4,081	3,297	5,781	6,507	4,195
Structural shapes	33,875	33,376	33,667	28,816	29,822
Fasteners	4,993	3,189	3,693	2,898	2,614
Pole-line hardware	4,839	4,078	3,788	2,955	3,013
Fencing, wire cloth, netting	21,920	16,022	17,722	17,330	15,916
Other and unspecified uses	37,839	31,304	30,484	21,810	27,853
Total	452,803	379,227	411,047	342,044	373,179
Brass products:					
Sheet, strip, plate	64,222	37,730	42,006	31,718	43,083
Rod and wire	51,130	32,554	36,639	26,551	32,387
Tubes	6,690	4,702	6,440	3,465	4,058
Castings and billets	3,634	2,808	2,880	2,211	7,499
Copper-base ingots	6,800	17,190	20,167	13,278	16,405
Other copper-base products	8,928	3,842	4,854	3,915	4,503
Total	141,404	98,826	112,986	81,138	107,935
Zinc-base alloys:					
Diecasting alloys	308,722	248,024	234,957	191,607	204,820
Dies and rod alloys	68	--	--	--	--
Slush and sand-casting alloys	5,266	6,203	8,408	6,147	8,071
Total	314,056	254,227	243,365	197,754	212,891
Rolled zinc	22,044	21,100	[1]23,156	[1]37,168	[1]56,291
Zinc oxide	35,513	27,047	25,657	32,374	36,201
Other uses:					
Light-metal alloys	12,850	11,137	8,183	8,326	12,538
Miscellaneous[2]	21,936	19,582	16,481	10,687	6,856
Total	34,786	30,719	24,664	19,013	19,394
Grand total	1,000,606	811,146	840,875	709,491	805,891

[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 17.—U.S. consumption of slab zinc in 1983, by industry

(Metric tons)

Industry	Special High Grade	High Grade	Continuous Galvanizing Grade	Controlled Lead Grade	Prime Western	Remelt	Total
Galvanizing	54,788	44,215	62,449	41,794	167,986	1,947	373,179
Brass and bronze	52,833	40,734	189	218	10,327	3,634	107,935
Zinc-base alloys	209,229	3,619	--	--	28	15	212,891
Rolled zinc	37,470	--	--	18,821	--	--	56,291
Zinc oxide	36,201	--	--	--	--	--	36,201
Other	16,169	2,456	--	--	769	--	19,394
Total	406,690	91,024	62,638	60,833	179,110	5,596	805,891

Table 18.—U.S. consumption of slab zinc in 1983, by State

(Metric tons)

State	Galva-nizers	Brass mills[1]	Die-casters[2]	Other[3]	Total
Alabama	7,436	W	--	W	9,240
Arizona	--	--	--	W	W
Arkansas	W	--	--	W	1,424
California	25,257	2,353	7,956	8,372	43,938
Colorado	W	--	W	W	W
Connecticut	2,290	9,558	W	W	18,530
Delaware	W	W	--	W	W
Florida	3,982	--	--	--	3,982
Georgia	W	--	W	--	7,192
Hawaii	W	--	--	--	W
Illinois	49,431	17,457	38,305	15,989	121,182
Indiana	63,556	W	W	W	89,500
Iowa	W	--	W	W	W
Kansas	--	--	W	--	W
Kentucky	W	--	--	--	W
Louisiana	W	--	W	--	2,889
Maine	W	--	--	--	W
Maryland	12,264	--	--	--	12,264
Massachusetts	3,326	W	--	W	4,103
Michigan	859	11,221	43,887	191	56,158
Minnesota	454	--	--	--	454
Mississippi	W	--	--	--	W
Missouri	2,948	W	W	W	4,276
Nebraska	8,133	W	W	W	8,771
New Jersey	1,487	4,167	4,866	2,165	12,685
New York	18,582	15,797	65,687	1,418	101,484
North Carolina	W	--	W	W	2,290
Ohio	53,847	W	36,883	W	99,693
Oklahoma	W	--	--	W	4,174
Oregon	W	W	--	--	835
Pennsylvania	47,398	5,679	W	W	80,910
Rhode Island	--	--	W	W	W
South Carolina	1,732	--	--	--	1,732
Tennessee	W	--	W	W	48,429
Texas	11,393	W	W	W	11,579
Utah	W	W	--	--	1,822
Virginia	W	W	W	W	2,771
Washington	W	--	--	W	2,168
West Virginia	W	--	--	W	18,521
Wisconsin	868	520	W	W	6,221
Undistributed	55,989	37,549	15,292	83,751	21,077
Total[4]	371,232	104,301	212,876	111,886	800,295

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-base alloy 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)

	1982	1983
Production:[1]		
Photoengraving plate	W	W
Strip and foil	W	W
Total rolled zinc[2]	36,365	54,980
Exports	995	957
Imports	700	319
Available for consumption	30,143	58,029

W Withheld to avoid disclosing company proprietary data; included in "Total rolled zinc."
[1]Figures represent net production. In addition, 27,997 tons in 1982 and 39,251 tons in 1983 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)

	1982		1983	
	Production	Shipments	Production	Shipments
Zinc oxide	123,461	127,434	129,596	135,054
Zinc sulfate	42,934	38,922	39,287	34,986
Zinc chloride[2]	11,888	12,292	13,606	13,456

[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

(Metric tons)

	1982				1983			
	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	30,506	32,374	35,969	98,849	34,531	36,201	33,196	103,928
Zinc sulfate	W	--	17,388	17,388	W	--	15,910	15,910
Zinc chloride[2]	--	--	5,675	5,675	--	--	6,518	6,518

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	1979	1980	1981	1982	1983
Agriculture	4,397	6,930	7,328	3,929	2,569
Ceramics	9,236	5,702	7,822	5,215	5,987
Chemicals	27,710	17,551	20,561	19,432	19,217
Paints	12,503	12,165	12,346	9,283	9,716
Photocopying	16,148	9,604	10,308	9,516	10,239
Rubber	93,075	61,796	69,364	62,923	67,971
Other	16,700	22,028	21,222	17,136	19,355
Total	179,769	135,776	148,951	127,434	135,054

Table 23.—Distribution of zinc sulfate shipments

(Metric tons)

Year	Agriculture	Other	Total
1980	27,768	7,928	35,696
1981	30,928	6,951	37,879
1982	29,882	9,040	38,922
1983	29,373	5,613	34,986

Table 24.—Stocks of slab zinc in the United States, December 31

(Metric tons)

	1979	1980	1981	1982	1983
Primary producers	56,971	18,190	41,124	r30,381	20,750
Secondary producers	2,095	4,362	3,540	3,831	3,149
Consumers	92,595	69,599	81,917	77,565	89,041
Merchants	(1)	33,650	68,773	47,397	35,199
Total	151,661	125,801	195,354	r159,174	148,139

rRevised.
[1]Stocks on Jan. 1, 1980, were 63,637 tons, which can be considered identical to stocks at yearend 1979.

Table 25.—U.S. consumer stocks of slab zinc at plants December 31, by grade

(Metric tons)

Year	Special High Grade	High Grade	Continuous Galvinizing Grade	Controlled Lead Grade	Prime Western	Remelt	Total
1982	36,312	8,047	1,615	6,863	24,599	129	77,565
1983	43,685	10,077	4,510	5,700	24,922	147	89,041

Table 26.—Average monthly U.S., LME,[1] and European producer prices for Prime Western zinc and equivalent

(Metallic zinc, cents per pound)

Month	1982			1983		
	United States[2]	LME cash	European producer	United States[2]	LME cash	European producer
January	42.17	37.10	41.39	38.61	31.68	36.29
February	42.72	37.30	39.69	38.62	30.88	34.02
March	39.23	35.78	40.19	37.90	30.75	34.02
April	35.51	33.65	39.01	38.00	31.61	34.02
May	34.67	34.01	39.01	38.11	33.34	34.02
June	34.60	31.33	36.79	39.46	32.56	35.38
July	35.66	32.80	36.29	40.01	33.54	35.38
August	37.79	32.43	36.29	40.56	36.67	36.88
September	39.64	33.97	36.29	42.98	37.98	39.92
October	40.83	34.06	36.29	46.11	38.93	40.53
November	40.39	32.18	36.29	47.55	38.97	41.96
December	38.46	30.30	36.29	48.74	38.85	43.09
Average	38.47	33.74	37.82	41.39	34.73	37.18

[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	1981		1982		1983	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Unwrought zinc and zinc alloys:						
Argentina	--	--	--	--	(1)	$3
Australia	1	$1	2	$8	12	46
Belgium-Luxembourg	9	25	5	16	(1)	2
Canada	320	760	260	573	416	762
Chile	6	17	--	--	3	57
Colombia	4	7	--	--	--	--
Costa Rica	26	44	21	35	12	21
Dominican Republic	26	25	2	3	2	4
Ecuador	4	8	1	4	--	--
Egypt	14	26	2	6	--	--
Germany, Federal Republic of	1	1	--	--	1	2
Guatemala	1	6	3	6	--	--
Honduras	--	--	--	--	1	4
Israel	5	20	3	14	--	--
Italy	--	--	(1)	1	2	14
Japan	29	88	75	83	28	76
Korea, Republic of	16	50	1	28	15	56
Leeward and Windward Islands	15	100	--	--	1	2
Mexico	21	193	175	507	4	17
Netherlands	--	--	5	27	--	--
New Zealand	1	7	(1)	3	1	7
Nicaragua	1	2	--	--	--	--
Nigeria	10	13	--	--	--	--
Panama	25	64	5	16	10	17
Philippines	2	3	3	6	(1)	1
Saudi Arabia	28	120	50	171	108	277
Singapore	1	3	1	3	40	131
South Africa, Republic of	30	51	4	11	3	8
Spain	12	22	(1)	1	--	--
Switzerland	3	7	60	253	72	377
Taiwan	7	18	442	490	288	260
United Arab Emirates	5	9	--	--	6	12
United Kingdom	57	275	73	293	41	181
Venezuela	14	28	1	18	4	14
Other	7	77	10	72	19	44
Total	701	2,070	1,204	2,648	1,089	2,395
Wrought zinc and zinc alloys:						
Algeria	2	8	--	--	--	--
Argentina	74	145	22	56	17	38
Australia	32	69	6	15	8	26
Austria	9	26	4	14	5	17
Belgium-Luxembourg	1	6	(1)	1	2	14
Bermuda	1	1	(1)	1	--	--
Canada	909	1,503	893	1,512	1,221	1,762
Chile	13	24	1	2	3	4
Colombia	75	137	40	96	14	42
Denmark	4	12	--	--	(1)	15
Dominican Republic	10	11	(1)	1	9	10
Ecuador	14	35	15	63	9	30
Egypt	2	5	(1)	1	11	25
El Salvador	4	11	8	21	12	36
Finland	1	3	3	1	2	14
France	9	20	18	23	5	9
Germany, Federal Republic of	4	34	--	--	1	2
Guatemala	10	26	3	10	1	3
Guyana	4	14	2	8	5	11
Hong Kong	69	80	1	3	3	4
India	60	124	166	157	9	22
Iran	--	--	--	--	4	7
Israel	27	50	12	26	--	--
Italy	45	99	5	13	--	--
Jamaica	--	--	--	--	3	10
Japan	28	65	153	156	39	55
Korea, Republic of	8	34	(1)	3	(1)	1
Kuwait	5	26	(1)	[r]1	--	--
Lebanon	3	8	--	--	--	--
Libya	--	--	--	--	119	340
Malaysia	6	10	--	--	--	--
Mexico	393	786	221	400	147	395
Morocco	--	--	--	--	2	5
Netherlands	6	11	1	1	--	--
New Zealand	9	18	1	3	--	--
Nicaragua	--	--	--	--	25	42
Pakistan	19	38	5	31	3	8
Panama	7	11	3	3	1	3

See footnotes at end of table.

Table 27.—U.S. exports of zinc and zinc alloys, by country —Continued

Country	1981		1982		1983	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Wrought zinc and zinc alloys —Continued						
Peru	50	$109	9	$28	4	$6
Philippines	37	93	15	45	34	108
Portugal	3	7	(1)	2	--	--
Saudi Arabia	172	378	56	153	28	72
Singapore	24	48	76	188	4	20
Somalia	--	--	--	--	5	5
South Africa, Republic of	116	197	49	133	13	42
Spain	23	46	30	74	6	22
Sri Lanka	22	44	5	18	4	12
Switzerland	3	5	(1)	3	--	--
Taiwan	33	85	17	51	72	123
Turkey	12	26	--	--	--	--
United Arab Emirates	2	7	1	4	1	12
United Kingdom	128	314	113	268	90	218
Uruguay	8	13	8	16	--	--
Venezuela	21	61	10	54	5	12
Other	143	315	51	r135	57	203
Total	2,660	5,198	2,023	3,799	2,003	3,805

r Revised.
1 Less than 1/2 unit.

Table 28.—U.S. exports of zinc

Year	Ores and concentrates		Blocks, pigs, anodes, etc.				Wrought zinc and zinc alloys				Waste and scrap (zinc content)		Dust (blue powder)	
			Unwrought		Unwrought alloys		Sheets, plates, strips		Angles, bars, pipes, rods, etc.					
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
1981	54,232	$29,280	323	$812	378	$1,258	1,500	$3,226	1,160	$1,972	30,046	$17,611	5,003	$7,841
1982	77,289	32,534	341	547	863	2,101	995	2,351	1,028	1,448	16,993	10,611	2,066	3,207
1983	60,168	22,868	427	801	662	1,594	957	2,142	1,046	1,663	20,942	8,169	1,914	3,000

Table 29.—U.S. exports of zinc ores and concentrates, by country

(Zinc content)

Country	1982 Quantity (metric tons)	1982 Value (thousands)	1983 Quantity (metric tons)	1983 Value (thousands)
Algeria	10,894	$6,344	3,724	$1,887
Belgium-Luxembourg	3,377	2,189	--	--
Bulgaria	7,067	3,210	9,934	3,900
Canada	27,397	12,071	39,781	15,061
Dominican Republic	--	--	(1)	1
Ecuador	1	1	(1)	1
El Salvador	--	--	1	3
France	710	362	--	--
German Democratic Republic	5,162	2,478	--	--
Germany, Federal Republic of	2,256	746	--	--
Guatemala	99	117	--	--
India	159	70	--	--
Jamaica	--	--	19	21
Japan	1	6	--	--
Korea, Republic of	--	--	115	99
Mexico	560	321	--	--
Netherlands	--	--	29	16
Philippines	60	39	(1)	2
Romania	4,567	2,026	--	--
Saudi Arabia	--	--	4	3
Spain	(1)	2	3,500	630
Sweden	10,039	554	--	--
Taiwan	3	3	22	15
Yugoslavia	4,937	1,995	3,039	1,229
Total	77,289	32,534	60,168	22,868

[1]Less than 1/2 unit.

Table 30.—U.S. general imports of zinc, by country

Country	1981 Quantity (metric tons)	1981 Value (thousands)	1982 Quantity (metric tons)	1982 Value (thousands)	1983 Quantity (metric tons)	1983 Value (thousands)
ORES AND CONCENTRATES (zinc content)						
Australia	903	$201	2,848	$872	2,261	$1,113
Belgium	497	242	--	--	--	--
Canada	53,673	22,607	10,574	4,570	13,715	3,370
Chile	432	295	21	10	27	15
Colombia	6	1	20	3	--	--
Germany, Federal Republic of	8,687	5,301	7,925	4,431	6,552	1,067
Honduras	4,167	2,623	6,303	2,117	12,632	3,920
Mexico	20,045	10,969	15,381	6,376	17,887	4,518
Peru	29,326	20,348	6,272	2,498	9,136	3,208
Total	117,736	62,587	49,344	20,877	62,210	17,211
BLOCKS, PIGS, OR SLABS[1]						
Algeria	721	579	6,499	5,578	2,051	1,846
Argentina	--	--	2,002	1,547	--	--
Australia	25,830	22,043	26,336	20,272	30,537	23,331
Austria	--	--	--	--	102	87
Belgium-Luxembourg	14,018	12,151	1,555	1,461	5,820	3,787
Brazil	1,493	1,159	10,500	9,680	--	--
Canada	308,647	285,642	239,839	200,731	307,156	263,145
Chile	1,450	1,212	--	--	--	--
China	1,492	1,140	258	210	--	--
Finland	29,156	25,231	20,774	16,514	25,402	20,614
France	17,882	16,491	5,377	4,682	8,932	6,858
Germany, Federal Republic of	22,817	24,228	4,702	3,621	29,675	23,645
Ghana	65	20	--	--	--	--
Italy	7,625	7,298	6,500	6,853	11,913	9,483
Japan	7,090	6,204	741	643	--	--
Korea, Republic of	1,500	1,240	--	--	--	--
Mexico	15,091	13,458	21,819	16,521	56,029	44,433
Namibia	994	836	--	--	--	--
Netherlands	20,216	17,579	7,121	5,688	21,544	16,546
Netherlands Antilles	--	--	--	--	100	85
Nigeria	--	--	--	--	2,553	2,073
Norway	10,801	9,200	9,723	8,063	9,197	7,277
Peru	43,339	37,836	48,565	35,639	45,318	34,729
Poland	600	573	476	450	917	1,082
South Africa, Republic of	--	--	--	--	1,000	644
Spain	28,671	23,545	6,573	5,599	18,728	14,453

See footnotes at end of table.

Table 30.—U.S. general imports of zinc, by country —Continued

Country	1981 Quantity (metric tons)	1981 Value (thousands)	1982 Quantity (metric tons)	1982 Value (thousands)	1983 Quantity (metric tons)	1983 Value (thousands)
BLOCKS, PIGS, OR SLABS[1] — Continued						
Sweden	--	--	--	--	143	$115
Tanzania	--	--	--	--	370	261
United Kingdom	13,280	$11,012	4,770	$3,750	9,602	7,387
Yemen-Sanaa	--	--	--	--	127	100
Yugoslavia	999	867	503	442	1,558	1,247
Zaire	28,540	22,778	22,408	15,943	24,593	18,623
Zambia	377	296	401	329	--	--
Total	602,694	542,618	447,442	364,216	613,367	501,851

[1]In addition, in 1983, 239 tons of zinc anodes was imported from Brazil, Canada, China, Denmark, the Federal Republic of Germany, Hong Kong, India, Mexico, the Netherlands, Norway, Peru, Sweden, Switzerland, Taiwan, and the United Kingdom.

Table 31.—U.S. imports for consumption of zinc, by country

Country	1981 Quantity (metric tons)	1981 Value (thousands)	1982 Quantity (metric tons)	1982 Value (thousands)	1983 Quantity (metric tons)	1983 Value (thousands)
ORES AND CONCENTRATES (zinc content)						
Australia	1,964	$305	2,971	$988	858	$114
Belgium	497	242	--	--	--	--
Canada	179,566	70,037	22,827	9,234	17,165	4,895
Chile	432	295	21	10	27	15
Colombia	6	1	20	3	--	--
Germany, Federal Republic of	8,687	5,301	7,925	4,431	6,552	1,067
Honduras	4,363	2,677	6,303	2,116	11,709	2,965
Mexico	21,120	11,165	20,534	7,853	17,988	4,536
Peru	29,075	20,230	6,208	2,497	8,857	2,956
Total	245,710	110,253	66,809	27,132	63,156	16,548
BLOCKS, PIGS, OR SLABS[1]						
Algeria	721	579	6,499	5,578	2,051	1,846
Argentina	--	--	2,002	1,547	--	--
Australia	25,830	22,043	26,334	20,272	30,537	23,331
Austria	--	--	--	--	102	87
Belgium-Luxembourg	14,018	12,151	1,555	1,461	5,820	3,787
Brazil	1,493	1,159	8,500	7,761	--	--
Canada	308,647	285,642	239,839	200,731	307,156	263,145
Chile	1,450	1,212	--	--	--	--
China	1,492	1,140	258	210	--	--
Finland	29,156	25,231	20,774	16,514	20,651	16,305
France	18,135	16,385	5,376	4,682	8,932	6,858
Germany, Federal Republic of	22,727	24,159	4,702	3,621	29,675	23,645
Ghana	65	20	--	--	--	--
Italy	6,626	6,518	6,500	6,853	11,913	9,483
Japan	15,003	12,456	6,852	5,106	4,305	3,425
Korea, Republic of	1,500	1,240	--	--	--	--
Mexico	15,146	13,491	23,161	17,480	59,568	46,706
Namibia	994	836	--	--	--	--
Netherlands	20,915	18,010	7,497	5,933	21,544	16,546
Netherlands Antilles	--	--	--	--	100	85
Nigeria	--	--	--	--	2,553	2,073
Norway	9,934	8,389	10,104	8,445	9,966	7,847
Peru	43,339	37,836	48,569	35,638	45,318	34,729
Poland	600	573	476	450	917	1,082
South Africa, Republic of	--	--	--	--	1,000	644
Spain	28,671	23,545	9,149	8,027	18,978	14,691
Sweden	--	--	--	--	143	115
Tanzania	--	--	--	--	370	261
United Kingdom	15,630	12,770	4,769	3,750	9,602	7,387
Yemen-Sanaa	--	--	--	--	127	100
Yugoslavia	999	867	503	442	1,558	1,247
Zaire	28,540	22,778	22,413	15,943	24,793	18,463
Zambia	376	296	401	329	--	--
Total	612,007	549,326	456,233	370,773	617,679	503,888

[1]In addition, in 1983, 239 tons of zinc anodes was imported from Brazil, Canada, China, Denmark, the Federal Republic of Germany, Hong Kong, India, Mexico, the Netherlands, Norway, Peru, 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)
1981	245,710	$110,253	612,007	$549,326	332	$472	5,782	$2,578
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

	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)	
1981	7,629	$4,090	184	$61	7,993	$9,519	$676,299
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

[1]Unwrought alloys of zinc were imported as follows, in metric tons: 1981—102 ($40,713); 1982—136 ($75,269); and 1983—49 ($34,907).
[2]In addition, the value of manufactures of zinc imported was as follows: 1981—$437,930; 1982—$532,674; and 1983—$542,571.

Table 33.—U.S. imports for consumption of zinc pigments and compounds

	1982		1983	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Zinc oxide	28,347	$23,640	31,588	$26,415
Zinc sulfide	502	607	835	899
Lithopone	1,098	586	1,308	725
Zinc chloride	921	737	1,147	892
Zinc sulfate	2,305	982	3,223	1,497
Zinc cyanide	40	73	90	170
Zinc hydrosulfite	222	392	268	464
Zinc compounds, n.s.p.f.	2,286	3,915	2,417	3,647

Table 34.—Zinc: World mine production (content of ore), by country[1]

(Thousand metric tons)

Country	1979	1980	1981	1982[p]	1983[e]
Algeria	[r]8.8	[r]15.4	20.0	22.0	[2]21.6
Argentina	37.5	33.4	35.2	36.4	[2]37.0
Australia	529.2	495.3	518.3	664.8	695.0
Austria	20.5	19.1	18.2	19.1	[2]19.4
Bolivia	51.6	50.3	47.0	45.7	47.5
Brazil	97.9	105.0	96.6	111.9	115.0
Bulgaria[e]	[r]75.0	[r]70.0	[r]65.0	[r]66.0	65.0
Burma	3.0	4.1	3.6	5.4	[2]4.5
Canada	[r]1,204.4	[r]1,059.0	1,096.0	1,189.0	1,070.0
Chile[3]	1.8	1.1	1.5	5.7	6.0
China[e]	160.0	160.0	160.0	160.0	160.0
Colombia	--	--	.2	.2	.2
Congo (Brazzaville)[e]	4.0	3.5	3.0	3.0	3.0
Czechoslovakia	8.8	7.2	6.8	6.9	7.0
Ecuador	[e]1.0	.6	.7	[e].1	[2].1
Finland	51.6	58.4	53.5	54.6	[2]55.9
France	37.0	35.8	37.4	37.0	[2]34.0
Germany, Federal Republic of	[r]117.1	[r]120.8	110.7	105.8	113.9
Greece	23.2	27.1	27.0	[e]22.0	20.0
Greenland	[r]86.6	[r]85.7	79.7	[e]77.0	[2]75.5
Guatemala	.3	--	3.0	1.0	--
Honduras	19.8	16.0	16.2	24.6	[2]38.0
Hungary[e]	2.6	2.8	2.0	2.0	2.0
India	39.5	26.5	29.1	[e]29.1	40.4
Iran[e]	25.0	30.0	35.0	[r]40.0	39.9
Ireland	[r]212.1	228.7	120.3	167.2	185.9
Italy	66.3	58.4	43.9	38.6	43.0

See footnotes at end of table.

Table 34.—Zinc: World mine production (content of ore), by country[1] —Continued

(Thousand metric tons)

Country	1979	1980	1981	1982[p]	1983[e]
Japan	243.4	238.1	242.0	251.4	[2]255.7
Korea, North[e]	145.0	140.0	140.0	140.0	140.0
Korea, Republic of	62.5	56.8	56.5	58.2	[2]57.0
Mexico	[r]242.9	[r]235.8	206.6	242.3	257.4
Morocco[e]	4.5	6.1	7.9	11.2	7.0
Namibia	23.3	31.9	29.6	32.2	[2]34.0
Nigeria[e]	--	--	.1	.1	.1
Norway	29.6	28.7	29.8	31.9	32.3
Peru	432.0	487.6	498.9	507.1	[2]553.1
Philippines	9.7	6.8	5.3	3.0	2.2
Poland	182.7	187.8	146.5	145.0	146.0
Romania[e]	60.0	60.0	55.0	55.0	50.0
South Africa, Republic of	53.8	79.1	87.2	91.5	[2]110.0
Spain	142.7	183.1	182.0	173.1	175.0
Sweden	169.9	167.4	180.9	185.0	[2]203.2
Tunisia	8.7	7.6	7.5	7.1	6.3
Turkey	24.9	23.3	30.7	31.5	[2]11.1
U.S.S.R.[e 3]	770.0	785.0	790.0	[r]800.0	805.0
United Kingdom	.6	4.4	10.9	10.2	9.0
United States[3]	267.3	317.1	312.4	303.2	[2]275.3
Vietnam[e]	6.0	6.5	6.0	6.0	7.0
Yugoslavia[4]	101.7	95.3	88.6	83.8	80.0
Zaire	73.0	67.0	63.3	82.1	[2]74.7
Zambia	46.6	[r]32.0	40.6	52.0	[2]55.2
Total	[r]5,985.4	[r]5,961.6	5,848.2	6,238.0	6,246.4

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through July 3, 1984.
[2]Reported figure.
[3]Recoverable content in concentrates.
[4]Content in ore hoisted.

Table 35.—Zinc: World smelter production, by country[1]

(Thousand metric tons)

Country	1979	1980	1981	1982[p]	1983[e]
Algeria, primary	27.3	30.0	31.0	[e]31.0	[2]31.1
Argentina, primary	38.7	[r]38.7	26.8	28.9	32.0
Australia:					
Primary[3]	[r]305.4	301.0	295.9	291.4	298.5
Secondary[e]	5.0	5.0	4.5	4.5	4.5
Total[e]	[r]310.4	306.0	300.4	[r]295.9	303.0
Austria, primary and secondary	23.2	22.1	22.7	22.6	[2]23.0
Belgium, primary and secondary	[r]252.6	[r]247.6	234.7	228.3	[2]262.6
Brazil:					
Primary	63.5	78.3	91.9	95.5	96.0
Secondary	15.3	17.7	19.0	14.4	15.0
Total	78.8	96.0	110.9	109.9	111.0
Bulgaria, primary and secondary[e]	89.0	90.0	90.0	90.0	90.0
Canada, primary	580.4	591.6	619.0	512.0	617.0
China, primary and secondary[e]	160.0	160.0	160.0	160.0	160.0
Czechoslovakia, primary and secondary[e]	11.5	9.6	9.0	[r]9.2	9.2
Finland, primary	147.1	146.7	139.8	143.9	[2]155.3
France:					
Primary[e]	228.6	232.8	232.1	223.8	231.8
Secondary[e]	20.0	20.0	25.0	20.0	18.0
Total	248.6	252.8	257.1	243.8	249.8
German Democratic Republic, primary and secondary[e]	17.0	[r]16.5	[r]16.0	[r]17.0	17.0

See footnotes at end of table.

Table 35.—Zinc: World smelter production, by country[1] —Continued

(Thousand metric tons)

Country	1979	1980	1981	1982[p]	1983[e]
Germany, Federal Republic of:					
Primary	333.7	342.8	331.5	303.4	327.7
Secondary	21.8	27.8	35.1	31.6	28.8
Total	355.5	370.6	366.6	335.0	356.5
Greece, secondary	NA	.3	NA	NA	NA
Hungary, secondary[e]	.6	.6	[r].2	.6	.6
India:					
Primary	63.3	43.6	57.4	52.6	62.0
Secondary	NA	.3	.2	[e].2	.2
Total	63.3	43.9	57.6	[e]52.8	62.2
Italy, primary and secondary	202.3	206.4	180.9	158.7	150.0
Japan:					
Primary	[r]688.2	[r]629.7	575.6	549.0	[2]579.0
Secondary	[r]101.2	[r]105.5	94.6	113.4	[2]122.3
Total	[r]789.4	[r]735.2	670.2	662.4	[2]701.3
Korea, North, primary[e]	120.0	120.0	120.0	120.0	120.0
Korea, Republic of, primary	83.0	79.1	83.9	99.2	108.0
Mexico, primary	161.7	143.9	126.5	127.0	179.0
Netherlands, primary and secondary	154.0	169.5	177.4	186.0	187.5
Norway, primary	77.8	79.4	80.3	78.7	79.0
Peru, primary	68.2	63.8	126.2	160.7	[2]154.0
Poland, primary and secondary	209.0	[r]217.0	167.1	165.4	170.3
Portugal, primary[e]	--	2.0	4.6	3.6	3.0
Romania, primary and secondary	46.5	45.9	45.2	44.0	[2]42.0
South Africa, Republic of, primary	75.4	81.4	80.9	79.7	[2]85.3
Spain, primary	182.7	151.8	179.5	187.0	190.0
Thailand, primary	([4])	[r]([4])	--	--	--
Turkey, primary	17.2	12.6	18.1	[r e]14.9	[2]8.8
U.S.S.R.:[e]					
Primary	[r]800.0	[r]815.0	[r]820.0	[r]830.0	835.0
Secondary	80.0	80.0	[r]85.0	[r]90.0	95.0
Total	[r]880.0	[r]895.0	[r]905.0	[r]920.0	930.0
United Kingdom, primary and secondary	76.7	86.7	81.7	79.3	87.7
United States:					
Primary	472.5	340.5	346.6	228.2	[2]235.7
Secondary	53.2	29.4	50.2	74.3	[2]69.4
Total	525.7	369.9	396.8	302.5	[2]305.1
Vietnam, primary[e]	5.4	5.5	5.5	5.0	6.0
Yugoslavia:					
Primary[e]	87.9	77.5	86.4	76.8	77.0
Secondary[e]	11.0	7.0	10.0	10.0	11.0
Total	98.9	84.5	96.4	86.8	[2]88.0
Zaire, primary	[r]43.7	43.8	57.6	64.4	[2]62.4
Zambia, primary	38.2	32.7	33.3	39.2	[2]37.5
Grand total	[r]6,259.8	[r]6,049.1	6,078.9	5,865.4	6,175.2
Of which:					
Primary	[r]4,709.9	[r]4,484.2	4,570.4	4,345.9	4,611.1
Secondary	[r]308.1	[r]293.6	323.8	359.0	364.8
Undifferentiated	[r]1,241.8	[r]1,271.3	1,184.7	1,160.5	1,199.3

[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 3, 1984.

[2]Reported figure.

[3]Excludes zinc dust.

[4]Less than 50 metric tons.

Zirconium and Hafnium

By W. Timothy Adams[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.

Zircon was extracted from sand deposits as a coproduct of ilmenite and rutile in Florida. Most zircon was used in the Eastern United States with approximately 50% being used in foundry sands. The remainder was used in refractories, ceramics, abrasives, and in miscellaneous uses, including the manufacture of chemicals and production of zirconium metal and alloys for nuclear applications and for chemical processing equipment. The value of reported consumption of zircon was about $12 million. Hafnium was used in nuclear reactors, refractory alloys, and cutting-tool alloys.

Nuclear powerplant construction continued at a virtual standstill in the United States. France and Japan continued their stable national nuclear power generation programs based on their intention to reduce their imports of high-cost energy.

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, 1983, of about 38 tons of zirconium sponge, 1,020 tons of zirconium ingots and shapes, 2 tons of zirconium scrap, 32 tons of hafnium ingots and shapes, 4 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)

	1979	1980	1981	1982	1983
Zircon:					
Production	W	W	W	W	W
Exports	8,856	7,727	11,630	11,011	13,222
Imports	110,842	113,784	91,108	68,465	44,487
Consumption[e] [1]	168,000	140,000	150,000	93,000	100,000
Stocks, yearend: Dealers and consumers[2]	37,465	69,473	33,385	[r] [e]48,595	[e]36,495
Zirconium oxide:					
Production[3]	11,130	10,218	8,251	5,059	[e]4,118
Exports	1,490	2,389	782	1,017	698
Imports	322	309	235	332	451
Consumption[e]	12,000	10,100	8,600	5,600	3,400
Stocks, yearend: Producers [3]	975	1,216	1,483	[r]1,357	[e]838

[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.

Table 2.—Producers of zirconium and hafnium materials in 1983

Company	Location	Materials
ZIRCONIUM MATERIALS		
Associated Minerals (USA) Ltd. Inc	Bow, NH	Oxide.
Do	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	Camden, NJ	Refractories and zircon.
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 Inc	Dresden, NY	Chemicals, ceramics, oxide.
TRW Inc	Cleveland, OH	Zircon ores.
Western Zirconium Co	Ogden, UT	Oxide, sponge, ingot, mill products.
Zedmark Inc	Butler, PA	Refractories.
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	Oxide, sponge, crystal bar, ingot.

DOMESTIC PRODUCTION

Zircon was recovered as a coproduct with titanium mineral concentrates from mineral sands at the dredging and milling facilities of E. I. du Pont de Nemours & Co. Inc. at Starke and Highland, FL, and of Associated Minerals (USA) Ltd. Inc. at Green Cove Springs, FL. Production data were withheld from publication to avoid disclosing company proprietary data. The combined zircon capacity at these plants was estimated to be 100,000 tons per year.

Five firms produced 33,339 tons of milled (ground) zircon from domestic and imported zircon. Five companies, excluding those that produce the oxide as an intermediate product in making zirconium sponge metal, produced 4,118 tons of zirconium dioxide.

Two companies, one with a plant in Oregon and another with a plant in Utah, produced primary zirconium sponge and coproduct hafnium sponge. These firms also converted zirconium sponge to ingot.

The production of alloys containing 3% to 70% zirconium increased significantly. Hafnium crystal bar production was estimated at 55 tons in 1983.

Teledyne Wah Chang Albany (TWCA) utilized only about 50% of its production capacity for zirconium metal because of reduced demand for zirconium mill products resulting from the continued slowdown in commercial nuclear powerplant construction, the major market for zirconium shapes.

The stability of the domestic zirconium market was discussed. The effects of weak demand, the dollar-franc exchange rate, long-term contracts, and the highly specialized nature of the metal were described.[2]

CONSUMPTION AND USES

Zircon and another zirconium mineral, baddeleyite, and zirconium compounds were used in refractories, ceramics, polishes, glazes, enamels, welding rods, chemicals, and sandblasting. The use of zirconium chemicals increased in the paint, textile, and pharmaceutical industries.

Foundries used about 50% of the domestic zircon produced in 1982. The remainder was consumed by the refractory, abrasives, ceramics, metals, and other industries. Domestic zircon was marketed in proprietary mixtures as foundry sand; in refractory sand blends with kyanite, sillimanite, and staurolite; in weighting agents; in zircon-titanium dioxide blends for welding-rod coatings; and for sandblasting applications. Zircon has largely replaced tin oxide as the major opacifying agent in ceramics because of its low price and its ability to combine well with a majority of colors used.

Baddeleyite from the Republic of South Africa was used mainly in the manufacture of alumina-zirconia abrasives, and also for ceramic colors, refractories, and other uses. The use of calcia, magnesia, or yttria transformation toughened (TT) zirconia in ceramic coatings in jet engines and in other high temperature oxidation- and stress-resistant applications continued to grow, but the quantity of zirconia consumed was small. Research activity in TT zirconia properties and applications was intense. The use of yttria-stabilized zirconia in ceramic coatings in jet engines and in other high temperature oxidation-resistant coatings continued to grow in 1983, but again the quantity of zirconia consumed was small. The market for zirconia ceramics continued to develop in the automobile industry, where the zirconia-oxygen cell functions as the working component in the oxygen sensor that is part of the microprocessor control of engines.

The nuclear power industry accounted for about 90% of the zirconium metal consumed, with the remainder being used primarily as corrosion-resistant metal in the chemical industry, for superalloys, and in electronics. Shipments of zirconium mill products were the same as in 1982, paralleling the construction of nuclear powerplants for electrical generating stations. There were no new orders for commercial nuclear powerplants for the fifth consecutive year. By midyear, 26 nuclear plants had suffered startup delays of up to 3 years, 6 plants were canceled, and 9 plants were postponed indefinitely.[3]

Hafnium metal consumption for nuclear reactor control rods remained the same as in 1982.

Table 3.—Estimated[1] consumption of zircon in the United States, by end use

(Short tons)

End use	1982	1983
Zircon refractories[2]	15,000	17,000
AZS refractories[3]	4,400	4,000
Zirconia[4] and AZ abrasives[5]	8,000	8,500
Alloys[6]	3,100	4,500
Foundry applications	46,000	49,000
Other[7]	16,500	17,000
Total	93,000	100,000

[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.

Table 4.—Estimated[1] consumption of zirconium oxide[2] in the United States, by end use

(Short tons)

End use	1982	1983
AZ abrasives	2,700	W
AZS refractories[3]	900	900
Other refractories	1,200	1,400
Chemicals	400	600
Glazes, opacifiers, colors	400	500
Total	5,600	3,400

W Withheld to avoid disclosing company proprietary data.
[1]Based on incomplete reported data.
[2]Excludes oxide produced by zirconium metal producers. Includes baddeleyite.
[3]Fused cast and bonded.

Table 5.—Yearend stocks of zirconium and hafnium materials

(Short tons)

Item	1982	1983
Zircon concentrate held by dealers and consumers excluding foundries	r e40,337	31,026
Milled zircon held by dealers and consumers excluding foundries	r e8,258	5,469
Zirconium:[1]		
Oxide	r1,357	e838
Sponge, ingot, scrap, alloys	r e697	686
Refractories	r e5,611	5,443
Hafnium: Sponge and crystal bar[e]	35	35

[e]Estimated. [r]Revised.
[1]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 1982	101-105	105-110	110-114
February 1983	92-101	101-110	110-114
August 1983	84- 92	92-100	104-108
November 1983	91-100	96-104	108-112

Table 7.—Published yearend prices of zirconium and hafnium materials

Specification of material	1982	1983
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]	\$111.00- 116.00	\$99.00- 108.00
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	.40	.50
99%+ ZrO_2, minus 325-mesh, c.i.f. Atlantic ports, per pound	.90	.90
Zirconium oxide:[3]		
Chemically pure, white, ground, barrels or bags, works, per pound	NA	NA
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
Insulating, unstabilized, 325° F, same basis, per pound	3.75	3.75
Dense, stabilized, 30° F, same basis, per pound	2.82	2.82
Glass-polishing grade, ton lots, bags, 94% to 97% ZrO_2, from works, per pound	NA	NA
Opacifier grade, 3,300-pound lots, 85% to 90% ZrO_2, bags, per pound	NA	NA
Stabilized oxide, 100-pound bags, 91% ZrO_2, milled, per pound	NA	NA
Zirconium oxychloride: Crystal, cartons, 5-ton lots, from works, per pound[3]	.87	.87
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	50.00- 137.50
Sponge, per pound	12.00- 17.00	12.00- 17.00
Sheets, strip, bars, per pound	18.00- 40.00	18.00- 40.00
Hafnium: Sponge, per pound[5]	70.00- 125.00	70.00- 125.00

NA Not available.
[1]E. I. du Pont de Nemours & Co. Inc. price list Dec. 1982 (effective Jan. 1, 1983); and Dec. 1983 (effective Jan. 1, 1984).
[2]Industrial Minerals (London). No. 183, Dec. 1982, p. 91; and No. 195, Dec. 1983, p. 88.
[3]Chemical Marketing Reporter. V. 223, No. 1, Jan. 3, 1983 (effective Dec. 31, 1982), p. 51; and v. 225, No 1, Jan. 2, 1984 (effective Dec. 30, 1983), p. 51.
[4]Ronson Metals Corp. Baddeleyite price lists. Jan. 1, 1983, and Jan. 1, 1984.
[5]American Metal Market. V. 91, No. 5, Jan. 7, 1983, p. 7; and v. 92, No. 4, Jan. 6, 1984, p. 6.

Table 8.—U.S. exports of zirconium ore and concentrate, by country

Country	1982 Pounds	1982 Value	1983 Pounds	1983 Value
Algeria	112,435	$39,045	112,435	$38,990
Argentina	802,694	151,990	3,277,240	552,148
Brazil	2,190,235	237,077	2,964,000	288,021
Canada	1,760,169	305,783	1,354,112	220,707
Colombia	1,420,507	350,900	1,280,956	284,945
Ecuador	46,296	14,318	157,629	49,770
Germany, Federal Republic of	10,005,789	1,100,270	8,034,681	1,026,241
India	80,159	26,089	106,906	31,120
Italy	--	--	207,552	41,553
Japan	9,543	5,490	6,985,108	365,297
Mexico	3,270,140	380,643	728,095	98,433
Suriname	286,379	7,379	19,684	3,740
Taiwan	229,072	140,032	--	--
United Kingdom	38,000	3,458	123,300	15,234
Venezuela	1,241,642	375,040	717,747	201,735
Other	r529,756	r130,531	373,755	98,397
Total	22,022,816	3,268,045	26,443,200	3,316,331

rRevised.

Table 9.—U.S. exports of zirconium, by class and country

Class and country	1982 Pounds	1982 Value	1983 Pounds	1983 Value
Zirconium and zirconium alloys, wrought:				
Belgium-Luxembourg	39,284	$2,064,439	58,944	$3,226,250
Canada	332,297	9,524,070	394,115	11,409,237
France	11,459	260,811	6,232	169,669
Germany, Federal Republic of	207,982	4,096,059	134,910	2,891,956
Italy	162	23,137	13,720	769,920
Japan	627,459	17,019,832	544,446	13,903,658
Korea, Republic of	1,669	52,466	17,777	592,836
Sweden	66,299	892,922	97,074	1,894,766
Switzerland	12,828	719,075	91	1,963
Taiwan	13,951	351,453	143	4,498
United Kingdom	135,745	2,389,076	26,790	550,894
Other	r2,974	r91,285	13,975	301,218
Total	1,452,109	37,484,625	1,308,217	35,716,865
Zirconium and zirconium alloys, unwrought and waste and scrap:				
Canada	8,142	31,379	648	6,157
France	359	2,883	4,093	65,817
Germany, Federal Republic of	43,855	203,935	8,010	26,250
Japan	185,257	5,202,865	161,181	3,498,325
Netherlands	--	--	5,176	65,595
United Kingdom	65,805	1,003,785	4,805	79,096
Other	r439	r22,043	2,337	55,743
Total	303,857	6,466,890	186,250	3,796,983

rRevised.

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

Country	1982 Pounds	1982 Value	1983 Pounds	1983 Value
Argentina	60,373	$128,785	23,364	$56,617
Brazil	77,458	229,615	29,976	111,732
Canada	82,959	186,141	141,933	257,405
France	899,198	3,447,163	114,065	196,340
Germany, Federal Republic of	36,304	105,065	55,561	75,284
Guatemala	--	--	10,307	9,309
Hong Kong	9,404	10,362	5,562	15,684
India	4,775	12,069	5,824	11,841
Italy	47,590	63,064	116,844	158,511
Jamaica	--	--	26,500	23,000
Japan	171,798	316,748	216,842	264,754
Mexico	108,948	54,658	214,175	202,340
Netherlands	62,940	79,285	37,519	47,448
Sweden	22,907	42,077	32,042	46,341
Taiwan	41,325	52,384	23,158	34,480
United Kingdom	369,033	598,424	317,352	338,185
Other	38,256	94,642	25,308	49,123
Total	2,033,268	5,420,482	1,396,332	1,898,394

Table 11.—U.S. imports for consumption of zirconium ores, by country

Country	1981 Quantity (short tons)	1981 Value (thousands)	1982 Quantity (short tons)	1982 Value (thousands)	1983 Quantity (short tons)	1983 Value (thousands)
Australia	71,852	$6,930	56,092	$5,142	36,140	$3,385
Austria[1]	--	--	59	7	118	13
Canada[1]	2,444	305	705	70	1,176	122
Malaysia	72	5	--	--	--	--
South Africa, Republic of[2]	16,740	1,138	11,603	919	7,053	897
Other	--	--	6	6	(3)	3
Total	91,108	8,378	68,465	6,144	44,487	4,420

[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 1983, by class and country

Class and country	Pounds	Value
Zirconium, wrought:		
Canada	4,105	$53,871
France	529,027	11,757,606
Germany, Federal Republic of	2,538	66,826
Japan	14,324	130,666
Spain	9	615
United Kingdom	1,230	12,305
Total	551,233	12,021,889
Zirconium, unwrought and waste and scrap:		
Canada	62,711	222,389
Denmark	1	438
France	4,189	15,901
Germany, Federal Republic of	4,871	194,836
Japan	127,145	419,083
United Kingdom	624	1,008
Total	199,541	853,655
Zirconium alloys, unwrought:		
Germany, Federal Republic of	1,137	24,836
United Kingdom	13,461	47,860
Total	14,598	72,696
Zirconium oxide:		
Denmark	3	398
France	176,369	186,007
Germany, Federal Republic of	11,337	42,471
Gibraltar	5,004	4,876
Japan	10,353	49,636
Switzerland	17	6,897
United Kingdom	698,734	1,573,343
Total	901,817	1,863,628
Zirconium compounds:		
Australia	35,274	18,720
Canada	5,426	2,436
France	74,345	80,614
Germany, Federal Republic of	79,244	148,913
Italy	252	5,968
Japan	837	8,973
South Africa, Republic of	1,395,619	705,805
United Kingdom	115,290	117,305
Total	1,706,287	1,088,734
Hafnium, unwrought and waste and scrap: France	478	50,058

WORLD REVIEW

Australia continued to lead the world in the production of zircon; however, with the mineral sands operation at Richards Bay in the Republic of South Africa reportedly producing at capacity, Australia no longer dominated the world market. Zircon was also produced in Brazil, China, India, Malaysia, Sri Lanka, Thailand, the U.S.S.R., and the United States. Baddeleyite was produced in Brazil and the Republic of South Africa.

It was estimated that approximately 90% of worldwide zircon consumption was accounted for by refractory, ceramic, and foundry uses. Market economy countries used approximately 8 million pounds of zirconium ingot for commercial nuclear power generating stations and an additional 2 million pounds for other purposes, mainly for chemical process equipment.

Australia.—The Commonwealth Scientific and Industrial Research Organization (CSIRO) decided to seek commercial assistance to develop a source of high-purity zirconia and related products in Australia. The capacity was to be established in 2 to 3 years in order to maintain Australia's role as leader in TT zirconia technology.[4]

Japan.—A process was announced for the production of a yttria-stabilized zirconium dioxide ceramic. Outstanding physical properties were claimed for the material.[5]

A distillation process was reported to decrease refining costs for zirconium metal by one-half if the monthly output was a minimum of 100 tons per month of product. A plant with a capacity of 100 to 200 tons per month was planned.[6]

The status of the Japanese nuclear power electrical generating industry was discussed. The problems of locating nuclear reactors in a seismically active area were described. Plans for Japanese nuclear reactor manufacture in both domestic and foreign markets were outlined.[7]

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

(Short tons)

Country	1979	1980	1981	1982[p]	1983[e]
Australia	490,500	541,837	468,138	509,317	510,000
Brazil	2,891	3,759	6,614	[e]3,850	4,400
China[e]	[r]13,200	[r]15,400	[r]16,500	[r]16,500	16,500
India[2]	13,426	16,336	13,669	[e]13,000	13,000
Malaysia[3]	1,401	[r]518	1,441	2,367	3,300
South Africa, Republic of[e]	90,000	88,000	110,000	[r]140,000	140,000
Sri Lanka	1,664	3,341	3,600	6,381	6,600
Thailand	128	67	115	216	220
U.S.S.R.[e]	80,000	80,000	80,000	[r]90,000	90,000
United States	W	W	W	W	W
Total	[r]693,210	[r]749,258	700,077	781,631	784,020

[e]Estimated. [p]Preliminary. [r]Revised. W Withheld to avoid disclosing company proprietary data; excluded from "Total."

[1]Includes data available through May 9, 1984.

[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

The Australian CSIRO revealed details on partially stabilized (PSZ) zirconia and on TT zirconia. Additions of calcium, magnesium, or yttrium oxide controlled the relationship between small tetragonal and monoclinic crystals contained in a cubic lattice. The shift of the tetragonal crystals to the monoclinic form under applied stress gave the TT zirconia its exceptional strength.[8]

Zirconium-aluminoxane catalysts reportedly offered several advantages over the normal Ziegler-Natta type catalyst used in the polymerization of olefins. They were indefinitely stable in the solid form, soluble in a variety of organic solvents, maintained catalytic activity for several days under reaction conditions, and had an extremely high level of catalytic activity.[9]

A new method for making amorphous

nickel-hafnium and amorphous nickel-zirconium and other noncrystalline metals was reported. The new techniques involved a rapid diffusion reaction with the temperature chosen high enough to produce a reaction but below the crystallization temperature.[10]

Current thought on the state-of-the-art, advantages, and disadvatages of the use of ceramics in heat engines was discussed. The applications of various ceramic materials, including zirconia, in heat engines were categorized and major materials requirements listed. Possible candidate ceramic materials were also described.[11]

Zirconium fluoride, hafnium fluoride, and other metal fluoride glasses were described. Advantages of fluoride glasses over silica glasses when used in fiber optics reportedly were their much greater transparency, which decreases the number of signal amplifiers needed, and their ability to transmit infrared radiation without attenuation.[12]

A critical review of published data on hydrogen, hydrogen cracking, and hydrogen-induced delayed cracking in zirconium and its alloys was presented. It was shown that solution temperature, cooling rate, and applied or residual stresses greatly affected hydride morphology and orientation. The most detrimental hydride morphology was shown to be when the hydride was oriented normal to the applied stress and had the morphology of a continuous sheet.[13]

The corrosion of equipment in the extraction process and manufacture of zirconium metal was discussed. Examples were given to show that zirconium metal was the material best able to withstand the corrosive conditions of its own manufacture.[14]

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[1]Physical scientist, Division of Nonferrous Metals.
[2]American Metal Market. Domestic Zirconium Market at Standstill. V. 91, No. 141, July 21, 1983, p. 7.
[3]Fairgreive, D. S. Zirconium; Marking Time During An Uncertain Period. Eng. and Min. J., v. 185, No. 3, Mar. 1984, p. 69.
[4]CSIRO Industrial Research News. Australia to Manufacture Zirconia. No. 161, 1983, pp. 1-2.
[5]Roskill's Letter From Japan. RLJ No. 81, Jan. 1982, p. 6.
[6]Page 18 of work cited in footnote 5.
[7]Business Week. Energy. Japan: The Unlikely Nuclear Giant. No. 2808, Sept. 19, 1983, p. 66.
[8]Chemical Engineering. Chementator. V. 90, No. 4, Feb. 21, 1983, p. 10.
[9]Chemical and Engineering News. Technology. Zirconium Catalysts Polymerize Olefins Faster. V. 61, No. 27, July 4, 1983, pp. 29-30.
[10]Chemical Week. Technology Newsletter. A New Production Method for Amorphous Metals. V. 133, No. 10, p. 38.
[11]Pascucci, M. R. The Role of Ceramics In Engines—An Assessment. Current Awareness Bull., Met. and Ceram. Inf. Center, No. 126, Aug. 1983, pp. 1-3.
[12]Pollack, A. The Potential of Halide Glasses. Technology. The New York Times, v. 132, No. 45,760, Aug. 4, 1983, p. D2.
[13]Northwood, D. O., and V. Kosasih. Hydrides and Delayed Hydrogen Cracking In Zirconium and Its Alloys. Int. Met. Rev., v. 28, No. 2, 1983, pp. 92-121.
[14]Metal Progress. Reactive Metals. Zirconium Holds Down Cost of Making Zirconium. V. 124, No. 6, Nov. 1983, pp. 11-12.

Other Metals

By Staff, Division of Nonferrous Metals

CONTENTS

ARSENIC[1]

Demand for arsenic trioxide dropped markedly during 1983, primarily as a result of a 27% reduction in cotton planting. As an oversupply of arsenic trioxide developed, prices declined for both domestic and imported material.

Domestic Data Coverage.—Commercial-grade arsenic trioxide and arsenic metal were produced by only one U.S. company, which voluntarily reported its production to the Bureau of Mines. To prevent disclosure of proprietary data, the production data have been withheld.

Legislation and Government Programs.—On June 5, 1980, the Environmental Protection Agency (EPA) listed inorganic arsenic as a hazardous air pollutant. The listing was based on EPA findings that inorganic arsenic was carcinogenic to humans and that there was significant public exposure to the pollutant. On July 11, 1983, acting under a deadline imposed by a New York district court in January 1983, EPA proposed regulations governing arsenic emissions.

The proposed regulations govern emissions from primary copper smelters processing high-arsenic feed materials containing 0.7% or greater arsenic, primary copper smelters processing low-arsenic feed materials containing less than 0.7% arsenic, and glass manufacturing plants. According to EPA estimates, over 85% of the 1,200 tons per year of arsenic emissions came from these three sources. EPA placed emphasis on the use of best available technology (BAT) in controlling emissions and estimated that the proposed standards would reduce total arsenic emissions approximately 20%, and the ground-level fugitive emissions, which are thought by EPA to pose the greatest risk to public health, by about 65%. EPA identified other source categories for which standards were not proposed: primary lead and zinc smelters, zinc oxide plants, arsenic chemical manufacturing plants, cotton gins, and secondary lead smelters.[2]

The proposed standards, which were opened to public debate, required additional emissions controls at 14 glass furnaces, 6 copper smelters processing low-arsenic feed materials, and ASARCO Incorporated's Tacoma, WA, smelter, the only smelter processing high-arsenic feed materials. Public debate at hearings held in Tacoma, WA, and Washington, DC, focused on EPA exposure models, emissions estimates, and health risk assessments, particularly in regard to the Tacoma smelter, where implementation of BAT control would leave the health risk at a relatively high level. Final EPA standards were expected to be issued late in 1984.

Cotton growing is the principal agricultural market for arsenical herbicides and desiccants. On January 12, 1983, the Agricultural Stabilization and Conservation Service, U.S. Department of Agriculture, published an interim rule establishing a program of payment-in-kind (PIK) for acreage diversion for some 1983 crops, including cotton.[3] Amendments to the rule were published on March 4.[4] Under the program, producers were offered a quantity of a commodity as compensation for acreage normally planted to that commodity. As a result of the program, cotton planted during the year declined by 27% from the 1982 level, greatly reducing the agricultural consumption of arsenicals.

On October 25, EPA published proposed rules on effluent discharge limitations for existing and potential new sources that manufacture inorganic chemicals. Arsenic was identified as one of the important pollutants found in the waste water from zinc chloride production, one of the six categories for which EPA proposed effluent limitation guidelines. The proposed regulation for zinc chloride was based on a BAT standard that calls for filtration of clarified waste water for removal of toxic metals.[5]

DOMESTIC PRODUCTION

Arsenic trioxide and commercial-grade arsenic metal were produced at the Tacoma, WA, copper smelter of Asarco. Arsenic trioxide was recovered there as a byproduct of the smelting of high-arsenic copper concentrates and ores, principally from the Philippines and Chile. Asarco also processed domestic arsenic-bearing residues and concentrates. High-arsenic materials were blended with domestic and foreign low-arsenic concentrates to reduce the overall arsenic content of feed material. Most of the arsenic trioxide was recovered from the flue dust generated by an initial concentrate roasting step, which causes the highly volatile arsenic to sublime. Arsenic metal was produced from high-purity imported arsenic trioxide. Arsenic trioxide production was limited by the necessity to comply with Federal and local regulations on the atmospheric emissions of sulfur dioxide and arsenic.

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.

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.

Williams Strategic Metals Inc., Wheat Ridge, CO, established commercial-scale facilities for recovering arsenic from lead smelter flue dusts. Production was scheduled to begin in January 1984.

U.S. Industrial Metals Corp. contracted to purchase 250,000 tons of high-arsenic flue dusts that have accumulated at the site of the closed Anaconda Minerals Co. copper smelter. The company reportedly planned to build a mill using an acid leach process to treat 200 tons of dust per day for recovery of copper and precious metals, but no plans were made for recovery of the arsenic.

CONSUMPTION AND USES

Arsenic compounds, principally arsenic trioxide, accounted for 97% of arsenic consumption in 1983. The estimated end-use distribution of arsenic was 60% in industrial chemicals (principally wood preservatives), 30% in agricultural chemicals (principally herbicides and desiccants), 5% in glass and ceramics, 3% in metallic form in nonferrous alloys, and 2% in other uses (animal feed additives, pharmaceuticals, etc.).

The bulk of metallic arsenic was used in copper- and lead-based alloys as a minor additive (about 0.5%) to increase strength in the posts and grids of lead-acid storage batteries and to improve corrosion resistance and tensile strength in copper alloys. A relatively small amount, less than 10 tons, of high-purity arsenic metal was used in the electronics industry. Gallium arsenide and its alloys were used in such products as light-emitting diodes and displays, room-temperature lasers, discrete microwave devices, solar cells, and photoemissive surfaces.[6]

Arsenical wood preservatives for pressure treating lumber were the largest end use for arsenic trioxide. In the preparation of CCA wood preservatives, arsenic acid, produced from arsenic trioxide, is mixed with copper oxide and chromic acid to form a leach-resistant waterborne preservative for pressure treating lumber.

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. The largest decline in demand for arsenic was in agricultural consumption, where cotton planting was reduced by 27% from the 1982 level. Most or all of the reduction was due to the U.S. Department of Agriculture's PIK program.

Arsenic trioxide is used in the glass industry primarily as a fining and decolorizing agent. With the advent in the late 1960's and early 1970's of environmental and occupational health laws governing arsenic exposure and emissions, glass companies eliminated or reduced to minimum amounts their consumption of arsenic compounds and began substituting arsenic acid for arsenic trioxide to reduce dusting during materials handling. As a result, arsenic usage has been limited to the pressed and blown glass sector, the use of arsenic in the flat and container glass industry having been virtually eliminated. During 1983, arsenic was used by an estimated 15 glass plants manufacturing pressed and blown glass products such as tableware, lead glass, and optical glass.

PRICES

The price of domestically produced arsenic trioxide, guaranteed minimum 95% purity, declined throughout the year in response to decreased demand and plentiful supply. The price for carload quantities, which had remained constant at $0.40 per pound throughout 1982, declined to $0.37 per pound early in the year and by October reached a low of $0.33 per pound. The price of domestically produced arsenic metal, marketed in 250-pound drums or 2,000-pound pallets, remained constant at $2.25 per pound throughout the year. Dealer prices for foreign material were somewhat lower at $1.95 per 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)

	1981	1982	1983
Trioxide, domestic, 95% As_2O_3, f.o.b. Tacoma, WA	40	40	33
Trioxide, Mexican, 99.13% As_2O_3, f.o.b. Laredo, TX	78	59	45
Metal, domestic, 99% As	275	245	225

FOREIGN TRADE

In response to a decrease in demand, imports of arsenic trioxide were at the lowest level since 1978. However, imports of arsenic acid more than tripled, partially offsetting the decline in trioxide imports. Exports of arsenic compounds amounted to only 85 tons.

Imports of arsenic trioxide from Canada were largely low-grade arsenical dusts and residues that had accumulated from the roasting of arsenic-bearing gold ores. In accordance with an agreement between Japanese smelters and Anaconda, arsenic trisulfide waste was shipped from Japan to the United States for disposal. The hazardous byproduct was created from smelting of arsenic-bearing concentrates that Anaconda began shipping to Japan when it closed its copper smelter in September 1980.

Table 2.—U.S. imports for consumption of arsenicals, by class and country

Class and country	1981 Quantity (metric tons)	1981 Value (thousands)	1982 Quantity (metric tons)	1982 Value (thousands)	1983 Quantity (metric tons)	1983 Value (thousands)
Arsenic trioxide:						
Australia	--	--	71	$121	37	$8
Belgium-Luxembourg	1,251	$708	1,030	1,205	946	848
Bolivia	38	77	22	43	--	--
Canada	5,581	965	3,352	786	2,525	542
China	431	585	1,280	1,998	17	36
France	749	1,093	1,992	2,479	667	706
Germany, Federal Republic of	133	226	16	19	1	6
Hong Kong	--	--	1	1	--	--
Japan	--	--	--	--	(1)	1
Korea, Republic of	198	389	186	289	--	--
Mexico	3,566	5,261	2,276	3,341	2,531	2,700
Namibia	--	--	--	--	16	11
Netherlands	--	--	36	42	--	--
Peru	50	57	--	--	--	--
Portugal	66	142	--	--	--	--
South Africa, Republic of	17	17	--	--	17	18
Spain	144	198	--	--	--	--
Sweden	4,902	3,259	4,192	4,717	3,430	3,528
Taiwan	--	--	50	75	--	--
U.S.S.R	40	91	30	68	--	--
United Kingdom	34	59	29	24	--	--
Zimbabwe	--	--	34	33	--	--
Total[2]	17,199	13,126	14,599	15,241	10,186	8,406
Arsenic acid:						
Australia	--	--	--	--	74	54
France	--	--	--	--	34	34
Germany, Federal Republic of	--	--	--	--	(1)	2
Mexico	549	747	--	--	--	--
Sweden	18	96	--	--	--	--
United Kingdom	944	1,557	699	865	2,277	2,304
Total	1,511	2,400	699	865	2,385	2,394
Arsenic sulfide:						
Canada	--	--	18	4	(1)	(1)
Japan	--	--	--	--	1,127	1,522
Other	--	--	(1)	5	--	--
Total	--	--	18	9	1,127	1,522
Arsenic metal:						
Belgium	--	--	--	--	(1)	7
Canada	11	307	4	297	6	328
China	30	171	31	133	128	428
Germany, Federal Republic of	(1)	10	1	47	1	111
Japan	(1)	6	(1)	3	(1)	30
Peru	5	28	--	--	--	--
Sweden	247	1,520	100	523	108	435
Total[2]	294	2,080	136	1,044	243	1,401
Lead arsenate:						
Peru	90	180	170	321	17	35
Other	--	--	(1)	(1)	(1)	2
Total	90	180	170	321	17	37
Sodium arsenate:						
Israel	--	--	476	104	--	--
Other	(1)	3	1	5	(1)	2
Total	(1)	3	477	109	(1)	2
Arsenic compounds, n.e.c.:						
Sweden	--	--	(1)	5	17	22
United Kingdom	2	118	362	591	9	108
Other	2	15	(1)	20	(1)	28
Total	4	133	362	616	26	158

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

Table 3.—U.S. import duties for arsenicals

Item	TSUS No.	Most favored nation (MFN) Jan. 1, 1983	Most favored nation (MFN) Jan. 1, 1984	Most favored nation (MFN) Jan. 1, 1987	Non-MFN Jan. 1, 1984
Arsenic metal	632.04	1.0 cent per pound.	0.8 cent per pound.	Free	6.0 cents per pound.
Trioxide and sulfide	417.62, 417.60	Free	Free	do	Free.
Other compounds	417.64	4.4% ad valorem.	4.2% ad valorem.	3.7% ad valorem.	25% ad valorem.

WORLD REVIEW

Canada.—Cominco Ltd.'s plant in Yellowknife, Northwest Territories, which was commissioned in 1982 and was designed to produce 5 tons per day of high-purity arsenic trioxide from sludge generated in the roasting of gold and silver ores, reportedly was experiencing startup difficulties. High-arsenic dusts and residues, accumulated from the roasting of arsenic-bearing gold ores from Campbell Red Lake Mines Ltd. in Ontario and Giant Yellowknife Mines Ltd. in the Northwest Territories, continued to be shipped to the United States for processing. Cominco, through its Electronics Materials Div., was a major North American supplier of high-purity arsenic and gallium arsenide crystals for the electronics industry. Cominco opened its gallium arsenide plant in Trail, British Columbia, in June 1981.

Chile.—The El Indio Mine, a gold-silver-copper mine inaugurated in December 1981, 80% owned by St. Joe International Corp., shipped high-arsenic ore and concentrate in 1983 to the United States for processing. The roaster, built to reduce arsenic content in the concentrates to levels acceptable for conventional smelting, has been running below capacity since commissioning. El Indio's arsenic trioxide refinery came on-stream during the fourth quarter of 1983 after experiencing startup difficulties and reportedly will be producing 300 to 400 tons per month of 97% arsenic trioxide.

Japan.—With at least three companies refining arsenic, Japan was a leading world producer of high-purity arsenic for electronic applications. Sumitomo Electric Industries Ltd. and Mitsubishi Metal Corp. were major suppliers of high-purity gallium arsenide crystals used for production of semiconductor devices. At least 10 Japanese companies were working on developing gallium arsenide integrated circuits.

Korea, Republic of.—According to the Republic of Korea's Energy-Resources Institute, a minable arsenic-bearing silver ore, with reserves estimated at 10.6 million tons, was identified in the southeastern part of the country. The deposit, which was believed to be commercially exploitable, contains an average of 12.6% arsenic and 156 grams of silver per ton.[7]

Philippines.—Lepanto Consolidated Mining Co. Inc., the major supplier of high-arsenic concentrates to Asarco's Tacoma (United States) smelter, was constructing a $17 million roaster located at the Philippine Associated Smelting and Refining Corp. (PASAR) complex on Leyte. Startup of the roaster plant, originally scheduled for November, was reportedly delayed until early 1984. The plant, which includes a large fluid bed roaster to volatilize arsenic, was expected to have the capacity to process 5,000 tons per month of high-arsenic concentrate and a crude arsenic trioxide capacity of 20 tons per day. The calcined concentrate was to go to the PASAR smelter for treatment. Lepanto's contract to supply concentrates to Tacoma was scheduled to expire in 1986.[8]

Table 4.—Arsenic trioxide:[1] World production, by country[2]

(Metric tons)

Country[3]	1979[r]	1980[r]	1981	1982[p]	1983[e]
France	5,550	[e]5,300	[e]5,200	5,100	5,000
Germany, Federal Republic of[e]	--	360	360	360	360
Japan	182	284	95	[e]100	100
Korea, Republic of	590	NA	170	306	NA
Mexico	6,537	6,932	6,517	4,740	4,700
Namibia[4]	2,221	1,288	1,370	1,895	[5]1,126
Peru[6]	1,415	2,475	2,164	1,663	1,800
Portugal[e]	345	200	196	200	190
Sweden[e 7]	5,080	4,080	4,000	4,000	4,000
U.S.S.R.[e]	7,700	7,700	7,800	7,900	8,000
United States	W	W	W	W	W
Total	29,620	28,619	27,872	26,264	25,276

[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 May 30, 1984.

[3]Austria, Belgium, China, Czechoslovakia, the German Democratic Republic, Hungary, Spain, the United Kingdom, Yugoslavia, and Zimbabwe have produced arsenic and/or arsenic compounds in previous years, but information is inadequate to make reliable estimates of output levels. 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.

[4]Output of Tsumeb Corp. Ltd. only.

[5]Reported figure.

[6]Output of Empresa Minera del Centro del Perú.

[7]Output of arsenic trioxide for sale plus the arsenic trioxide equivalent of the output of metallic arsenic for sale.

TECHNOLOGY

The Bureau of Mines investigated the removal of arsenic from high-arsenic flue dusts and related materials so that these materials could subsequently be treated for metal recovery. In the process, lead smelter dust containing 10% arsenic was leached at 90° C with 20% sulfuric acid to maximize dissolution of arsenic, zinc, cadmium, and indium. Indium was removed from solution using solvent extraction, followed by precipitation of arsenic with iron sulfate and calcium carbonate to form a fixed, stable precipitate for waste pond containment. The lead residue could be recycled to the lead blast furnace and the leach liquor returned to the electrolytic zinc plant.[9]

The Bureau also investigated the removal of arsenic from mining industry waste streams by adsorbing arsenic on hydrated titanium dioxide granules. Following the use of sulfur dioxide to precipitate arsenic from sulfuric acid leach solutions generated from the leaching of smelter flue dusts, the granules were used to scavenge the remaining arsenic. Tests using synthetic solutions resulted in a maximum arsenic loading of 14% on the granules, but loading was much lower when actual leach solutions were used. The granules were also used in an attempt to selectively scavenge arsenic from an ion exchange effluent stream from a Bureau of Mines process to recover titanium from Searles Lake brine, but unacceptable amounts of tungsten were adsorbed by the granules.[10]

Harris Microwave Semiconductor Inc., Milpitas, CA, introduced the first commercially available gallium arsenide integrated circuit. The circuit reportedly operates at up to five times the speed of the fastest silicon chips. In December, Harris brought on-line what was described as the capacity to grow the largest high-purity gallium arsenide single-crystal ingots with crystals up to 5 inches in diameter and 10 kilograms in weight.[11]

The gallium arsenide integrated circuit market was expected to grow markedly within the next decade, with an estimated 42 U.S. companies in some stage of developing gallium arsenide integrated circuit capabilities.[12] Rockwell International and Honeywell Inc. were awarded Defense Advanced Research Projects Agency funding to establish a pilot line for the fabrication of complex gallium arsenide integrated circuit chips. The 3-year program calls for the pilot line to achieve a minimum throughput of

100 3-inch wafers per week for at least the last 6 months of the program. The long-term objective of the program is to establish pilot lines to serve as gallium arsenide foundry resources for the U.S. Department of Defense.[13] Approximately 60 gallium arsenide projects were sponsored by Government defense agencies during 1983.

CESIUM AND RUBIDIUM[14]

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.

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 metal 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. Another supplier in past years, the Kerr-McGee Chemical Corp., Trona, CA, sold all of its stocks of ores and other source materials and ceased production of cesium and rubidium.

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 magnetohydrodynamic (MHD) generators, solar photovoltaic cells, and therimonic and turboelectric power generators. Commercial consumption included uses for high-voltage rectifying tubes, which change alternating current to direct current, and for infrared lighting, where cesium vapor emits long-wavelength radiation that is invisible to the eye. 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 slightly in 1983, reportedly because of higher costs of production. 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 1983

Compound	Base price per pound[1]	
	Technical grade	High-purity grade
Cesium bromide	$34.25	$69.50
Cesium carbonate	34.25	69.50
Cesium chloride	36.50	72.50
Cesium fluoride	43.50	80.00
Cesium hydroxide	41.25	78.00
Rubidium carbonate	83.50	125.00
Rubidium chloride	84.50	126.00
Rubidium fluoride	91.00	132.00
Rubidium hydroxide	91.00	132.00

[1]Price is for quantities of less than 100 pounds, f.o.b. Revere, PA, excluding packaging costs.

Source: Cabot Corp., KBI Div.

FOREIGN TRADE

The increase in imports was attributed to a slight increase in demand and the strengthening of the U.S. dollar against foreign currencies. Trade data on raw materials and metal were not available. Tariff schedules established at the Tokyo Round of trade negotiations are shown in table 7.

Table 6.—U.S. imports for consumption of cesium compounds, by country

Country	1982				1983			
	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
Germany, Federal Republic of	9,645	$403,047	6,995	$395,379	13,655	$507,876	2,930	94,532
Netherlands	--	--	--	--	220	10,949	--	--
United Kingdom	--	--	7	1,015	--	--	3	397
Total	9,645	403,047	7,002	396,394	13,875	518,825	5,352	97,707

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 Bernic Lake Mine of the Tantalum Mining Corp. of Canada Ltd., the major source of pollucite for the United States, remained closed in 1983, having shut down at the end of 1982. The reasons given for the continued shutdown were lack of demand and high costs of production.

Bikita Minerals (Pvt.) Ltd., which operated several mines that produced cesium and rubidium minerals in the Victoria District of Zimbabwe, ceased all production at the end of 1982. The mines reportedly remained closed at the end of 1983, although several shipments of ore were reportedly sent to Japan.

TECHNOLOGY

Development continued on MHD generation of electric power, in which cesium and rubidium salts are used. Work continued at the Pacific Northwest Laboratories of Battelle Memorial Institute at Richland, WA, on the coal gasifier MHD unit. Research on conventional MHD development was continued on a 20-ton-megawatt, two-stage, coal-fired combustor under a program of the U.S. Department of Energy at Butte, MT.

Conversion of the Ryazan thermal powerplant in central U.S.S.R. into a 500-megawatt MHD unit fueled by natural gas reportedly was approved. Power Ministry officials stated that the plant will consist of a 250-megawatt MHD generator plus a 300-megawatt standard steam turbine, with an overall energy conversion efficiency of 60%.[15]

GERMANIUM[16]

Domestic production and consumption of germanium decreased significantly during 1983 compared with that of 1982.

Domestic Data Coverage.—Domestic refinery production data for germanium are developed by the Bureau of Mines based on discussions with domestic producers concerning total industry production.

DOMESTIC PRODUCTION

Eagle-Picher Industries Inc., Quapaw, OK, was the sole domestic producer of primary germanium. Kawecki Berylco Industries Inc., a division of Cabot, Revere, PA; Atomergic Chemetals Co., Plainview, NY; and Bunker Rare Metals, Irving, TX;

produced germanium products using imported metal, oxide, and scrap and domestic scrap.

Jersey Minière Zinc Co., Clarksville, TN, produced germanium-rich residues as a byproduct of processing zinc ores mined at Gordonsville and Elmwood, TN. These residues were shipped to Métallurgie Hoboken-Overpelt SA in Belgium for germanium recovery and refining.

Musto Explorations Ltd. of Vancouver, Canada, completed a feasibility study on the Apex Mine, an abandoned copper mine at St. George, UT, and announced its decision to put the mine into production. The major products of this project were to be germanium hydroxide and gallium hydroxide, with byproducts of copper, silver, and zinc. Underground development work began in October. The mine was expected to produce 120 tons of ore per day. Ore reserves were estimated at 243,000 tons containing 0.032% gallium and 0.064% germanium. The company also expected to build a plant capable of treating 100 tons of ore per day and announced a target date of March 1985 for start of production. Estimated annual production levels for the first 3 years were 10,000 kilograms of contained gallium and 17,900 kilograms of contained germanium.[17] Eagle-Picher Industries was expected to purchase 8,000 kilograms of germanium hydroxide from Musto on a long-term contract basis.[18]

Domestic refinery production from both primary and secondary materials for 1983 was estimated to be approximately 20,000 kilograms. The decrease in production from the 1982 estimated production of 26,000 kilograms was the result of lower demand. Based on the U.S. producer price for refined germanium metal, the approximate value of the production was $21 million.

CONSUMPTION AND USES

The apparent consumption of germanium was estimated at 35,000 kilograms, a significant decrease from the 42,000 kilograms estimated in 1982. The estimated consumption pattern for various end uses of germanium in 1983 was as follows: infrared systems, 50%; fiber optics, 15%; semiconductors, 15%; detectors, 10%; and other uses, 10%.

The largest end use for germanium continued to be in infrared optics despite a slowdown in the rapid growth evident over the past few years, owing in part to a delay in some previously planned military projects involving infrared systems 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.

Another growing market for germanium in recent years was fiber optic telecommunications systems. However, improvements in the technology used to manufacture fiber optic cables and the increased use of monomodal fibers over multimodal fibers led to a decrease in the amount of germanium consumed by this industry during 1983. This market should continue to grow as several companies announced plans to install fiber optic cable systems in the near future. In February, American Telephone & Telegraph Co. (AT&T) placed into operation its fiber optic cable system connecting New York and Washington, DC. AT&T announced that it planned to extend this line from Boston, MA, to Richmond, VA, as well as setting up additional lines in Pennsylvania, Texas, North Carolina, and Georgia.[19] A new transatlantic phone system using fiber optic cables known as TAT-8 and owned by 28 international telecommunications companies was expected to be ready for operation in June 1988.[20] Illinois Bell Telephone Co. and Bell Telephone of Canada also announced plans to install fiber optic cable systems in their respective jurisdictions. 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 was an important constituent in many systems.

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 copper, aluminum, 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 the year at $1,060 and $660 per kilogram, respectively. Some discounting by domestic producers was evident during 1983 because of the competition from imported material.

FOREIGN TRADE

A comparison of the value per kilogram of imported germanium material with the published producer price for germanium metal indicates that much 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 6,500 kilograms.

Table 8.—U.S. imports for consumption of germanium, by class and country

Class and country	1982 Gross weight (kilograms)	1982 Value	1983 Gross weight (kilograms)	1983 Value
Unwrought and waste and scrap:				
Belgium-Luxembourg	1,854	$4,018,956	4,540	$1,737,715
Canada	143	5,590	--	--
China	--	--	651	455,784
France	--	--	1,328	635,696
Germany, Federal Republic of	179	219,004	303	3,531,509
Italy	--	--	1,683	635,507
Japan	53	38,792	10	2,600
Netherlands	100	50,063	1,843	774,095
Singapore	--	--	910	542,463
Switzerland	--	--	448	188,612
United Kingdom	821	95,577	4,075	617,274
Total	3,150	4,427,982	15,791	9,121,255
Wrought:				
Belgium-Luxembourg	6,955	3,648,870	4,061	1,256,342
Canada	3	850	--	--
China	--	--	10	10,027
France	1,934	974,825	--	--
Germany, Federal Republic of	118	129,494	1,040	115,761
Netherlands	155	52,238	--	--
United Kingdom	144	52,500	14	23,256
Total	9,309	4,858,777	5,125	1,405,386

Table 9.—U.S. import duties for germanium metal and germanium dioxide

Item	TSUS No.	Most favored nation (MFN) Jan. 1, 1983	Most favored nation (MFN) Jan. 1, 1984	Non-MFN Jan. 1, 1983-Jan. 1, 1984
Germanium dioxide	423.00	4.4% ad valorem	4.2% ad valorem	25% ad valorem.
Metal, unwrought and waste and scrap	628.25	do	do	Do.
Metal, wrought	628.30	7.3% ad valorem	6.8% ad valorem	45% ad valorem.

WORLD REVIEW

World production was estimated at 85,000 kilograms.[21] Germanium was produced by Métallurgie Hoboken-Overpelt, Belgium; Société Minière et Métallurgique de Peñarroya, France; Societá Mineraria e Metallurgica di Pertusola S.A., Italy; Bleibergerbergwerksunion AG, Austria; and Preussag Metall AG, Federal Republic of Germany. Germanium refineries were also located in China, Japan, and the U.S.S.R.

INDIUM[22]

Indium was produced by Indium Corp. of America, Utica, NY; NJZ Alloys Inc., a joint venture of New Jersey Zinc Co. and Indium Corp., at a plant in Palmerton, PA; Williams, Wheat Ridge, CO; and The Arconium Corp., Providence, RI. Both NJZ and Williams sent their indium product to Indium Corp. for further refining and marketing. Domestic production declined in 1983, as imports continued to gain 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 primarily as a result of a general economic improvement. Usage in the categories of fusible alloys and solders was especially strong as a generally lower indium price enhanced its competitive position. Consumption for nuclear control rods remained low. Research studies continued on a broad range of possible new uses, especially for solar cells and an indium-tin oxide coating for glass. 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 price of indium initially rose and then declined during 1983. The price was \$2.60 per troy ounce at the start of the year, rose to \$3.50 per troy ounce by the end of March, then later declined in two stages to end the year at \$2.65 per troy ounce.

FOREIGN TRADE

Imports of indium-rich residues rose sharply to meet increased domestic demand. France was the leading supplier, followed by Italy and Belgium-Luxembourg.

The duty on unwrought and waste and scrap indium (TSUS 628.45) was 1.1% ad valorem for most favored nations (MFN) and 25% ad valorem for non-MFN. The duty on wrought indium (TSUS 628.50) was 6.3% ad valorem for MFN and 45% ad valorem for non-MFN. For indium compounds (TSUS 423.96), the duty was 2.5% ad valorem for MFN and 25% ad valorem for non-MFN.

Table 10.—U.S. imports for consumption of indium, by class and country

(Thousand troy ounces and thousand dollars)

Class and country	1981		1982		1983	
	Quantity	Value	Quantity	Value	Quantity	Value
Unwrought and waste and scrap:						
Belgium-Luxembourg	91	579	141	452	218	556
Canada	14	159	14	124	33	135
China	5	30	--	--	(1)	10
France	59	307	83	226	278	521
Germany, Federal Republic of	(1)	8	--	--	(1)	1
Hong Kong	--	--	--	--	(1)	12
Ireland	--	--	24	59	--	--
Italy	4	17	165	292	259	435
Japan	105	601	114	323	3	24
Netherlands	13	85	23	69	16	37
Peru	85	619	26	96	49	129
Switzerland	(1)	2	--	--	32	77
United Kingdom	65	580	95	486	182	780
Zaire	5	42	--	--	--	--
Total[2]	446	3,029	685	2,127	1,071	2,719
Wrought:						
Germany, Federal Republic of	(1)	3	--	--	(1)	1
Hong Kong	--	--	--	--	(1)	5
Ireland	(1)	2	--	--	--	--
Japan	1	7	(1)	2	1	11
Peru	10	60	--	--	--	--
United Kingdom	4	51	1	57	1	59
Total	15	123	1	59	2	76

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

WORLD REVIEW

In response to a general economic improvement, world production increased. Industry sources reported that Peñarroya, with facilities in France and Italy, emerged as a very important producer during the year. Other major world refiners included Métallurgie Hoboken-Overpelt in Belgium, Nippon Mining Co. Ltd. in Japan, and Mining and Chemical Products Ltd. in the United Kingdom.

RHENIUM[23]

Rhenium was produced by one domestic firm in 1983. Consumption of rhenium increased an estimated 49% over that of 1982 to 8,800 pounds. Imports increased from 5,369 pounds in 1982 to 6,570 pounds in 1983. The major use continued to be bimetallic platinum-rhenium catalysts to produce low-lead and lead-free gasoline. The price of rhenium decreased throughout the year, falling to $250 per pound for the metal and $200 per pound for the perrhenic acid by yearend.

Domestic Data Coverage.—Domestic consumption data for rhenium are developed by the Bureau of Mines by means of an annual voluntary domestic survey. Of the 63 operations to which a survey request was sent, 94% responded, representing an estimated 41% of the total consumption shown in table 11.

Table 11.—Salient U.S. rhenium statistics

(Pounds of contained rhenium)

	1979	1980	1981	1982	1983
Mine production	W	W	W	W	W
Consumption[e]	9,500	7,300	6,600	5,900	8,800
Imports (metal)	927	513	580	176	623
Imports for consumption of ammonium perrhenate	8,299	4,991	9,089	5,193	5,947
Stocks, Dec. 31	W	W	W	W	W

[e]Estimated. W Withheld to avoid disclosing company proprietary data.

DOMESTIC PRODUCTION

Rhenium is produced from molybdenite (MoS_2) concentrates, which are a byproduct of porphyry copper ores produced from mines located in the southwestern United States.

S. W. Shattuck Chemical Co. was the only producer of rhenium during the year. Four other producers—Kennecott, Duval Corp., M&R Refractory Metals, and Molycorp Inc.—remained idle owing to the low price for rhenium.

CONSUMPTION AND USES

During 1983, the domestic consumption of rhenium increased an estimated 49% above that of 1982 to 8,800 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 (Al_2O_3) as the support medium. The characteristics that make the platinum-rhenium reforming catalysts so attractive, when compared with the monometallic platinum catalysts, include a lower price, the ability to tolerate greater carbon accumulation, the resistance toward common poisons like sulfur, and the ability to operate at higher temperatures and lower pressures. The platinum-rhenium catalysts are easily regenerated. The regeneration of these catalysts reduces the annual demand for output of first-generation catalytic feedstock. About 93% of the rhenium and 98% of the platinum can be recovered in this process.

Of the three basic types of bimetallic reforming catalysts, the semiregenerative type accounted for about 60% of the total reforming capacity. 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 7% of the total domestic 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 and its products continued to decline. This trend began during the second half of 1980 after the price of rhenium reached a record high, which encouraged the recycling of bimetallic platinum-rhenium reforming catalysts by the oil industry. During the first quarter of 1983, the average price of rhenium metal was about \$350 per pound. By the middle of the year, the price decreased to about \$300 per pound, dropping to approximately \$250 per pound by yearend. The price of perrhenic acid was about \$300 per pound during the first quarter and decreased to about \$250 per pound by the middle of the year, falling to about \$200 per pound by the end of the year.

FOREIGN TRADE

U.S. imports for consumption of rhenium totaled 6,570 pounds, an increase of 22.4% over that of 1982. Ammonium perrhenate, with 5,947 pounds of metal content, was the main form of rhenium imported. This represents a 14.5% increase over that of 1982.

The value of these imports was \$1,130,000. About two-thirds of the imports of ammonium perrhenate originated from Chile and one-third from the Federal Republic of Germany. Imports of rhenium metal totaled 623 pounds, which represents a 254% increase over that of 1982. The value of these imports totaled almost \$180,000 and all but 10 pounds originated from the Federal Republic of Germany.

The import duty on ammonium perrhenate from countries with MFN status was 3.6% ad valorem; the import duty from countries with non-MFN status and least developed-developing countries (LDDC) was 25% and 3.1% ad valorem, respectively. The duty on rhenium metal from countries with MFN status was 4.2% ad valorem for unwrought metal and 6.8% ad valorem for wrought metal. The duty on wrought and unwrought metal from countries with non-MFN status was 45% and 25% ad valorem, respectively. For the LDDC, the duty on wrought metal was 5.5% ad valorem and on unwrought metal 3.7% ad valorem. The duty on waste and scrap had been suspended indefinitely.

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

(Rhenium content)

Country	1979		1980		1981		1982		1983	
	Gross weight (pounds)	Value	Gross weight (pounds)	Value	Gross weight (pounds)	Value	Gross weight (pounds)	Value	Gross weight (pounds)	Value
Chile	4,335	$1,380	2,049	$2,775	5,767	$2,401	4,609	$669	4,057	$712
Germany, Federal Republic of	3,898	1,854	2,721	4,720	3,322	896	584	134	1,890	419
Poland	66	25	--	--	--	--	--	--	--	--
U.S.S.R	--	--	135	229	--	--	--	--	--	--
Yugoslavia	--	--	86	165	--	--	--	--	--	--
Total	8,299	3,259	4,991	7,889	9,089	3,297	5,193	803	5,947	1,131

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

Country	1979		1980		1981		1982		1983	
	Gross weight (pounds)	Value	Gross weight (pounds)	Value	Gross weight (pounds)	Value	Gross weight (pounds)	Value	Gross weight (pounds)	Value
Belgium-Luxembourg	--	--	--	--	--	--	--	--	--	--
France	238	$97,836	100	$43,587	--	--	--	--	--	--
Germany, Federal Republic of	468	426,735	390	539,985	578	$573,009	174	$87,413	613	$174,000
U.S.S.R	220	82,594	--	--	--	--	--	--	--	--
United Kingdom	--	--	23	84,135	--	--	2	556	--	--
Other[1]	1	478	--	--	2	1,429	--	--	10	6,000
Total	927	607,643	513	667,707	580	574,438	176	87,969	623	180,000

[1]Includes Austria, Sweden, and Switzerland.

WORLD REVIEW

World production of rhenium in 1983 was estimated to be 24,800 pounds, exclusive of U.S. production. Rhenium was recovered from byproduct MoS_2 from porphyry copper deposits in Canada, Chile, Iran, Peru, the U.S.S.R., and the United States. The only exception was in the U.S.S.R., where rhenium was also recovered as a byproduct from the Dzhezkazgan sedimentary copper deposit in Kazakhstan. Rhenium metal and compounds were produced from 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 9,000 pounds of rhenium, were exported to the Federal Republic of Germany and the United States.

Chile.—Chilean production of rhenium was estimated at 7,000 pounds, the largest amount produced by a market economy country. The Corporación Nacional del Cobre de Chile continued to mine rhenium. Recovery of rhenium in Chile was done by the independent converting facility Molibdenos y Metales S.A. on a toll basis. Other rhenium resources in Chile are Los Pelambres, Quebrada Blanca, El Abra, and the Disputada de las Condes Mines.

SELENIUM[24]

An increase in domestic demand for refined selenium during 1983 was balanced by a large increase in domestic production and a reduction in imported material. A balanced supply-demand relationship for refined selenium resulted in relatively little increase in the price of selenium.

Domestic Data Coverage.—Domestic production data for selenium are developed by the Bureau of Mines from a voluntary survey of U.S. operations. The three domestic refiners of selenium responded to a survey of their stocks, primary refined production, and shipments of selenium to consumers, representing 100% of those values shown in table 14.

Table 14.—Salient selenium statistics

(Kilograms of contained selenium unless otherwise specified)

	1979	1980	1981	1982	1983
United States:					
Production, primary refined	[1]266,312	[1]140,880	251,949	242,996	353,860
Shipments to consumers	211,981	140,960	207,854	307,610	374,030
Exports, metal, waste and scrap	151,174	81,769	60,523	117,267	93,368
Imports for consumption	310,213	283,709	311,566	347,329	297,029
Apparent consumption	371,020	342,901	458,898	537,672	577,691
Stocks, yearend, producer[2]	284,473	284,394	292,558	254,210	152,790
Dealers' price, average per pound, commercial-grade[3]	[4]\$13.65-\$15.31	[4]\$10.95-\$12.66	\$4.38	\$3.53	\$3.87
World: Refinery production	1,621,167	1,271,496	1,270,834	[p]1,119,821	[e]1,326,533

[e]Estimated. [p]Preliminary.
[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.

Legislation and Government Programs.—On October 25, the EPA published proposed rules on effluent discharge limitations for existing and potential new sources that manufacture inorganic chemicals. Selenium was identified as a toxic pollutant in the waste water of plants producing cadmium salts. EPA identified 12 facilities in the United States producing cadmium compounds in this category, 5 of which produced cadmium pigments and 7 of which produced cadmium salts without associated pigment production. The proposed limitations, based on the best practical technology (BPT) standard, called for lime precipitation with clarification for heavy metals removal followed by filtration for further removal of metal hydroxides and other suspended solids. Selenium was also found in the treated waste water of one copper sulfate plant, but not in the raw waste water. The limitations would require that selenium be adequately controlled if added to the waste water during treatment.

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. Despite a decline in refined copper production from primary materials, production of refined selenium increased to its highest level in 10 years as stocks of semirefined metal were refined.

Primary selenium was recovered from both domestic and imported materials at three U.S. copper refineries: AMAX Copper Inc., at Carteret, NJ; Asarco, at Amarillo, TX; and Kennecott, at Magna, UT. Selenium-bearing copper slimes from other domestic copper refiners were either shipped to the above refineries or exported for processing. High-purity selenium metal and various selenium compounds were produced from commercial-grade metal by the three copper refineries and other processors. Phelps Dodge Refining Corp. installed selenium refining facilities at its El Paso, TX, copper refinery and reportedly was stockpiling crude selenium materials. Startup of the selenium refinery was planned for early 1984, having been delayed during 1983 owing to strike activity and low selenium prices.

During the fourth quarter, selenium production at AMAX's Carteret refinery was sharply curtailed when most of the copper refinery closed. Carteret, which use to process large quantities of No. 2 copper scrap and blister, as well as processing anode slimes from other companies, changed its emphasis to the processing of high-precious-metal-bearing scrap. Future selenium production was expected to be minimal.

Because of the high cost of processing selenium-bearing scrap relative to the low price of selenium, production of secondary selenium from scrap xerographic materials and used selenium rectifiers by two U.S. companies was discontinued during 1982. Scrap xerographic materials containing selenium were exported to Canada and the United Kingdom for processing to recover the selenium.

CONSUMPTION AND USES

Consumption of refined selenium continued to increase for the fourth consecutive year and was at its highest level since the peak year of 1974.

Domestic producers provided additional quantities of selenium to meet the increased consumption as net imports of selenium declined from that of 1982. Consumption of selenium in all major end uses increased with major increases reported for pigment and metallurgical applications. Estimated selenium consumption by end-use category was electronic and photocopier components, 33%; glass manufacturing, 27%; pigments, 20%; metallurgical applications, 7%; and other, including animal feed and chemicals, 13%.

The major electronic usages of selenium were as a photoreceptor used in the drums of plain paper electrophotographic copiers, and as a semiconductor in the production of selenium rectifiers. Although usage as the predominant photoreceptor continues to grow, selenium rectifier usage has declined, owing to the advent of low-cost silicon rectifiers.

The primary use of selenium in the glass industry was in container glass where it was used as a decolorant to compensate for the yellow-green tint imparted by ferrous ions. Selenium was finding increasing usage in architectural plate glass, where it was used in combination with cobalt oxide and iron oxide to reduce solar heat transmission.

With the improvement of the U.S. automobile and construction industries, use of selenium in cadmium sulfoselenide red pigments increased markedly above the depressed 1982 level. These pigments, which have a range of color from light orange to maroon, depending on selenium content, have good heat stability and are important colorants for plastics, glass, and ceramics.

STOCKS

In the face of strong demand and decreased primary copper refinery production, producer stocks of selenium declined sharply, as stocks of granular selenium, a semirefined form of selenium, were processed into refined products. At the 1983 rate of consumption, yearend producers' stocks represented about a 3-month supply of selenium. Consumer stocks of refined selenium at yearend were reported to be at minimum working levels.

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.

Although there was a slight price recovery during the year, with a high range of \$4.20 to \$4.50 per pound in October, the average annual price for selenium was only slightly above the 1982 value, which was the lowest in 30 years.

FOREIGN TRADE

Increased domestic production and shipments of selenium more than satisfied the increase in U.S. demand with the result that imports of selenium declined from the high level of 1982. Although Canada continued to be the largest supplier of imported selenium metal, imports from that country dropped by about 30% for the second consecutive year. Chile, which supplied 21,000 kilograms to the United States in 1982 but none in 1983, accounted for most of the remaining decline in imported selenium. Approximately 75,000 kilograms of imported selenium, primarily from the United Kingdom, was refined from scrap that had been exported from the United States for processing.

Table 15.—U.S. exports of selenium metal, waste and scrap in 1983, by country

Country	Quantity (kilograms of contained selenium)	Value
Australia	2,211	\$19,941
Belgium	1,611	24,049
Canada	1,448	23,146
Colombia	250	2,163
Germany, Federal Republic of	1,996	17,600
India	41	655
Ireland	8,375	24,955
Jamaica	100	1,488
Japan	10,048	75,287
Mexico	9,979	97,010
Netherlands	8,052	64,368
Philippines	292	6,458
Portugal	635	4,810
Switzerland	1,996	15,400
United Kingdom	46,334	393,801
Total	93,368	771,131

Table 16.—U.S. imports for consumption of selenium in 1983, by class and country

Class and country	Quantity (kilograms of contained selenium)	Value
Unwrought and waste and scrap:		
Belgium-Luxembourg	34,643	\$930,511
Canada	84,602	1,679,022
Germany, Federal Republic of	20,901	373,953
Japan	54,651	1,340,519
Peru	8,941	66,313
Sweden	853	27,096
Taiwan	1,100	8,036
United Kingdom	65,373	997,809
Total	271,064	5,423,259
Selenium dioxide:		
Germany, Federal Republic of	4,437	69,285
Sweden	142	10,514
Total	4,579	79,799
Selenium salts:		
Japan	603	5,596
Korea, Republic of	5,168	8,524
United Kingdom	150	8,550
Total	5,921	22,670
Sodium selenite:		
Canada	841	36,794
Germany, Federal Republic of	10,090	257,357
Sweden	230	4,128
United Kingdom	3,801	77,975
Total	14,962	376,254
Other selenium compounds:		
Japan	25	1,735
United Kingdom	478	18,208
Total	503	19,943
Grand total	297,029	5,921,925

Table 17.—U.S. import duties for selenium

Item	TSUS No.	Most favored nation (MFN) Jan. 1, 1983	Most favored nation (MFN) Jan. 1, 1984	Most favored nation (MFN) Jan. 1, 1987	Non-MFN Jan. 1, 1984
Selenium metal	632.40	Free	Free	Free	Free.
Selenium dioxide and salts	420.50, 420.52	do	do	do	Do.
Sodium selenite and other selenium compounds	421.625, 420.54	4.4% ad valorem.	4.2% ad valorem.	3.7% ad valorem.	25% ad valorem.

WORLD REVIEW

Estimated world production of selenium increased over the depressed 1982 level, yet fell below the estimated world demand of over 1,400 tons. Consequently, producer stocks of selenium declined.

Canada.—Production of refined selenium at Noranda Mines Ltd.'s Canadian Copper Refiners Div. (CCR) increased above 1982 levels, when production and shipments were curtailed owing to a 17-week strike. CCR operated Canada's largest selenium recovery plant at its Montreal East refinery, which 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. At least some of the material exported to the United States was refined from U.S. scrap that had been exported to Canada for processing.

Japan.—Japan was the world's largest producer of refined selenium, derived primarily from imported copper concentrates. Mitsubishi Metal 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, Sumitomo Metal Mining Co. Ltd., Nippon Mining, and Mitsui Mining and Smelting Co. Ltd., produced primary selenium.

Table 18.—Selenium: World refinery production, by country[1]

(Kilograms of contained selenium)

Country[2]	1979	1980	1981	1982[p]	1983[e]
Belgium[e]	60,000	60,000	60,000	60,000	60,000
Canada[3]	511,702	377,203	350,010	222,000	295,000
Chile	38,950	17,100	33,665	23,011	23,000
Finland	17,541	17,250	9,122	10,020	10,000
Japan	510,105	471,311	428,081	410,490	[4]433,122
Mexico	75,000	46,000	12,000	29,000	30,000
Peru	18,320	22,908	22,478	20,851	21,500
Sweden	57,000	51,000	44,000	[r e]44,000	44,000
United States	266,312	140,880	251,949	242,996	[4]353,860
Yugoslavia	46,257	45,140	35,600	[e]35,000	34,000
Zambia[5]	19,980	22,704	23,929	22,453	22,051
Total	1,621,167	1,271,496	1,270,834	1,119,821	1,326,533

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

[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 May 30, 1984.

[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 was 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]1979 data for fiscal year ending June 31, 1979; 1980 data for 9-month period ending Mar. 31, 1980; 1981-83 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 use of selenium in the microalloying of low-carbon proprietary low-alloy construction steels was reviewed in a recent paper. Relatively small additions (up to 0.35%) of selenium and/or tellurium are added to the steel to improve transverse ductility, toughness, cutability, and machinability. Recently, an addition method applicable to injection casters was devised that involves wrapping a powdered core material, such as selenium, and dispensing it from a reel in measured quantities.[25]

Researchers at the University of Washington investigated the use of selenium contained in slow-release pellets planted with Douglas Fir seedlings to inhibit deer from browsing on the seedlings. The selenium is absorbed by the roots and eliminated by the tree as dimethyl selenide gas, which has a garlic-like odor and serves to repell the deer. Browsing on the seedlings causes the trees to become deformed and results in millions of dollars in damage every year.[26]

Similarly, researchers at the University of California, Davis, experimented with the administration of selenium pellets to cattle in northern California to combat selenium-deficient feed and forage. The pellets are retained in the fore stomach where they slowly release selenium for periods estimated as long as 3 years. The pellets, manufactured in Australia, were already being used in the livestock industry there and in the United Kingdom.[27]

The National Cancer Institute in Bethesda, MD, investigated dietary cancer preventative agents. Selenium has been identified as a potential modifier of the process of carcinogenesis. Two papers presented reviews of studies concerning the toxicity of dietary selenium and its role as a cancer prevention agent.[28]

TELLURIUM[29]

Production of tellurium declined in 1983, following the continued decline in domestic copper refinery production, of which it is a byproduct. Though consumption increased over the 1982 record low, a large oversupply of tellurium continued to depress prices.

Domestic Data Coverage.—Domestic tellurium refinery production data were obtained from the only domestic producer on a voluntary survey form. To prevent disclosure of proprietary data, tellurium production data have been withheld.

Table 19.—Salient U.S. tellurium statistics[1]

(Kilograms of contained tellurium unless otherwise specified)

	1979	1980	1981	1982	1983
Refinery production	W	W	W	W	W
Shipments to consumers	W	W	W	W	W
Imports for consumption	76,095	29,420	37,953	16,602	11,829
Apparent consumption	224,080	80,685	85,202	45,978	56,639
Stocks, yearend, producer	W	W	W	W	W
Producers' price, yearend, commercial-grade	[2]$20.00	[2]$19.77	$14.00	$10.00	$9.00

W Withheld to avoid disclosing company proprietary data.
[1]World refinery production for selected countries is given in table 22.
[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 metal was recovered from copper anode slimes, a byproduct of electrolytic copper refining, by Asarco, at Amarillo, TX. AMAX discontinued production of tellurium at its Carteret, NJ, copper refinery during 1982. However, AMAX remained a major consumer of tellurium for use in tellurium copper alloys.

CONSUMPTION AND USES

Apparent consumption of tellurium increased slightly above the 1982 record low level yet remained well below the levels of prior years. The increase was due to increased consumption of tellurium by the steel industry, in response to increased steel consumption in the domestic automobile and construction industries. Tellurium consumption by end use was estimated as iron and steel products, 65%; nonferrous metals, 17%; chemicals, including rubber manufacturing, 8%; other, including xerographic and electronic applications, 10%.

Tellurium's principal use was as an alloying metal in the production of free-machining steel. The addition of up to 0.1%

tellurium improves the machinability of steel. Similarly, the addition of tellurium improves the machining characteristics and corrosion resistance of copper alloys. Tellurium catalysts have found application in various oxidation, hydrogenation, and halogenation reactions. However, the use of tellurium catalysts was greatly reduced with the closure of Oxirane Corp.'s ethylene glycol plant in 1979. Photoconductive mercury-cadmium-telluride (MCT) was 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 account for most of the detector-grade, 99.99999%, tellurium consumed in the market economy countries.

PRICES

As the oversupply of tellurium continued, quoted prices for commercial-grade tellurium continued the decline begun in 1980, following the sharp decline in consumption. The producer price for commercial-grade tellurium, quoted on a daily basis, began the year at $9.50 per pound and dropped to $9.00 per pound in July. 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 in the form of minus 40-mesh to minus 200-mesh powder containing a minimum of 75% tellurium.

FOREIGN TRADE

Despite an increase in consumption, the continued oversupply of domestic material resulted in the decline of tellurium imports to the lowest level since 1966. Data on tellurium exports were not available.

Table 20.—U.S. imports for consumption of tellurium in 1983, by class and country

Class and country	Quantity (kilograms of contained tellurium)	Value
Unwrought and waste and scrap:		
Belgium	992	$17,870
Canada	9,461	540,080
Germany, Federal Republic of	2	343
Japan	95	5,574
U.S.S.R	9	10,500
United Kingdom	1,001	27,419
Total	11,560	601,786
Compounds:		
Canada	215	5,533
Germany, Federal Republic of	4	1,378
Japan	([1])	887
United Kingdom	50	12,064
Total	269	19,862
Grand total	11,829	621,648

[1]Less than 1/2 unit.

Table 21.—U.S. import duties for tellurium

Item	TSUS No.	Most favored nation (MFN)			Non-MFN
		Jan. 1, 1983	Jan. 1, 1984	Jan. 1, 1987	Jan. 1, 1984
Tellurium metal	632.48	2.0% ad valorem.	1.5% ad valorem.	Free	25% ad valorem.
Compounds	421.90	4.4% ad valorem.	4.2% ad valorem.	3.7% ad valorem.	Do.

WORLD REVIEW

Belgium.—Métallurgie Hoboken-Overpelt began production from its new facilities for recovering tellurium from lead refinery wastes. The plant has an estimated capacity of 75 tons per year of tellurium.

Canada.—Noranda Mines was Canada's principal producer of tellurium at its CCR Div., which refines anode copper from three Canadian smelters. Tellurium was recovered from the anode slimes, which contain about 2% tellurium. Production of tellurium increased markedly above 1982 levels, when a 17-week strike curtailed production.

Cominco is the leading world producer of high-purity tellurium at its plant in Trail, British Columbia. To meet the growing demand for detector-grade tellurium for infrared sensors, Cominco has reportedly greatly increased its tellurium refining capacity over the past 2 years.

Table 22.—Tellurium: World refinery production, by country[1]

(Kilograms of contained tellurium)

Country[2]	1979	1980	1981	1982[p]	1983[e]
Canada[3]	47,204	8,974	21,297	18,000	24,000
Fiji	[e]22,700	11,350	--	--	--
India[4]	--	200	220	[e]220	200
Japan	55,500	68,700	61,700	62,800	65,000
Peru	21,233	20,920	21,310	20,726	21,700
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 May 30, 1984.

[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

Researchers at the University of Delaware investigated the use of tellurium in hydrodenitrogenation catalysts to be used in the processing of heavy petroleum crudes and derived crudes such as shale oil and tar sand crude. Their research, which was specifically devoted to the removal of nitrogen from shale oil, reportedly showed that tellurium can produce a 10% improvement in performance when added as a promoter to the usual cobalt-molybdenum oxide catalyst.[30]

A report to the National Materials Advisory Board assessed MCT materials technology. MCT semiconductors are one of the most important semiconductors for Department of Defense and National Aeronautics and Space Administration applications. It is the principal material used for infrared detection systems. Department of Defense research was placing emphasis on developing the technology to produce larger arrays containing greater numbers of detectors in the field of view.[31]

THALLIUM[32]

Historically, the commercial domestic source for the production of thallium was flue dusts and residues from the smelting of certain zinc ores. During 1983, however, no domestic operations recovered thallium.

Domestic Data Coverage.—Domestic production data for thallium are developed by the Bureau of Mines from a voluntary survey of U.S. operations, but no domestic producers were in operation.

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 switches, high-density liquids, alloys, photosensitive devices, and radioactive isotopes for cardiovascular diagnostic procedures. Domestic requirements for thallium were met by imports and withdrawals from stocks.

PRICES

Metal traders reported that the price of imported thallium metal ranged from \$35 to \$45 per pound depending on the purity of the metal.

WORLD REVIEW

World production data for thallium were not available. The U.S. reserves in zinc ores were estimated at 70,000 pounds. Rest-of-world reserves were estimated to be 750,000 pounds of thallium.

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[1]Prepared by Daniel Edelstein, physical scientist.
[2]Federal Register. National Emission Standards for Hazardous Air Pollutants, Proposed Standards for Inorganic Arsenic. V. 48, No. 140, July 20, 1983, pp. 33112-33180.
[3]———. Special Program of Payment in Kind for Acreage Diversion for 1983 Crops of Wheat, Corn, Grain Sorghum, Upland Cotton and Rice, Interim Rule. V. 48, No. 8, Jan. 12, 1983, pp. 1476-1479.
[4]———. Special Program of Payment in Kind for Acreage Diversion for 1983 Crops of Wheat, Corn, Grain Sorghum, Upland Cotton and Rice, Final Rule. V. 48, No. 44, Mar. 4, 1983, pp. 9233-9235.
[5]———.Inorganic Chemicals Manufacturing Point Source Category; Effluent Limitations Guidelines, Pretreatment Standards, and New Source Performance Standards; Proposed Rule. V. 48, No. 207, Oct. 25, 1983, pp. 49408-49435.
[6]Lederer, W. H., and R. J. Fensterheim (eds.). Arsenic—Industrial, Biomedical, Environmental Perspectives. Van Nostrand Reinhold Co. Inc., New York, 1983, pp. 72-88.
[7]Precious Metals. V. 7, No. 6, June 1983, p. 2.
[8]Copper Studies. V. 1, No. 5, Nov. 1983, p. 9.
[9]Bloom, P. A., J. H. Maysilles, and H. Dolezal. Hydrometallurgical Treatment of Arsenic-Containing Lead-Smelter Flue Dust. BuMines RI 8679, 1982, 12 pp.
[10]Madsen, B. W., and D. A. Martin. Selective Recovery of Arsenic From Aqueous Solutions With Hydrated Titanium Dioxide. BuMines RI 8756, 1983, 8 pp.
[11]American Metal Market. Harris Has First Commercial IC'S Based on Gallium Arsenide. V. 92, No. 35, Feb. 20, 1984, p. 21.
[12]Japanese IC Makers Eye Markets for GaAs Parts. Electron., v. 54, No. 15, July 23, 1983, p. 98.
[13]Defense Advanced Research Projects Agency. Statement of Work for Low Power, Radiation Hard GaAs LSI Pilot Line.
[14]Prepared by W. Timothy Adams, physical scientist.
[15]Chemical Engineering. Chementator. V. 91, No. 3, Feb. 6, 1984, p. 11.
[16]Prepared by Patricia A. Plunkert, physical scientist.
[17]Musto Explorations Ltd. Press release, Nov. 17, 1983, 2 pp.; available from Musto Explorations Ltd., Vancouver, British Columbia, Canada.
[18]Mining Journal (London). Musto To Go Ahead With Apex. V. 301, No. 7737, Dec. 2, 1983, pp. 395-396.
[19]American Metal Market. Fiber Optic Route Added. V. 91, No. 75, Apr. 18, 1983, p. 25.
[20]———. AT&T Playing Major Role in \$335 Million Trans-Atlantic System Employing Fiber Optics. V. 91, No. 226, Nov. 18, 1983, p. 1.
[21]Adams, J. H. Germanium. Eng. and Min. J., v. 185, No. 3, Mar. 1984, pp. 99-100.
[22]Prepared by James F. Carlin, Jr., physical scientist.
[23]Prepared by John W. Blossom, physical scientist.
[24]Prepared by Daniel Edelstein, physical scientist.
[25]Selenium-Tellurium Development Association Inc. Microalloying with Selenium and Tellurium. Bull. 25, p. 1.
[26]———. Selenium as a Preventive for Deer Browse. Bull. 24, p. 4.
[27]Page 3 of work cited in footnote 26.
[28]Buell, D. N. Potential Hazards of Selenium as a Chemoprevention Agent. Seminars in Oncology, v. 10, No. 3, Sept. 1983, pp. 311-321.
Helzlsouer, K. J. Selenium and Cancer Prevention. Seminars in Oncology, v. 10, No. 3, Sept. 1983, pp. 305-310.
[29]Prepared by Daniel Edelstein, physical scientist.
[30]Page 2 of work cited in footnote 2.
[31]National Materials Advisory Board. Assessment of Mercury-Cadmium-Telluride Materials Technology. Natl. Acad. Press, NMAB-377, 1982, 193 pp.
[32]Prepared by Patricia A. Plunkert, physical scientist.

Table 23.—U.S. imports for consumption of thallium in 1983, by country

Country	Compounds			Unwrought and waste and scrap	
	Gross weight (pounds)	Content[e] (pounds)	Value	Gross weight (pounds)	Value
Belgium-Luxembourg	631	505	\$10,876	1,540	\$25,839
Canada	--	--	--	2	963
Germany, Federal Republic of	235	188	18,062	11	667
Japan	661	529	9,484	--	--
Sweden	--	--	--	2	732
U.S.S.R	2	1	132,766	2	247,941
United Kingdom	24	19	842	--	--
Total	1,553	1,242	172,030	1,557	276,142

[e]Estimated.

Table 24.—U.S. import duties for thallium

Item	TSUS No.	Most favored nation (MFN)		Non-MFN
		Jan. 1, 1983	Jan. 1, 1984	Jan. 1, 1983-Jan. 1, 1984
Unwrought metal	632.50	2.5% ad valorem	1.9% ad valorem	25% ad valorem.
Compounds	422.00	4.4% ad valorem	4.2% 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.

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, roofing compounds, etc.[2]

Data on quantity and value of bituminous limestone produced are not available to the Bureau of Mines. Data on gilsonite production and value available to the Bureau of Mines are withheld to avoid disclosing company proprietary data.

GREENSAND[3]

Greensand (glauconite), a natural silicate of potassium, aluminum, iron, and magnesium, continued to be produced only by Inversand Co., a subsidiary of Hungerford and Terry Inc., near Clayton, NJ. 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. A secondary product of 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[4]

Imports for consumption of crude or block meerschaum, 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 the material probably consisted of shaped or formed meerschaum blocks. In 1982, crude or block meerschaum imports were from Somalia and the United Kingdom. The Federal Republic of Germany was the major supplier in previous years.

Crude or block meerschaum continued to be mined chiefly in Somalia, Tanzania, and Turkey. The block material was used by companies in New York and Ohio for manufacturing smokers' pipes. Turkish production was estimated to be 200 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[5]

Although reported annual production, exports, and consumption of cultured quartz crystal declined moderately, industry representatives indicated that a turnaround occurred during the final quarter, with production nearing full capacity at yearend. Lascas mine production from Arkansas increased significantly owing to increasing market shares in Japan and the United States, the two major market economy producers of cultured quartz crystal. Lascas imports from Brazil declined substantially during the year primarily as a result of competition from the U.S. source. Domestic consumption of natural quartz crystal continued at relatively low levels because most of the quartz crystal consumed was cultured.

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, 100% responded, representing the total production shown in table 1. Of the 27 operations that consumed quartz crystal, 25 responded, representing approximately 100% of total consumption, also shown in table 1. Consumption for the two nonrespondents 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)

	1979	1980	1981	1982	1983
Production:					
Mine[e] [1]	314	400	175	200	600
Cultured	575	757	660	478	426
Exports:					
Natural:[2]					
Quantity	NA	91	127	69	28
Value	NA	$366	$490	$380	$156
Cultured:[2]					
Quantity	NA	219	125	115	80
Value	NA	$3,209	$4,600	$3,500	$3,258
Lascas:[3]					
Quantity	NA	NA	NA	NA	339
Imports of Brazilian lascas:[2]					
Quantity	428	816	389	417	153
Value	$216	$402	$233	$245	$121
Consumption:					
Natural (electronic- and optical-grade)	15	17	14	16	13
Cultured (lumbered)	NA	393	282	99	112
Cultured (as grown)	269	[r]372	[r]327	[r]383	312
Total	NA	[r]782	[r]623	[r]498	437

[e]Estimated. [r]Revised. NA Not available.
[1]Includes primarily lascas with some specimen and jewelry material.
[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 2.1 million pounds, of which 1.47 million pounds of stockpile-grade quartz crystal was excess to the stockpile goal. Total sales of natural quartz crystal by the General Services Administration was 4,000 pounds.

The Federal Emergency Management Agency awarded a contract to the National Materials Advisory Board (NMAB), which was part of the National Academy of Sciences. NMAB planned to reassess quartz requirements for the National Defense Stockpile.

DOMESTIC PRODUCTION

Various grades of lascas, the nutrient feedstock for growing cultured quartz, were produced in Jessieville, AR, by Coleman Crystal Inc., the major U.S. producer. Production estimates increased substantially owing to increased sales to crystal growers in Japan and the United States. Reasons for the market gain were reliability of supply, consistency of material quality, and a slightly lower price than that of Brazilian material.

Geomex Mines Services Inc. purchased the old Coleman Mine, which previously had been mined for gem stones, and began selling various grades of lascas from the mine by yearend.

Production of cultured quartz crystal declined by 11%. However, during the final quarter of the year, demand increased sharply and production approached full capacity.

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 consumption by the crystal-device-fabrication industry. Motorola Inc., Chicago, IL, produced for both internal consumption and the domestic fabrication industry. The other four growers, AT&T Technologies Inc., North Andover, MA; Bliley Electric Co., Erie, PA; Electro Dynamics Corp., Shawnee Mission, KS; and P. R. Hoffman Co., Carlisle, PA, produced only for internal consumption.

In a major industry development, Sawyer Research, Eastlake, OH, a subsidiary of Brush Wellman Inc., Cleveland, OH, was sold to a domestic investor group for $6.5 million. Brush Wellman received $3 million in cash and a $3.25 million note at the closing, and there were post-closing adjustments.[6]

CONSUMPTION AND USES

U.S. consumption of lascas by the seven growers was 677,000 pounds, a 27% increase from the 533,000 pounds reported in 1982.

Twenty-seven companies in eleven States consumed quartz crystal. Of these companies, 18 consumed only cultured quartz crystal, 1 consumed only natural quartz crystal, and 8 consumed both natural and cultured material.

Reported total domestic consumption of both natural and cultured electronic- and/or optical-grade quartz was approximately 12% less than that of 1982.

Cultured quartz continued to be widely used by the piezoelectric industry in filters, oscillators, and signal processors. The equipment markets for these devices were military, aerospace, and commercial, with the latter including industrial, automotive, and specialty consumer markets. Examples of equipment that used cultured quartz devices include weapons systems, radar, cellular telephones, paging equipment, radios, watches, clocks, video games, computers, and automobiles.

Imported natural quartz was used 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 and natural electronic- and optical-grade stocks of quartz crystal totaled approximately 116,000 pounds at the beginning of the year and declined to approximately 90,000 pounds by yearend. The decline was attributed to increased sales during the fourth quarter. The yearend total included 37,000 pounds of natural and 53,000 pounds of cultured crystal.

PRICES

The average reported value of lascas consumed for production of cultured quartz crystal was $0.62 per pound, 2 cents per pound below that of 1982. The average value for cultured quartz crystal, based on reported sales of 198,940 pounds, was $42.88 per pound, down about 3% from that of 1982. Based on total sales, the average value of grown crystal decreased 27% to $21.84 per pound, and that for lumbered crystal increased 7% to $49.12 per pound.

FOREIGN TRADE

The two independent quartz crystal growers continued to export significant quantities of cultured material to foreign markets. Japan received 51%, the Republic of Korea received 21%, and the Federal Republic of Germany received 7% of the total exports reported by the Bureau of the Census.

Most of the natural crystal exported was later consumed in nonpiezoelectric uses such as quartz carvings and figurines.

Imports of Brazilian lascas, designated "Crude Brazilian Pebble," declined significantly as U.S. quartz growers relied more heavily on domestic sources.

This was the first year that lascas export figures were obtained.

STAUROLITE[7]

Staurolite is a naturally occurring, complex, hydrated aluminosilicate of iron having a variable but uncertain composition. Its formula can be generalized as $Fe_2Al_9Si_4O_{22}(OH)_2$. 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 1983 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 iron and nonferrous foundries, owing to its low thermal expansion, high thermal conductivity, and high melting point. It is also used 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 1983 production of staurolite increased 5% over that of 1982; shipments decreased 2% in tonnage and 4% in price per short ton. Domestic productive capacity remained at about 135,000 short tons per year. However, an improvement in the proportion recovered was considered to be possible.

Staurolite had been produced in India in small quantities and sometimes by other nations as well.

STRONTIUM[8]

The U.S. strontium industry experienced a major restructuring during 1983. FMC Corp., for many years the leading domestic producer of strontium compounds, announced plans to terminate production of these compounds by closing its strontium plant in 1984.

Japan and the United States remained the world's leading consumers of strontium compounds. Domestic consumption of primary strontium on a carbonate equivalent basis ($SrCO_3$) increased by 28%. Imports of celestite, the commercial mineral form of strontium, recovered from the 1982 recession level.

For the second year, Spain surpassed Mexico as the largest world supplier of strontium minerals.

Domestic Data Coverage.—Domestic consumption data for strontium minerals 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, all responded, representing 100% of total production.

The Strontium survey is also used to calculate the distribution of primary strontium compounds by end use. Of the 14 operations to which a survey request was sent, 93% responded, representing 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 1983

Company	Location	Compounds
Barium and Chemicals Inc	Steubenville, OH	Various.
Chemical Products Corp	Cartersville, GA	Carbonate.
FMC Corp	Modesto, CA	Carbonate and nitrate.
Mallinckrodt Inc	St. Louis, MO	Various.
Milwhite Co. Inc	Houston, TX	Sulfate.
Mineral Pigments Corp	Beltsville, MD	Chromate.

DOMESTIC PRODUCTION

Strontium minerals had not been produced commercially in the United States since 1959. However, a number of firms produced strontium compounds from imported celestite.

CONSUMPTION AND USES

Domestic consumption of strontium in the manufacture of various strontium compounds increased 28% to 34,313 short tons of $SrCO_3$ equivalent from the revised 1982 figure of 26,755 tons. The recovery was led by increased sales of strontium chemicals for color television picture tubes.

The major domestic industry development of 1983 was the announcement by FMC of plans to close its plant at Modesto, CA, and terminate its barium and strontium chemicals business by mid-1984. The decision was apparently prompted by continued losses resulting from increased foreign competition and shrinking domestic markets. In related industry news, Chemical Products Corp., Cartersville, GA, the other major strontium compounds producer, planned to expand its $SrCO_3$ production capacity in 1984 to meet any shortfall in supply precipitated by FMC's pullout.[9]

Television picture tube manufacture continued as the major end use for strontium compounds in the United States. Screen glass contained up to 7% strontium oxide, which limits X-ray emission during picture generation.[10]

Pyrotechnics and signals continued as the second largest end use. Pyrotechnics employed strontium nitrate, which imparts a brilliant red color to a flame. Strontium nitrate was manufactured from $SrCO_3$. Strontium pyrotechnics were used in military and civilian signal flares as well as in fireworks for entertainment.

$SrCO_3$ was used in ferrite ceramic magnets, which have a high magnetic coercivity and are used for automobile windshield wiper motors, heater motor fans, many home appliance motors, and loudspeakers.

Strontium chromate was used as a corrosion inhibitor in pigments. Although one of the major domestic producers discontinued manufacturing strontium pigments, other manufacturers made up for most of the lost production, and strontium consumption in this application declined only slightly during the year.

Another significant use of $SrCO_3$ was in the electrolytic production of high-purity zinc, in which it may be added to the electrolyte to promote the elimination of lead from the zinc cathode.

Small quantities of strontium were used in drilling muds, fluorescent lights, toothpaste, plastics, electronic components, pharmaceuticals, and welding fluxes. Small quantities of strontium metal were produced by research companies.

Table 3.—U.S. distribution of primary strontium compounds, by end use

(Percent)

End use	1981	1982	1983
Electrolytic production of zinc	4	3	4
Ferrite ceramic magnets	5	7	5
Pigments and fillers	4	4	3
Pyrotechnics and signals	15	15	14
Television picture tubes	65	62	64
Unidentified	7	9	10
Total	100	100	100

PRICES

The average value of imported strontium minerals at U.S. ports was $74.42 per ton, or $12.23 more than that of 1982. Prices for strontium minerals are usually determined by direct negotiations between buyer and seller and are seldom published.

FOREIGN TRADE

Imports for consumption of strontium minerals increased to slightly higher than those of 1981. Mexico, with 94% of the import market, and Spain provided all of the 1983 imports.

For the second consecutive year, imports for consumption of strontium compounds and metal declined significantly; the leading U.S. suppliers were, in descending order, the Federal Republic of Germany, Italy, France, and Canada.

Table 4.—U.S. imports for consumption of strontium minerals, by country

Country	1982		1983	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Canada	74	$7	--	--
Mexico	32,992	2,042	47,007	$3,080
Spain	9	8	2,789	626
Total	33,075	2,057	49,796	3,706

Source: Bureau of the Census.

Table 5.—U.S. imports for consumption of strontium compounds and metal, by country

Country	1982		1983	
	Pounds	Value	Pounds	Value
Strontium carbonate, not precipitated:				
Germany, Federal Republic of	--	--	39,683	$11,047
United Kingdom	34	$1,745	38	3,764
Total	34	1,745	39,721	14,811
Strontium carbonate, precipitated:				
Germany, Federal Republic of	2,864,676	797,280	938,007	290,620
Netherlands	3,120	3,010	--	--
United Kingdom	12	1,864	5,143	8,007
Total	2,867,808	802,154	943,150	298,627
Strontium chromate:[1]				
Canada	462,815	634,893	53,010	59,131
France	27,006	27,714	235,284	240,994
Germany, Federal Republic of	14,318	10,427	3,337	5,588
Poland	35,274	21,199	--	--
Spain	--	--	28,660	31,034
United Kingdom	228	2,073	10,155	10,788
Total	539,641	696,306	330,446	347,535
Strontium nitrate:				
Germany, Federal Republic of	1,228	5,774	--	--
Italy	363,200	136,160	815,414	351,230
Spain	41,887	14,007	45,194	15,622
United Kingdom	13	874	--	--
Total	406,328	156,815	860,608	366,852
Strontium compounds, n.s.p.f.:				
France	4,000	5,040	--	--
Germany, Federal Republic of	8,973	16,523	18,963	21,132
Japan	44,092	32,693	24,246	13,698
Netherlands	--	--	366	4,453
Spain	--	--	39,683	14,028
United Kingdom	771	1,273	16,983	21,411
Total	57,836	55,529	100,241	74,722
Strontium metal, unwrought: Canada	14,633	137,070	1,991	22,790
Grand total	3,886,280	1,849,619	2,276,157	1,125,337

[1]Imported as strontium chromate pigment (TSUS 473.19).

Source: Bureau of the Census.

WORLD REVIEW

Deposits of strontium minerals are found in many parts of the world, but approximately 89% of estimated world production was from, in descending order, Spain, Mexico, the United Kingdom, and Turkey. Spain was the largest producer of strontium minerals for the second consecutive year.

In Japan, television picture tubes, the largest Japanese market for $SrCO_3$ fell by 16% to 25,000 tons of $SrCO_3$ in 1982. Demand in the ferrite magnet sector fared just as poorly. Total consumption of $SrCO_3$ fell 22% in 1982 to 6,000 tons. There was a substantial shift by stereo equipment manufacturers to substitute barium carbonate magnets for the higher priced strontium carbonate types.[11]

Table 6.—Strontium minerals: World production, by country[1]

(Short tons)

Country[2]	1979	1980	1981	1982[p]	1983[e]
Algeria[e]	[3]3,200	[r]3,300	[r]3,300	[r]3,300	3,300
Argentina	134	295	342	855	880
Iran[e 4]	[r]9,700	[r]6,100	[r]5,500	[r]5,000	5,500
Italy	1,866	1,161	7,382	3,607	3,300
Mexico	43,562	44,931	45,574	34,917	33,000
Pakistan	747	276	325	300	330
Spain	19,842	20,944	39,683	38,500	38,600
Turkey[e]	19,800	17,600	16,500	16,500	16,500
United Kingdom	6,724	7,386	16,000	19,800	19,800
Total	[r]105,575	[r]101,993	134,606	122,779	121,210

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through May 30, 1984.
[2]In addition to the countries listed, China, the Federal Republic of Germany, 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]Reported figure.
[4]Year beginning Mar. 21 of that stated.

WOLLASTONITE[12]

Wollastonite is a natural calcium metasilicate, usually white or light colored, and has a theoretical composition of $CaO \cdot SiO_2$, equivalent to 48.3% lime combined with 51.7% silica. Over the years, wollastonite has become a useful filler in ceramics, plastics, paints, resins, and other materials.

Domestic production data for wollastonite are developed by the Bureau of Mines by means of a voluntary domestic survey. All three active mines responded, representing 100% of total production.

The tonnage of wollastonite sold or used in the United States in 1983 decreased 3%. Specific data are withheld to avoid disclosing company proprietary data. The three producers 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.

A study by C. H. Kline & Co. indicated that wollastonite use as a plastics filler was projected to increase about 14% annually from 8 million to 23 million pounds between 1980 and 1988. Wollastonite is one of several surface-treated functional minerals offered by NYCO for use as a filler in plastics and resins.[13]

The Finnish company Oy Partek AB entered into a joint agreement with the state-owned Sudanese Mining Corp. to exploit a 500,000-short-ton wollastonite deposit at Dirbat, in the Sudan, 90 miles northwest of Port Sudan. Detailed investigations financed by Finland were being carried out in cooperation with the Geological and Mineral Resources Department of the Sudan. The deposit was estimated to contain ore with an average wollastonite content of 71%, and the ore was to be used in both local and export markets.[14]

In India, wollastonite production had grown substantially from 4,380 tons in 1979 to 6,380 tons in 1980 and 17,560 tons in 1981. Wolkem Pvt. Ltd., the main producer, produced a variety of grades for domestic uses (ceramics, insecticides, etc.) and for export, mainly to Europe.[15]

Chemical Marketing Reporter and the American Paint & Coatings Journal, at yearend 1983, quoted the price of paint-grade wollastonite, 400-mesh, bagged, in carload lots, f.o.b. works, as $134 per ton, and 325-mesh material as $117 per ton.

ZEOLITES[16]

Production of natural zeolites in the United States in 1983 remained at about 5,000 short tons. Market development activities remained high, but sales were mostly sporadic and to diverse markets. The largest single sale was made by Phelps Dodge Zeolite Co., formerly Occidental Petroleum Co., from its Barstow, CA, mine, to British Nuclear Industries Inc. The Anaconda Company laid off its zeolite sales and research staff during the first part of the year.

Teague Mineral Products Co. developed the capacity to grind 25 tons per day of a 10-micrometer product suitable for use as a filler for plywood glue, as a paint filler, and possibly as a replacement for synthetic zeolites in detergent.[17] The use as a filler in plywood glue was being patented and was expected to reduce delamination, the largest cause of product rejection and which occurs when water vapor or ammonia is released from the glue.

An animal nutrition periodical reported that swine fed clinoptilolite as 10% of their diet experienced, from age 29 days to 60 days, a 34% increase in the weight-gain-to-feed ratio and deposited 24% less body fat.[18]

According to a Soviet technical journal, crushed clinoptilolite rock, when replacing the quartz in rapid quartz filters, was more effective than quartz in removing iron, aluminum, phytoplankton, bacteria, and other pollutants from industrial waste waters.[19]

Leonard Minerals Co. incorporated its zeolite operations to form the Zeotech Corp., which offered a variety of granules and powders for agricultural and chemical carrier uses. Their Turflite product, for example, could improve the water retention capacity of sand from 18% to 25% when present as 20% of the mixture.

The possibility of a health hazard related to zeolite continued to receive attention. An industry magazine reported that both asbestos and erionite were found in the lungs of mesothelioma victims in Turkey and that both were elongate minerals.[20] A National Institute of Occupational Safety and Health official was quoted as saying that the small numbers of workers and their relatively short-term exposure to natural zeolites did not provide a meaningful basis for an in-depth investigation.

A complete description of the Neapolitan yellow tuff in Italy was given in an industrial minerals periodical.[21] This deposit was used for dimension stone from at least Roman and Grecian days as well as for pozzolan in pozzolanic cements. It is uniquely monozeolitic and is over 50% phillipsite. The bed has good hardness and high-packed density. The 2.37 milli-equivalent-per-gram exchange capacity of a 30- to 50-mesh sample was notable.

Science magazine announced that research on zeolite characterization will be among the activities of a new advanced materials center.[22] The research will be headed by Heinz Heinemann, at the new National Center for Advanced Materials to be located at the Lawrence Berkeley Laboratory in California.

A technical magazine article predicted that the 1980 market of 162,500 tons of zeolite would increase 52% to 247,500 tons by 1985, and the 1980 market of 123,000 tons of zeolite used in detergents would increase 62% to 200,475 tons for the same period.[23] That prediction, however, must be viewed in light of a chemical magazine article published 1 month later that reported that the Proctor & Gamble Corp. had removed zeolites as an ingredient of its most popular brands of detergents, Cheer and Tide.[24] Previously, zeolite made up 16% to 18% of the formulation for these detergents.

According to a report on the current status of the synthetic zeolite industry in Western Europe, several nations have imposed restrictions on the use of phosphates in detergents.[25] However, based on selected European countries' capacity to produce detergent zeolite, a large detergent market is anticipated. Zeolites for adsorption uses were estimated to have a total market of only 12,000 to 15,000 tons per year in Western Europe.

Table 7.—Detergent zeolite capacity in selected European countries, by company

Country and company	Annual capacity (short tons)	Status
France:		
Pechiney Ugine Kuhlmann-Rhône-Poulenc S.A	8,000	NA.
Germany, Federal Republic of:		
Degussa	65,000	On-stream.
Henkel	65,000	Do.
Italy:		
Degussa	30,000	Planned.
Mira Lanza	NA	Do.
Montedison S.p.A	3,000	NA.
Do	25,000	Planned.
Netherlands:		
Akzo	5,000	On-stream.
Zinkwit-Crosfield	NA	NA.

NA Not available.

Western Europe's use of zeolite fluid-bed cracking catalysts has increased greatly but demand lags behind production capacity. Total capacity of the four manufacturing plants, one each in the Federal Republic of Germany and the United Kingdom and two in the Netherlands, is 110,000 tons per year. Even with an expected market of 40,000 to 50,000 tons per year in 1985 and shipment of 20,000 tons yearly to the Middle East and South America, there is excessive capacity.

There was reported use of 800 kilograms of zeolite in a tank used as a prototype heat storage unit in a single-family dwelling. Storage capacity was sufficient to keep a well-insulated house warm for a week. Analysis of gathered data indicates the capability of a 30% increase in capacity as the unit acts as a heat pump. Regeneration can be accomplished using offpeak power.

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[1]Prepared by Wilton Johnson, mineral specialist.

[2]Jackson, D. (ed.) American Gilsonite: Mining Solid Hydrocarbon. Eng. and Min. J., v. 180, No. 7, July 1981, pp. 88-91.

[3]Prepared by James P. Searls, physical scientist.

[4]Prepared by Sarkis G. Ampian, physical scientist.

[5]Prepared by John E. Ferrell, physical scientist.

[6]The Wall Street Journal. Brush Wellman Finishes Sale of Quartz Line for $6.5 Million. Nov. 8, 1983, p. 28.

[7]Prepared by Harold A. Taylor, Jr., physical scientist.

[8]Prepared by John E. Ferrell, physical scientist.

[9]Chemical Week. FMC Drops Two Product Lines. V. 133, No. 4, July 27, 1983, p. 17.

[10]Roskill Information Services Ltd. (London). The Economics of Strontium. 3d ed., 1982, 62 pp.

[11]———. Roskill's Letter From Japan. RW No. 89, Sept. 1983, p. 16.

[12]Prepared by Michael J. Potter, physical scientist.

[13]Chemical Marketing Reporter. Plastic Fillers Seen Gaining. V. 223, No. 25, June 20, 1983, pp. 3, 25-26.

[14]Industrial Minerals (London). Company News & Mineral Notes. No. 191, Aug. 1983, p. 98.

[15]Clarke, G. M. The Industrial Minerals of India. Ind. Miner. (London), No. 191, Aug. 1983, p. 45.

[16]Prepared by Robert A. Clifton, physical scientist.

[17]Industrial Minerals (London). Teague Begins Micronizing of Zeolites. No. 186, Mar. 1983, pp. 16-17.

[18]Cool, W. M., and J. M. Willard. Effect of Clinoptilolite on Swine Nutrition. Nutr. Rep. Int., v. 26, No. 5, pp. 759-766.

[19]Rudenko, G. G., Y. I. Tarasevich, V. A. Kravehenko, and A.G. Sidorovich. Experience in Using Clinoptilolite as a Filtering Material for Rapid Filters at an Industrial Water Treatment Plant. Khim. Tekhnol., Vody, v. 5, No. 1, 1983, pp. 54-55 (Russ.).

[20]Chemical Week. Early Health Warnings Over Exposure to Zeolites. V. 133, No. 75, Aug. 3, 1983, p. 25.

[21]De'Gennaro, M., C. Collelo, E. Franco, and R. Aeillo. Italian Zeolites. Mineralogical and Technical Features of Neapolitan Yellow Tuff. Ind. Miner. (London), No. 186, Mar. 1983, pp. 47-53.

[22]Robinson, A. L. Berkeley Advanced Materials Center Ok'd. Science, v. 219, No. 4586, Feb. 1983, pp. 827-828.

[23]High Technology. R&D May Add Fuel to Zeolite Boom. V. 3, No. 7, July 1983, p. 63.

[24]Chemical Week. Technology Newsletter—Greasing the Skids for Zeolites. V. 133, No. 6, Aug. 10, 1983, p. 53.

[25]European Chemical News. Zeolites in West Europe. V. 41, No. 1106, Nov. 1983, p. 18.

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-nine monthly, quarterly, semiannual, and annual surveys cover the entire mineral economic cycle from production to trade and consumption.

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 847-380

Figure 1.—A typical survey form.

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 Liaison Officers, State geologists, Federal organizations (e.g., Mine Safety and Health Administration (MSHA), 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.

SURVEY PROCESSING

The 169 surveys yield more than 70,000 responses from approximately 30,000 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 for 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 verbally. Periodic visits to important minerals establishments are also made by Bureau commodity specialists or State Liaison Officers. These visits are made to gather missing data and also to point out the importance of the companies' reporting to the production of accurate national as well as State and county statistics. By showing the use of these statistics and the impact of nonresponse, the Bureau hopes to encourage as complete and accurate a canvass as possible.

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

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

Protection of Proprietary Data.—The Bureau of Mines relies on the cooperation of the U.S. minerals industry to provide the minerals data that are presented in this and other Bureau publications. Without substantial response to survey requests, the Bureau would not be able to present reliable statistics. The Bureau in turn respects the proprietary nature of the data received from 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 Foreign Data. 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.

"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 Data Source Directory, January 1983" (Bureau of Mines Information Circular 8935) is a compilation of information on the availability, content, and location of minerals data in the Federal Government. Included in the directory are descriptions of data bases, publications, information systems, and information offices having data pertaining to all aspects of mineral production, consumption, trade, and related information.[1]

For additional information on Bureau publications, contact the Division of Publication, U.S. Bureau of Mines, 2401 E Street, NW, Washington, DC 20241.

The Bureau also makes available its survey mailing lists, which include the company and plant names, Standard Industrial Classification (SIC) codes, and the addresses to which the survey forms are mailed. Information on purchasing copies of these lists can be obtained from the Division of Minerals Information Systems, U.S. Bureau of Mines, 2401 E Street, NW, Washington, DC 20241.

[1]Available from Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402. Stock number 024-004-022116-1, price $9.50.

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