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Bureau of Mines

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Minerals Yearbook

CENTENNIAL EDITION 1981

Volume I

METALS AND MINERALS

Prepared by staff of the

BUREAU OF MINES

UNITED STATES DEPARTMENT OF THE INTERIOR • James G. Watt, 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.

U.S. GOVERNMENT PRINTING OFFICE

WASHINGTON : 1982

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Foreword

This edition of the Minerals Yearbook marks the centennial of the first annual publication of comprehensive mineral industry statistics by the Federal Government. The need for complete, reliable mineral statistics on a regular basis was recognized in 1880, when Clarence King, then Director of the United States Geological Survey, stated in his annual report:

"As a whole it is true, and can never be refuted, that the Federal Government alone can successfully prosecute the noble work of investigating and making known the natural mineral wealth of the country, current modes of mining and metallurgy, and the industrial statistics of production."

In reponse to this suggestion the Forty-seventh Congress, in an appropriations act of August 7, 1882 (22 Stat. 329), placed collection of mineral statistics on an annual basis, stating in the act that". . . not to exceed ten thousand dollars of the amount appropriated in this paragraph may be applied under the direction of the Secretary of the Interior to the procuring of statistics in relation to mines and mining other than gold and silver . . ."

Data on minerals production for 1882, collected under this appropriation, along with census data for 1880 and such data as were available for 1881, were published in a report entitled"Mineral Resources of the United States."That volume began the annual series that has continued unbroken to the present.

"Mineral Resources of the United States"was compiled and published by the Geological Survey from the initial volume through the volume covering 1923. Beginning with the 1924 edition, compilation and publication of this report became the responsibility of the Bureau of Mines, then part of the Department of Commerce. The title"Mineral Resources of the United States"continued in use through the 1931 edition, when after a half century of publication, the title was changed to the current"Minerals Yearbook."

The first"Minerals Yearbook"covered the period 1932-33 and had a statistical appendix. Before the edition was completed, however, the Bureau of Mines was transferred to the Department of the Interior; therefore, the statistical appendix bears the seal of the Department of the Interior, rather than that of the Commerce Department.

Throughout a century of publication, the content, format, and length of these volumes have changed in response to user requirements and a changing industry. Initially a single volume of some 800 pages, the Yearbook became a two-part report "Metals"and"Nonmetals"in 1907 and continued in that format through the 1931 edition. From the combined 1932-33 edition through that of 1951, it returned to single-volume format, although the editions of 1932-33, 1934, and 1935 each had a statistical appendix. Beginning with the 1952 edition, the multivolume format of commodity and geographic area coverage was instituted, continuing through this edition as follows:

1952-62—Volume I, Metals and Minerals
Volume II, Fuels
Volume III, Area Reports
1963-65—Volume I, Metals and Minerals
Volume II, Fuels
Volume III, Area Reports, Domestic
Volume IV, Area Reports, International
1966-69—Volume I-II, Metals, Minerals, and Fuels
Volume III, Area Reports, Domestic
Volume IV, Area Reports, International
1970-76—Volume I, Metals, Minerals, and Fuels
Volume II, Area Reports, Domestic
Volume III, Area Reports, International
1977-81—Volume I, Metals and Minerals
Volume II, Area Reports, Domestic
Volume III, Area Reports, International

Commodity coverage has also changed thoughout the period. Some minerals that were given substantial space in the early volumes no longer have separate chapters, and new mineral commodities have been added. The 1882 edition contained 48 commodity or commodity group chapters whereas this edition contains 71. Data on the mineral fuels, included in the Yearbook from its onset, were deleted beginning with the 1977 edition, when responsibilities for those commodities were transferred to the new Department of Energy.

As we move into the second century of publication, our philosophy remains to publish a viable document responsive to the needs of its varied user community. To this end we continue to invite constructive comments and suggestions from our readers.

Robert C. Horton, *Director*

Acknowledgments

This volume of the Minerals Yearbook, covering metals and minerals, 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 mineral 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. 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.

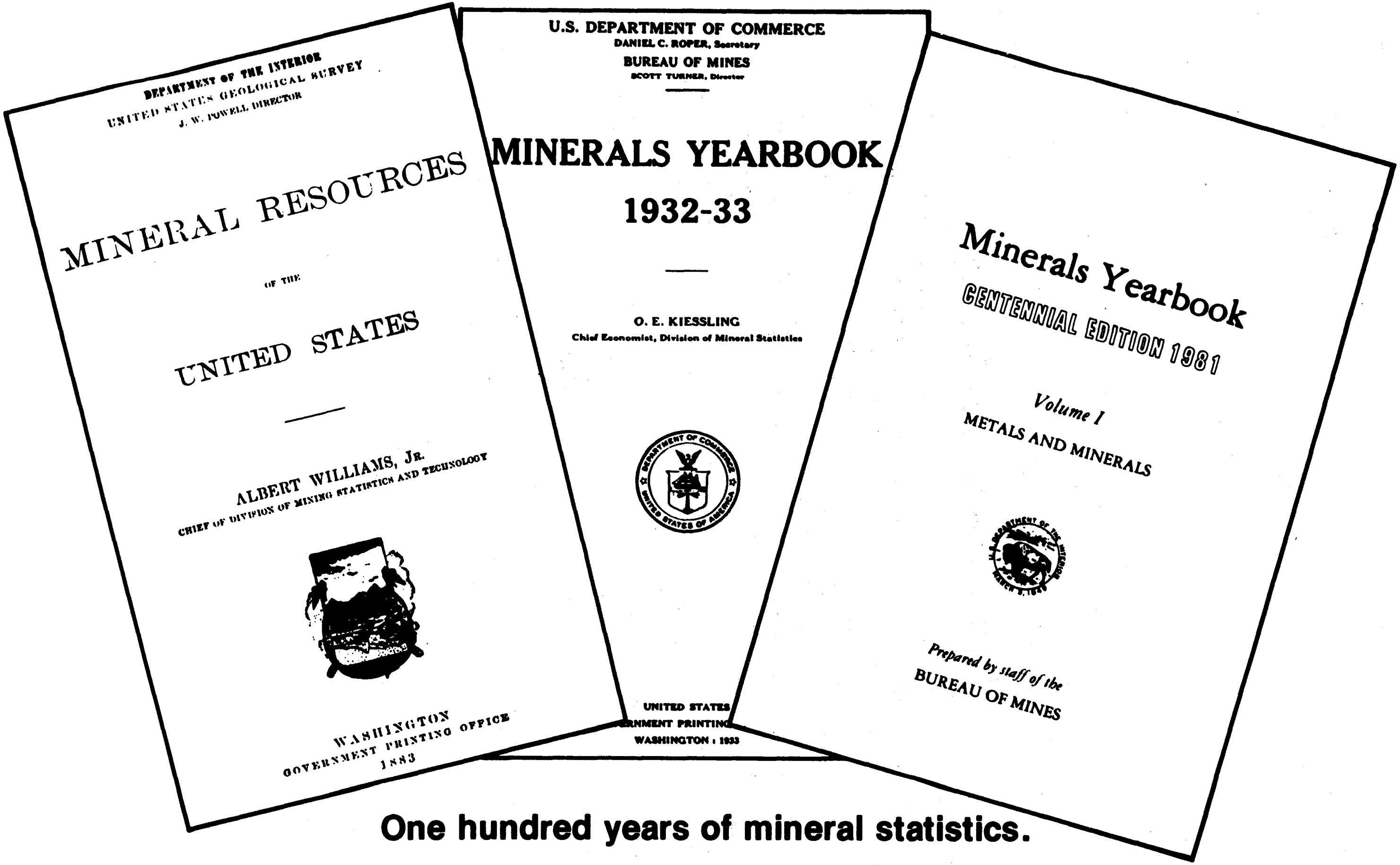
Statistics on world production were compiled in the Division of Foreign Data from numerous sources including reports from the Foreign Service, U.S. Department of State. U.S. foreign trade data were obtained from reports of the Bureau of the Census, U.S. Department of Commerce.

The Branch of Publication Support 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 supporting information by numerous cooperating State agencies. These organizations are listed in the acknowledgments to Volume II.

In this the centennial volume, acknowledgment is also extended to the past authors, statisticians, and editors who initiated, improved, and expanded this annual minerals report, in response to a changing industry and changes in the needs of our user community. Their foresight and dedication insured that the fledgling 1882 volume that covered a domestic minerals industry whose nonfuel mineral output was valued at $283 million, kept pace with an industry whose 1981 output was valued at over $25 billion.

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



One hundred years of mineral statistics.

Contents

Mining and Quarrying Trends in the Metal and Nonmetal Industries

By Charles D. Martens[1]

Raw nonfuel minerals produced in the United States during 1981 had an estimated value of $25 billion, about the same as that of 1980. In terms of 1980 dollars, the value of minerals produced during 1981 was $23 billion.[2]

This chapter includes tables for 1980 that were not available for publication in the 1980 Minerals Yearbook, but does not include the corresponding tables for 1981.

The underlying causes of the overall decline in U.S. nonfuel mine production during 1981 were varied, but the common factor was the worldwide recession. In some cases the decline was traced to foreign competition. For example, iron ore production was lower in part because of increased imports of steel products such as coiled steel sheet. Another problem experienced by the domestic mining industry was the continuing difficulty in attracting capital. This was due in part to the attractiveness of investments outside the mining industry, such as short-term, high-interest securities. Another reason was the importation of commodities from countries where overall costs were lower because of such factors as high ore grade, lower taxes, lower wages, government subsidies, and less stringent safety and environmental regulations.

The dominant trends in the nonfuel mining industry during 1981 were to reduce costs and improve or close uneconomic operations. Exploration and development of new mines was curtailed except for precious metals and a few other minerals. Mining equipment manufacturers emphasized design refinement to improve performance and efficiency.

Emphasis on cutting costs in existing mines created a need for sophisticated operations and equipment controls that were sometimes met by new technology such as computer applications. The use of low-cost portable computers in the mining industry for exploration, geochemistry, and ore blending was expected to expand to other applications such as open pit design and ore reserve estimation.

Legislation and Government Programs.—In March 1981, President Reagan called for the expenditure of $100 million to purchase strategic and critical materials for the Nation's stockpiles. Of this sum, $78 million was allocated for purchasing cobalt.

The U.S. Department of the Interior (DOI) organized an effort during 1980 and 1981 to make more public lands available for mineral exploration. This effort was expected to become an important part of the policy to help ensure an adequate supply of strategic and critical minerals. A DOI task force on strategic and critical minerals began meeting during 1981 to recommend a national minerals policy.

During 1981, the DOI Office of Surface Mining (OSM) began an extensive program of review and revision of regulations established under the Surface Mining Control and Reclamation Act of 1977. Of the approximately 34 areas on which rule revisions were being considered, the following actions were taken during 1981. The so-called "State window" provision was replaced by one that allowed the States to adopt regulations that are as effective as Federal regulations in meeting the requirements of the Surface Mining Control and Reclamation

Act of 1977. A third draft of revised regulations on Areas Unsuitable for Mining and a second draft on Permitting were issued. Proposed revised rules were also issued on Inspection and Enforcement, Bonding, Abandoned Mine Lands, State Program Approval Procedures, and Effluent Limitations and Sedimentation Ponds. Some of the overall effects of these proposed changes would be to shift part of the regulatory responsibility to individual States and to make compliance easier for mine operators.

During 1981, a series of lawsuits was filed in the District of Columbia U.S. District Court challenging various OSM regulations. Most of the cases brought by the American Mining Congress and the National Coal Association were stayed pending OSM regulatory reform. In a more basic action, the Supreme Court ruled that the Surface Mining Control and Reclamation Act of 1977 is constitutional.

The Economic Recovery Tax Act of 1981 was passed. Designed to increase capital investment, the act allows accelerated depreciation schedules and encourages research and development by industry, including mining.

Exploration.—With the exception of continuing high levels of exploration for precious metals and the increased activity in Alaska, exploration for nonfuel minerals declined in 1981. Exploration increased significantly in Alaska as a result of the passage of the Alaska National Interest Lands Conservation Act in December 1980. This act, which designated those areas that were to be in the public domain, conversely removed uncertainty about other areas, effectively opening them to exploration.

One of the reported technical trends in exploration was the improvement of data interpretation through the use of computers. Computers make this possible by rapid reduction of data and by their capacity to search the assembled data for matches to geophysical models developed by the user. Computers also make it feasible to collect and use more data. More capability at lower cost led to the increased use of portable microcomputers for evaluation of data in the field. Exploration teams were increasingly using digital recording, some with microprocessor control, to record data from analog instruments. Digital computers, which promise to eventually replace most programable calculators, provided important new capabilities in the field for digital filtering of data, video presentations, and modeling algorithms.

Significant advances were achieved in electromagnetic exploration techniques in both frequency-domain and time-domain systems.[3] Advances in frequency-domain systems included the Genie system developed by Scintrex Ltd. This ground-based exploration system does not require a wire connection between the transmitter and receiver. For this reason, and because of the system's low sensitivity to coil orientation or position, it is expected to be good for reconnaissance. Scintrex also began marketing an induced polarization spectral receiver, a microprocessor-controlled unit whose output to a cassette tape can record 10 time intervals of secondary voltage decay from up to 6 receiver dipoles. Phoenix Geophysics Inc. began testing its 100-kilowatt induced polarization-resistivity transmitter. Although developed for oilfield exploration, the transmitter was expected to have application in exploring deep mineral deposits.

Advances in time-domain electromagnetic systems chiefly consisted of increasing signal strength to increase capabilities for exploring at greater depths. Crone Geophysics Ltd. increased the power of its pulse electromagnetic system by changing to a 20-ampere transmitter-loop capability. GEOEX Proprietary Ltd. modified its SIROTEM II system to increase transmitter power by incorporating a portable motor generator. Geonics Ltd. developed a digital recording system for logging data with its EM-37 system.

Advances were made in airborne gravity surveys for mining and petroleum exploration. Carson Manufacturing Inc. used a modified shipborne La-Coste-Romberg platform in helicopters for flying grid surveys to achieve accuracies of 0.5 milligal.

Surface magnetic surveys were facilitated by the introduction of detectors having built-in data storage and processing capabilities. Both GeoMetrics Inc. and EDA Instruments Inc. introduced field magnetometers with these accessories.

Some technical advances in borehole exploration technology were announced. Mount Sopris Instrument Co. introduced a logging system that features microprocessor control and the capability of recording up to four data channels. Owl Technical Associates Inc. announced a 1.5-inch-diameter version of its digital deviation probe. A magnetic susceptibility sonde was introduced into the United States by OYO Instruments Inc.

Long-term field trials were initiated in New Mexico on a retractable core bit drilling system developed under a Bureau of

Mines contract. The system allows bit changes without removing the drill string.

One of the leading drilling equipment manufacturers announced the availability of hydrostatic controls on a widely used diamond core drill. The industry is increasingly using hydraulic controls for more accurate drilling control and ease of use.

Development.—Technological advances for mine development included the use of a large rodless shaft borer for excavating a coal mine shaft. This type of borer could be applied to nonfuel mineral mine development. The first of four large shafts planned for a coal mine being developed by the Jim Walter Resources Corp. was bored using a Wirth V Mole machine produced by Wirth Maschinen-und Bohrgerate-Fabrik GmbH of the Federal Republic of Germany. After a pilot hole was drilled and reamed using conventional raise boring equipment, the shaft was bored to a diameter of 7 meters in one downward pass. The Wirth V Mole has the capability of boring a shaft up to 8.5 meters in diameter. Muck was dropped down the pilot hole, and concreting followed the boring down the 520-meter-deep shaft.

Other improvements included the use of Dosco boom-type continuous miners for metal mine development. Cities Service Co. reported good success with these machines for developing its copper mine at Miami, Ariz. Cities Service also planned to use these continuous miners for production.

Surface Mining.—During 1981, automated computerized truck dispatching systems were successfully used in several mines. Increases in truck productivity in the range of 14% to 20% were reported. Because truck operation typically accounts for 50% of surface mining costs, the benefits were significant. The system consists of a radio and display in each truck, 10 to 20 or more signposts that sense the number of passing or nearby trucks, and a computer and dispatching station. The computer keeps track of the location of all the trucks, plus many other facts and conditions, such as shovel location and status, ore analyses, ore requirements, equipment maintenance to be performed, and segregated material such as toxic overburden or topsoil. The computer continuously determines optimal dispatching to move the most material at the least cost. Radio signals to the truck result in a dashboard display telling the driver which shovel or dump to go to.

Elsewhere in surface mining, improvements in truck design continued to reduce haulage costs. Komatsu Ltd. introduced 120- and 170-ton trucks with mechanical transmissions. These are reportedly the first trucks in this common size range for mining that are not powered by electrical wheel motors. Elimination of the need for power train electrical system maintenance and the need for an onsite electrician are the chief advantages claimed.

Development of low-energy detonating cord systems for use in surface mining was announced by the E. I. du Pont de Nemours & Co. The advantages claimed for the low-energy detonating cord are reduced ignition noise from cord runs on the surface and less disruption of the blasting agent as ignition passes through the agent prior to detonation. Non-cap-sensitive blasting agents such as ammonium nitrate-fuel oil (AN-FO) and water gels are thought to be disrupted and made less effective by high-energy detonating cord.

Trolley-assisted motor systems for haulage trucks that were used at United States Steel Corp.'s Lac Jeannine Mine from 1970 to 1977 were being reconsidered by some companies and were the subject of recent Bureau of Mines research. This approach was being evaluated by some mines because of the potential cost savings from using low-cost electrical power from local coal-fired generating plants rather than increasing the size of the less efficient truck-mounted, diesel-fueled engine generators to meet peak load requirements.

A new 34-cubic-yard electric shovel was announced by Bucyrus-Erie Co. The shovel is equipped with heavy-duty alternating current (AC) motors controlled by solid-state electronic equipment. Bucyrus-Erie also introduced a similarly equipped version of their widely used 27-cubic-yard bucket shovel. These are the first electric shovels with AC motors, which cost less to repair and require less maintenance than direct current (DC) motors. The solid-state controls and AC motors give more available horsepower than do static DC systems and are compatible with most mine electrical distribution systems.

Track-mounted hydraulic excavators were reported to be widely used in central Georgia for mining small pods of kaolin clay. In these mines, draglines were not selective enough and wheel loaders had poor traction. The hydraulic excavators were more mobile than draglines, had fast cycling, and had both high penetration and high breakout force.

The Bureau of Mines announced the results of field trials with a bulldozer blade system that reduced the cost of reclaiming windrows of displaced overburden at a strip mine. The three special-purpose blades were successfully tested at a lignite mine in Texas and a coal mine in Arizona. The blades provided 50% savings in earthmoving costs. These devices, as well as a bulldozer-work-rate indicator developed by the Bureau of Mines, can be applied to other similar mining and construction operations.

Underground Mining.—Sublevel open stoping operations using large-diameter drill holes for blasting were reportedly successful at Cities Service's Cherokee copper mine in Tennessee. Introduction of a track-mounted hydraulically actuated rotary drill capable of drilling 6-3/4-inch-diameter holes was the key factor in increasing the efficiency of its operations.

FMC Corp. initiated longwall mining in one of its trona mines in lieu of production with continuous miners. The longwall system was expected to improve safety and mining costs.

A low portable crusher for underground mines, with an estimated output of 250 tons per hour and capable of crushing up to 30-inch-diameter rocks, was developed and tested in a quarry by a Bureau of Mines contractor. The crusher was expected to increase the efficiency of ore handling and allow crushing of waste rock near the face for construction and backfilling stopes.

A Bureau of Mines contractor developed a cooler for mine ventilation air that sprays cool water directly into a ventilating duct rather than using a conventional heat exchanger. Greater efficiency and reduced maintenance during extensive tests at the Homestake gold mine in South Dakota led to the purchase of additional coolers by Homestake Mining Co.

In Situ Mining.—There were additional applications of in situ mining because it offers a means of mining otherwise inaccessible or scattered deposits while reducing environmental damage and reclamation costs.

Several improvements were made for in situ mining of uranium. Union Carbide Corp. reported successful field trials of a leachant containing dissolved oxygen. The leachant was only one-twentieth as costly as hydrogen peroxide-type leachants and was more chemically stable in the delivery pipelines.

The Bureau of Mines developed a three-part modeling system that simulates specific multiwell sites for uranium leaching fields. The model consists of an integrated system using two computer programs with laboratory chemical analysis of core samples of the ore. The outputs of the hydrology computer program include streamlines that are used in the mass transport computer program to generate information about the projected field, such as the uranium output during 3 months of operation. The system allows comprehensive modeling to predict leaching and groundwater flows during production and restoration, thereby reducing expensive trial and error methods of establishing field configurations and operating parameters. The program has been tested by projecting performance at two leach fields, one for Intercontinental Energy Corp. and the other for Rocky Mountain Energy Co. These uses of the system provided new insights into field configuration and are expected to improve mining and reclamation when those fields are developed.

In another in situ development, FMC initiated a demonstration project by injecting solutions into two trona wells at Green River, Wyo. By yearend, eight wells had been drilled for this relatively large demonstration project. After 20 years of research, the company had committed $30 million to the 10-well project.

Plans were completed during 1981 to test the borehole mining system developed by the Bureau of Mines for mining phosphate. The system was previously tested successfully in both uranium-bearing sands and oil sands. In this mining method, a hole is drilled down through the ore zone and the ore is dislodged by a high-pressure water jet. The slurry is pumped to the surface from the cavity by a jet pump. After the ore has been processed the tailings are backfilled into the cavity. The method is most applicable to small, rich ore bodies or where minimal land disturbance is advantageous or required.

The Los Alamos National Laboratory drilled two parallel boreholes 2.6 miles deep to tap heat energy from a hot granite formation. The bottom 3,000 feet were precision drilled at an angle of 35° from the vertical. Spring water will be pumped down one hole, radiate to the other hole through interstices created by hydraulic fracturing, and return as steam. When used to generate electricity, the steam will have a projected power output of 35 megawatts.

Beneficiation and Processing.—The Bureau of Mines developed two selective flocculation-desliming processes that increased U.S. iron ore reserves by 50 to 75 years at current consumption rates. Both a cationic and an anionic flotation process were developed. For the cationic process, concentrates averaged 37.7% by weight of the feed and contained 63.0% iron and 5.3% SiO_2, with an iron recovery of 73.5%. The reagent cost was $1.44 per long ton of crude ore, and 88% of the process water requirements were filled using reclaimed water. The anionic process was almost as efficient.

The Bureau of Mines also developed a model for predicting and improving the dump leaching of ores containing a variety of copper sulfide minerals. Accurate predictions of copper extractions during 500 days of large-scale tests were made using the model.

A survey of ore sampling and blending control was completed at large iron ore mines on the Mesabi Range. Shovel location was the chief method for controlling the blending of taconite ore for producing pellets. Shovels are moved at intervals ranging from 1 day to a week or more, depending on ore composition changes and the blending needed to maintain the ore within processing specifications. Computer programs were used for determining shovel movements for blending. The number of variables considered and the sophistication of the programs vary according to the difficulty in consistently meeting the specifications of the mine product as the ore quality changes at the excavation places. In the Tilden Mine, ore is blended by narrowly limiting several variables such as total oxides, talc, concentrate weight recovery, and concentrate silica. Blasthole sample data are processed with a portable computer used to generate a daily printout for determining shovel locations.

In Bureau of Mines tests on copper tailings containing about 0.38% recoverable titanium dioxide, almost 70% of the recoverable titanium dioxide was captured as a 34% concentrate. The tailings contained 0.75% titanium dioxide of which about 67% was rutile.

A continuous electrostatic separator was developed by the Bureau of Mines for sorting fine mineral particles. Minerals such as rutile, zircon, monazite, celestite, and ilmenite were separated from quartz gangue and to a lesser degree from quartz-feldspar mixtures. Other minerals including barite, scheelite, witherite, and sphalerite were separated from quartz. The unit separates particles based on the dielectric constant of the material.

The Bureau of Mines continued to improve its method for heap leaching of gold and silver ores and tailings. In its agglomeration method, low-grade gold and silver ore are tumbled with small amounts of portland cement and water to form pellets that, after curing, are strong enough to be piled for leaching. Agglomeration serves to bind together the finer ore particles and thereby enhance the rate at which leaching solutions can percolate through the heap. At a number of mines in the West, particularly in Nevada, heap leaching was being used to extract gold and silver from newly mined ore as well as from abandoned tailings piles.

Goldera Resources Inc. and Normarc Explorations Ltd. planned to use cyanide solution to heap leach low-grade material at the Mary Ann ore dump in Nevada to recover about 25,000 ounces of silver.

Health and Safety.—Accidental deaths in the metal and nonmetal mines declined from 103 during 1980 to 84 during 1981. This is the lowest number of U.S. mine fatalities since 1958 when sand and gravel fatalities were first included in the statistics.

The Bureau of Mines continued developing fire protection equipment for surface mining equipment. A system designed for AN-FO trucks and another for draglines were announced. Systems have been developed previously for haulage trucks, bulldozers, excavators, augers, and other equipment. By the end of 1981, almost 10% of U.S. mining companies had fire protection systems derived from this research on their trucks.

Erie Mining Co. developed a comprehensive system to reduce truck fire damage. In addition to improving inspections, Erie Mining installed additional suppression systems, solenoid-operated fuel cutoffs, shielding for hot components, and high-temperature-resistant wires in critical circuits.

Field-tested techniques developed by the Bureau of Mines related to ground control safety included a lightweight, easy to use, solid projectile device for shooting down hangups in ore passes and chutes; a rock fracturing system that reduces rockburst occurrence; an economical method for measuring stresses in mine walls; and steel-reinforced concrete cribbing to replace timber cribbing.

The Bureau of Mines also developed a computer program that simulated the effect of fires on mine ventilation. The program simulates how a fire affects airflow and quality at specific locations and times in a mine.

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[1]General engineer, Office of Technical Information.
[2]Based on inflation rate derived from gross national product data.
[3]Crebs, T. J. Moderate Increase Again Reported in Geophysical Activity. Min. Eng., May 1982, 3 pp.
Corbett, J., Anaconda Minerals Co. Unpublished communication, 1982. Available upon request from C. D. Martens, Bureau of Mines, Washington, D.C.

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:									
1976	573	1,250	1,820	73	15	87	646	1,260	1,910
1977	490	1,030	1,530	74	12	87	564	1,050	1,610
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
Nonmetals:									
1976	2,000	393	2,390	80	6	86	2,080	399	2,480
1977	2,120	472	2,590	80	6	86	2,200	478	2,680
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
Total metals and nonmetals:[1]									
1976	2,570	1,640	4,210	153	21	174	2,720	1,660	4,390
1977	2,610	1,510	4,120	155	18	173	2,760	1,520	4,290
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

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

Table 2.—Material handled at surface and underground mines in 1980, by commodity[1]

(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	3,250	14,900	18,200	--	--	--	3,250	14,900	18,200
Copper	219,000	530,000	749,000	21,100	1,230	22,300	240,000	531,000	771,000
Gold:									
Lode	3,550	9,190	12,700	6,240	1,140	7,380	9,790	10,300	20,100
Placer	2,980	4,270	7,250	--	--	--	2,980	4,270	7,250
Iron ore	234,000	251,000	485,000	2,740	3	2,740	237,000	251,000	488,000
Lead	W	--	W	10,800	2,860	13,600	10,800	2,860	13,600
Platinum	W	--	W	--	--	--	W	--	W
Silver	758	6,020	6,780	1,220	614	1,840	1,980	6,630	8,610
Titanium and ilmenite	27,200	W	27,200	--	--	--	27,200	W	27,200
Tungsten	3	--	3	727	124	851	730	124	854
Uranium	11,500	324,000	336,000	6,640	3,550	10,200	18,200	328,000	346,000
Zinc	--	29	29	7,120	1,170	8,290	7,120	1,200	8,310
Other[3]	17,900	40,600	58,400	20,500	410	21,000	38,400	41,000	79,400
Total[2]	520,000	1,180,000	1,700,000	77,000	11,100	88,200	597,000	1,190,000	1,790,000
NONMETALS									
Abrasives[4]	214	57	271	261	--	261	475	57	532
Asbestos	1,750	5,520	7,270	W	--	W	1,750	5,520	7,270
Barite	3,770	503	4,280	--	--	--	3,770	503	4,280
Clays	44,300	[e]38,500	82,700	184	[e]3	187	44,400	[e]38,500	82,900
Diatomite	707	1,670	2,370	--	--	--	707	1,670	2,370
Feldspar	1,870	3,780	5,650	--	--	--	1,870	3,780	5,650
Fluorspar	W	W	W	361	(5)	361	361	(5)	361
Gypsum	9,810	3,500	13,300	2,650	--	2,650	12,500	3,500	16,000
Mica (scrap)	526	--	526	--	--	--	526	--	526
Perlite	825	265	1,090	--	--	--	825	265	1,090
Phosphate rock	231,000	485,000	716,000	W	W	W	231,000	485,000	716,000
Potassium salts	--	--	--	19,900	138	20,000	19,900	138	20,000
Pumice	3,840	13	3,860	--	--	--	3,840	13	3,860
Salt	1,770	--	1,770	11,000	--	11,000	12,800	--	12,800
Sand and gravel	794,000	--	794,000	--	--	--	794,000	--	794,000
Sodium carbonate (natural)	--	--	--	12,900	W	12,900	12,900	W	12,900

See footnotes at end of table.

Table 2.—Material handled at surface and underground mines in 1980, by commodity[1] —Continued

(Thousand short tons)

Commodity	Surface			Underground			All mines[2]		
	Crude ore	Waste	Total[2]	Crude ore	Waste	Total[2]	Crude ore	Waste	Total
NONMETALS —Continued									
Stone:									
Crushed and broken	950,000	e75,500	1,030,000	30,300	e209	30,500	980,000	e75,700	1,060,000
Dimension	6,340	e1,640	7,980	23	--	23	6,370	e1,640	8,010
Talc, soapstone, pyrophyllite	1,090	1,690	2,780	433	18	451	1,530	1,710	3,230
Other[6]	8,200	2,360	10,500	200	30	230	8,400	2,390	10,800
Total[2]	2,060,000	620,000	2,680,000	78,200	396	78,600	2,140,000	620,000	2,760,000
Grand total[2]	2,580,000	1,800,000	4,380,000	155,000	11,500	167,000	2,730,000	1,810,000	4,540,000

[e]Estimated. W Withheld to avoid disclosing company proprietary data; included with "Other metals" and "Other nonmetals."
[1]Excludes material from wells, ponds, or pumping operations.
[2]Data may not add to totals shown because of independent rounding.
[3]Antimony, beryllium, manganiferous ore, mercury, molybdenum, nickel, rare-earth metals, tin, vanadium, and metal items indicated by symbol W.
[4]Abrasive stone, emery, garnet, and tripoli.
[5]Less than 1/2 unit.
[6]Aplite, boron minerals, graphite, greensand marl, iron oxide pigments (crude), kyanite, lithium minerals, magnesite, olivine, tube-mill liners, vermiculite, wollastonite, and nonmetal items indicated by symbol W.

Table 3.—Material handled at surface and underground mines (including sand and gravel and stone) in 1980, by State[1]

(Thousand short tons)

State	Surface			Underground			All mines[2]		
	Crude ore	Waste	Total[2]	Crude ore	Waste	Total[2]	Crude ore	Waste	Total
Alabama	37,200	3,640	40,800	8	--	8	37,200	3,640	40,800
Alaska	51,100	5,190	56,300	W	W	W	51,100	5,190	56,300
Arizona	185,000	248,000	434,000	15,300	870	16,200	201,000	249,000	450,000
Arkansas	36,800	15,100	51,800	W	W	W	36,800	15,100	51,800
California	170,000	37,700	208,000	750	82	832	171,000	37,800	209,000
Colorado	41,700	49,000	90,700	21,700	1,570	23,300	63,400	50,600	114,000
Connecticut	15,600	782	16,300	(3)	--	(3)	15,600	782	16,300
Delaware	1,080	--	1,080	--	--	--	1,080	--	1,080
Florida	309,000	381,000	690,000	W	W	W	309,000	381,000	690,000
Georgia	54,800	15,500	70,300	W	W	W	54,800	15,500	70,300
Hawaii	7,740	521	8,260	--	--	--	7,740	521	8,260
Idaho	16,400	60,100	76,500	1,610	499	2,110	18,000	60,600	78,600
Illinois	83,900	4,580	88,500	2,160	12	2,170	86,100	4,590	90,700
Indiana	53,600	3,220	56,800	1,710	4	1,710	55,300	3,230	58,500
Iowa	39,500	2,440	42,000	2,070	12	2,090	41,600	2,460	44,100
Kansas	28,800	1,920	30,700	2,900	13	2,920	31,700	1,930	33,600
Kentucky	36,400	3,040	39,400	6,860	48	6,910	43,200	3,090	46,300
Louisiana	28,400	974	29,400	4,180	--	4,180	32,600	974	33,600
Maine	8,190	160	8,350	--	--	--	8,190	160	8,350
Maryland	30,300	2,010	32,300	122	1	123	30,500	2,010	32,500
Massachusetts	21,700	843	22,500	--	--	--	21,700	843	22,500
Michigan	125,000	39,300	164,000	4,120	--	4,120	129,000	39,300	169,000
Minnesota	197,000	174,000	371,000	--	--	--	197,000	174,000	371,000
Mississippi	15,600	1,540	17,200	--	--	--	15,600	1,540	17,200
Missouri	54,200	4,310	58,600	18,200	2,800	21,000	72,500	7,110	79,600
Montana	19,400	2,090	21,500	401	105	505	19,800	2,200	22,000
Nebraska	14,300	335	14,600	211	1	212	14,500	336	14,800
Nevada	18,900	11,700	30,500	247	148	395	19,100	11,800	30,900
New Hampshire	7,170	182	7,350	--	--	--	7,170	182	7,350
New Jersey	28,000	1,030	29,100	W	--	W	28,000	1,030	29,100
New Mexico	41,800	224,000	266,000	24,000	1,790	25,800	65,800	226,000	292,000
New York	58,100	3,470	61,600	3,880	50	3,930	62,000	3,510	65,500
North Carolina	59,600	50,900	111,000	--	--	--	59,600	50,900	111,000
North Dakota	5,230	W	5,230	--	--	--	5,230	W	5,230
Ohio	81,500	5,240	86,800	3,180	10	3,190	84,700	5,250	90,000
Oklahoma	42,300	2,730	45,000	W	W	W	42,300	2,730	45,000
Oregon	40,000	4,030	44,000	W	W	W	40,000	4,030	44,000
Pennsylvania	76,000	6,250	82,200	3,160	59	3,210	79,100	6,300	85,400
Rhode Island	2,710	17	2,730	--	--	--	2,710	17	2,730

See footnotes at end of table.

Table 3.—Material handled at surface and underground mines (including sand and gravel and stone) in 1980, by State[1] —Continued

(Thousand short tons)

State	Surface			Underground			All mines[2]		
	Crude ore	Waste	Total[2]	Crude ore	Waste	Total[2]	Crude ore	Waste	Total
South Carolina	24,400	2,870	27,300	--	--	--	24,400	2,870	27,300
South Dakota	7,680	471	8,150	W	W	W	7,680	471	8,150
Tennessee	49,600	11,800	61,300	9,400	1,240	10,600	59,000	13,000	72,000
Texas	135,000	69,700	205,000	1,260	W	1,260	137,000	69,700	206,000
Utah	46,900	110,000	157,000	5,510	1,940	7,450	52,400	112,000	164,000
Vermont	4,770	986	5,750	258	--	258	5,030	986	6,010
Virginia	53,600	4,620	58,200	1,680	17	1,690	55,300	4,640	59,900
Washington	31,700	5,700	37,400	63	14	77	31,700	5,710	37,500
West Virginia	12,100	1,100	13,200	2,120	15	2,140	14,200	1,110	15,300
Wisconsin	44,700	7,770	52,500	W	W	W	44,700	7,770	52,500
Wyoming	22,500	220,000	242,000	14,400	45	14,400	36,900	220,000	257,000
Undistributed	--	(3)	(3)	3,750	180	3,930	3,750	180	3,930
Total[2] [4]	2,580,000	1,800,000	4,380,000	155,000	11,500	167,000	2,730,000	1,810,000	4,540,000

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]Less than 1/2 unit.
[4]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 1980

(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	$7.00	$20.89	$27.89	--	--	--	$7.00	$20.89	$27.89
Copper	10.31	3.29	13.60	$16.13	$3.97	$20.10	10.80	3.35	14.15
Gold:									
Lode	18.30	1.38	19.68	90.59	7.11	97.70	34.67	2.67	37.34
Placer	1.83	--	1.83	--	--	--	1.83	--	1.83
Iron ore	10.55	--	10.55	20.84	W	20.84	10.67	--	10.67
Lead	.82	2.02	2.84	44.58	15.18	59.76	43.76	14.93	58.69
Platinum	W	--	W	--	--	--	W	--	W
Silver	41.59	16.98	58.57	238.22	31.87	270.09	160.40	25.98	186.38
Titanium and ilmenite	4.36	2.33	6.69	--	--	--	4.36	2.33	6.69
Tungsten	72.24	--	72.24	52.76	5.39	58.15	52.84	5.37	58.21
Uranium	34.53	--	34.53	69.59	6.57	76.16	43.64	1.71	45.35
Zinc	--	--	--	26.81	10.06	36.87	26.81	10.06	36.87
Average[1]	12.05	1.65	13.70	34.59	5.80	40.39	14.83	2.16	16.99
NONMETALS									
Asbestos	9.74	--	9.74	W	--	W	9.74	--	9.74
Barite	17.37	.19	17.56	--	--	--	17.37	.19	17.56
Clays	18.52	--	18.52	8.27	--	8.27	18.48	--	18.48
Diatomite	93.90	--	93.90	--	--	--	93.90	--	93.90
Feldspar	11.10	5.71	16.81	--	--	--	11.10	5.71	16.81
Fluorspar	16.73	--	16.73	39.40	8.27	47.67	38.64	7.99	46.63
Gypsum	8.36	--	8.36	8.22	--	8.22	8.33	--	8.33
Mica (scrap)	8.11	--	8.11	--	--	--	8.11	--	8.11
Perlite	11.39	--	11.39	--	--	--	11.39	--	11.39
Phosphate rock	5.41	.05	5.46	W	--	W	5.41	.05	5.46
Potassium salts	--	--	--	14.69	--	14.69	14.69	--	14.69
Pumice	2.75	--	2.75	--	--	--	2.75	--	2.75

See footnotes at end of table.

Table 4.—Value of principal mineral products and byproducts of surface and underground ores mined in the United States in 1980 —Continued

(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
NONMETALS —Continued									
Salt	$10.34	$4.62	$14.96	$14.23	$1.53	$15.76	$13.71	$1.94	$15.65
Sand and gravel	2.88	--	2.88	--	--	--	2.88	--	2.88
Sodium carbonate (natural)	--	--	--	49.40	--	49.40	49.40	--	49.40
Stone:									
Crushed and broken	3.25	.04	3.29	4.35	--	4.35	3.29	.03	3.32
Dimension	20.35	2.60	22.95	W	--	W	20.35	2.60	22.95
Talc, soapstone, pyrophyllite	9.58	1.57	11.15	8.90	--	8.90	9.38	1.10	10.48
Average[1]	4.03	.05	4.08	16.00	.34	16.34	4.47	.06	4.53
Average, metals and nonmetals[1]	5.63	.37	6.00	24.94	2.96	27.90	6.70	.51	7.21
Average, nonmetals (excluding stone and sand and gravel)[1]	9.00	.11	9.11	23.25	.54	23.79	10.90	.17	11.07
Average, metals and nonmetals (excluding stone and sand and gravel)[1]	10.90	1.07	11.97	30.07	3.70	33.77	13.33	1.40	14.74

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

Table 5.—Crude ore and total material handled at surface and underground mines in 1980, by commodity

(Percent)

Commodity	Crude ore		Total material	
	Surface	Underground	Surface	Underground
METALS				
Antimony	--	100.0	--	100.0
Bauxite	100.0	--	100.0	--
Beryllium	100.0	--	100.0	--
Copper	91.2	8.8	97.1	2.9
Gold:				
Lode	36.3	63.7	63.4	36.6
Placer	100.0	--	100.0	--
Iron ore	98.8	1.2	99.4	.6
Lead	--	100.0	--	100.0
Manganiferous ore	100.0	--	100.0	--
Mercury	100.0	--	100.0	--
Molybdenum	37.3	62.7	70.4	29.6
Nickel	100.0	--	100.0	--
Platinum	100.0	--	100.0	--
Rare-earth metals	100.0	--	100.0	--
Silver	38.3	61.7	78.7	21.3
Tin	100.0	--	100.0	--
Titanium and ilmenite	100.0	--	100.0	--
Tungsten	.4	99.6	.3	99.7
Uranium	63.5	36.5	97.1	2.9
Vanadium	100.0	--	100.0	--
Zinc	--	100.0	.3	99.7
Average	87.1	12.9	95.1	4.9
NONMETALS				
Abrasives	[1]100.0	W	[1]100.0	W
Aplite	100.0	--	100.0	--
Asbestos	[1]100.0	W	[1]100.0	W
Barite	100.0	--	100.0	--
Boron minerals	100.0	--	100.0	--
Clays	99.6	.4	99.8	.2
Diatomite	100.0	--	100.0	--
Feldspar	100.0	--	100.0	--
Fluorspar	3.0	97.0	7.9	92.1
Gypsum	78.8	21.2	83.4	16.6
Iron oxide pigments (crude)	100.0	--	100.0	--
Kyanite	100.0	--	100.0	--
Lithium minerals	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	100.0	W
Potassium salts	--	100.0	--	100.0
Pumice	100.0	--	100.0	--
Salt	13.8	86.2	13.8	86.2
Sand and gravel	100.0	--	100.0	--
Sodium carbonate (natural)	--	100.0	--	100.0
Stone:				
Crushed and broken	96.9	3.1	97.1	2.9
Dimension	[1]100.0	W	[1]100.0	W
Talc, soapstone, pyrophyllite	71.6	28.4	86.0	14.0
Vermiculite	100.0	--	100.0	--
Average	99.1	.9	99.2	.8
Average, metals and nonmetals	98.4	1.6	89.5	10.5

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 6.—Crude ore and total material handled at surface and underground mines in 1980, by State

(Percent)

State	Crude ore		Total material	
	Surface	Underground	Surface	Underground
Alabama	100.0	--	100.0	--
Alaska	100.0	--	100.0	--
Arizona	92.4	7.6	96.4	3.6
Arkansas	[1]100.0	W	[1]100.0	W
California	99.6	.4	99.6	.4
Colorado	65.7	34.3	79.6	20.4
Connecticut	100.0	--	100.0	--
Delaware	100.0	--	100.0	--
Florida	100.0	--	100.0	--
Georgia	98.3	1.7	98.6	1.4
Hawaii	100.0	--	100.0	--
Idaho	91.0	9.0	97.3	2.7
Illinois	97.5	2.5	97.6	2.4
Indiana	96.9	3.1	97.1	2.9
Iowa	95.0	5.0	95.3	4.7
Kansas	90.8	9.2	91.3	8.7
Kentucky	84.1	15.9	85.1	14.9
Louisiana	87.2	12.8	87.6	12.4
Maine	100.0	--	100.0	--
Maryland	[1]100.0	W	[1]100.0	W
Massachusetts	100.0	--	100.0	--
Michigan	96.8	3.2	97.5	2.5
Minnesota	100.0	--	100.0	--
Mississippi	100.0	--	100.0	--
Missouri	74.8	25.2	73.6	26.4
Montana	98.0	2.0	97.7	2.3
Nebraska	[1]100.0	W	[1]100.0	W
Nevada	98.7	1.3	98.7	1.3
New Hampshire	100.0	--	100.0	--
New Jersey	100.0	--	100.0	--
New Mexico	63.5	36.5	91.2	8.8
New York	93.7	6.3	94.0	6.0
North Carolina	100.0	--	100.0	--
North Dakota	100.0	--	100.0	--
Ohio	96.2	3.8	96.5	3.5
Oklahoma	[1]100.0	W	[1]100.0	W
Oregon	100.0	--	100.0	--
Pennsylvania	96.0	4.0	96.2	3.8
Rhode Island	100.0	--	100.0	--
South Carolina	100.0	--	100.0	--
South Dakota	[1]100.0	W	[1]100.0	W
Tennessee	84.1	15.9	85.2	14.8
Texas	99.1	.9	99.4	.6
Utah	89.5	10.5	95.5	4.5
Vermont	94.9	5.1	95.7	4.3
Virginia	97.0	3.0	97.2	2.8
Washington	[1]100.0	W	[1]100.0	W
West Virginia	85.1	14.9	86.1	13.9
Wisconsin	[1]100.0	W	[1]100.0	W
Wyoming	61.1	38.9	94.4	5.6
Average	98.4	1.6	89.5	10.5

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 in 1980, by commodity[1]

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	10	--	1	4	5	--	--
Copper	39	--	1	5	7	17	9
Gold:							
Lode	44	20	10	5	6	3	--
Placer	36	8	10	12	6	--	--
Iron ore	35	--	2	4	8	14	7
Lead	33	15	6	3	2	7	--
Platinum	1	--	--	--	1	--	--
Silver	43	20	10		7	--	--
Titanium and ilmenite	5	--	--	--	1	4	--
Tungsten	29	26	--		2	--	--
Uranium	265	43	73	103	44	2	--
Zinc	20	1	1	4	13	1	--
Other[2]	20	4	4	5	3	2	2
Total	580	137	118	152	105	50	18
NONMETALS							
Abrasives[3]	15	2	6	5	2	--	--
Asbestos	4	--	1	--	2	1	--
Barite	32	--	6	17	9	--	--
Clays	1,033	64	247	603	118	1	--
Diatomite	10	--	2	6	2	--	--
Feldspar	16	--	3	3	10	--	--
Fluorspar	5	--	2	2	1	--	--
Gypsum	73	3	5	26	39	--	--
Mica (scrap)	13	2	6	3	2	--	--
Perlite	13	1	3	6	3	--	--
Phosphate rock	44	--	4	2	11	15	12
Potassium salts	7	--	--	--	--	7	--
Pumice	225	16	131	71	7	--	--
Salt	21	1	3	3	8	6	--
Sand and gravel	6,165	125	982	3,115	1,870	72	1
Sodium carbonate	4	--	--	--	--	4	--
Stone:							
Crushed and broken	3,975	132	476	1,451	1,744	171	1
Dimension	388	97	168	113	10	--	--
Talc, soapstone, pyrophyllite	44	7	13	18	6	--	--
Other[4]	30	6	6	7	8	2	1
Total	12,117	456	2,064	5,451	3,852	279	15
Grand total	12,697	593	2,182	5,603	3,957	329	33

[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]Aplite, boron minerals, graphite, greensand marl, iron oxide pigments (crude), kyanite, lithium, magnesite, olivine, tube-mill liners, vermiculite, and wollastonite.

Table 8.—Twenty-five leading metal and nonmetal[1] mines in the United States in 1980, in order of output of crude ore

Mine	State	Operator	Commodity	Mining method
		METALS		
Minntac	Minnesota	United States Steel Corp	Iron ore	Open pit.
Sierrita	Arizona	Duval Sierrita Corp	Copper	Do.
Utah Copper	Utah	Kennecott Minerals Co	do	Do.
Hibbing Taconite	Minnesota	Pickands Mather & Co	Iron ore	Do.
Tilden	Michigan	Tilden Mining Co	do	Do.
Empire	do	Empire Iron Mining	do	Do.
Thunderbird	Minnesota	Oglebay Norton Co	do	Do.
Morenci	Arizona	Phelps Dodge Corp	Copper	Do.
Climax	Colorado	Climax Molybdenum Co., a division of AMAX Inc.	Molybdenum	Caving and open pit.
Erie Commercial	Minnesota	Pickands Mather & Co	Iron ore	Open pit.
Tyrone	New Mexico	Phelps Dodge Corp	Copper	Do.
Bagdad	Arizona	Cyprus-Bagdad Copper Co	do	Do.
Peter Mitchell	Minnesota	Reserve Mining Co	Iron ore	Do.
San Manuel	Arizona	Magma Copper Co	Copper	Caving.
Ray Pit	do	Kennecott Minerals Co	do	Open pit.
Pinto Valley	do	Cities Service Co	do	Do.
Twin Buttes	do	Anamax Mining Co	do	Do.
Henderson	Colorado	Climax Molybdenum Co., a division of AMAX Inc.	Molybdenum	Caving.
Berkeley Pit	Montana	The Anaconda Company	Copper	Open pit.
Trail Ridge	Florida	E. I. du Pont de Nemours & Co.	Titanium	Dredging.
Lakehurst	New Jersey	ASARCO Incorporated	do	Do.
Eisenhower	Arizona	do	Copper	Open pit.
National Pellet Project	Minnesota	Hanna Mining Co	Iron ore	Do.
Highland	Florida	E. I. du Pont de Nemours & Co.	Titanium	Dredging.
New Cornelia	Arizona	Phelps Dodge Corp	Copper	Open pit.
		NONMETALS		
Noralyn	Florida	International Minerals & Chemical Corp.	Phosphate rock.	Open pit.
Suwannee	do	Occidental Petroleum Corp	do	Do.
Ft. Green	do	Williams Co	do	Do.
Ft. Meade	do	Mobil Oil Corp	do	Do.
Kingsford	do	International Minerals & Chemical Corp.	do	Do.
Swift Creek	do	Occidental Petroleum Corp	do	Do.
Clear Spring	do	International Minerals & Chemical Corp.	do	Do.
Payne Creek	do	Williams Co	do	Do.
Georgetown	Texas	Texas Crushed Stone Co	Stone	Open quarry.
Haynsworth	Florida	American Cyanamid Co	Phosphate rock.	Open pit.
Hookers	do	W. R. Grace & Co	do	Do.
Ft. Meade	do	Gardinier, Inc	do	Do.
Lee Creek	North Carolina	Texasgulf Inc	do	Do.
Rockland	Florida	United States Steel Corp	do	Do.
Thornton	Illinois	General Dynamics Corp	Stone	Open quarry.
Lonesome	Florida	American Cyanamid Co	Phosphate rock.	Open pit.
Big Four	do	Amax Phosphate, Inc	do	Do.
Watson	do	Estech General Chemical Corp.	do	Do.
Calcite	Michigan	United States Steel Corp	Stone	Open quarry.
Stoneport	do	Presque Isle Corp	do	Do.
Bonny Lake	Florida	W. R. Grace & Co	Phosphate rock.	Open pit.
Nichols	do	Mobil Oil Corp	do	Do.
Silver City	do	Estech General Chemical Corp.	do	Do.
International	New Mexico	International Minerals & Chemical Corp.	Potassium salts.	Stopes.
FEC Hialea	Florida	Rinker Materials Corp	Stone	Open quarry.

[1]Brines and materials from wells excepted.

Table 9.—Twenty-five leading metal and nonmetal[1] mines in the United States in 1980, in order of output of total materials handled

Mine	State	Operator	Commodity	Mining method
		METALS		
Tyrone	New Mexico	Phelps Dodge Corp	Copper	Open pit.
Utah Copper	Utah	Kennecott Minerals Co	do	Do.
Minntac	Minnesota	United States Steel Corp	Iron ore	Do.
Hibbing Taconite	do	Pickands Mather & Co	do	Do.
Pima	Arizona	Cyprus-Pima Mining Co	Copper	Do.
Sierrita	do	Duval Sierrita Corp	do	Do.
Shirley	Wyoming	Getty Oil Co	Uranium	Do.
Do	do	Pathfinder Minerals Corp	do	Do.
Climax	Colorado	Climax Molybdenum Co., a division of AMAX Inc.	Molybdenum	Caving and open pit.
Morenci	Arizona	Phelps Dodge Corp	Copper	Open pit.
Jackpile-Paquate	New Mexico	The Anaconda Company	Uranium	Do.
Highland	Wyoming	Exxon Corp	do	Do.
Empire	Michigan	Empire Mining Co	Iron ore	Do.
Erie Commercial	Minnesota	Pickands Mather & Co	do	Do.
Bagdad	Arizona	Cyprus Bagdad Copper Co	Copper	Do.
Chino	New Mexico	Kennecott Minerals Co	do	Do.
Conquista	Texas	Continental Oil Co	Uranium	Do.
Pinto Valley	Arizona	Cities Service Co	Copper	Do.
Eagle Mountain	California	Kaiser Steel Corp	Iron ore	Do.
Eisenhower	Arizona	ASARCO Incorporated	Copper	Do.
Thunderbird	Minnesota	Oglebay Norton Co	Iron ore	Do.
Peter Mitchell	do	Reserve Mining Co	do	Do.
Panna Mara	Texas	Chevron Resources Co	Uranium	Do.
Tilden	Michigan	Tilden Mining Co	Iron ore	Do.
Mineral Park	Arizona	Duval Corp	Copper	Do.
		NONMETALS		
Suwannee	Florida	Occidental Petroleum Corp	Phosphate rock.	Open pit.
Kingsford	do	International Minerals & Chemical Corp.	do	Do.
Lee Creek	North Carolina	Texasgulf Inc	do	Do.
Swift Creek	Florida	Occidental Petroleum Corp	do	Do.
Noralyn	do	International Minerals & Chemical Corp.	do	Do.
Ft. Green	do	Williams Co	do	Do.
Payne Creek	do	do	do	Do.
Ft. Meade	do	Mobil Oil Corp	do	Do.
Rockland	do	United States Steel Corp	do	Do.
Haynsworth	do	American Cyanamid Co	do	Do.
Lonesome	do	do	do	Do.
Clear Spring	do	International Minerals & Chemical Corp.	do	Do.
Hookers	do	W. R. Grace & Co	do	Do.
Bonny Lake	do	do	do	Do.
Ft. Meade	do	Gardinier, Inc	do	Do.
Nichols	do	Mobil Oil Corp	do	Do.
Mabie Canyon	Idaho	Conda Partnership	do	Do.
Silver City	Florida	Estech General Chemical Corp.	do	Do.
Wooley Valley	Idaho	Stauffer Chemical Co	do	Do.
Watson	Florida	Estech General Chemical Corp.	do	Do.
Conda	Idaho	J. R. Simplot Co	do	Do.
Big Four	Florida	Amax Phosphate, Inc	do	Do.
Georgetown	Texas	Texas Crushed Stone Co	Stone	Open quarry.
Vernal	Utah	Chevron Resources Co	Phosphate rock.	Open pit.
Saddle Creek	Florida	Williams Co	do	Do.

[1]Brines and materials from wells excepted.

Table 10.—Ore treated or sold per unit of marketable product at surface and underground mines in the United States in 1980, by commodity[1]

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	3,190	1,540	2.1:1	--	--	--	3,190	1,540	2.1:1
Copper ---- thousand short tons	221,000	1,110	198.8:1	20,500	161	127.0:1	242,000	1,270	189.7:1
Gold:									
Lode ---- thousand troy ounces	8,090	242	33.5:1	2,370	350	6.8:1	10,500	592	17.7:1
Placer ---- do	3,200	10	334.6:1	--	--	--	3,200	10	334.6:1
Iron ore ---- thousand long tons	235,000	67,700	3.5:1	2,750	1,560	1.8:1	238,000	69,300	3.4:1
Lead ---- thousand short tons	W	W	W	10,700	563	19.1:1	10,700	563	19.1:1
Silver ---- thousand troy ounces	804	1,620	.5:1	1,230	14,200	.1:1	2,030	15,800	.1:1
Titanium and ilmenite ---- thousand short tons	7,350	594	12.4:1	--	--	--	7,350	594	12.4:1
Uranium ---- do	18,800	12	1,630.4:1	6,580	8	809.0:1	25,300	20	1,290.1:1
Zinc ---- do	--	--	--	7,180	257	27.9:1	7,180	257	27.9:1
NONMETALS									
Asbestos ---- do	3,120	88	35.5:1	W	W	W	3,120	88	35.5:1
Barite ---- do	3,760	2,230	1.7:1	--	--	--	3,760	2,230	1.7:1
Clays ---- do	44,300	44,300	1.0:1	184	184	1.0:1	44,400	44,400	1.0:1
Diatomite ---- do	1,070	689	1.6:1	--	--	--	1,070	689	1.6:1
Feldspar ---- do	1,850	626	3.0:1	--	--	--	1,850	626	3.0:1
Fluorspar ---- do	W	W	W	315	90	3.5:1	315	90	3.5:1
Gypsum ---- do	9,730	9,730	1.0:1	2,650	2,650	1.0:1	12,400	12,400	1.0:1
Mica (scrap) ---- do	526	81	6.5:1	--	--	--	526	81	6.5:1
Perlite ---- do	1,450	638	2.3:1	--	--	--	1,450	638	2.3:1
Phosphate rock ---- do	231,000	59,800	3.9:1	W	W	W	231,000	59,800	3.9:1
Potassium salts ---- do	--	--	--	19,700	2,060	9.6:1	19,700	2,060	9.6:1
Pumice ---- do	5,630	3,760	1.5:1	--	--	--	5,630	3,760	1.5:1
Salt ---- do	1,770	1,550	1.1:1	11,600	11,500	1.0:1	13,300	13,000	1.0:1
Sand and gravel ---- do	795,000	791,000	1.0:1	--	--	--	795,000	791,000	1.0:1
Sodium carbonate (natural) ---- do	--	--	--	12,400	6,860	1.8:1	12,400	6,860	1.8:1
Stone:									
Crushed and broken ---- do	[e]950,000	941,000	1.0:1	[e]30,300	29,900	1.0:1	[e]980,000	971,000	1.0:1
Dimension ---- do	[e]6,340	1,180	5.4:1	W	W	W	[e]6,340	1,180	5.4:1
Talc, soapstone, pyrophyllite ---- do	1,760	763	2.3:1	738	327	2.3:1	2,490	1,090	2.3:1

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

Table 11.—Material handled per unit of marketable product at surface and underground mines in the United States in 1980, by commodity[1]

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	17,800	1,540	9.4:1	--	--	--	17,800	1,540	9.4:1
Copper ---- thousand short tons	749,000	1,110	557.5:1	22,300	161	131.2:1	771,000	1,270	503.5:1
Gold:									
Lode ---- thousand troy ounces	12,800	242	47.5:1	7,380	350	18.6:1	20,100	592	30.4:1
Placer ---- do	7,270	10	576.8:1	--	--	--	7,270	10	576.8:1
Iron ore ---- thousand long tons	476,000	67,700	6.0:1	2,740	1,560	1.8:1	479,000	69,300	5.9:1
Lead ---- thousand short tons	W	W	W	13,600	563	20.2:1	13,600	563	20.2:1
Silver ---- thousand troy ounces	6,780	1,620	4.1:1	1,840	14,200	.1:1	8,610	15,800	.5:1
Titanium and ilmenite ---- thousand short tons	27,500	594	46.2:1	--	--	--	27,500	594	46.2:1
Uranium ---- do	336,000	12	22,202.9:1	10,200	8	925.9:1	346,000	20	13,387.6:1
Zinc ---- do	29	--	--	8,290	257	28.0:1	8,310	257	28.0:1
NONMETALS									
Asbestos ---- do	7,270	88	82.6:1	W	W	W	7,270	88	82.4:1
Barite ---- do	4,280	2,230	1.9:1	--	--	--	4,280	2,230	1.9:1
Clays ---- do	82,700	44,300	1.9:1	187	184	1.0:1	82,900	44,400	1.9:1
Diatomite ---- do	2,370	689	3.5:1	--	--	--	2,370	689	3.4:1
Feldspar ---- do	5,650	626	9.0:1	--	--	--	5,650	626	9.0:1
Fluorspar ---- do	W	W	W	361	90	4.0:1	361	90	4.0:1
Gypsum ---- do	13,300	9,730	1.1:1	2,650	2,650	1.0:1	16,000	12,400	1.1:1
Mica (scrap) ---- do	526	81	6.5:1	--	--	--	526	81	6.5:1
Perlite ---- do	1,090	638	1.7:1	--	--	--	1,090	638	1.7:1
Phosphate rock ---- do	716,000	59,800	11.6:1	W	W	W	716,000	59,800	11.6:1
Potassium salts ---- do	--	--	--	20,000	2,060	9.7:1	20,000	2,060	9.7:1
Pumice ---- do	3,860	3,760	1.0:1	--	--	--	3,860	3,760	1.0:1
Salt ---- do	1,770	1,550	1.1:1	11,000	11,500	1.0:1	12,800	13,000	1.0:1
Sand and gravel ---- do	794,000	791,000	1.0:1	--	--	--	794,000	791,000	1.0:1
Sodium carbonate (natural) ---- do	--	--	--	12,900	6,860	1.9:1	12,900	6,860	1.9:1
Stone:									
Crushed and broken ---- do	[e]1,030,000	941,000	1.1:1	[e]30,500	29,900	1.0:1	[e]1,060,000	971,000	1.1:1
Dimension ---- do	[e]7,980	1,180	6.7:1	W	W	W	[e]7,980	1,180	6.7:1
Talc, soapstone, pyrophyllite ---- do	2,780	763	3.5:1	451	327	1.4:1	3,230	1,090	2.9:1

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

Table 12.—Mining methods used in open pit mining in 1980, by commodity

(Percent)

Commodity	Total material handled	
	Preceded by drilling and blasting	Not preceded by drilling and blasting[1]
METALS		
Bauxite	78	22
Copper	97	3
Gold:		
Lode	70	30
Placer	--	100
Iron ore	87	13
Manganiferous ore	90	10
Mercury	3	97
Molybdenum	92	8
Nickel	18	82
Rare-earth metals	100	--
Silver	100	--
Tin	--	100
Titanium and ilmenite	4	96
Tungsten	--	100
Uranium	57	43
Vanadium	10	90
NONMETALS		
Abrasives	93	7
Aplite	7	93
Asbestos	95	5
Barite	15	85
Boron minerals	100	--
Clays	--	100
Diatomite	--	100
Feldspar	74	26
Fluorspar	60	40
Gypsum	89	11
Iron oxide pigments (crude)	--	100
Kyanite	100	--
Lithium minerals	85	15
Magnesite	100	--
Mica (scrap)	39	61
Millstones	17	83
Olivine	100	--
Perlite	52	48
Phosphate rock	5	95
Pumice	16	84
Salt	--	100
Sand and gravel	--	100
Stone:		
Crushed and broken	99	1
Dimension	--	100
Talc, soapstone, pyrophyllite	97	3
Vermiculite	--	100
Average	20	80

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

Table 13.—Development and exploration activity in the United States in 1980, 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	12,800	0.5	--	--	12,800	0.5
Raising	167,000	6.5	208	0.4	168,000	6.4
Drifting, crosscutting, or tunneling	850,000	33.1	5,510	9.4	855,000	32.5
Solution mining	1,540,000	59.9	52,800	90.2	1,590,000	60.6
Total[1]	2,570,000	100.0	58,500	100.0	2,630,000	100.0
EXPLORATION						
Diamond drilling	1,240,000	8.0	171,000	20.9	1,410,000	8.7
Churn drilling	48,200	.3	2,580	.3	50,800	.3
Rotary drilling	10,900,000	70.3	416,000	50.9	11,300,000	69.3
Percussion drilling	1,040,000	6.7	63,200	7.7	1,100,000	6.8
Other drilling	2,240,000	14.5	143,000	17.5	2,380,000	14.6
Trenching	36,900	.2	22,400	2.7	59,300	.3
Total[1]	15,500,000	100.0	818,000	100.0	16,300,000	100.0
Grand total[1]	18,000,000	XX	877,000	XX	18,900,000	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 1980, by commodity

(Feet)

Commodity	Development					Exploration						
	Shaft and winze sinking	Raising	Drifting, crosscutting, or tunneling	Solution mining	Total[1]	Diamond drilling	Churn drilling	Rotary drilling	Percussion drilling	Other drilling	Trenching	Total[1]
METALS												
Copper	2,150	34,500	100,000	--	137,000	223,000	--	35,400	62,900	83,200	330	405,000
Gold	1,040	80,400	41,200	--	123,000	233,000	18,700	291,000	132,000	4,900	32,500	712,000
Iron ore	--	--	1,500	--	1,500	28,200	--	11,200	--	--	--	39,400
Lead	100	3,610	48,600	--	52,300	234,000	28,500	153,000	6,910	145,000	--	567,000
Molybdenum	--	W	W	--	W	161,000	--	16,100	3,900	2,630	--	184,000
Nickel	--	--	--	--	--	1,180	--	--	--	--	--	1,180
Silver	1,970	6,060	40,500	--	48,600	37,700	--	9,440	18,200	6,580	3,700	75,600
Tin	--	--	--	--	--	--	--	--	1,810	--	300	2,110
Tungsten	--	8,270	10,600	--	18,800	41,600	--	200	5,710	--	--	47,500
Uranium	7,440	20,100	529,000	1,490,000	2,050,000	164,000	300	10,100,000	807,000	1,550,000	--	12,600,000
Zinc	130	6,270	51,000	--	57,400	111,000	--	--	745	100	--	112,000
Zirconium	--	--	--	--	--	1,500	--	--	--	--	--	1,500
Other[2]	--	8,170	27,500	50,000	85,700	2,000	800	260,000	--	440,000	--	703,000
Total[1]	12,800	167,000	850,000	1,540,000	2,570,000	1,240,000	48,200	10,900,000	1,040,000	2,240,000	36,900	15,500,000
NONMETALS												
Barite	--	--	--	--	--	256	--	2,550	8,220	--	16,900	27,900
Boron minerals	--	--	--	--	--	4,600	--	34,400	--	--	--	39,000
Gypsum	--	--	--	--	--	--	--	--	--	--	3,500	3,500
Phosphate rock	--	--	4,850	10,000	14,900	9,930	2,580	248,000	--	--	--	260,000
Sulfur	--	--	--	--	--	3,400	--	2,900	--	--	--	6,300
Talc, soapstone, pyrophyllite	--	W	W	--	W	4,350	--	--	54,000	--	--	58,400
Other[3]	--	208	660	42,800	43,600	149,000	--	128,000	1,000	143,000	2,000	423,000
Total[1]	--	208	5,510	52,800	58,500	171,000	2,580	416,000	63,200	143,000	22,400	818,000
Grand total[1]	12,800	168,000	855,000	1,590,000	2,630,000	1,410,000	50,800	11,300,000	1,100,000	2,380,000	59,300	16,300,000

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Data may not add to totals shown because of independent rounding.
[2]Antimony, bauxite, beryllium, cobalt, columbium-tantalum, and manganese.
[3]Clays, diatomite, fluorspar, perlite, potassium salts, and sodium carbonate (natural).

Table 15.—Development and exploration in 1980, by State

(Feet)

State	Development					Exploration						
	Shaft and winze sinking	Raising	Drifting, crosscutting, or tunneling	Solution mining	Total[1]	Diamond drilling	Churn drilling	Rotary drilling	Percussion drilling	Other drilling	Trenching	Total[1]
Alaska	--	60	20	--	80	20,500	8,000	--	--	180	7,390	36,000
Arizona	512	32,200	72,100	--	105,000	44,400	--	35,300	5,150	--	1,600	86,400
California	--	1,590	7,020	--	8,610	15,400	680	159,000	1,050	3,850	2,370	182,000
Colorado	630	15,000	136,000	--	151,000	188,000	10,000	1,150,000	2,980	241,000	--	1,590,000
Florida	--	--	--	--	--	--	--	163,000	--	--	--	163,000
Georgia	--	--	--	--	--	--	--	115,000	--	138,000	--	253,000
Idaho	1,800	7,050	21,900	10,000	40,700	44,800	2,580	26,400	--	2,630	--	76,400
Illinois	--	--	--	--	--	121,000	--	--	--	--	--	121,000
Michigan	--	--	--	--	--	21,600	--	7,550	--	--	--	29,200
Minnesota	--	--	--	--	--	16,800	--	--	--	--	--	16,800
Missouri	--	350	42,700	--	43,100	211,000	28,500	143,000	6,810	144,000	16,900	551,000
Montana	135	754	17,200	--	18,100	75,000	--	195,000	55,000	2,410	1,000	328,000
Nebraska	--	--	--	--	--	15,600	--	4,410	--	--	--	20,000
Nevada	160	8,070	9,820	--	18,100	57,500	796	350,000	178,000	9,030	27,000	622,000
New Mexico	7,070	16,100	346,000	--	369,000	108,000	--	2,290,000	804,000	500,000	3,000	3,700,000
North Carolina	--	--	--	--	--	4,850	--	--	--	--	--	4,850
Oregon	30	600	1,900	--	2,530	1,770	--	18,200	--	2,000	--	21,900
South Dakota	--	12,200	28,000	--	40,200	182,000	--	772,000	--	--	--	954,000
Tennessee	--	2,390	45,100	--	47,500	33,000	--	74,600	745	100	--	109,000
Texas	--	--	--	1,490,000	1,490,000	4,900	--	1,650,000	--	--	--	1,660,000
Utah	1,730	65,400	104,000	--	171,000	66,100	300	1,340,000	27,000	17,000	--	1,450,000
Washington	--	1,330	1,490	--	2,820	18,400	--	22,100	100	2,000	--	42,700
Wyoming	640	185	5,690	42,800	49,300	14,300	--	2,520,000	17,800	145,000	--	2,700,000
Undistributed[2]	130	4,820	16,100	50,800	71,900	147,000	--	262,000	3,840	1,170,000	--	1,590,000
Total[1]	12,800	168,000	855,000	1,590,000	2,630,000	1,410,000	50,800	11,300,000	1,100,000	2,380,000	59,300	16,300,000

[1]Data may not add to totals shown because of independent rounding.
[2]Includes Alabama, Arkansas, Indiana, Kansas, Kentucky, Maine, New York, Pennsylvania, South Carolina, Virginia, and Wisconsin.

Table 16.—Total material (ore and waste) produced by mine development in the United States in 1980, by commodity and State

(Thousand short tons)

	Shaft and winze sinking	Raising	Drifting, crosscutting, or tunneling	Stripping	Total[1]
COMMODITY					
METALS					
Copper	37	85	1,020	129,000	130,000
Gold	57	611	180	2,990	3,840
Iron ore	--	--	3	73,500	73,500
Lead	1	19	2,240	--	2,260
Silver	43	61	188	177	469
Tin	--	--	--	400	400
Uranium	114	84	2,460	80,600	83,300
Zinc	1	18	1,080	29	1,120
Other[2]	--	135	400	21,500	22,000
Total[1]	252	1,010	7,570	308,000	317,000
NONMETALS					
Phosphate rock	--	--	19	24,200	24,200
Talc, soapstone, pyrophyllite	--	([3])	9	110	120
Other[4]	--	([3])	2	2,490	2,500
Total[1]	--	([3])	30	26,800	26,800
Grand total[1]	252	1,010	7,600	335,000	344,000
STATE					
Alabama	--	--	--	W	W
Alaska	--	([3])	([3])	2,080	2,080
Arizona	14	75	691	43,200	44,000
Arkansas	--	--	--	2,410	2,410
California	--	5	64	50	119
Colorado	6	133	1,020	27,400	28,500
Georgia	--	--	--	W	W
Idaho	42	70	160	10,600	10,900
Michigan	--	--	--	W	W
Minnesota	--	--	--	63,700	63,700
Missouri	--	5	2,190	--	2,190
Montana	W	2	86	W	99
Nevada	1	29	86	1,260	1,380
New Mexico	115	71	1,150	85,800	87,100
New York	--	4	41	--	45
North Carolina	--	--	--	9,390	9,390
Oklahoma	--	--	--	W	W
Oregon	([3])	2	4	([3])	6
Pennsylvania	W	W	W	--	W
South Dakota	--	W	W	--	W
Tennessee	--	8	1,170	3	1,180
Texas	--	--	--	91	91
Utah	66	553	796	4,500	5,920
Virginia	--	W	W	W	W
Washington	--	10	4	4	18
Wyoming	5	([3])	22	71,200	71,200
Undistributed	2	46	128	13,300	13,500
Total[1]	252	1,010	7,600	335,000	344,000

W Withheld to avoid disclosing company proprietary data; included with "Undistributed."
[1]Data may not add to totals shown because of independent rounding.
[2]Antimony, bauxite, beryllium, molybdenum, and tungsten.
[3]Less than 1/2 unit.
[4]Abrasives, barite, fluorspar, gypsum, and potassium salts.

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

(Thousand pounds)

Year	Coal mining	Metal mining	Quarrying and nonmetal mining	Total mineral industry	Construction work and other uses	Total industrial
1976	1,798,873	488,653	493,656	2,781,182	547,347	3,328,529
1977	2,093,312	446,406	522,678	3,062,396	647,354	3,709,750
1978	[1]2,168,630	[1]574,213	[1]604,955	3,347,798	[2]581,391	3,929,189
1979	[r] [1]2,237,393	[r] [1]612,820	[r] [1]653,033	[r]3,503,246	[r] [2]587,212	[r]4,090,458
1980	[1]2,503,359	[1]559,229	[1]624,184	3,686,772	587,690	4,274,462

[r]Revised.
[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 1977-80 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				
1976	41,123	204	1,090	42,417
1977	46,663	225	694	47,582
1978	38,530	208	618	39,356
1979	44,891	281	615	45,787
1980	52,476	81	716	53,273
OTHER HIGH EXPLOSIVES				
1976	34,521	24,265	65,891	124,677
1977	34,407	25,174	63,378	122,959
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
WATER GELS AND SLURRIES				
1976	30,871	205,429	74,176	310,476
1977	42,406	154,704	75,062	272,172
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
AMMONIUM NITRATE: FUEL-MIXED AND UNPROCESSED				
1976	1,692,358	258,755	352,499	2,303,612
1977	1,969,836	266,303	383,544	2,619,683
1978	2,038,865	314,135	455,041	2,808,041
1979	[r]2,091,980	[r]350,102	[r]484,404	[r]2,926,486
1980	2,332,055	362,850	473,383	3,168,288
TOTAL				
1976	1,798,873	488,653	493,656	2,781,182
1977	2,093,312	446,406	522,678	3,062,396
1978	2,168,630	574,213	604,955	3,347,798
1979	[r]2,237,393	[r]612,820	[r]653,033	[r]3,503,246
1980	2,503,359	559,229	624,184	3,686,772

[r]Revised.

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 ordinarily 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 gold, silver, copper, lead, zinc, and tin, 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, Division of Foreign Data.

Table 1.—Value of crude nonfuel mineral production[1] in the United States, by mineral group

(Million dollars)

	Metals	Nonmetals	Total
1979	r8,536	r15,438	r23,974
1980	r8,922	r16,224	r25,146
1981	8,758	16,415	25,173

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

Table 2.—Nonfuel mineral production[1] in the United States

Mineral	1979 Quantity	1979 Value (thousands)	1980 Quantity	1980 Value (thousands)	1981 Quantity	1981 Value (thousan
METALS						
Antimony ore and concentrate short tons, antimony content	722	W	343	W	646	
Bauxite thousand metric tons, dried equivalent	1,821	$24,875	1,559	$22,353	1,510	$26,4
Copper (recoverable content of ores, etc.) metric tons	1,443,556	2,960,675	[r]1,181,116	[r]2,666,931	1,538,160	2,886,4
Gold (recoverable content of ores, etc.) troy ounces	[r]964,390	[r]296,550	[r]969,782	[r]594,050	1,377,946	633,3
Iron ore, usable (excluding byproduct iron sinter) thousand long tons, gross weight	86,130	2,811,574	69,562	2,543,484	72,158	2,914,6
Iron oxide pigments, crude short tons	74,548	2,578	62,642	4,043	67,214	4,1
Lead (recoverable content of ores, etc.) metric tons	525,569	609,929	[r]550,366	[r]515,189	445,535	358,8
Manganiferous ore (5% to 35% Mn) short tons, gross weight	240,696	2,902	173,887	2,444	175,760	2,8
Mercury 76-pound flasks	29,519	8,299	30,657	11,939	27,904	11,5
Molybdenum (content of concentrate) thousand pounds	143,504	871,067	149,311	1,344,181	118,916	945,5
Nickel (content of ore and concentrate) short tons	15,065	W	14,653	W	12,099	
Silver (recoverable content of ores, etc.) thousand troy ounces	[r]37,896	[r]420,261	[r]32,329	[r]667,278	40,685	427,9
Titanium concentrate: Ilmenite short tons, gross weight	646,399	32,965	593,704	32,041	523,681	37,0
Tungsten ore and concentrate thousand pounds of contained W	6,646	55,785	6,036	50,575	7,815	62,2
Vanadium (recoverable in ore and concentrate) short tons	5,520	73,892	4,806	64,370	5,126	71,4
Zinc (recoverable content of ores, etc.) metric tons	267,341	219,841	[r]317,103	[r]261,671	312,418	306,8
Combined value of beryllium, magnesium chloride for magnesium metal, platinum-group metals (1980-81), rare-earth metals, tin, titanium (rutile), zircon concentrate, and values indicated by symbol W	XX	144,962	XX	141,492	XX	68,1
Total	XX	[r]8,536,000	XX	[r]8,922,000	XX	8,758,0
NONMETALS (EXCEPT FUELS)						
Abrasive stones[2] short tons	2,094	2,064	2,131	2,233	4,501	1,17
Asbestos metric tons	93,354	28,925	80,079	30,599	75,618	30,6
Asphalt and related bitumens, native: Bituminous limestone, sandstone, gilsonite thousand short tons	1,614	25,622	1,252	25,030	1,261	27,65
Barite do	2,113	53,581	2,245	65,957	2,849	102,43
Boron minerals do	1,590	310,211	1,545	366,760	1,481	435,38
Bromine thousand pounds	497,000	114,500	[r]380,400	[r]95,400	389,500	90,20
Calcium chloride short tons	719,709	51,884	581,012	47,950	704,691	61,69
Carbon dioxide, natural thousand cubic feet	2,028,045	3,243	1,628,424	2,561	1,577,053	2,60
Cement:						
Masonry thousand short tons	3,748	204,797	3,040	188,456	2,738	161,81
Portland do	78,978	3,650,436	71,612	3,613,332	68,197	3,515,60
Clays do	54,689	846,089	48,790	898,947	44,379	988,84
Diatomite do	717	90,323	689	100,610	687	113,01
Emery short tons	[e]10,005	[e]204	[r]W	[r]W	W	W
Feldspar do	740,472	21,474	[e]710,000	[e]23,200	665,000	21,00
Fluorspar do	109,299	12,162	92,635	12,611	115,404	18,41
Garnet (abrasive) do	21,240	[r]1,535	26,909	[r]1,098	25,451	2,05
Gem stones[e]	NA	8,230	NA	6,930	NA	7,62
Gypsum thousand short tons	14,630	99,868	12,376	[r]103,059	11,497	98,10
Helium:						
Crude million cubic feet	[r]537	[r]6,444	299	3,588	175	2,10
High-purity do	[r]1,080	[r]24,840	1,159	26,657	1,223	31,79
Lime thousand short tons	20,945	862,459	19,010	842,922	18,856	884,19
Mica: Scrap do	134	7,708	[r]116	[r]6,262	133	8,21
Peat do	798	15,517	788	16,190	757	18,78
Perlite short tons	660,000	16,435	638,000	16,500	591,000	17,41
Phosphate rock thousand metric tons	51,611	1,045,655	54,415	1,256,947	53,624	1,437,98
Potassium salts thousand metric tons, K_2O equivalent	2,388	279,199	2,217	353,862	1,908	328,90
Pumice thousand short tons	[r]1,172	[r]4,864	[r]543	[r]4,267	499	4,31
Pyrites thousand metric tons	1,049	17,087	847	13,812	797	49,16

See footnotes at end of table.

Table 2.—Nonfuel mineral production[1] in the United States —Continued

Mineral	1979 Quantity	1979 Value (thousands)	1980 Quantity	1980 Value (thousands)	1981 Quantity	1981 Value (thousands)
NONMETALS (EXCEPT FUELS) — Continued						
Salt ------- thousand short tons--	45,793	$538,352	40,352	$656,164	38,907	$636,328
Sand and gravel ----------do----	979,000	2,427,000	r792,700	r2,289,000	p754,800	p2,290,000
Sodium sulfate (natural) ----do----	533	29,689	583	r36,387	608	43,186
Stone[3] ---------------do----	r1,100,860	r3,398,703	r984,856	r3,404,736	874,381	3,276,967
Sulfur, Frasch process thousand metric tons--	7,507	449,433	7,400	720,511	5,910	715,683
Talc and pyrophyllite thousand short tons--	e1,453	e20,364	1,473	25,626	1,343	31,497
Tripoli ------------short tons--	[4]116,009	[4]6,279	121,233	676	107,330	617
Vermiculite -- thousand short tons--	346	21,955	337	23,483	320	26,181
Combined value of aplite, graphite (1979), iodine, kyanite, lithium minerals, magnesite, magnesium compounds, marl (greensand), olivine, sodium carbonate (natural), staurolite, wollastonite, and values indicated by symbol W ------------------	XX	r740,271	XX	r941,212	XX	933,515
Total ------------------	XX	r15,438,000	XX	r16,224,000	XX	16,415,000
Grand total --------------	XX	r23,974,000	XX	r25,146,000	XX	25,173,000

eEstimated. pPreliminary. 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 abrasive stone and bituminous limestone and sandstone; all included elsewhere in table.

[4]Data represent prepared tripoli.

Table 3.—Nonfuel minerals produced in the United States and principal producing States in 1981

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

Table 4.—Value of nonfuel mineral production in the United States and principal nonfuel minerals produced in 1981

State	Value (thousands)	Rank	Percent of U.S. total	Principal minerals, in order of value
Alabama	$312,657	22	1.24	Cement, stone, lime, clays.
Alaska	127,541	38	.51	Sand and gravel, stone, gold, tin.
Arizona	2,565,840	1	10.19	Copper, molybdenum, cement, silver.
Arkansas	281,548	25	1.12	Bromine, cement, stone, sand and gravel.
California	1,975,016	3	7.85	Cement, boron minerals, sand and gravel, stone.
Colorado	965,766	7	3.84	Molybdenum, cement, sand and gravel, silver.
Connecticut	62,691	43	.25	Stone, sand and gravel, feldspar, lime.
Delaware	[1]2,800	50	.01	Magnesium compounds, sand and gravel.
Florida	1,725,589	4	6.85	Phosphate rock, stone, cement, clays.
Georgia	804,455	9	3.20	Clays, stone, cement, sand and gravel.
Hawaii	58,727	44	.23	Stone, cement, sand and gravel, lime.
Idaho	430,748	18	1.71	Silver, phosphate rock, zinc, lead.
Illinois	428,316	19	1.70	Stone, sand and gravel, cement, lime.
Indiana	258,832	26	1.03	Stone, cement, sand and gravel, lime.
Iowa	232,311	29	.92	Cement, stone, sand and gravel, gypsum.
Kansas	249,060	27	.99	Cement, salt, stone, helium.
Kentucky	207,759	31	.83	Stone, lime, cement, sand and gravel.
Louisiana	573,959	14	2.28	Sulfur, salt, sand and gravel, cement.
Maine	38,369	46	.15	Cement, sand and gravel, stone, gem stones.
Maryland	178,655	34	.71	Stone, cement, sand and gravel, clays.
Massachusetts	97,037	39	.39	Stone, sand and gravel, lime, clays.
Michigan	1,438,355	6	5.71	Iron ore, cement, magnesium compounds, salt.
Minnesota	2,151,871	2	8.55	Iron ore, sand and gravel, stone, lime.
Mississippi	91,791	41	.36	Cement, sand and gravel, clays, stone.
Missouri	870,326	8	3.46	Lead, cement, stone, lime.
Montana	305,071	23	1.21	Copper, cement, silver, gold.
Nebraska	73,995	42	.29	Cement, sand and gravel, stone, lime.
Nevada	503,649	16	2.00	Gold, barite, silver, diatomite.
New Hampshire	25,510	47	.10	Sand and gravel, stone, clays, gem stones.
New Jersey	142,012	37	.56	Stone, sand and gravel, zinc, titanium concentrate.
New Mexico	694,677	12	2.76	Copper, potassium salts, gold, cement.
New York	491,971	17	1.95	Stone, cement, salt, sand and gravel.
North Carolina	376,530	21	1.50	Phosphate rock, stone, sand and gravel, cement.
North Dakota	22,445	48	.09	Sand and gravel, salt, lime, clays.
Ohio	554,190	15	2.20	Stone, lime, sand and gravel, salt.
Oklahoma	236,612	28	.94	Cement, stone, sand and gravel, iodine.
Oregon	146,847	36	.58	Stone, sand and gravel, cement, nickel.
Pennsylvania	633,056	13	2.51	Cement, stone, lime, sand and gravel.
Rhode Island	[e]5,279	49	.02	Sand and gravel, stone, gem stones.
South Carolina	205,476	32	.82	Cement, stone, clays, sand and gravel.
South Dakota	193,374	33	.77	Gold, stone, cement, sand and gravel.
Tennessee	417,618	20	1.66	Zinc, stone, pyrites, cement.
Texas	1,658,203	5	6.59	Cement, sulfur, stone, sand and gravel.
Utah	783,232	10	3.11	Copper, gold, molybdenum, potassium salts.
Vermont	51,019	45	.20	Stone, asbestos, sand and gravel, talc.
Virginia	282,533	24	1.12	Stone, cement, lime, sand and gravel.
Washington	212,478	30	.84	Cement, sand and gravel, stone, lime.
West Virginia	96,447	40	.38	Sand and gravel, stone, cement, salt.
Wisconsin	156,333	35	.62	Sand and gravel, stone, iron ore, lime.
Wyoming	770,338	11	3.06	Sodium carbonate, clays, iron ore, cement.
Total	25,173,000	XX	100.00	

[e]Estimated. XX Not applicable.
[1]Incomplete total.

Table 5.—Value of nonfuel mineral production per capita and per square mile in 1981, by State

State	Area (square miles)	1981 population (thousands)	Value of mineral production				
			Total (thousands)	Per square mile		Per capita	
				Dollars	Rank	Dollars	Rank
Alabama	51,609	3,890	$312,657	6,058	27	80	24
Alaska	586,412	400	127,541	217	50	319	10
Arizona	113,909	2,718	2,565,840	22,525	4	944	2
Arkansas	53,104	2,286	281,548	5,302	30	123	17
California	158,693	23,669	1,975,016	12,446	12	83	22
Colorado	104,247	2,889	965,766	9,264	17	334	9
Connecticut	5,009	3,108	62,691	12,516	10	20	46
Delaware	2,057	595	[1]2,800	1,361	46	5	50
Florida	58,560	9,740	1,725,589	29,467	1	177	12
Georgia	58,876	5,464	804,455	13,664	8	147	15
Hawaii	6,450	965	58,727	9,105	19	61	28
Idaho	83,557	944	430,748	5,155	31	456	7
Illinois	56,400	11,418	428,316	7,594	21	38	39
Indiana	36,291	5,490	258,832	7,132	23	47	36
Iowa	56,290	2,913	232,311	4,127	35	80	23
Kansas	82,264	2,363	249,060	3,028	39	105	19
Kentucky	40,395	3,661	207,759	5,143	32	57	29
Louisiana	48,523	4,204	573,959	11,828	13	137	16
Maine	33,215	1,125	38,369	1,155	47	34	41
Maryland	10,577	4,216	178,655	16,891	6	42	38
Massachusetts	8,257	5,737	97,037	11,752	14	17	48
Michigan	58,216	9,258	1,438,355	24,707	3	155	14
Minnesota	84,068	4,077	2,151,871	25,597	2	528	6
Mississippi	47,716	2,521	91,791	1,924	44	36	40
Missouri	69,686	4,917	870,326	12,489	11	177	13
Montana	147,138	787	305,071	2,073	43	388	8
Nebraska	77,227	1,570	73,995	958	48	47	37
Nevada	110,540	799	503,649	4,556	33	630	3
New Hampshire	9,304	921	25,510	2,742	41	28	45
New Jersey	7,836	7,364	142,012	18,123	5	19	47
New Mexico	121,666	1,300	694,677	5,710	28	534	5
New York	49,576	17,557	491,971	9,924	15	28	44
North Carolina	52,586	5,874	376,530	7,160	22	64	27
North Dakota	70,665	653	22,445	318	49	34	42
Ohio	41,222	10,797	554,190	13,444	9	51	33
Oklahoma	69,919	3,025	236,612	3,384	37	78	25
Oregon	96,981	2,633	146,847	1,514	45	56	30
Pennsylvania	45,333	11,867	633,056	13,964	7	53	31
Rhode Island	1,214	947	[e]5,279	4,348	34	6	49
South Carolina	31,055	3,119	205,476	6,616	25	66	26
South Dakota	77,047	690	193,374	2,510	42	280	11
Tennessee	42,244	4,591	417,618	9,886	16	91	21
Texas	267,338	14,228	1,658,203	6,203	26	117	18
Utah	84,916	1,461	783,232	9,224	18	536	4
Vermont	9,609	511	51,019	5,310	29	100	20
Virginia	40,817	5,346	282,533	6,922	24	53	32
Washington	68,192	4,130	212,478	3,116	38	51	34
West Virginia	24,181	1,950	96,447	3,988	36	49	35
Wisconsin	56,154	4,705	156,333	2,784	40	33	43
Wyoming	97,914	471	770,338	7,867	20	1,636	1
Total[2] or average	3,615,055	225,864	25,173,000	6,963	XX	111	XX

[e]Estimated.
XX Not applicable.
[1]Incomplete total.
[2]Excludes Washington, D.C. (which has no mineral production), with an area of 67 square miles and a population of 638,000.

Table 6.—Nonfuel mineral production[1] in the United States, by State

Mineral	1979		1980		1981	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
ALABAMA						
Cement:						
Masonry ----- thousand short tons--	303	$13,930	242	$13,012	193	$10,721
Portland ----------------do----	2,578	103,187	2,491	108,438	2,270	89,216
Clays[2] ----------------do----	2,571	33,824	2,022	29,832	1,910	25,406
Gem stones----------------------	NA	2	NA	1	NA	1
Lime --------- thousand short tons--	1,273	54,182	1,128	53,685	1,219	59,454
Sand and gravel-------------do----	13,747	31,319	[r]11,076	[r]25,504	[p]10,382	[p]23,064
Stone:						
Crushed-----------------do----	26,443	83,566	23,433	82,270	20,706	88,377
Dimension ---------------do----	12	2,071	11	2,259	7	2,130
Combined value of asphalt (native), bauxite, clays (bentonite), mica (scrap, 1979-80), phosphate rock, and salt -----------	XX	14,286	XX	13,373	XX	14,288
Total ----------------------	XX	336,367	XX	[r]328,374	XX	312,657
ALASKA						
Gem stones----------------------	NA	60	NA	50	NA	60
Gold (recoverable content of ores, etc.) troy ounces--	6,675	2,053	[r]12,881	[r]7,890	25,316	11,636
Lead----------------metric tons--	--	--	31	29	W	W
Sand and gravel--- thousand short tons--	50,900	104,905	44,911	85,214	[p]46,400	[p]87,500
Silver (recoverable content of ores, etc.) thousand troy ounces--	([3])	5	8	172	2	25
Stone (crushed) --- thousand short tons--	3,656	15,458	3,990	19,978	5,359	26,855
Tin ----------------metric tons--	W	W	W	W	136	1,200
Combined value of barite (1979-80), platinum-group metals (1980-81), tungsten, and values indicated by symbol W ----------	XX	1,384	XX	1,983	XX	265
Total ----------------------	XX	123,865	XX	[r]115,316	XX	127,541
ARIZONA						
Clays --------- thousand short tons--	138	642	151	1,151	148	1,105
Copper (recoverable content of ores, etc.) metric tons--	946,002	1,940,211	[r]770,118	[r]1,738,908	1,040,813	1,953,142
Gem stones----------------------	NA	4,000	NA	3,100	NA	3,250
Gold (recoverable content of ores, etc.) troy ounces--	101,840	31,316	[r]79,631	[r]48,779	100,339	46,120
Gypsum-------- thousand short tons--	231	1,245	209	2,017	213	2,594
Lead (recoverable content of ores, etc.) metric tons--	354	411	[r]162	[r]152	993	800
Lime --------- thousand short tons--	673	27,186	514	23,904	538	29,913
Molybdenum (content of concentrate) thousand pounds--	35,101	213,065	35,668	341,965	35,808	254,345
Pumice -------- thousand short tons--	[r]1	[r]5	[r]9	[r]13	1	3
Sand and gravel-------------do----	[4]30,520	[4]74,716	24,399	73,773	[p]22,679	[p]69,855
Silver (recoverable content of ores, etc.) thousand troy ounces--	7,479	82,941	[r]6,268	[r]129,363	8,055	84,728
Stone:						
Crushed----- thousand short tons--	[r]6,708	[r]23,763	[r]6,205	[r]24,780	6,315	26,263
Dimension ---------------do----	5	110	W	45	W	578
Zinc ---------------metric tons--	W	W	W	W	138	135
Combined value of asbestos, barite (1981), cement, fluorspar (1979), perlite, pyrites, salt, tungsten, vanadium (1980-81), and values indicated by symbol W ----------	XX	90,870	XX	[r]83,037	XX	93,009
Total ----------------------	XX	2,490,481	XX	[r]2,470,987	XX	2,565,840
ARKANSAS						
Abrasives--------------short tons--	273	1,520	280	1,686	W	W
Bauxite------- thousand metric tons--	1,430	20,555	1,299	19,252	1,242	22,185
Clays --------- thousand short tons--	1,044	7,686	1,150	14,402	880	9,333
Gem stones----------------------	NA	150	NA	140	NA	200
Lime --------- thousand short tons--	160	6,287	175	7,785	149	8,102
Sand and gravel-------------do----	16,465	35,200	[r]13,017	[r]34,562	[p]12,742	[p]40,336
Stone:						
Crushed-----------------do----	19,978	53,723	20,666	61,399	13,834	47,260
Dimension ---------------do----	14	528	8	355	7	411
Combined value of barite, bromine, cement, gypsum, talc, tripoli, vanadium, and value indicated by symbol W -----------	XX	179,447	XX	[r]153,061	XX	153,721
Total ----------------------	XX	305,096	XX	[r]292,642	XX	281,548

See footnotes at end of table.

Table 6.—Nonfuel mineral production[1] in the United States, by State —Continued

Mineral	1979 Quantity	1979 Value (thousands)	1980 Quantity	1980 Value (thousands)	1981 Quantity	1981 Value (thousands)
CALIFORNIA						
Asbestos short tons	76,332	$20,434	W	W	W	W
Boron minerals thousand short tons	1,590	310,211	1,545	$366,760	1,481	$435,387
Cement, portland do	9,724	541,815	8,797	542,487	7,896	518,966
Clays do	2,531	18,621	2,558	17,766	2,309	19,118
Diatomite do	422	60,989	W	W	W	W
Gem stones	NA	240	NA	200	NA	300
Gold (recoverable content of ores, etc.) troy ounces	r5,010	r1,541	r4,078	r2,498	6,271	2,882
Gypsum thousand short tons	1,624	10,354	1,644	12,763	1,456	13,948
Lead (recoverable content of ores, etc.) metric tons	2	2	W	W	W	W
Lime thousand short tons	564	25,545	554	29,444	472	26,834
Mercury 76-pound flasks	151	43	226	88	85	35
Perlite thousand short tons	W	W	W	W	36	1,044
Pumice do	r121	r1,331	r58	r1,340	98	1,501
Sand and gravel do	129,348	347,385	r114,663	r363,904	p112,050	p381,669
Silver (recoverable content of ores, etc.) thousand troy ounces	64	712	49	1,017	53	560
Stone:						
Crushed thousand short tons	r39,267	r105,489	r37,760	r118,140	34,560	118,698
Dimension do	41	2,258	36	1,967	29	1,909
Talc do	176	6,960	100	1,863	111	5,855
Zinc (recoverable content of ores, etc.) metric tons	W	W	--	--	W	W
Combined value of calcium chloride, carbon dioxide, cement (masonry, 1979), copper, feldspar, iron ore, magnesium compounds, molybdenum, peat, potassium salts, rare-earth concentrates, salt, sodium carbonates, sodium sulfate, tungsten, wollastonite (1981), and values indicated by symbol W	XX	312,925	XX	r411,619	XX	446,310
Total	XX	r1,766,855	XX	r1,871,856	XX	1,975,016
COLORADO						
Clays thousand short tons	[2]521	[2]2,717	336	2,223	276	1,734
Copper (recoverable content of ores, etc.) metric tons	362	742	461	1,041	W	W
Gem stones	NA	70	NA	70	NA	80
Gold (recoverable content of ores, etc.) troy ounces	13,850	4,259	39,447	24,164	51,069	23,473
Gypsum thousand short tons	275	1,727	227	3,409	203	2,346
Lead (recoverable content of ores, etc.) metric tons	7,554	8,767	10,272	9,615	11,431	9,207
Molybdenum thousand pounds	W	W	102,498	915,304	73,615	636,037
Peat thousand short tons	33	299	29	327	33	299
Sand and gravel do	25,680	[4]56,263	[4]27,433	[4]74,452	p [4]25,700	p [4]72,300
Silver (recoverable content of ores, etc.) thousand troy ounces	2,809	31,151	2,987	61,653	3,009	31,650
Stone:						
Crushed thousand short tons	rW	rW	rW	rW	6,969	24,083
Dimension do	3	163	6	259	1	64
Zinc (recoverable content of ores, etc.) metric tons	9,910	8,149	13,823	11,406	W	W
Combined value of carbon dioxide, cement, clays (bentonite, 1979), iron ore, lime, perlite, pyrites, salt, sand and gravel (industrial), tin, tungsten concentrate, vanadium, and values indicated by symbol W	XX	r711,791	XX	r160,592	XX	164,493
Total	XX	826,098	XX	1,264,515	XX	965,766
CONNECTICUT						
Clays thousand short tons	112	435	92	482	73	391
Lime do	33	2,053	19	1,352	16	1,190
Sand and gravel[4] do	9,990	23,612	7,103	18,692	p6,500	p18,100
Stone:						
Crushed do	8,271	38,767	7,977	40,283	7,247	38,115
Dimension do	13	475	15	723	19	910
Combined value of feldspar, gem stones, mica, and industrial sand	XX	3,894	XX	4,231	XX	3,985
Total	XX	69,236	XX	65,763	XX	62,691

See footnotes at end of table.

Table 6.—Nonfuel mineral production[1] in the United States, by State —Continued

Mineral	1979 Quantity	1979 Value (thousands)	1980 Quantity	1980 Value (thousands)	1981 Quantity	1981 Value (thousands)
DELAWARE						
Clays ---- thousand short tons	11	$9	--	--	--	--
Sand and gravel ---- do	1,674	3,281	1,075	$2,398	p1,200	p$2,800
Total	XX	5 3,290	XX	5 2,398	XX	p 5 2,800
FLORIDA						
Cement:						
Masonry ---- thousand short tons	255	13,098	285	22,074	288	20,757
Portland ---- do	2,957	126,562	3,574	182,590	3,518	199,064
Clays ---- do	681	2 31,308	614	2 24,164	731	2 35,319
Gem stones	NA	4	NA	5	NA	6
Lime ---- thousand short tons	210	11,440	195	12,434	191	11,343
Peat ---- do	153	2,190	154	2,398	157	2,885
Sand and gravel ---- do	21,708	39,520	r 4 14,412	r 4 28,766	p14,149	p32,719
Stone (crushed) ---- do	r63,787	r188,896	66,209	215,972	65,067	226,192
Combined value of clays (kaolin), magnesium compounds, phosphate rock, rare-earth concentrate, sand and gravel (industrial, 1980), staurolite, titanium concentrates (ilmenite and rutile), and zircon concentrates	XX	r856,589	XX	r1,020,855	XX	1,197,304
Total	XX	r1,269,607	XX	r1,509,258	XX	1,725,589
GEORGIA						
Cement:						
Masonry ---- thousand short tons	102	5,172	89	5,464	89	4,392
Portland ---- do	1,335	55,117	1,231	55,463	1,150	45,423
Clays ---- do	8,322	437,671	8,283	500,555	8,029	553,726
Gem stones	NA	20	NA	20	NA	20
Sand and gravel[4] ---- thousand short tons	5,014	10,792	4,858	11,898	p4,700	p12,000
Stone:						
Crushed ---- do	40,902	154,021	40,884	162,642	35,730	153,751
Dimension ---- do	244	17,908	231	17,466	268	17,894
Talc ---- do	W	W	25	116	26	182
Combined value of barite, bauxite, feldspar, iron oxide pigments (crude), kyanite, mica, peat, sand and gravel (industrial), and value indicated by symbol W	XX	18,870	XX	r17,663	XX	17,067
Total	XX	699,571	XX	r771,287	XX	804,455
HAWAII						
Cement:						
Masonry ---- thousand short tons	12	1,077	13	960	10	807
Portland ---- do	469	29,346	358	23,722	302	23,024
Sand and gravel ---- do	1,081	3,063	1,035	2,855	p1,100	p2,900
Stone:						
Crushed ---- do	rW	rW	rW	rW	6,036	31,403
Dimension ---- do	1	W	W	11	(3)	4
Combined value of gem stones, lime, pumice, salt, and values indicated by symbol W	XX	r30,418	XX	r32,169	XX	589
Total	XX	63,904	XX	r59,717	XX	58,727
IDAHO						
Antimony ore and concentrate, antimony content ---- short tons	W	W	83	W	432	W
Clays ---- thousand short tons	28	263	27	301	26	288
Copper (recoverable content of ores, etc.) metric tons	3,618	7,421	3,103	7,006	4,245	7,966
Gem stones	NA	60	NA	60	NA	75
Gold (recoverable content of ores, etc.) troy ounces	24,140	7,423	W	W	W	W
Lead (recoverable content of ores, etc.) metric tons	42,636	49,479	38,607	36,139	38,397	30,923
Phosphate rock ---- thousand metric tons	4,880	95,728	4,991	100,873	5,361	108,964
Sand and gravel ---- thousand short tons	7,719	18,149	4 5,299	4 14,203	p5,100	p13,200
Silver (recoverable content of ores, etc.) thousand troy ounces	17,144	190,129	13,695	282,663	16,546	174,033
Stone[6] ---- thousand short tons	rW	rW	2,007	7,240	1,437	6,206
Zinc (recoverable content of ores, etc.) metric tons	29,660	24,391	27,722	22,876	W	W

See footnotes at end of table.

Table 6.—Nonfuel mineral production[1] in the United States, by State—Continued

Mineral	1979 Quantity	1979 Value (thousands)	1980 Quantity	1980 Value (thousands)	1981 Quantity	1981 Value (thousands)
IDAHO—Continued						
Combined value of cement, garnet (abrasives), gypsum, lime, perlite, pumice, sand and gravel (industrial), stone (dimension), tungsten ore (1980-81), vanadium, and values indicated by symbol W	XX	[r]$44,839	XX	$50,734	XX	$89,093
Total	XX	[r]437,882	XX	522,095	XX	430,748
ILLINOIS						
Cement, portland thousand short tons	1,889	79,604	1,649	75,315	1,574	61,536
Clays[2] do	542	2,355	459	1,919	322	1,540
Gem stones	NA	15	NA	15	NA	15
Peat thousand short tons	86	1,610	79	1,505	46	1,502
Sand and gravel do	45,448	134,190	31,725	122,332	[p]28,546	[p]118,986
Stone:						
Crushed do	63,551	188,130	53,309	180,656	44,159	165,218
Dimension do	3	128	2	103	2	85
Combined value of barite, cement (masonry), clays (fuller's earth), fluorspar, lead, lime, silver, tripoli, and zinc	XX	70,498	XX	61,436	XX	79,434
Total	XX	476,530	XX	443,281	XX	428,316
INDIANA						
Cement:						
Masonry thousand short tons	W	W	W	W	252	10,972
Portland do	2,389	95,549	1,769	73,049	1,538	59,344
Clays do	1,185	2,341	932	1,930	691	1,602
Gem stones	--	--	--	--	NA	1
Peat thousand short tons	76	1,242	84	1,414	105	3,140
Sand and gravel do	[4]27,050	[4]55,842	22,031	52,939	[p]20,457	[p]49,979
Stone:						
Crushed do	[r]34,147	[r]92,630	30,910	92,106	25,349	79,910
Dimension do	[r]181	[r]10,504	161	14,046	145	13,672
Combined value of abrasives (natural), gypsum, lime, sand and gravel (industrial, 1979), and values indicated by symbol W	XX	59,036	XX	52,986	XX	40,212
Total	XX	[r]317,144	XX	288,470	XX	258,832
IOWA						
Cement:						
Masonry thousand short tons	69	3,844	48	3,340	41	3,227
Portland do	2,371	109,628	1,998	101,008	1,779	92,099
Clays do	870	2,883	754	2,555	476	2,375
Gem stones	--	--	--	--	NA	1
Gypsum thousand short tons	1,695	13,777	1,468	13,136	1,383	12,706
Peat do	11	270	11	276	10	453
Sand and gravel do	17,495	39,686	[4]12,683	[4]32,722	[p][4]12,100	[p][4]32,000
Stone:						
Crushed do	32,471	103,215	26,542	92,603	22,424	82,891
Dimension do	10	508	10	509	W	W
Combined value of other nonmetals and value indicated by symbol W	XX	4,090	XX	5,727	XX	6,559
Total	XX	277,901	XX	251,876	XX	232,311
KANSAS						
Cement:						
Masonry thousand short tons	89	4,525	60	3,310	51	2,835
Portland do	2,086	88,619	1,835	86,103	1,641	81,792
Clays do	[2]1,061	[2]2,636	886	2,325	915	4,756
Gem stones	--	--	--	--	NA	1
Salt[7] thousand short tons	1,900	61,184	1,572	64,276	1,410	60,148
Sand and gravel do	14,280	26,490	[4]12,124	[4]23,817	[p]10,600	[p]21,000
Stone:						
Crushed do	19,308	56,038	17,398	54,731	14,143	45,738
Dimension do	W	W	18	937	14	605

See footnotes at end of table.

Table 6.—Nonfuel mineral production[1] in the United States, by State —Continued

Mineral	1979 Quantity	1979 Value (thousands)	1980 Quantity	1980 Value (thousands)	1981 Quantity	1981 Value (thousands)
KANSAS—Continued						
Combined value of clays (bentonite, 1979), gypsum, helium (crude and high-purity), lime, pumice, salt (brine), sand and gravel (industrial, 1980-81), and value indicated by symbol W	XX	$25,074	XX	$26,094	XX	$32,185
Total	XX	264,566	XX	261,593	XX	249,060
KENTUCKY						
Clays thousand short tons	794	3,259	748	3,692	490	2,395
Gem stones	NA	1	NA	1	NA	1
Sand and gravel[4] thousand short tons	11,726	23,721	7,767	17,637	[P]7,000	[P]15,547
Stone (crushed) do	W	W	W	W	32,433	108,257
Zinc (recoverable content of ores, etc.) metric tons	--	--	--	--	W	W
Combined value of cement, clays (ball clay), lime, sand and gravel (industrial), and values indicated by symbol W	XX	180,946	XX	182,970	XX	81,559
Total	XX	207,927	XX	204,300	XX	207,759
LOUISIANA						
Clays thousand short tons	416	6,073	380	5,841	[2]380	[2]6,338
Gem stones	--	--	--	--	NA	1
Salt thousand short tons	14,207	113,167	12,662	132,182	12,565	113,190
Sand and gravel do	[4]20,446	[4]54,081	18,505	66,413	[P]18,293	[P]66,426
Stone (crushed) do	W	W	W	W	[6]7,228	[6]34,566
Sulfur (Frasch) thousand metric tons	2,858	W	2,590	W	2,235	W
Combined value of cement, clays (bentonite, 1981), gypsum, lime, sand and gravel (1979), and values indicated by symbol W	XX	281,955	XX	379,330	XX	353,438
Total	XX	455,276	XX	583,766	XX	573,959
MAINE						
Clays thousand short tons	90	163	78	174	57	166
Gem stones	NA	W	NA	W	NA	W
Peat thousand short tons	3	202	8	534	W	W
Sand and gravel do	11,022	20,534	6,978	15,434	[P]7,100	[P]14,400
Stone (crushed) do	2,069	7,492	1,130	3,969	1,375	5,532
Combined value of other nonmetals and values indicated by symbol W	XX	17,507	XX	16,856	XX	18,271
Total	XX	45,898	XX	36,967	XX	38,369
MARYLAND						
Clays[2] thousand short tons	975	2,854	733	2,267	597	1,984
Gem stones	--	--	--	--	NA	2
Lime thousand short tons	12	444	12	497	9	441
Peat do	3	W	4	W	W	W
Sand and gravel do	13,988	39,033	10,732	33,625	[P]10,900	[P]35,000
Stone:						
Crushed do	21,561	80,550	18,945	77,431	16,485	74,289
Dimension do	30	1,150	15	612	34	1,002
Combined value of cement, clays (ball clay), and values indicated by symbol W	XX	68,931	XX	71,703	XX	65,937
Total	XX	192,962	XX	186,135	XX	178,655
MASSACHUSETTS						
Clays thousand short tons	156	367	210	870	259	1,322
Lime do	198	9,918	180	10,806	170	10,793
Peat do	2	56	W	W	W	W
Sand and gravel do	[4]16,705	[4]37,164	[4]13,925	[4]34,459	[P]13,087	[P][4]33,600
Stone:						
Crushed do	8,586	39,570	7,316	36,804	7,997	41,037
Dimension do	48	4,389	51	7,018	50	8,616
Combined value of gem stones, sand and gravel (industrial), and values indicated by symbol W	XX	1,082	XX	1,254	XX	1,669
Total	XX	92,546	XX	91,211	XX	97,037

See footnotes at end of table.

Table 6.—Nonfuel mineral production[1] in the United States, by State —Continued

Mineral	1979		1980		1981	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
MICHIGAN						
Cement:						
Masonry ----- thousand short tons--	262	$16,455	206	$14,292	173	$10,584
Portland ----------------do----	5,682	252,058	4,651	224,685	3,871	180,641
Clays ------------------do----	2,072	7,430	1,982	7,212	1,610	5,862
Gem stones--------------------	NA	10	NA	10	NA	15
Gypsum-------- thousand short tons--	2,526	14,633	1,383	8,605	1,066	6,762
Iron ore (usable), thousand long tons, gross weight--	17,196	596,478	15,895	634,355	14,193	W
Lime --------- thousand short tons--	1,057	43,373	836	36,750	807	36,800
Peat --------------------do----	258	4,847	253	4,739	237	4,540
Salt --------------------do----	3,080	82,540	2,406	104,842	2,321	103,293
Sand and gravel-------------do----	50,169	116,597	36,597	98,354	p32,893	p95,787
Stone:						
Crushed----------------do----	39,809	99,832	32,121	91,727	30,013	94,324
Dimension --------------do----	9	166	7	144	6	129
Combined value of bromine, calcium chloride, copper, iodine, iron oxide pigments (crude), magnesium compounds, silver, and value indicated by symbol W ------------	XX	272,107	XX	r259,435	XX	899,618
Total --------------------	XX	1,506,526	XX	r1,485,150	XX	1,438,355
MINNESOTA						
Clays --------- thousand short tons--	[2]135	[2]1,905	94	1,206	84	1,077
Gem stones--------------------	NA	5	NA	5	NA	5
Iron ore (usable), thousand long tons, gross weight--	59,682	1,965,710	45,472	1,686,839	50,176	2,062,118
Lime --------- thousand short tons--	140	5,133	162	3,562	155	3,818
Manganiferous ore --------short tons--	181,503	W	119,029	W	139,571	W
Peat--------- thousand short tons--	21	827	25	1,140	25	940
Sand and gravel[4] -------------do----	30,939	55,427	25,110	49,180	p23,200	p46,800
Stone:						
Crushed----------------do----	9,751	22,175	8,606	21,731	6,995	18,438
Dimension --------------do----	38	11,543	44	14,189	41	14,298
Combined value of abrasive stone, clays (kaolin, 1979), sand and gravel (industrial), and values indicated by symbol W------	XX	5,265	XX	4,458	XX	4,377
Total --------------------	XX	2,067,990	XX	1,782,310	XX	2,151,871
MISSISSIPPI						
Clays --------- thousand short tons--	1,820	21,841	1,596	21,714	1,218	23,309
Lime --------------------do----	70	1,571	31	707	--	--
Sand and gravel[4] -------------do----	16,940	37,797	11,710	31,606	p10,400	p28,800
Stone (crushed) --------------do----	W	W	W	W	1,984	5,451
Combined value of cement, magnesium compounds (1979-80), sand and gravel (industrial), stone (crushed, 1981), and values indicated by symbol W --------------	XX	46,480	XX	49,913	XX	34,231
Total --------------------	XX	107,689	XX	103,940	XX	91,791
MISSOURI						
Barite--------- thousand short tons--	89	3,679	117	5,570	185	9,725
Cement:						
Masonry ----------------do----	82	4,159	62	3,117	103	5,495
Portland ----------------do----	4,430	194,285	3,515	156,368	3,732	168,567
Clays ------------------do----	2,351	20,522	1,817	16,798	1,747	18,414
Copper (recoverable content of ores, etc.) metric tons--	13,021	26,705	13,576	30,655	8,411	15,783
Gem stones--------------------	NA	10	NA	15	NA	10
Gold (recoverable content of ores, etc.) troy ounces--	32	10	W	W	--	--
Lead (recoverable content of ores, etc.) metric tons--	472,054	547,824	497,170	465,393	389,721	313,870
Lime --------- thousand short tons--	1,790	70,187	1,667	63,733	W	W
Sand and gravel-------------do----	12,558	31,310	8,900	26,753	p8,778	p18,702
Silver (recoverable content of ores, etc.) thousand troy ounces--	2,201	24,410	2,357	48,653	1,837	19,322
Stone:						
Crushed----- thousand short tons--	56,380	139,944	48,296	130,254	40,910	116,297
Dimension --------------do----	([3])	85	W	W	W	W
Zinc (recoverable content of ores, etc.) metric tons--	61,682	50,723	r62,886	r51,893	52,904	51,966

See footnotes at end of table.

Table 6.—Nonfuel mineral production[1] in the United States, by State —Continued

Mineral	1979 Quantity	1979 Value (thousands)	1980 Quantity	1980 Value (thousands)	1981 Quantity	1981 Value (thousands)
MISSOURI—Continued						
Combined value of asphalt (native, 1979-80), gold (1980), iron ore, iron oxide pigments (crude), and values indicated by symbol W	XX	$46,706	XX	$55,633	XX	$132,175
Total	XX	1,160,559	XX	r1,054,835	XX	870,326
MONTANA						
Antimony ______ short tons	W	W	260	W	214	W
Clays ______ thousand short tons	424	11,508	626	22,200	601	23,111
Copper (recoverable content of ores, etc.) metric tons	69,854	143,268	37,749	85,236	62,485	117,257
Gem stones	NA	100	NA	90	NA	100
Gold (recoverable content of ores, etc.) troy ounces	24,050	7,395	48,366	29,627	54,267	24,943
Lead (recoverable content of ores, etc.) metric tons	258	299	295	276	194	157
Lime ______ thousand short tons	216	8,965	223	9,001	194	7,621
Sand and gravel ______ do	7,012	15,106	[4]6,639	[4]16,057	p [4]6,100	p [4]14,900
Silver (recoverable content of ores, etc.) thousand troy ounces	3,302	36,618	2,024	41,773	2,989	31,437
Stone (crushed) ___ thousand short tons	2,527	7,806	1,962	6,302	1,582	5,137
Talc ______ do	343	5,940	312	11,310	W	W
Zinc (recoverable content of ores, etc.) metric tons	104	86	71	59	25	24
Combined value of barite, cement, gypsum, iron ore (1979 and 1981), peat, phosphate rock, sand and gravel (industrial, 1980-81), stone (dimension), tungsten, vermiculite, and values indicated by symbol W	XX	54,196	XX	57,619	XX	80,384
Total	XX	291,287	XX	279,550	XX	305,071
NEBRASKA						
Clays ______ thousand short tons	156	454	154	456	136	409
Gem stones	NA	W	NA	W	NA	W
Sand and gravel ___ thousand short tons	16,197	33,001	10,538	22,981	p10,319	p22,844
Stone (crushed) ______ do	4,995	19,362	3,775	16,301	3,139	14,024
Combined value of cement, lime, and values indicated by symbol W	XX	46,364	XX	40,736	XX	36,718
Total	XX	99,181	XX	80,474	XX	73,995
NEVADA						
Barite ______ thousand short tons	1,804	35,707	1,918	47,800	2,482	79,716
Clays ______ do	76	1,163	64	2,082	73	2,948
Gem stones	NA	1,000	NA	900	NA	1,000
Gold (recoverable content of ores, etc.) troy ounces	250,097	76,905	r278,495	r170,595	524,802	241,220
Gypsum ______ thousand short tons	1,075	6,771	852	8,276	778	6,914
Iron ore ______ thousand long tons	W	W	W	W	99	e1,490
Lead (recoverable content of ores, etc.) metric tons	24	28	26	24	W	W
Mercury ______ 76-pound flasks	29,368	8,256	30,431	11,851	27,819	11,514
Molybdenum ______ pounds	39,826	242	--	--	--	--
Perlite ______ thousand short tons	5	71	6	92	W	W
Sand and gravel[4] ______ do	10,498	21,387	8,439	18,360	p6,000	p12,800
Silver (recoverable content of ores, etc.) thousand troy ounces	560	6,215	r940	r19,402	3,039	31,970
Stone (crushed) ___ thousand short tons	rW	rW	rW	rW	1,343	5,664
Zinc (recoverable content of ores, etc.) metric tons	W	W	2	2	W	W
Combined value of cement (portland), copper, diatomite, fluorspar, lime, lithium compounds, magnesite, pumice (1979), salt, sand and gravel (industrial), talc (1979-80), tungsten and values indicated by symbol W	XX	r102,501	XX	r114,846	XX	108,413
Total	XX	260,246	XX	r394,230	XX	503,649

See footnotes at end of table.

Table 6.—Nonfuel mineral production[1] in the United States, by State —Continued

Mineral	1979 Quantity	1979 Value (thousands)	1980 Quantity	1980 Value (thousands)	1981 Quantity	1981 Value (thousands)
NEW HAMPSHIRE						
Sand and gravel ___ thousand short tons__	7,086	$15,301	6,334	$15,837	[p]5,800	[p]$15,900
Stone:						
Crushed ____________ do____	866	2,172	590	2,281	665	2,599
Dimension ____________ do____	86	5,774	103	7,167	89	6,889
Combined value of other nonmetals ______	XX	11	XX	121	XX	122
Total ____________________	XX	23,258	XX	25,406	XX	25,510
NEW JERSEY						
Clays _________ thousand short tons__	67	559	63	525	62	563
Gem stones____________________	NA	1	NA	1	NA	1
Lime _________ thousand short tons__	W	W	--	--	--	--
Peat ____________________ do____	23	549	20	564	26	1,476
Sand and gravel_____________ do____	10,781	44,682	8,596	45,535	[p]8,105	[p]45,838
Stone (crushed)[6] ___________ do____	13,950	63,174	11,830	61,886	10,434	57,819
Zinc (recoverable content of ores, etc.) metric tons__	31,118	25,589	28,859	23,814	16,198	15,911
Combined value of iron ore (1981), magnesium compounds, marl (greensand), stone (dimension), titanium concentrate (ilmenite), and value indicated by symbol W ___	XX	17,135	XX	17,123	XX	20,404
Total ____________________	XX	151,689	XX	149,448	XX	142,012
NEW MEXICO						
Clays[2] _________ thousand short tons__	74	124	60	114	64	119
Copper (recoverable content of ores, etc.) metric tons__	164,281	336,934	149,394	337,328	154,114	289,204
Gem stones____________________	NA	180	NA	150	NA	200
Gold (recoverable content of ores, etc.) troy ounces__	[r]14,966	[r]4,602	[r]15,847	[r]9,707	65,749	30,221
Gypsum________ thousand short tons__	251	3,244	182	1,688	166	2,256
Lead (recoverable content of ores, etc.) metric tons__	43	49	--	--	W	W
Manganiferous ore (5% to 35% Mn) short tons__	33,152	W	35,198	W	12,741	W
Mica (scrap) _____ thousand short tons__	17	W	W	W	W	W
Peat ____________________ do____	2	40	2	40	--	--
Perlite __________________ do____	588	14,874	539	14,404	489	14,983
Potassium salts __ thousand metric tons__	2,005	228,776	1,869	289,011	1,601	261,200
Pumice ________ thousand short tons__	[r]191	[r]1,181	[r]84	[r]814	93	919
Sand and gravel______________ do____	7,141	18,245	7,050	17,676	[p]7,300	[p]18,000
Silver (recoverable content of ores, etc.) thousand troy ounces__	W	W	W	W	1,632	17,170
Stone:						
Crushed______ thousand short tons__	[r]3,001	[r]9,112	[r]2,581	[r]9,473	4,162	12,485
Dimension ______________ do____	20	117	18	91	26	173
Combined value of barite (1979-80), carbon dioxide, cement, clays (fire clay), helium (high-purity, 1980-81), lime, molybdenum, salt, vanadium, zinc, and values indicated by symbol W __________________	XX	[r]72,383	XX	[r]85,113	XX	47,747
Total ____________________	XX	[r]689,861	XX	[r]765,609	XX	694,677
NEW YORK						
Clays[2] _________ thousand short tons__	836	3,027	596	2,479	597	2,310
Emery _______________ short tons__	10,005	204	[r]W	[r]W	W	W
Gem stones____________________	NA	20	NA	20	NA	30
Lead (recoverable content of ores, etc.) metric tons__	458	532	876	820	968	780
Peat __________ thousand short tons__	38	630	43	917	39	811
Salt ____________________ do____	6,387	77,751	5,509	99,395	5,597	103,668
Sand and gravel_____________ do____	[4]26,242	[4]55,889	[4]21,918	[4]53,276	[p]21,255	[p] [4]56,300
Silver (recoverable content of ores, etc.) thousand troy ounces__	11	117	21	427	29	303
Stone:						
Crushed______ thousand short tons__	37,499	114,174	34,483	120,764	30,681	117,689
Dimension ______________ do____	27	2,626	25	2,414	21	2,291
Zinc (recoverable content of ores, etc.) metric tons__	12,133	9,977	33,629	27,750	36,889	36,235

See footnotes at end of table.

Table 6.—Nonfuel mineral production[1] in the United States, by State —Continued

Mineral	1979 Quantity	1979 Value (thousands)	1980 Quantity	1980 Value (thousands)	1981 Quantity	1981 Value (thousands)
NEW YORK—Continued						
Combined value of cement, clays (ball clay), garnet (abrasive), gypsum, iron ore, lime, sand and gravel (industrial), talc, titanium concentrate (ilmenite), wollastonite, and values indicated by symbol W	XX	[r]$190,169	XX	[r]$187,526	XX	$171,554
Total	XX	[r]455,116	XX	[r]495,788	XX	491,971
NORTH CAROLINA						
Clays[2] ---- thousand short tons	3,308	8,385	2,852	7,308	2,110	6,838
Feldspar ---- short tons	523,663	[e]14,531	[e]499,600	[e]15,062	462,864	13,517
Gem stones	NA	50	NA	40	NA	50
Mica, scrap ---- thousand short tons	84	5,847	[r]77	[r]4,647	92	6,398
Sand and gravel ---- do	11,203	29,733	9,309	28,735	[p]8,936	[p]32,640
Stone:						
Crushed ---- do	39,864	125,319	34,764	125,019	28,833	117,092
Dimension ---- do	49	3,932	55	4,536	30	2,773
Talc and pyrophyllite ---- do	[e]130	[e]692	W	W	[8]104	[8]825
Combined value of cement, clays (kaolin), lithium compounds, olivine, phosphate rock, and value indicated by symbol W	XX	153,752	XX	194,986	XX	196,397
Total	XX	342,241	XX	[r]380,333	XX	376,530
NORTH DAKOTA						
Gem stones	NA	1	NA	2	NA	2
Peat ---- thousand short tons	([3])	W	W	31	W	36
Sand and gravel ---- do	6,648	15,128	5,173	14,457	[p]4,900	[p]14,100
Combined value of clays, lime, salt, and values indicated by symbol W	XX	6,105	XX	7,886	XX	8,307
Total	XX	21,234	XX	22,376	XX	22,445
OHIO						
Cement:						
Masonry ---- thousand short tons	170	10,869	126	8,549	105	7,129
Portland ---- do	1,921	87,483	1,625	77,696	1,461	69,517
Clays ---- do	3,374	13,495	2,718	11,516	2,217	10,411
Gypsum ---- do	W	W	136	1,346	148	1,566
Lime ---- do	3,392	141,663	2,786	122,817	2,767	127,751
Peat ---- do	8	191	10	166	10	191
Salt ---- do	4,135	79,598	3,228	87,371	3,608	90,254
Sand and gravel ---- do	45,944	121,048	36,972	114,291	[p]36,087	[p]118,493
Stone:						
Crushed ---- do	50,717	149,819	42,441	136,929	36,950	125,588
Dimension ---- do	50	1,702	35	1,558	W	W
Combined value of abrasives, gem stones, and values indicated by symbol W	XX	1,452	XX	101	XX	3,290
Total	XX	607,320	XX	562,340	XX	554,190
OKLAHOMA						
Clays ---- thousand short tons	949	1,999	972	2,249	838	2,064
Gem stones	--	--	--	--	NA	2
Gypsum ---- thousand short tons	1,480	9,770	1,326	11,230	1,177	9,870
Helium:						
High-purity ---- million cubic feet	395	9,085	349	8,027	49	1,274
Crude ---- do	35	420	23	276	22	264
Pumice ---- thousand short tons	1	W	1	W	1	W
Sand and gravel ---- do	12,101	32,502	11,881	37,162	[p]11,700	[p]38,117
Stone:						
Crushed ---- do	28,312	66,666	28,173	76,267	29,930	83,407
Dimension ---- do	38	1,383	16	678	18	738
Combined value of cement, feldspar, iodine, lime, salt, tripoli, and values indicated by symbol W	XX	80,696	XX	88,244	XX	100,876
Total	XX	202,521	XX	224,133	XX	236,612

See footnotes at end of table.

Table 6.—Nonfuel mineral production[1] in the United States, by State —Continued

Mineral	1979 Quantity	1979 Value (thousands)	1980 Quantity	1980 Value (thousands)	1981 Quantity	1981 Value (thousands)
OREGON						
Clays thousand short tons	139	$263	172	$321	176	$300
Copper (recoverable content of ores, etc.) metric tons	2	4	--	--	W	W
Gem stones	NA	500	NA	450	NA	600
Gold (recoverable content of ores, etc.) troy ounces	W	W	^{r}W	^{r}W	2,830	1,301
Lead (recoverable content of ores, etc.) metric tons	(3)	(3)	--	--	W	W
Nickel (content of ores and concentrates) short tons	15,065	W	14,653	W	12,099	W
Pumice thousand short tons	^{r}W	^{r}W	^{r}219	^{r}1,318	W	W
Sand and gravel do	17,874	45,829	16,005	47,300	^{p}14,400	^{p}42,400
Silver (recoverable content of ores, etc.) thousand troy ounces	2	17	1	17	7	79
Stone:						
Crushed thousand short tons	^{r}W	^{r}W	^{r}19,251	^{r}49,606	16,482	46,055
Dimension do	(3)	4	15	231	(3)	5
Combined value of cement, diatomite, lime, talc, and values indicated by symbol W	XX	^{r}118,704	XX	^{r}52,727	XX	56,107
Total	XX	^{r}165,321	XX	^{r}151,970	XX	146,847
PENNSYLVANIA						
Cement:						
Masonry thousand short tons	415	24,177	324	20,298	293	14,799
Portland do	6,508	259,756	5,570	237,684	5,150	215,883
Clays[2] do	2,468	20,099	1,650	12,112	1,246	7,497
Gem stones	--	--	--	--	NA	5
Lime thousand short tons	2,153	96,569	1,768	84,291	1,690	85,418
Mica (scrap) do	4	W	3	W	3	134
Peat do	24	531	26	552	25	647
Sand and gravel do	20,150	71,740	15,603	68,257	^{p} [4]14,300	^{p} [4]55,400
Stone:						
Crushed do	71,432	224,014	61,143	218,231	53,258	207,821
Dimension do	77	5,961	65	6,397	51	7,193
Tripoli short tons	W	W	W	W	1,263	W
Zinc (recoverable content of ores, etc.) metric tons	21,447	17,636	22,556	18,613	24,732	24,293
Combined value of clays (kaolin), sand and gravel (industrial, 1981), and values indicated by symbol W	XX	1,237	XX	1,171	XX	13,966
Total	XX	721,720	XX	667,606	XX	633,056
RHODE ISLAND						
Sand and gravel thousand short tons	3,537	6,737	2,506	4,945	^{p}1,900	^{p}4,100
Stone (crushed) do	249	1,148	203	1,208	141	1,116
Combined value of other nonmetals	XX	1	XX	17	XX	63
Total	XX	7,886	XX	6,170	XX	^{p}5,279
SOUTH CAROLINA						
Cement, portland thousand short tons	1,831	79,377	1,704	74,539	1,765	79,407
Clays[2] do	2,272	24,492	2,211	25,169	1,632	28,600
Gem stones	NA	5	NA	5	NA	10
Manganiferous ore thousand short tons	26	W	20	W	23	W
Sand and gravel do	8,321	26,665	5,556	22,855	^{p}5,303	^{p}23,531
Stone:						
Crushed do	16,589	48,352	16,107	49,207	14,825	49,830
Dimension do	9	482	12	703	18	1,109
Combined value of cement (masonry), clays (fuller's earth), copper (1981), gold (1981), mica (scrap), peat (1979), silver (1981), vermiculite, and values indicated by symbol W	XX	22,277	XX	22,301	XX	22,989
Total	XX	201,650	XX	194,779	XX	205,476

See footnotes at end of table.

Table 6.—Nonfuel mineral production[1] in the United States, by State —Continued

Mineral	1979 Quantity	1979 Value (thousands)	1980 Quantity	1980 Value (thousands)	1981 Quantity	1981 Value (thousands)
SOUTH DAKOTA						
Cement:						
Masonry ----- thousand short tons--	7	$434	6	$377	6	$454
Portland ---------------do----	670	31,273	459	23,042	450	23,290
Clays -----------------do----	205	292	[2]169	[2]283	116	209
Gem stones---------------------	NA	50	NA	50	NA	70
Gold (recoverable content of ores, etc.) troy ounces--	245,912	75,618	[r]267,642	[r]163,947	278,162	127,854
Mica, scrap------ thousand short tons--	([3])	2	([3])	4	W	W
Sand and gravel-------------do----	6,001	10,119	4,209	8,243	[p]4,000	[p]7,900
Silver (recoverable content of ores, etc.) thousand troy ounces--	58	643	51	1,058	56	587
Stone:						
Crushed------ thousand short tons--	3,891	10,317	3,151	8,942	2,985	9,085
Dimension --------------do----	36	13,268	42	15,035	50	17,543
Combined value of beryllium (1981), clays (bentonite, 1980-81), feldspar, gypsum, iron ore (1980), lime, and value indicated by symbol W -------------------	XX	6,670	XX	6,873	XX	6,382
Total ---------------------	XX	148,686	XX	[r]227,854	XX	193,374
TENNESSEE						
Cement:						
Masonry ----- thousand short tons--	170	8,600	132	7,241	66	3,209
Portland ---------------do----	1,335	57,146	1,304	58,827	974	39,378
Clays -----------------do----	1,561	26,071	1,188	22,844	1,047	23,134
Gem stones---------------------	NA	1	NA	1	NA	5
Phosphate rock -- thousand metric tons--	1,873	14,770	1,582	12,765	1,328	16,201
Sand and gravel--- thousand short tons--	11,210	29,056	8,921	24,930	[p]7,942	[p]26,210
Stone:						
Crushed----------------do----	45,718	133,727	38,584	126,993	[6]32,497	[6]113,729
Dimension --------------do----	12	1,000	10	883	11	1,063
Zinc (recoverable content of ores, etc.) metric tons--	85,119	69,995	[r]111,754	[r]92,218	117,684	115,597
Combined value of barite, copper, gold (1981), lead (1979), lime, pyrites, silver, stone (crushed, 1981) ----------------	XX	45,378	XX	47,133	XX	79,092
Total ---------------------	XX	385,744	XX	[r]393,835	XX	417,618
TEXAS						
Cement:						
Masonry ----- thousand short tons--	268	15,593	241	18,310	229	15,699
Portland ---------------do----	9,353	475,836	9,517	535,690	10,262	567,391
Clays -----------------do----	3,871	21,533	3,763	27,022	4,172	29,135
Gem stones---------------------	NA	170	NA	160	NA	200
Gypsum-------- thousand short tons--	1,903	11,438	1,681	14,124	1,783	14,900
Helium (high-purity)-- million cubic feet--	38	874	35	805	238	6,188
Lime --------- thousand short tons--	1,507	59,520	1,515	67,075	1,393	67,158
Salt -----------------do----	11,283	67,602	9,978	93,414	8,397	84,240
Sand and gravel-------------do----	52,846	167,076	46,704	171,576	[p]45,442	[p]178,492
Stone:						
Crushed----------------do----	74,612	188,746	76,483	220,265	72,454	219,086
Dimension --------------do----	17	3,636	37	7,095	42	5,543
Sulfur (Frasch) -- thousand metric tons--	4,649	W	4,810	W	3,674	W
Talc and pyrophyllite thousand short tons--	207	1,544	401	4,295	282	4,127
Combined value of asphalt (native), fluorspar (1979 and 1981), graphite (1979), helium (crude), iron ore, magnesium chloride, magnesium compounds, sodium sulfate and values indicated by symbol W ----------	XX	391,071	XX	574,820	XX	466,044
Total ---------------------	XX	1,404,639	XX	1,734,651	XX	1,658,203

See footnotes at end of table.

Table 6.—Nonfuel mineral production[1] in the United States, by State —Continued

Mineral	1979 Quantity	1979 Value (thousands)	1980 Quantity	1980 Value (thousands)	1981 Quantity	1981 Value (thousands)
UTAH						
Clays thousand short tons	355	$1,246	365	$1,517	290	$2,296
Copper (recoverable content of ores, etc.) metric tons	193,082	396,003	157,775	356,251	211,276	396,471
Gem stones	NA	75	NA	70	NA	80
Gold (recoverable content of ores, etc.) troy ounces	260,916	80,232	179,538	109,978	227,706	104,663
Gypsum thousand short tons	292	2,450	287	2,612	300	2,705
Iron ore (usable), thousand long tons, gross weight	1,618	19,391	1,307	18,540	691	W
Lead (recoverable content of ores, etc.) metric tons	W	W	[r]W	[r]W	1,662	1,338
Lime thousand short tons	198	8,250	259	13,293	333	16,679
Perlite do	W	W	(3)	2	(3)	4
Pumice do	(9)	(9)	(9)	(9)	--	--
Salt do	1,204	14,723	1,157	19,373	1,072	21,775
Sand and gravel[4] do	10,363	18,621	8,906	17,234	[p]9,122	[p]18,186
Silver (recoverable content of ores, etc.) thousand troy ounces	2,454	27,216	[r]2,203	[r]45,476	2,883	30,321
Stone:						
Crushed thousand short tons	[r]3,452	[r]11,339	[r]2,954	[r]12,123	2,840	12,157
Dimension do	5	216	3	272	3	280
Zinc (recoverable content of ores, etc.) metric tons	W	W	[r]W	[r]W	1,576	1,548
Combined value of asphalt (native), beryllium concentrate, carbon dioxide (natural), cement, magnesium compounds, molybdenum, phosphate rock, potassium salts, sand and gravel (industrial, 1979-80), sodium sulfate, tungsten, vanadium, and values indicated by symbol W	XX	169,520	XX	[r]166,883	XX	174,729
Total	XX	749,282	XX	[r]763,624	XX	783,232
VERMONT						
Sand and gravel thousand short tons	3,660	6,240	1,900	4,171	[p]1,900	[p]4,200
Stone:						
Crushed do	2,077	13,927	1,320	4,787	1,319	5,144
Dimension do	180	23,006	169	23,649	207	30,756
Talc do	346	2,755	318	2,753	W	W
Combined value of other nonmetals and value indicated by symbol W	XX	8,208	XX	7,277	XX	10,919
Total	XX	54,136	XX	42,637	XX	51,019
VIRGINIA						
Clays thousand short tons	1,059	3,512	762	3,172	502	2,016
Gem stones	NA	15	NA	15	NA	20
Lead (recoverable content of ores, etc.) metric tons	1,596	1,852	1,563	1,463	1,607	1,294
Lime thousand short tons	872	34,935	824	33,872	804	35,984
Sand and gravel[4] do	11,803	32,268	8,264	29,508	[p]7,400	[p]27,700
Stone:						
Crushed do	51,080	165,223	44,615	167,839	37,071	152,630
Dimension do	9	2,042	27	2,287	4	1,130
Zinc (recoverable content of ores, etc.) metric tons	11,406	9,380	[r]12,038	9,934	9,731	9,558
Combined value of aplite, cement, gypsum, iron oxide pigments (crude), kyanite, sand and gravel (industrial), silver (1981), talc, and vermiculite	XX	60,562	XX	57,216	XX	52,201
Total	XX	309,789	XX	305,306	XX	282,533
WASHINGTON						
Cement:						
Masonry thousand short tons	10	741	W	W	15	1,284
Portland do	1,761	98,659	1,546	89,208	1,560	100,845
Clays[2] do	339	1,549	301	1,571	263	1,524
Gem stones	NA	170	NA	150	NA	200
Peat thousand short tons	11	148	W	W	W	W
Pumice do	(9)	(9)	(9)	(9)	--	--
Sand and gravel do	[4]24,258	[4]59,382	[4]19,019	[4]46,731	[p]18,404	[p]49,458
Silver thousand troy ounces	W	W	W	W	67	709

See footnotes at end of table.

Table 6.—Nonfuel mineral production[1] in the United States, by State —Continued

Mineral	1979 Quantity	1979 Value (thousands)	1980 Quantity	1980 Value (thousands)	1981 Quantity	1981 Value (thousands)
WASHINGTON—Continued						
Stone:						
Crushed ______ thousand short tons__	r15,255	r$35,985	r11,085	rW	9,516	$25,619
Dimension ______________do____	4	268	6	$248	15	2,378
Combined value of clays (fire clay), copper (1979 and 1981), diatomite, gold, gypsum, lead (1979-80), lime, olivine, sand and gravel (industrial 1979-80), tungsten (1979 and 1981), and values indicated by symbol W__	XX	28,248	XX	r69,454	XX	30,461
Total ______________________	XX	225,150	XX	207,362	XX	212,478
WEST VIRGINIA						
Clays[2] _________ thousand short tons__	330	592	291	642	220	502
Salt ______________________do____	1,078	W	W	W	W	W
Sand and gravel[4] _____________do____	4,138	18,501	2,728	11,454	p2,700	p11,500
Stone (crushed) _____________do____	11,713	37,624	9,766	36,305	7,885	28,399
Combined value of cement, clays (fire clay), lime, sand and gravel (industrial), stone (dimension, 1979), and values indicated by symbol W ____________________	XX	61,878	XX	57,885	XX	56,046
Total ______________________	XX	118,595	XX	106,286	XX	96,447
WISCONSIN						
Iron ore (usable), thousand long tons, gross weight__	736	W	679	W	W	W
Lime _________ thousand short tons__	429	19,060	357	17,287	326	17,548
Peat ______________________do____	11	720	11	535	10	535
Sand and gravel______________do____	32,046	58,576	22,014	r47,571	p20,400	p52,280
Stone:						
Crushed_________________do____	23,924	52,804	20,603	49,245	15,189	39,962
Dimension ______________do____	54	4,204	45	4,501	40	4,259
Combined value of abrasive stone, cement, clays, lead (1979), zinc (1979), and values indicated by symbol W ____________	XX	44,318	XX	33,151	XX	41,749
Total ______________________	XX	179,682	XX	r152,290	XX	156,333
WYOMING						
Clays _________ thousand short tons__	3,471	75,096	3,081	71,512	3,855	100,926
Gem stones______________________	NA	200	NA	190	NA	250
Gypsum________ thousand short tons__	366	3,100	312	2,731	299	2,625
Sand and gravel______________do____	45,265	411,419	45,454	412,523	p5,200	p12,400
Stone _________________do____	5,013	15,634	4,374	14,835	3,224	9,858
Combined value of cement, feldspar (1979), iron ore, lead (1981), lime, phosphate rock (1979), sand and gravel (industrial, 1979-80), silver (1981), sodium carbonate, and zinc (1981) ______________________	XX	484,727	XX	658,755	XX	644,279
Total ______________________	XX	590,176	XX	760,546	XX	770,338

eEstimated. pPreliminary. rRevised. NA Not available. W Withheld to avoid disclosing company proprietary data. XX Not applicable.

[1]Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
[2]Excludes certain clays; value included with "Combined value" figure.
[3]Less than 1/2 unit.
[4]Excludes industrial sand and gravel; value included with "Combined value" figure.
[5]Total of items listed.
[6]Excludes certain stones; value included with "Combined value" figure.
[7]Excludes salt in brines; value included with "Combined value" figure.
[8]Excludes talc; value included with "Combined value" figure.
[9]Revised to none.

Table 7.—Mineral production[1] in the islands administered by the United States

(Thousand short tons and thousand dollars)

Area and mineral	1979		1980		1981	
	Quantity	Value	Quantity	Value	Quantity	Value
American Samoa: Stone	3	21	r11	199	6	127
Guam: Stone	669	2,483	529	2,163	332	W
Virgin Islands: Stone	W	2,828	W	W	W	W

rRevised. W Withheld to avoid disclosing company proprietary data.
[1]Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

Table 8.—Mineral production[1] in the Commonwealth of Puerto Rico

(Thousand short tons and thousand dollars)

Mineral	1979		1980		1981	
	Quantity	Value	Quantity	Value	Quantity	Value
Cement	1,406	70,197	1,482	102,872	1,226	105,420
Clays	260	556	291	677	200	474
Lime	37	3,307	27	4,131	34	3,884
Salt	27	639	--	--	--	--
Sand and gravel	NA	NA	NA	NA	NA	NA
Stone	14,119	59,659	24,046	104,179	20,578	98,263
Total	XX	[2]134,358	XX	[2]211,859	XX	[2]208,041

NA Not available. 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 9.—U.S. exports of principal minerals and products, excluding mineral fuels

Mineral	1980 Quantity	1980 Value (thousands)	1981 Quantity	1981 Value (thousands)
METALS				
Aluminum:				
Ingots, slabs, crude ---- short tons	714,906	$1,107,398	344,161	$526,646
Scrap ---- do	444,681	483,138	241,162	236,204
Plates, sheets, bars, etc ---- do	306,214	715,899	263,672	625,181
Castings and forgings ---- do	7,496	30,626	8,930	40,482
Aluminum sulfate ---- metric tons	11,200	2,476	25,296	3,439
Other aluminum compounds ---- do	48,000	41,200	48,049	37,174
Antimony, metals and alloys, crude ---- short tons	453	1,186	324	908
Bauxite including bauxite concentrate thousand metric tons	28	6,761	41	8,090
Beryllium ---- pounds	58,455	3,867	78,189	3,094
Bismuth, metals and alloys ---- do	128,732	942	78,703	708
Cadmium ---- metric tons	236	464	239	332
Chromium:				
Ore and concentrate:				
Exports ---- thousand short tons	6	1,447	71	5,893
Reexports ---- do	44	8,544	67	9,575
Ferrochromium ---- do	32	22,233	14	10,361
Cobalt ---- thousand pounds	583	14,576	834	16,462
Copper:				
Ore, concentrate, composition metal, unrefined (copper content) ---- metric tons	117,508	226,145	166,293	231,181
Scrap ---- do	61,225	93,059	50,078	70,106
Refined copper and semimanufactures ---- do	105,377	440,967	127,613	517,950
Other copper manufactures ---- do	41,071	94,760	18,451	37,464
Ferroalloys not elsewhere listed:				
Ferrophosphorus ---- short tons	44,692	6,778	7,463	2,031
Ferroalloys, n.e.c ---- do	4,710	10,130	6,358	8,439
Gold:				
Ore and base bullion ---- troy ounces	1,416,634	860,501	1,199,421	570,549
Bullion, refined ---- do	4,702,197	2,787,431	5,237,585	2,501,337
Iron ore ---- thousand long tons	5,689	230,568	5,546	244,685
Iron and steel:				
Pig iron ---- short tons	73,000	8,016	16,274	1,960
Iron and steel products (major):				
Steel mill products ---- do	4,100,718	2,556,619	2,903,863	2,275,267
Other steel products ---- do	407,101	947,094	443,796	1,138,745
Iron and steel scrap:				
Ferrous scrap including rerolling materials, ships, boats, other vessels for scrapping ---- thousand short tons	11,423	1,257,049	6,524	653,118
Lead:				
Ores and concentrates ---- metric tons	27,615	11,118	33,043	18,958
Pigs, bars, anodes, sheets, etc ---- do	164,458	164,835	23,320	25,996
Scrap ---- do	119,651	62,221	59,419	22,388
Magnesium, metal and alloys, scrap, semimanufactured forms, n.e.c ---- short tons	56,761	127,706	34,855	90,853
Manganese:				
Ore and concentrate ---- do	52,537	6,328	65,064	5,132
Ferromanganese ---- do	11,686	7,657	14,925	12,477
Silicomanganese ---- do	6,489	3,468	3,941	2,172
Metal ---- do	12,320	11,460	2,523	3,980
Molybdenum:				
Ore and concentrate (molybdenum content) thousand pounds	68,217	715,431	51,350	406,816
Metals and alloys, crude and scrap ---- do	614	4,870	2,641	9,763
Wire ---- do	705	15,984	543	9,030
Semimanufactured forms, n.e.c ---- do	306	7,471	165	4,768
Powder ---- do	425	4,103	270	2,820
Ferromolybdenum ---- do	1,760	17,104	455	2,983
Compounds ---- do	10,154	89,303	7,328	40,686
Nickel:				
Alloys and scrap including unwrought metal, ingots, bars, sheets, anodes, etc ---- short tons	45,204	285,545	37,671	259,712
Catalysts ---- do	3,530	18,559	3,890	25,601
Nickel-chrome electric resistance wire ---- do	1,087	11,766	660	8,262
Semifabricated forms, n.e.c ---- do	6,854	55,613	4,557	40,093
Platinum-group metals:				
Ore and scrap ---- troy ounces	173,053	68,836	212,426	61,409
Palladium, rhodium, iridium, osmiridium, ruthenium, osmium (metal and alloys including scrap) ---- do	302,457	99,494	259,745	61,136
Platinum (metal and alloy) ---- do	289,454	172,876	391,194	179,344
Rare earths: Ferrocerium and alloys ---- short tons	17	196	11	117
Selenium ---- thousand pounds	180	1,689	133	668
Silicon:				
Ferrosilicon ---- short tons	27,488	18,572	15,768	12,136
Silicon carbide, crude and in grains ---- do	[r]13,661	[r]13,264	11,511	11,148
Silver:				
Ore, concentrate, waste, sweepings thousand troy ounces	23,645	582,855	12,772	151,090
Bullion, refined ---- do	57,206	1,326,878	15,131	181,380
Tantalum:				
Ore, metal, other forms ---- thousand pounds	950	65,329	303	20,520
Powder ---- do	251	39,880	97	19,999

See footnotes at end of table.

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

Mineral	1980 Quantity	1980 Value (thousands)	1981 Quantity	1981 Value (thousands)
METALS —Continued				
Tin:				
Ingots, pigs, bars, etc.:				
Exports ---- metric tons	595	$10,194	2,361	$31,053
Reexports ---- do	3,699	62,382	3,719	55,505
Tinplate and ternplate ---- do	641,401	440,671	345,718	220,993
Titanium:				
Ore and concentrate ---- short tons	17,830	3,444	7,297	2,099
Unwrought and scrap metal ---- do	3,757	16,660	3,595	9,506
Intermediate mill shapes and mill products, n.e.c ---- do	5,123	113,551	6,049	159,454
Pigments and oxides ---- do	45,795	49,357	62,432	66,402
Tungsten (tungsten content):				
Ore and concentrate ---- thousand pounds	2,029	15,454	175	1,150
Carbide powder ---- do	1,440	22,716	1,213	18,158
Alloy powder ---- do	[r]1,140	18,308	2,138	32,207
Vanadium:				
Ore and concentrate (vanadium content) ---- do	92	517	111	575
Pentoxide, etc ---- do	1,448	2,728	692	2,012
Ferrovanadium ---- do	1,605	6,995	869	4,397
Zinc:				
Slabs, pigs, or blocks ---- metric tons	302	664	323	812
Sheets, plates, strips, other forms, n.e.c ---- do	2,103	3,810	1,500	3,226
Waste, scrap, dust (zinc content) ---- do	34,054	21,612	35,049	25,452
Semifabricated forms, n.e.c ---- do	1,289	2,580	1,538	3,230
Ores and concentrates ---- do	54,457	29,473	54,232	29,280
Zirconium:				
Ore and concentrate ---- thousand pounds	15,455	2,732	23,260	3,838
Oxide ---- do	4,778	3,680	1,565	2,254
Metals, alloys, other forms ---- do	1,388	29,408	1,361	35,015
NONMETALS				
Abrasives:				
Industrial diamond, natural or synthetic:				
Powder or dust ---- thousand carats	28,534	70,248	28,471	65,777
Other ---- do	3,569	51,229	2,297	30,978
Diamond grinding wheels ---- do	730	7,437	694	7,706
Other natural and artificial metallic abrasives and products	NA	[r]112,286	NA	113,016
Asbestos:				
Exports:				
Unmanufactured ---- metric tons	[r]48,219	[r]20,737	64,126	21,439
Products ---- do	NA	[r]141,299	NA	144,531
Reexports:				
Unmanufactured ---- do	452	330	293	159
Products ---- do	NA	354	NA	599
Barite:				
Natural barium sulfate and carbonate ---- short tons	96,819	13,794	62,187	9,947
Boron:				
Boric acid ---- do	[r]47,000	23,735	46,184	24,602
Sodium borates, refined ---- do	324,862	[e]64,737	227,543	[e]58,000
Calcium:				
Other calcium compounds including precipitated calcium carbonate ---- do	25,068	15,589	25,659	11,713
Chloride ---- do	49,215	9,754	32,794	13,004
Dicalcium phosphate ---- do	43,314	27,577	55,862	33,434
Cement: Hydraulic and clinker ---- do	186,404	16,997	302,777	31,564
Clays:				
Kaolin or china clay ---- thousand short tons	1,392	133,716	1,412	155,999
Bentonite ---- do	898	62,207	862	64,537
Other ---- do	924	67,224	877	72,378
Diatomite ---- do	173	32,238	162	32,933
Feldspar, leucite, nepheline syenite ---- thousand pounds	25,998	896	28,050	1,110
Fluorspar ---- short tons	17,865	1,660	11,261	1,194
Gem stones:				
Diamond ---- thousand carats	1,325	1,041,200	3,215	854,100
Pearls	NA	5,063	NA	5,856
Other	NA	71,460	NA	101,649
Graphite ---- short tons	8,880	3,695	11,344	4,433
Gypsum:				
Crude, crushed or calcined ---- thousand short tons	88	11,774	157	14,590
Manufactures, wallboard and plaster articles	NA	15,448	NA	20,844
Helium ---- million cubic feet	[e]298	10,629	389	17,084
Lithium hydroxide ---- thousand pounds	6,681	9,600	6,040	9,542
Lime ---- short tons	41,843	3,990	28,429	3,996
Magnesium compounds:				
Magnesite, dead-burned ---- do	56,038	13,279	20,926	4,727
Magnesite, crude, caustic calcined, lump or ground ---- do	51,703	17,692	36,683	14,559
Mica:				
Sheet, waste, scrap, ground ---- do	14,462	4,200	10,920	3,437
Manufactured ---- pounds	NA	[r]7,665	NA	7,000

See footnotes at end of table.

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

Mineral	1980 Quantity	1980 Value (thousands)	1981 Quantity	1981 Value (thousands)
NONMETALS —Continued				
Mineral-earth pigments, iron oxide, natural and synthetic ---- short tons	5,046	$9,132	4,967	$11,704
Nitrogen compounds (major) ---- thousand short tons	11,121	1,842,383	8,371	1,397,786
Phosphate rock ---- thousand metric tons	14,320	508,524	10,554	419,999
Phosphatic fertilizers:				
Superphosphates ---- do	34,412	287,366	22,097	245,341
Ammonium phosphates ---- do	4,995	1,095,944	3,942	789,770
Elemental phosphorus ---- metric tons	30,443	45,631	27,929	42,723
Mixed chemical fertilizers ---- thousand metric tons	NA	NA	NA	NA
Pigments and compounds: Zinc oxide (metal content) ---- do	([1])	344	1	1,112
Potash:				
Potassium chloride ---- metric tons	[r]1,161,640	[r]131,180	700,420	80,678
Potassium sulfate ---- do	[r]140,000	[r]23,113	79,600	16,095
Pumice and pumicite ---- short tons	[e]1,000	NA	[e]1,000	NA
Quartz, crystal, natural ---- thousand pounds	91	366	[e]127	[e]490
Salt:				
Crude and refined ---- thousand short tons	831	[r]12,829	1,043	18,070
Shipments to noncontiguous territories ---- do	22	4,296	71	9,145
Sand and gravel:				
Construction:				
Sand ---- do	587	6,661	613	6,298
Gravel ---- do	687	1,480	652	2,454
Industrial: Sand ---- do	1,177	32,519	1,132	27,984
Sodium compounds:				
Sodium sulfate ---- do	129	12,740	124	12,980
Sodium carbonate ---- do	1,094	121,945	1,051	121,107
Stone:				
Crushed ---- do	3,084	21,239	3,598	25,949
Dimension ---- do	176	[r]15,170	227	17,867
Sulfur: Crude ---- thousand metric tons	1,673	185,866	1,392	187,407
Talc, crude and ground ---- thousand short tons	275	14,963	311	15,095
Total	XX	[r]23,290,651	XX	17,581,927

[e]Estimated. [r]Revised. NA Not available. XX Not applicable.
[1]Less than 1/2 unit.

Table 10.—U.S. imports for consumption of principal minerals and products, excluding mineral fuels

Mineral	1980 Quantity	1980 Value (thousands)	1981 Quantity	1981 Value (thousands)
METALS				
Aluminum:				
Metal short tons	580,515	$777,606	710,656	$990,869
Scrap do	59,802	59,718	81,994	79,141
Plates, sheets, bars, etc do	72,723	152,136	142,512	308,677
Aluminum oxide (alumina) metric tons	4,358,000	782,902	3,978,000	837,932
Antimony:				
Ore and concentrate (antimony content) short tons	5,235	11,646	5,168	9,095
Sulfide including needle or liquated do	34	216	106	249
Metal do	2,590	7,277	2,631	6,569
Oxide do	12,224	15,771	12,170	19,922
Arsenic:				
White (As_2O_3 content) do	12,528	7,352	18,958	13,126
Metallic do	266	1,524	323	2,079
Bauxite, crude thousand metric tons	14,087	NA	12,802	NA
Beryllium ore short tons	1,703	1,168	2,138	2,002
Bismuth, metal and alloys, gross weight pounds	2,217,359	5,364	2,436,249	4,883
Cadmium: Metal metric tons	2,617	14,181	[p]3,090	[p]13,369
Calcium:				
Metal pounds	227,814	582	235,436	751
Chloride short tons	46,439	2,071	86,865	4,088
Cesium compounds pounds	[r]11,822	619	24,415	1,049
Chromium:				
Ore and concentrate (Cr_2O_3 content) thousand short tons	410	56,525	368	49,948
Ferrochromium (gross weight) do	297	153,487	428	213,611
Ferrochromium-silicon do	5	[r]2,313	11	6,000
Metal do	4	[r]28,369	4	24,626
Cobalt:				
Metal thousand pounds	14,992	358,583	13,906	238,820
Oxide (gross weight) do	414	7,630	444	5,375
Salts and compounds (gross weight) do	655	[r]3,572	1,249	4,969
Columbium ore do	4,595	20,289	1,882	10,102
Copper (copper content):				
Ore and concentrate metric tons	[r]52,360	72,636	39,132	56,548
Matte do	392	719	2,718	3,232
Blister do	44,537	86,284	30,124	68,083
Refined in ingots, etc do	426,948	935,262	330,625	582,085
Scrap do	22,769	40,865	27,002	40,705
Ferroalloys not elsewhere listed, includes spiegeleisen short tons	[r]8,933	[r]36,390	7,055	38,730
Gallium kilograms	6,175	2,637	5,536	2,472
Germanium do	3,329	3,004	22,350	12,328
Gold:				
Ore and base bullion troy ounces	451,509	243,230	487,675	214,927
Bullion do	4,090,488	2,506,889	4,164,476	1,942,560
Hafnium pounds	600	32	5,310	126
Indium thousand troy ounces	299	5,103	461	3,152
Iron ore thousand long tons	25,058	772,844	28,328	947,977
Iron and steel:				
Pig iron short tons	400,031	63,036	468,125	71,013
Iron and steel products (major):				
Steel mill products do	15,495,075	6,887,462	19,898,371	10,247,660
Other products do	753,181	825,702	822,396	954,618
Scrap including tinplate thousand short tons	582	61,192	556	62,126
Lead:				
Ore, flue dust, matte (lead content) metric tons	29,615	23,927	27,206	20,196
Base bullion (lead content) do	296	509	449	340
Pigs and bars (lead content) do	81,300	87,629	100,108	87,026
Reclaimed scrap, etc. (lead content) do	2,868	2,905	2,661	2,220
Sheet, pipe, shot do	950	1,508	474	726
Magnesium:				
Metallic and scrap short tons	3,324	5,048	6,122	10,182
Alloys (magnesium content) do	344	1,770	625	2,652
Sheets, tubing, ribbons, wire, other forms (magnesium content) do	89	1,443	150	4,804
Manganese:				
Ore (35% or more contained manganese) do	697,516	46,413	639,141	42,643
Ferromanganese do	605,703	211,365	671,178	226,618
Ferrosilicon-manganese (manganese content) do	74,975	29,291	129,005	49,754
Metal do	7,915	[r]8,032	8,343	8,419
Mercury:				
Compounds pounds	32,371	222	37,258	273
Metal 76-pound flasks	9,416	2,841	12,408	5,005

See footnotes at end of table.

Table 10.—U.S. imports for consumption of principal minerals and products, excluding mineral fuels —Continued

Mineral	1980 Quantity	1980 Value (thousands)	1981 Quantity	1981 Value (thousands)
METALS —Continued				
Molybdenum:				
Ore and concentrate (molybdenum content) thousand pounds	1,825	$10,475	1,988	$9,911
Waste and scrap (gross weight) do.	373	7,246	NA	2,674
Metal:				
Unwrought (molybdenum content) do.	163	2,637	153	2,893
Wrought (gross weight) do.	137	4,031	93	2,557
Ferromolybdenum (gross weight) do.	45	243	1,175	6,353
Material in chief value molybdenum (molybdenum content) do.	1,953	18,701	1,651	9,574
Compounds do.	4,431	27,034	5,164	18,052
Nickel:				
Ore short tons	1,124	13	513	42
Pigs, ingots, shot, cathodes do.	116,193	708,693	123,141	747,920
Plates, bars, etc do.	5,831	54,947	3,864	36,897
Slurry do.	77,459	208,742	94,796	223,060
Scrap do.	3,572	18,481	5,226	17,496
Powder and flakes do.	15,244	98,666	14,124	93,325
Ferronickel do.	51,741	104,156	69,853	119,321
Oxide do.	4,182	21,753	4,330	21,779
Platinum-group metals:				
Unwrought:				
Grains and nuggets (platinum) troy ounces	15,427	6,768	1,891	862
Sponge (platinum) do.	1,191,803	560,642	888,995	424,780
Sweepings, waste, scrap do.	376,500	76,543	235,379	58,462
Iridium do.	26,090	12,974	11,110	6,203
Palladium do.	1,202,342	252,075	1,114,313	142,180
Rhodium do.	109,591	84,421	73,738	45,847
Ruthenium do.	98,488	4,220	180,438	6,833
Other platinum-group metals do.	122,454	105,559	44,337	16,455
Semimanufactured:				
Platinum do.	230,344	130,537	179,321	83,972
Palladium do.	114,246	23,256	116,548	13,717
Rhodium do.	686	594	1,733	657
Other platinum-group metals do.	13,811	2,834	1,814	288
Rare-earth metals:				
Ferrocerium and other cerium alloys short tons	72	902	92	1,249
Monazite do.	[r]5,675	1,850	8,233	3,158
Metals including scandium and yttrium pounds	[r]8,468	307	3,750	168
Rhenium:				
Metal including scrap do.	513	668	580	574
Ammonium perrhenate do.	4,991	7,889	9,089	3,297
Selenium and selenium compounds do.	625,472	7,966	686,887	7,766
Silicon:				
Metal (over 96% silicon content) short tons	21,839	53,117	29,636	58,034
Ferrosilicon do.	71,152	42,640	155,648	80,317
Silver:				
Ore and base bullion thousand troy ounces	9,700	187,019	9,769	100,422
Bullion do.	[r]64,762	1,331,877	75,921	837,174
Sweepings, waste, doré do.	4,237	87,114	8,425	90,853
Tantalum ore thousand pounds	2,510	78,829	1,952	57,726
Tellurium pounds	64,860	1,629	83,671	1,811
Thallium do.	176	14	882	87
Tin:				
Concentrate (tin content) metric tons	840	11,089	232	2,975
Dross, skimmings, scrap, residue, tin alloys, n.s.p.f. do.	1,312	4,215	2,583	3,387
Tinfoil, powder, flitters, etc	NA	9,154	NA	8,666
Tin scrap and other tin-bearing material excluding tinplate scrap	NA	13,819	NA	16,357
Tin compounds metric tons	171	2,285	170	2,098
Titanium:[1]				
Ilmenite short tons	552,482	27,088	505,042	36,215
Rutile do.	281,605	62,619	202,373	59,024
Metal do.	10,052	108,777	11,637	139,801
Ferrotitanium and ferrosilicon titanium do.	623	1,679	615	1,582
Pigments do.	97,590	91,986	124,906	127,396
Tungsten ore and concentrate (tungsten content) thousand pounds	11,372	87,129	11,752	91,195
Vanadium (vanadium content):				
Ferrovanadium do.	525	3,477	1,968	13,288
Vanadium pentoxide do.	1,711	8,364	669	3,344
Vanadium-bearing materials do.	3,572	9,535	4,870	11,751

See footnotes at end of table.

Table 10.—U.S. imports for consumption of principal minerals and products, excluding mineral fuels —Continued

Mineral	1980 Quantity	1980 Value (thousands)	1981 Quantity	1981 Value (thousands)
METALS —Continued				
Zinc:				
Ore (zinc content) metric tons	182,370	$74,033	245,710	$110,253
Blocks, pigs, slabs do	410,163	319,288	612,007	549,326
Sheets, etc do	1,342	1,041	332	472
Fume (zinc content) do	25	7	184	61
Waste and scrap do	3,470	1,361	5,782	2,578
Dross, skimmings do	4,062	1,732	7,629	4,090
Dust, powder, flakes do	3,928	3,672	7,993	9,519
Manufactures	NA	254	NA	438
Zirconium:				
Ore including zirconium sand short tons	113,784	10,595	91,108	8,378
Metal, scrap, compounds do	1,934	25,026	1,647	22,122
NONMETALS				
Abrasives:				
Diamond (industrial) thousand carats	21,848	110,566	20,404	110,510
Other	NA	r158,276	NA	188,667
Asbestos metric tons	327,296	91,809	337,618	103,893
Barite:				
Crude and ground thousand short tons	1,854	102,401	1,946	108,599
Witherite short tons	22,207	736	99	87
Chemicals do	25,097	10,623	22,309	11,938
Boron:				
Boric acid do	9,938	6,393	1,124	763
Calcium borate, crude do	r69,400	6,218	98,100	15,202
Cement: Hydraulic and clinker thousand short tons	5,263	195,573	3,997	151,240
Clays short tons	34,052	6,688	33,314	7,895
Cryolite do	17,086	9,442	7,188	4,679
Feldspar:				
Crude do	232	112	108	44
Ground and crushed do	172	21	98	18
Fluorspar do	899,219	94,103	826,783	104,938
Gem stones:				
Diamond thousand carats	4,161	2,251,195	4,407	2,201,262
Emeralds do	3,601	141,413	2,298	131,560
Other	NA	r342,123	NA	433,428
Graphite short tons	61,318	15,765	68,708	23,998
Gypsum:				
Crude, ground, calcined thousand short tons	7,367	35,895	7,595	39,605
Manufactures	NA	15,985	NA	12,115
Iodine, crude thousand pounds	6,234	28,848	6,099	36,231
Lime:				
Hydrated short tons	62,423	3,129	65,717	3,471
Other do	417,792	16,044	438,623	18,092
Lithium:				
Ore do	r3,893	r460	e4,000	NA
Compounds do	62	r1,841	280	1,845
Magnesium compounds:				
Crude magnesite do	46	20	12	2
Lump, ground, caustic-calcined magnesia do	12,406	2,122	12,065	2,177
Refractory magnesia, dead-burned, fused magnesite, dead-burned dolomite do	72,719	16,830	76,810	23,114
Compounds do	36,124	5,907	35,382	6,241
Mica:				
Uncut sheet and punch thousand pounds	11,877	3,305	11,558	2,747
Scrap do	73	7	352	23
Manufactures do	831	3,487	664	3,059
Mineral-earth pigments, iron oxide pigments:				
Ocher, crude and refined short tons	1	1	150	80
Siennas, crude and refined do	244	116	98	42
Umber, crude and refined do	4,434	686	5,919	944
Vandyke brown do	687	260	1,070	340
Other natural and refined do	817	298	971	970
Synthetic do	33,262	18,674	31,453	16,539
Nepheline syenite:				
Crude do	6,760	71	2,780	25
Ground, crushed, etc do	497,580	11,193	503,320	11,504
Nitrogen compounds (major) including urea thousand short tons	5,110	583,808	4,844	610,574
Peat:				
Fertilizer-grade short tons	344,363	r38,223	291,732	37,955
Poultry- and stable-grade do	57,204	r5,997	50,198	6,845
Phosphate, crude thousand metric tons	486	12,856	13	420
Phosphatic materials:				
Fertilizer and fertilizer materials thousand metric tons	32	5,737	16	3,112
Ammonium phosphates used as fertilizers do	294	53,053	--	--
Elemental phosphorus do	(2)	928	(2)	1,247
Other do	77	16,630	92	15,509

See footnotes at end of table.

Table 10.—U.S. imports for consumption of principal minerals and products, excluding mineral fuels —Continued

Mineral	1980		1981	
	Quantity	Value (thousands)	Quantity	Value (thousands)
NONMETALS —Continued				
Pigments and salts:				
Lead pigments and compounds metric tons	12,934	$15,225	15,186	$15,233
Zinc pigments and compounds do	38,628	30,062	38,615	33,501
Potash do	8,193,000	648,000	7,903,300	750,400
Pumice:				
Crude or unmanufactured short tons	4,618	133	2,954	70
Wholly or partly manufactured do	[r]189,700	[r]1,085	89,329	601
Manufactured, n.s.p.f	NA	92	NA	126
Quartz crystal (Brazilian pebble) thousand pounds	816	402	389	233
Salt thousand short tons	5,263	44,071	4,974	49,157
Sand and gravel:				
Industrial sand do	39	1,575	5	621
Other sand and gravel do	502	1,143	333	1,987
Sodium compounds:				
Sodium bicarbonate do	2	425	3	680
Sodium carbonate do	18	2,389	12	1,625
Sodium sulfate do	230	13,242	275	19,135
Stone:				
Crushed do	[r]3,590	[r]10,576	3,355	9,300
Dimension do	NA	88,948	NA	131,416
Calcium carbonate fines do	294	3,248	270	4,577
Strontium:				
Mineral short tons	38,646	2,147	49,699	3,206
Compounds do	2,932	1,888	4,627	3,400
Sulfur and compounds, sulfur ore and other forms, n.e.s thousand metric tons	2,523	138,852	2,522	209,766
Talc, unmanufactured thousand short tons	21	3,720	27	4,562
Total	XX	[r]26,096,469	XX	28,828,659

[e]Estimated. [p] Preliminary. [r] Revised. NA Not available. XX Not applicable.
[1]Includes titanium slag averaging about 70% TiO_2. For detail, see Titanium chapter.
[2]Less than 1/2 unit.

Table 11.—Comparison of world and U.S. production of selected nonfuel mineral commodities

(Thousand short tons unless otherwise specified)

Mineral	1980			1981[p]		
	World production[1]	U.S. production	U.S. percent of world production	World production[1]	U.S. production	U.S. percent of world production
METALS, MINE BASIS						
Antimony (content of ore and concentrate) short tons	71,727	343	([2])	65,246	646	1
Arsenic, white[3] do.	31,666	W	NA	31,651	W	NA
Bauxite[4] thousand metric tons	88,786	1,559	2	85,729	1,510	2
Beryl[3] short tons	2,767	W	NA	2,903	W	NA
Bismuth thousand pounds	7,162	W	NA	7,159	W	NA
Chromite	10,746	--	--	10,225	--	--
Cobalt (content of ore and concentrate) short tons	33,738	--	--	34,449	--	--
Columbium-tantalum concentrate (gross weight) thousand pounds	81,071	NA	NA	84,958	NA	NA
Copper (content of ore and concentrate) thousand metric tons	7,656	1,181	15	8,171	1,538	19
Gold (content of ore and concentrate) thousand troy ounces	39,141	970	2	40,785	1,378	3
Iron ore (gross weight) thousand long tons	881,720	69,613	8	847,184	73,174	9
Lead (content of ore and concentrate) thousand metric tons	3,428	550	16	3,353	446	13
Manganese ore (35% or more Mn, gross weight)	29,091	--	--	25,985	--	--
Mercury thousand 76-pound flasks	204	31	15	207	28	14
Molybdenum (content of ore and concentrate) thousand pounds	241,745	150,686	62	240,387	139,900	58
Nickel (content of ore and concentrate)	821	15	2	772	12	2
Platinum-group metals[3] thousand troy ounces	6,836	3	([2])	6,823	6	([2])
Silver (content of ore and concentrate) do.	339,800	32,329	10	364,912	40,685	11
Tin (content of ore and concentrate) metric tons	246,493	W	NA	252,509	W	NA
Titanium concentrates (gross weight):						
Ilmenite	4,019	549	14	3,979	509	13
Rutile	460	W	NA	398	W	NA
Tungsten concentrate (contained tungsten) thousand pounds	114,059	6,072	5	108,351	7,948	7
Vanadium (content of ore and concentrate) short tons	38,281	4,806	13	38,933	5,126	13
Zinc (content of ore and concentrate) thousand metric tons	5,775	317	5	5,841	312	5
METALS, SMELTER BASIS						
Aluminum (primary only)	17,006	5,130	30	16,613	4,948	30
Cadmium metric tons	18,130	1,578	9	17,721	1,603	9
Cobalt short tons	33,227	500	2	31,278	447	1
Copper smelter (primary and secondary)[5] thousand metric tons	7,939	1,053	13	8,325	1,378	17
Iron, pig	562,534	68,699	12	552,037	73,755	13
Lead, smelter (primary and secondary)[6] thousand metric tons	5,134	1,223	24	4,981	1,136	23
Magnesium (primary only)	350	169	48	328	143	44
Nickel[7]	806	44	5	770	49	6
Selenium[8] thousand pounds	3,018	311	10	2,954	555	19
Steel, raw	787,477	[9]111,835	14	776,398	[9]119,912	15
Tellurium[8] thousand pounds	321	W	NA	279	W	NA
Tin metric tons	250,099	[10]3,000	1	242,097	[10]2,000	1
Zinc (primary and secondary) thousand metric tons	6,057	370	6	6,140	393	6
NONMETALS						
Asbestos do.	4,887	80	2	4,726	76	2
Barite	8,069	[11]2,245	28	8,715	[11]2,849	33
Boron minerals	3,091	1,545	50	3,252	1,481	46
Bromine thousand pounds	760,569	[11]378,100	50	760,597	[11]378,200	50
Cement, hydraulic	974,825	[12]76,709	8	978,919	[12]72,932	7
Clays:						
Bentonite[8]	6,669	[11]4,185	63	7,443	[11]4,947	66
Fuller's earth[8]	1,941	[11]1,534	79	1,998	[11]1,656	83
Kaolin[3]	25,941	[11]7,879	30	25,452	[11]7,660	30
Corundum	32	--	--	32	--	--
Diamond thousand carats	42,107	--	--	39,121	--	--

See footnotes at end of table.

Table 11.—Comparison of world and U.S. production of selected nonfuel mineral commodities —Continued

(Thousand short tons unless otherwise specified)

Mineral	1980 World production[1]	1980 U.S. production	1980 U.S. percent of world production	1981[p] World production[1]	1981[p] U.S. production	1981[p] U.S. percent of world production
NONMETALS —Continued						
Diatomite	1,645	[11]689	42	1,638	[11]687	42
Feldspar[3]	3,480	710	20	3,444	665	19
Fluorspar	5,436	93	2	5,508	115	2
Graphite	654	--	--	655	--	--
Gypsum	86,310	12,376	14	84,982	11,497	14
Iodine, crude thousand pounds	25,521	W	NA	26,517	W	NA
Lime (sold or used)	130,779	[12]19,037	15	128,908	[12]18,890	15
Magnesite	12,489	W	NA	12,272	W	NA
Mica (including scrap and ground[8]) thousand pounds	[13]730,840	[13]454,000	62	[13]772,976	[13]500,000	65
Nitrogen, N content of ammonia	78,673	16,244	21	78,778	15,648	20
Peat	224,711	785	([2])	224,959	686	([2])
Perlite	1,628	[11]638	39	1,585	[11]591	37
Phosphate rock thousand metric tons	138,333	54,415	39	138,630	53,624	39
Potash (K_2O equivalent) do	27,673	2,239	8	27,357	2,156	8
Pumice[8 14]	14,021	[11]543	4	14,084	[11]499	4
Salt	185,788	[11 12]40,378	22	183,106	[11 12]38,915	21
Sodium compounds, natural and manufactured:						
Sodium carbonate	31,442	8,275	26	31,214	8,281	27
Sodium sulfate	4,791	1,139	24	4,848	1,143	24
Strontium[8] short tons	94,560	--	--	93,665	--	--
Sulfur, all forms thousand metric tons	56,635	11,866	21	55,669	12,145	22
Talc and pyrophyllite	7,428	1,240	17	7,292	1,343	18
Vermiculite[8]	588	337	57	576	320	56

[p]Preliminary. NA Not available. W Withheld to avoid disclosing company proprietary data.
[1]For those commodities for which U.S. data are withheld to avoid disclosing company proprietary data, the world total excludes U.S. output and the U.S. percent of world production cannot be reported.
[2]Less than 0.5%.
[3]World total does not include an estimate for output in China.
[4]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.
[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.
[13]Excludes sericite mica.
[14]Excludes volcanic cinder (included in previous editions).

Abrasive Materials

By J. Fletcher Smoak[1]

CONTENTS

Consumption of abrasive materials in the United States in 1981 was approximately $340 million, of which 37% was industrial diamond (natural and synthetic), 39% manufactured abrasives, and 24% natural abrasives.

Production and shipments of natural abrasives, excluding emery and industrial diamond, decreased in quantity 9% and 7%, respectively, when compared with that of 1980. Emery showed the largest change in output, decreasing 30% in quantity and 20% in value.

Production of nonmetallic manufactured abrasives material plus shipments of metallic abrasives material decreased 5% in quantity but increased 4% in value. Nonmetallic manufactured abrasives consisted of aluminum oxide (fused) and crude silicon carbide produced in the United States and Canada and accounted for 63% of the value of all manufactured abrasives. Metallic abrasives shipments included chilled and annealed iron shot and grit, steel shot and grit, plus cut wire, aluminum, and stainless steel shot and equaled 37% of the value of all manufactured abrasives.

Although total imports increased in value, imports of industrial diamond decreased 7% in quantity and the value was approximately the same as that of 1980. Total exports and reexports of abrasive material decreased in value.

Table 1.—Salient abrasives statistics in the United States

	1977	1978	1979	1980	1981
Natural abrasives production by producers:					
Tripoli (crude) ______ short tons__	125,661	138,311	e127,878	121,233	107,330
Value ______ thousands__	$777	$849	e$831	$676	$617
Special silica stone [1] ______ short tons__	2,200	e2,175	e2,094	2,131	[2]4,501
Value ______ thousands__	$3,236	e$2,630	e$2,064	$2,233	[2]$1,176
Garnet ______ short tons__	21,980	20,822	21,240	26,909	25,451
Value[3] ______ thousands__	r$1,303	r$1,310	r$1,535	r$1,908	$2,059
Emery ______ short tons__	W	W	10,005	W	W
Value ______ thousands__	W	W	$204	W	W
Manufactured abrasives [4] [5] ______ short tons__	640,723	550,877	712,733	r614,963	[5]586,915
Value[5] ______ thousands__	$186,654	$172,554	$230,024	r$216,946	[5]$225,503
Foreign trade (natural and artificial abrasives):					
Exports (value) ______ do____	$121,579	$138,659	$185,587	$193,679	$189,719
Reexports (value) ______ do____	$35,363	$41,016	$42,922	$47,521	$27,758
Imports for consumption (value) ______ do____	$192,870	$231,720	$270,599	r$268,842	$299,177

eEstimated. rRevised. W Withheld to avoid disclosing company proprietary data.

[1]Includes grinding pebbles, grindstones, oilstones, tube-mill liners, and whetstones. Finished product data for 1977-80 and crude production data for 1981.

[2]The large increase in quantity and decrease in value was caused by changes in reporting procedure. In 1977-80, quantity and value were for finished products; 1981 data were for crude mined quantity and value (first marketable value). Finished product data are shown in table 7.

[3]Primary garnet—denotes first marketable product.

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

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

FOREIGN TRADE

Imports of abrasive materials in 1981 were 11% higher in value than in 1980 and exports plus reexports decreased 10% in value. Net imports, the excess of imports over exports and reexports, were valued at $81.7 million.

Industrial diamond imports totaled 20.4 million carats of loose material valued at $111 million, a decrease of 7% in quantity with no appreciable change in value from that of 1980. Ireland, the largest U.S. source of imported industrial diamonds in terms of quantity, shipped to the United States a total of 9.3 million carats valued at $19.3 million, a decrease of 6% in quantity and 8% in value from that of 1980. The share of imports from Ireland was 46% of the total quantity and 17% of the total value. Of the 9.3 million carats from Ireland, 8.2 million carats were synthetic powder and dust with an average value of $2.00 per carat.

The Republic of South Africa, the largest U.S. source of imported industrial diamonds in terms of value, shipped to the United States a total of 4.0 million carats valued at $46.3 million, a decrease of 26% in quantity and 21% in value from that of 1980. The share of imports from the Republic of South Africa was 20% of the total quantity and 42% of the total value. Of the 4.0 million carats, 3.0 million carats were industrial diamond stones with an average value of $14.60 per carat.

Exports of industrial diamonds, loose, were 28.3 million carats, nearly the same as in 1980; the value was $69.5 million, a decrease of 7%. Reexports of industrial diamond, loose, were 2.4 million carats, a decrease of 33%; the value was $27.3 million, a decrease of 42%. The diamond content in diamond wheels, exported and reexported, was 694,116 carats, a decrease of 5%; the declared value was $7.7 million, an increase of 4%. Imports of diamond wheels are listed by number and value; the value in 1981 increased to $5.6 million from $4.5 million in 1980.

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

(Thousands)

Kind	1980 Quantity	1980 Value	1981 Quantity	1981 Value
NATURAL ABRASIVES				
Industrial diamond, natural or synthetic, powder or dust carats	28,162	$68,866	27,887	$64,166
Industrial diamond, natural or synthetic, other do	301	5,570	450	5,331
Emery, natural corundum, pumice in blocks pounds	31,612	1,195	35,585	1,099
MANUFACTURED ABRASIVES				
Artificial corundum (fused aluminum oxide) do	37,857	18,864	32,326	17,046
Silicon carbide, crude or in grains do	27,311	13,258	22,979	11,137
Carbide abrasives, n.e.c. do	811	1,472	684	1,481
Other refined abrasives do	24,760	6,958	36,419	8,688
Grinding and polishing wheels and stones:				
Diamond carats	696	7,161	682	7,547
Polishing stones, whetstones, oilstones, hones, similar stone number	681	2,181	844	2,501
Wheels and stones, n.e.c pounds	5,978	23,330	5,813	26,361
Abrasive paper and cloth, coated with natural or artificial abrasive materials do	19,141	35,912	16,462	35,497
Grit and shot, including wire pellets do	31,882	8,912	27,608	8,865
Total	XX	193,679	XX	189,719

XX Not applicable.

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

(Thousands)

Kind	1980 Quantity	1980 Value	1981 Quantity	1981 Value
NATURAL ABRASIVES				
Industrial diamond, natural or synthetic, powder or dust carats	372	$1,382	584	$1,611
Industrial diamond, natural or synthetic, other do	3,268	45,659	1,847	25,647
Emery, natural corundum, pumice in blocks pounds	113	35	73	16
MANUFACTURED ABRASIVES				
Silicon carbide, crude or in grains do	11	6	41	11
Grinding and polishing wheels and stones:				
Diamond carats	34	276	12	159
Wheels and stones, n.e.c.[1] pounds	30	134	35	139
Abrasive paper and cloth, coated with natural or artificial abrasive materials do	10	29	62	172
Grit and shot, including wire pellets do	--	--	11	3
Total	XX	47,521	XX	27,758

XX Not applicable.

[1]Includes value of hones, whetstones, pulpstones, oilstones, polishing stones, and quantity and value of other abrasive wheels.

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

(Thousands)

Kind	1980 Quantity	1980 Value	1981 Quantity	1981 Value
Corundum, crude or crushed ---short tons--	(1)	(1)	--	--
Emery, flint, rottenstone, tripoli, crude or crushed ---do---	6	$504	9	$529
Silicon carbide, crude ---do---	78	29,112	80	33,602
Aluminum oxide, crude ---do---	181	48,520	188	61,762
Other crude artificial abrasives ---do---	1	196	1	254
Abrasives, ground grains, pulverized or refined:				
Rottenstone and tripoli ---do---	(2)	1	(2)	5
Silicon carbide ---do---	5	8,314	5	8,611
Aluminum oxide ---do---	7	4,914	9	7,784
Emery, corundum, flint, garnet, other, including artificial abrasives ---do---	4	5,744	2	4,554
Papers, cloths, other materials wholly or partly coated with natural or artificial abrasives ---	(3)	38,207	(3)	45,304
Hones, whetstones, oilstones, polishing stones --- number--	235	337	464	490
Abrasive wheels and millstones:				
Burrstones manufactured or bound up into millstones ---short tons--	(2)	1	(2)	1
Solid natural stone wheels --- number--	72	93	22	150
Diamond ---do---	93	4,526	92	5,607
Abrasive wheels bonded with resins ---pounds--	3,794	7,066	5,215	8,728
Other ---	(3)	7,614	(3)	7,335
Articles not specifically provided for:				
Emery or garnet ---	(3)	44	(3)	17
Natural corundum or artificial abrasive materials ---	(3)	579	(3)	1,235
Other, n.s.p.f ---	(3)	2,123	(3)	2,211
Diamond, natural and synthetic:				
Diamond dies --- number--	9	393	11	488
Crushing bort --- carats--	60	209	12	55
Natural industrial diamond stones ---do---	5,013	69,118	4,638	70,998
Miners' diamond ---do---	[4]1,161	10,183	1,310	11,858
Powder and dust, synthetic ---do---	12,003	20,775	10,874	20,215
Powder and dust, natural ---do---	3,604	10,269	3,570	7,384
Total ---	XX	[r]268,842	XX	299,177

[r]Revised. XX Not applicable.
[1]Revised to zero.
[2]Less than 1/2 unit.
[3]Quantity not reported.
[4]Includes 679 carats of synthetic miners' diamond.

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 11% in quantity and nearly 9% in value in 1981. Processed tripoli, sold or used (table 6), decreased 8% in quantity but increased 5% in value. The decreases in production were attributed to depressed general economic conditions. Of the processed tripoli, 62% was used for fillers in 1981 and 38% was used for abrasives, slightly changed from that in 1980.

The six tripoli producers in 1981 were Malvern Minerals Co., Garland County, Ark., which produced crude and finished material; Midwestern Minerals Corp., which produced crude material in Ottawa County, Okla., and finished material in Benton County, Ark.; American Tripoli Co., Div. of The Carborundum Co., which produced crude in Ottawa County, Okla., and finished material in Newton County, Mo.; Illinois Minerals Co. and Tammsco, Inc., both in Alexander County, Ill., which produced crude and finished amorphous (microcrystalline) silica; and Keystone Filler and Manufacturing Co., in Northumberland County, Pa., which processed rottenstone (decomposed fine-grained siliceous limestone or shale). The producer list had not changed since 1975.

Malvern Minerals Co., Hot Springs, Ark., reported plans for expansion in 1982 that would double its processing capacity. Illinois Minerals Co., Cairo, Ill., reported that an ongoing plant expansion increased its production of various product grades by almost 50%.

Prices for tripoli and amorphous silica are reported in table 5.

Table 5.—Quoted prices for tripoli and amorphous silica

Tripoli, paper bags, carload lots, f.o.b., in cents per pound:	
White, Elco, Ill.: Air floated through 200 mesh	2.75
Rose and cream, Seneca, Mo., and Rogers, Ark.:	
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, Ill.:	
Through 200 mesh, 90% to 95%	$65.00
Through 200 mesh, 96% to 99%	66.00
Through 325 mesh, 90% to 95%	67.00
Through 325 mesh, 96% to 98%	69.50
Through 325 mesh, 98% to 99.4%	71.00
Through 325 mesh, 99.5%	86.50
Through 400 mesh, 99.9%	116.50
Below 15 micrometers, 99%	124.50
Below 10 micrometers, 99%	175.00

Source: Engineering and Mining Journal, December 1981.

Table 6.—Processed tripoli[1] sold or used by producers in the United States, by use[2]

Use		1977	1978	1979	1980	1981
Abrasives	short tons	70,631	75,574	53,600	39,352	34,494
Value	thousands	$2,805	$3,709	$2,468	$2,253	$2,206
Filler	short tons	42,599	36,505	62,409	59,909	56,932
Value	thousands	$2,212	$2,220	$3,811	$4,025	$4,393
Other	short tons	2,689	[e]2,190	--	--	--
Value	thousands	$119	[e]$97	--	--	--
Total	short tons	115,919	114,269	116,009	99,261	91,426
Value[3]	thousands	$5,136	$6,026	$6,279	$6,277	$6,600

[e]Estimated.
[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

Special silica stone products produced in 1981 included oilstones-whetstones from Arkansas and Indiana, grindstones from Ohio, grinding pebbles and tube-mill liners from Minnesota, and deburring media from Ohio and Wisconsin.

Companies that mined novaculite and produced oilstones-whetstones in Garland County, Ark., were Hiram A. Smith, Inc., and Halls Arkansas Oilstone, Inc. Norton Pike Div. of Norton Co. mined novaculite in Garland County, Ark., and produced the finished stones in Littleton, N.H. Arkansas Whetstone Co. mined novaculite in Hot Springs County, Ark., and produced the finished stones in Garland County, Ark. Companies that produced oilstones-whetstones in Garland County, Ark., but did not operate mines were: Arkansas Abrasives, Inc.; Frontier Whetstones Cutting Co.; Natural Hones, Inc.; Pioneer Whetstones Co.; and Poor Boy Whetstones. Hindostan Whetstone Co. operated a plant in Lawrence County, Ind., to finish cuticle stone obtained from a quarry in Orange County, Ind. Cleveland Quarries Co. produced grindstones at its Amherst quarry in Lorain County, Ohio. Jasper Stone Co. produced grinding media, both rough and rounded, from its quarry in Rock County, Minn.; and Baraboo Quartzite Co., Inc., produced deburring media at its quarry in Sauk County, Wis.

Table 7.—Special silica stone products sold or used in the United States[1]

Year	Quantity (short tons)	Value (thousands)
1977	2,200	$3,236
1978[e]	2,175	2,630
1979	2,094	2,064
1980	2,131	2,233
1981	2,023	[2]4,258

[e]Estimated.
[1]Includes grinding pebbles, grindstones, oilstones, tubemill liners, and whetstones.
[2]Large increase in value because finished stone producers who purchase crude material from other producers have been included.

GARNET

The United States accounted for about 75% of the world's garnet production. The rest was produced primarily in India, the U.S.S.R., and Australia. Sales of domestic garnet decreased 4% in quantity, but increased 5% in value in 1981. Four producers were active—two in New York and one each in Idaho and Maine. Barton Mines Corp., Warren County, N.Y., sold garnet for use in coated abrasives, glass grinding and polishing, and metal lapping. The NYCO Div. of Processed Minerals, Inc., Essex County, N.Y., reported that its garnet was used mostly in sandblasting and in bonded abrasives. Emerald Creek Garnet Milling Co. operated two mines in Benewah County, Idaho, and reported that its garnet was used chiefly in sandblasting and water filtration. Industrial Garnet Extractives, Inc., near Rangeley in Oxford County, Maine, produced almandine garnet and a garnet-containing utility grit that was used largely in sandblasting and water filtration. Industrial Garnet started a new drying, screening, and bagging line that doubled its processing capacity. NYCO completed a plant expansion that more than tripled its capacity and improved product sizing.

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

Year	Quantity (short tons)	Value (thousands)
1977	20,022	[r]$3,315
1978	22,058	[r]3,918
1979	23,303	[r]4,647
1980	26,550	[r]4,934
1981	25,519	5,204

[r]Revised.

CORUNDUM AND EMERY

Corundum.—No domestic corundum was produced in the United States in 1981, and there were no imports of abrasive-grade corundum in 1980-81. Demand was met by withdrawal from stocks. The United Nations embargo against Zimbabwean corundum had been removed. However, the United States had not directly imported corundum from Zimbabwe since 1968. In recent years, the domestic supply had almost entirely consisted of material imported from Zimbabwe via the Republic of South Africa by one firm in Massachusetts. Another firm, also in Massachusetts, had accounted for one-half of the total domestic consumption. Corundum was used in grinding and polishing optical components.

The latest 1981 prices quoted in Engineering and Mining Journal for crystal corundum were $170 to $187 per short ton of crude material, c.i.f. U.S. ports, in March 1981. This is the same price quoted in December 1980.

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

(Short tons)

Country[2]	1977	1978	1979	1980[p]	1981[e]
India	[e]1,440	1,193	1,002	1,603	1,650
Kenya	--	(3)	[e](3)	[e](3)	--
South Africa, Republic of	152	20	82	155	[4]100
U.S.S.R.[e]	8,800	9,400	9,400	9,500	9,500
Uruguay	464	[r]246	250	250	250
Zimbabwe	5,342	8,120	18,329	20,592	20,945
Total	[r]16,198	[r]18,979	29,063	32,100	32,445

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

[1]Table includes data available through May 26, 1982.

[2]In addition to the countries listed, Argentina may have produced minor quantities of this commodity, but output is not reported and available information is inadequate for formulation of reliable estimates of output levels.

[3]Less than 1/2 unit.

[4]Reported figure.

Emery.—Two companies, De Luca Emery Mine, Inc., and John Leardi Emery Mine, operated emery mines in 1981, both near Peekskill in Westchester County, N.Y. The crude material was processed by two companies: Washington Mills Abrasive, Co., North Grafton, Mass.; and Emeri-Crete, Inc., New Castle, N.H. Domestic emery was used mostly in aggregates as a nonslip additive for floors, pavements, and stair treads. Minor uses for domestic emery were as coated abrasives and tumbling or deburring media.

World production of emery was principally in Greece and Turkey. In 1980, production of emery in Greece was estimated to be 10,000 tons. Production of emery in Turkey in 1980 was reported to be 44,000 tons. No values are available on the production in either country.

Prices quoted for emery by domestic suppliers in December 1981 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 in 1981 was estimated to be 57 million carats, a 14% increase over that of 1980. Secondary production, salvage from used diamond tools and from wet and dry diamond-containing waste, was estimated to be 2.3 million carats in 1981.

The Government stockpile inventory as of December 31, 1981, included 23.7 million carats of crushing bort and 17.7 million carats of stones, exceeding the respective goals of 22.0 million carats and 7.7 million carats by 1.7 million carats and 10.0 million carats, respectively. Available for disposal from prior enabling legislation were 1.7 million carats of bort and 3.7 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 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. World reserves are only marginally sufficient to meet world demand for industrial stones through 2000. However, the discovery of a large deposit of diamond predominantly of industrial quality in Australia may substantially improve the supply by 1986. Increased use of synthetic polycrystalline diamond compacts and other synthetic products could also alleviate any supply shortfall.

Exports and reexports of industrial diamond dust and powder, including synthetics, totaled 28.5 million carats valued at $65.8 million. Exports and reexports of stones totaled 2.3 million carats valued at

$31.0 million.

Domestic exploration for diamonds continued. More than 90 kimberlite occurrences were known in the Colorado-Wyoming State line district and the Iron Mountain district of Wyoming. Microdiamonds have been recovered from some of the State line diatremes near Tie Siding, Wyo. A $2.5 million test plant has been built in Fort Collins, Colo., to evaluate diamond-bearing rock.

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

(Thousand carats and thousand dollars)

Year	Quantity	Value
1979	25,325	110,934
1980	21,848	110,566
1981	20,404	110,510

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

(Thousand carats and thousand dollars)

Country	Natural industrial diamond stones (including glazers' and engravers' diamond, unset)				Miners' diamond[2]				Powder and dust, synthetic				Powder and dust, natural			
	1980		1981		1980		1981		1980		1981		1980		1981	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Australia	--	--	6	51	--	--	5	76	--	--	--	--	--	--	2	11
Belgium-Luxembourg	534	3,513	648	6,226	6	67	17	80	658	1,119	60	179	365	766	563	830
Canada	20	292	9	78	31	54	34	76	15	20	24	30	7	42	16	39
Congo	31	657	152	2,430	--	--	--	--	--	--	--	--	4	99	--	--
Finland	--	--	--	--	--	--	--	--	585	731	632	790	--	--	--	--
France	3	12	([3])	4	--	--	--	--	2	5	--	--	--	--	2	3
Germany, Federal Republic of	2	93	19	225	([3])	([3])	--	--	85	228	90	216	43	134	58	116
Ghana	10	278	2	71	--	--	--	--	--	--	--	--	--	--	--	--
Greece	--	--	1	3	--	--	--	--	414	413	305	343	--	--	6	4
Hong Kong	1	9	([3])	14	--	--	--	--	2	5	1	1	38	48	--	--
Ireland	41	253	18	138	242	1,953	11	82	8,189	15,611	8,198	16,414	1,390	3,063	1,067	2,652
Israel	8	211	39	1,327	--	--	--	--	1	1	1	1	2	34	2	3
Japan	28	1,375	42	1,966	--	--	--	--	739	733	801	779	5	9	4	16
Liberia	5	63	--	--	--	--	1	29	--	--	([3])	8	16	63	--	--
Mexico	1	32	--	--	--	--	6	56	--	--	--	--	17	12	--	--
Netherlands	96	1,389	33	1,177	--	--	--	--	27	24	5	9	22	61	20	47
South Africa, Republic of	3,715	52,182	2,968	43,322	12	111	94	366	666	1,123	252	451	1,024	4,895	679	2,189
Switzerland	3	117	30	908	--	--	--	--	197	225	165	315	105	198	244	268
U.S.S.R.	--	--	--	--	--	--	--	--	135	151	2	8	60	53	--	--
United Kingdom	414	6,356	547	9,033	16	138	3	34	123	189	176	262	96	156	439	769
Venezuela	44	1,344	36	1,023	8	309	2	279	--	--	--	--	--	--	--	--
Zaire	10	46	3	78	820	7,247	1,131	10,460	10	20	--	--	397	604	455	410
Other Africa, n.e.c	18	694	56	2,762	--	--	([3])	([3])	--	--	--	--	--	--	--	--
Other	31	204	30	162	26	304	7	317	155	181	162	409	r13	r31	12	27
Total[4]	5,013	69,118	4,638	70,998	1,161	10,183	1,310	11,858	12,003	20,775	10,874	20,215	3,604	10,269	3,570	7,384

r Revised.
[1] Excludes 59,772 carats of crushing bort in 1980 from the Republic of South Africa, and 12,072 carats from Ireland, the Republic of South Africa, Zaire, and the United Kingdom in 1981.
[2] Includes 679 carats of synthetic miners' diamond in 1980.
[3] Less than 1/2 unit.
[4] Data may not add to totals shown because of independent rounding.

WORLD REVIEW

Angola.—The state-controlled Endiema Corp. reportedly assumed all diamond prospecting. Output had fallen following independence in 1974 but had started to improve in 1979.[2] Production was concentrated in the Luanda district where over 40 mines, all run by the state-owned company Companhia de Diamantes de Angola, are in operation.[3]

Australia.—The Ashton Joint Venture evaluation program continued through 1981. Major drilling and sampling was performed on the kimberlite pipe AK-1, and sampling was performed on the alluvial deposits. A total of 34,300 tons had been sampled from the kimberlite pipe yielding 152,000 carats of diamond, and 52,100 tons had been sampled from the alluvial deposits yielding 104,000 carats. Agreement was reached with the Australian Government and engineering studies were underway on a proposal for a plant with an initial capacity of 2.25 million tons per year. Recommendation was expected to be made soon to the participants to proceed with the final design and construction of a large-scale commercial plant.[4]

Evaluation of the samples indicated 10% gem-quality stones, 30% near gem quality, and the balance industrial-grade diamond.[5] Drilling had shown diamond to a depth of 200 meters. Test work on the kimberlite pipe AK-1 indicated that it contained 160 million tons, and if the average surface grade of 5 carats per ton were to persist, the potential total could be 800 million carats to a depth of 200 meters.[6] Commercial operation was expected to start in late 1983 from the three alluvial deposits near the pipe.

Dampier Mining Co. was carrying out exploration work for diamond in the Kimberly region of Western Australia and entered into an agreement for exploration on the Stannite's lease in the Northern Territory.[7]

Botswana.—Production startup of the new Jwaneng Mine was scheduled for early 1982. The plant was designed to have a treatment rate of 4.8 million tons per year. It was estimated that 5 million carats per year could be recovered of which 60% to 70% would be industrial-grade diamond.[8]

Ghana.—The last operating mine was expected to close in 1983 since reserves were expected to be exhausted. This, however, may not mean the end of diamond mining in Ghana because results of exploration on a large deposit in the Birim River Valley have been favorable.[9]

Guinea.—Large-scale prospecting had proved most encouraging. A $70 million diamond mining joint venture was to be launched by Bridge Oil Pty. Ltd. of Australia, Industrial Diamond Co. of the United Kingdom, Simonieres Vischer of Switzerland, and the Guinean Government.[10] Production was scheduled to start in August 1983 at 200,000 carats per year and increase to 500,000 carats per year by 1985. Prospecting so far had indicated reserves of 1 million carats.[11]

India.—The discovery of three reasonably large diamond stones in the Vajrakarur area of Andhra Pradesh led the Geological Survey of India to embark on a 3-year program of intensive diamond exploration.[12]

Namibia.—De Beers Consolidated Mines, Ltd., of the Republic of South Africa, has stepped up the pace of prospecting. Exploration efforts were concentrated in three areas. The greatest effort was between Chamis Bay and Bogenfels on the coast. Another intensive prospecting program was inaugurated in the northeastern corner of Namibia. De Beers was also reexamining the old German digs near Luderitz, working its way along the Orange River. De Beers also increased offshore prospecting.[13]

South Africa, Republic of.—Three kimberlite pipes had been discovered near the western border with Namibia. De Beers had several diamond pipes in South Africa at an advanced stage of development that could be brought to production within the next few years. De Beers also entered into an agreement with Anglo Transvaal to examine and exploit a kimberlite pipe discovered on the farm Venetia.[14] De Beers was building a sampling plant at the site.[15]

De Beers was to close the treatment plant at Tweepad in its Namaqualand division until market conditions improved. The plant processed about 10% of the diamond from the mine. Also closed was one conglomerate treatment plant, a sample plant, and two small screening plants at the Consolidated Diamond Mine in Namibia.[16]

U.S.S.R.—The U.S.S.R.'s first underground diamond mine was under development in the Yakut region. It was expected to go into operation during the period 1982-85.[17] Twin shafts were to be sunk—one, 6.5 meters in diameter, for ore removal and the other for ventilation. Both shafts were to be approximately 1,000 meters deep.[18]

TECHNOLOGY

A drill bit was produced incorporating natural diamond and synthetic diamond compacts. This bit exceeded the life of a standard tungsten carbide bit by more than 40 times, thus reducing trips to change the bits with a saving of as much as 40 hours on a 2,000-foot hole in coal seams. The drilling rates exceeded the carbide bit rate by up to three times. The higher penetration rate and longer bit life reduced drilling costs significantly.[19]

A polycrystalline synthetic diamond compact (PDC) core bit drilled five times faster than natural diamond core bits and produced better quality cores in pressure core drilling of San Andreas dolomite. The PDC drill increased penetration rates by 4 to 5 times that of surface set diamond core bits and by 10 times over tungsten carbide core bits in drilling uranium-bearing rock strata.[20]

Sandia Laboratories developed a diffusion bonding technique for attaching polycrystalline diamond compact cutters to mounting studs on drill bits. The final goal of the project was to attach the cutters directly to the drill bits, thereby eliminating the studs. One of the most significant advances recently made in the bonding technology industry had been that of attaching polycrystalline diamond compact cutters to steel.[21]

Solid sintered diamond shapes (over 80% by volume diamond) were produced by incorporating diamond powder (0.7 to 90 micrometers) into a cobalt-silicon or cobalt-titanium metal alloy matrix. Shapes could be produced at lower temperatures and pressures when cobalt alloys were used instead of cobalt metal. The pressures and temperatures required were between 50 and 55 kilobars and 1,300° and 1,400° C, respectively. The high strength of the diamond matrix results from a sinter bonding of the diamonds. Leaching the bonding metal with acid did not destroy the sintered bond.

Diamond layers could be sintered onto cobalt-silicon and cobalt-titanium substrates with pressures of 55 to 58 kilobars and temperatures of 1,400° C to 1,500° C. It was also possible to sinter the diamond layers onto a tool-grade steel base if a cobalt alloy was used as an interface.[22]

A new synthetic polycrystalline diamond drill was developed by a domestic manufacturer. The tool cuts rather than grinds through rock formations and was claimed to drill three times faster than conventional surface set diamond bits. The thermal stability of the 0.3-carat diamond (1,200° C without degradation) was a major technological breakthrough.[23]

Polycrystalline diamond tools were designed to replace tungsten carbide tools in the machining of silicon-aluminum alloy engine parts. The edge life of the PDC tools averaged 18,000 engines, a 450-to-1 improvement over the carbide tools. Because the aluminum alloy does not weld to the PDC, burring was eliminated.[24]

A manufacturer of carbon components converted its production procedure almost entirely to diamond-tooled operations. This led to a total time saving of between 35% and 40% and reduced the production cost per component by around 25%. Such savings reflect the elimination of a complete machining operation as well as a material cost saving of approximately 40%.[25]

A breakthrough occurred in the manufacture of rotary diamond dressing wheels. A manufacturer developed an electroforming system called the Elmet process, which eliminates the need for hand-setting of diamond and provides a strong matrix at low temperature. This factor results in a very low degree of distortion; therefore, precision rolls can be produced without the need for subsequent lapping or grinding.[26]

An ultrathin diamond saw blade was developed for use in sawing silicon chips. The blade produces a kerf of only 0.0025 inch. This ultrathin cut reduces the waste of the expensive silicon material.[27]

The use of synthetic diamond compacts as inserts in chain saws for cutting granite (blue stone) in Europe increased cutting rates from 54 square feet per hour with tungsten carbide inserts to 102 square feet per hour.[28] In a similar application in the United States, a stone company, cutting oolitic limestone, doubled its output and increased the cutting life of the chain by 21 times when compared with tungsten carbide.[29]

Use of a diamond electroplated wire in a cutting machine produced cost savings of up to 60% in marble quarrying in Italy. The single diamond wire could cut approximately 500 square meters of marble in 150 to 250 hours.[30]

The use of diamond abrasive for grinding and polishing dimension stones was tested in Eastern Europe. Tests in the U.S.S.R. using diamond abrasive in dimension stone polishing doubled the output when compared with conventional abrasive polishing. Similar experiments carried out in Italy resulted in significant savings in dimension stone polishing.[31]

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

(Thousand carats)

Country	1977 Gem	1977 Industrial	1977 Total	1978 Gem	1978 Industrial	1978 Total	1979 Gem	1979 Industrial	1979 Total	1980p Gem	1980p Industrial	1980p Total	1981e Gem	1981e Industrial	1981e Total
Africa:															
Angola	265	88	353	r488	r162	r650	630	211	841	1,125	375	1,500	1,050	350	1,400
Botswana	404	2,287	2,691	r420	2,379	r2,799	659	3,735	4,394	765	4,336	5,101	744	4,217	[2]4,961
Central African Republic	178	119	297	199	85	284	205	110	315	227	123	350	200	100	300
Ghana	230	1,717	1,947	142	1,281	1,423	125	1,128	1,253	126	1,132	1,258	100	900	1,000
Guinea[e]	25	55	80	25	55	80	27	58	85	12	26	38	12	26	38
Ivory Coast	r20	r19	r [2]39	r22	r23	r45	24	24	48	--	--	--	--	--	--
Lesotho	39	3	42	62	5	67	48	4	52	50	4	54	49	4	[2]53
Liberia[3]	163	163	326	128	180	308	170	132	302	123	175	298	117	169	[2]286
Namibia	1,901	100	2,001	1,803	95	1,898	1,570	83	1,653	1,482	78	1,560	1,186	62	[2]1,248
Sierra Leone	423	538	961	353	426	779	419	436	855	317	275	592	320	275	595
South Africa, Republic of:															
Finsch Mine	r365	r2,061	2,426	r403	r2,227	2,630	465	2,120	2,585	465	2,442	2,907	1,002	3,463	[2]4,465
Premier Mine	r378	r1,632	2,010	r380	r1,603	1,983	468	1,613	2,081	407	1,632	2,039	510	1,530	[2]2,040
Other De Beers properties[4]	r1,216	r1,441	2,657	r1,254	r1,395	2,649	1,850	1,370	3,220	1,550	1,489	3,039	1,603	1,069	[2]2,672
Other	r372	r178	550	r320	r145	465	403	95	498	390	147	537	314	35	349
Total	r2,331	r5,312	7,643	r2,357	r5,370	7,727	3,186	5,198	8,384	2,812	5,710	8,522	3,429	6,097	[2]9,526
Tanzania	204	204	408	r141	r141	r282	157	157	314	137	137	274	140	140	280
Zaire	533	10,681	11,214	640	10,603	11,243	294	8,440	8,734	345	9,890	10,235	260	7,240	7,500
Other areas:															
Australia	--	--	--	--	--	--	--	--	--	--	48	48	[2]21	[2]184	[2]205
Brazil	r236	r384	r620	r236	r384	r620	236	384	620	253	414	667	228	372	600
Guyana	7	10	17	7	10	17	6	10	16	4	6	10	4	6	10
India	15	3	18	14	2	16	14	2	16	e12	e2	e14	12	2	14
Indonesia[e]	3	12	15	3	12	15	3	12	15	3	12	15	3	12	15
U.S.S.R.[e]	2,100	8,200	10,300	2,150	8,400	10,550	2,200	8,500	10,700	2,250	8,600	10,850	2,120	8,480	10,600
Venezuela	204	483	687	r271	r549	r820	247	556	803	238	483	721	[2]102	[2]388	[2]490
Grand total	r9,281	r30,378	r39,659	r9,461	r30,162	r39,623	10,220	29,180	39,400	10,281	31,826	42,107	10,097	29,024	39,121

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

[1]Table includes data available through May 30, 1982. 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 (1980-81), Central African Republic (1977-78), Liberia (1977-78), Sierra Leone (1977-78), and Venezuela (1978-81), 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. China also produces some natural diamond, but output is not reported.

[2]Reported figure.

[3]Total exports.

[4]All company output from the Republic of South Africa, except for that credited to the Finsch and Premier Mines for the years indicated; excludes De Beers Group output from Botswana, Lesotho, and Namibia.

MANUFACTURED ABRASIVES

Six firms produced crude fused alumina in the United States and Canada (table 13). Production was 64% of the furnace capacity of United States and Canadian plants. Reported 1981 production of white, high-purity material increased 9% to 37,000 tons, and production of regular material increased 5% to 166,000 tons. Of the combined output of white and regular material, 13% was, for nonabrasives applications, principally in the manufacture of refractories. Stocks reported totaled 16,500 tons as of December 31, 1981.

Washington Mills Abrasives Co. had produced for many years high-grade aluminum oxide and emery grains at its North Grafton, Mass., plant from crude ore supplied by other manufacturers. In September 1980, production of crude, high-quality fused aluminum oxide started at its new furnace plant in Niagara Falls, Ontario, Canada. The plant had been located in Canada because of the abundant supply of electrical energy and the availability of labor trained in arc furnace use. The plant contained the world's second largest electric arc furnace for the conversion of bauxite ore into aluminum oxide. Two products were produced depending on how rapidly the fused aluminum oxide was cooled. The first was basic aluminum oxide for the production of abrasive grains. The second was microcrystalline material that was converted into a tumbling media for the mass finishing market.

Two firms produced fused alumina-zirconium abrasives (table 13). Both firms operated plants in Canada, and one of the firms produced material in the United States. All production was used for abrasives applications. Output, 88% of furnace capacity in 1981, increased in both tonnage and value during the year.

Seven firms in the United States and Canada produced silicon carbide in 10 plants (table 13) in 1981. The companies produced crude material for abrasives, refractories, and other nonabrasive uses. Total production was 69% of capacity. Output decreased 8% in tonnage but increased 7% in value during the year. Abrasives use increased by 14% and accounted for 38% of the output. Metallurgical applications use decreased by 13% and accounted for 44% of the output. Refractory applications suffered the greatest decrease in use, 38%, and accounted for 15% of the total output. Stocks totaled 14,700 tons as of December 31, 1981.

Norton Co. had recently completed a $21 million expansion of its abrasive grain plant in Huntsville, Ala., and had a $5.1 million expansion project underway at its vitrified grinding wheels facility in Worchester, Mass. This expansion, along with a $3 million expansion of manufacturing capacity at its Niagara Falls, Ontario, Canada, plant, was scheduled for completion in 1982.

Universal Grinding Wheel Co. completed a $4 million expansion at its Salem, Ill., bonded abrasive plant during late 1981. The expansion included new presses, finishing equipment, and greater oven and kiln facilities.

In the Stockpile Report to the Congress by the General Services Administration, December 31, 1981, the inventory of crude fused aluminum oxide in calendar year 1981 was approximately 250,000 tons, and the stocks of aluminum oxide abrasive grain were about 50,800 tons. The stocks of silicon carbide crude were 80,550 tons, and the goal was 29,000 tons.

Metallic abrasives were produced by 11 firms in 13 plants in the United States in 1981. Steel shot and grit comprised 92% of the total quantity of metallic abrasives sold or used; chilled iron shot and grit, 6%; and annealed iron shot and grit, 2%. The following three States supplied 80% of the total sold or used: Pennsylvania, 29%; Ohio, 26%; and Michigan, 25%. Other large suppliers operated in Indiana and Virginia. The total quantity, sold or used, decreased 2% from that of 1980, but the value increased 3%.

Cleveland Metal Abrasives Co. closed both of its operating plants in 1981. One plant was located in Toledo, Ohio, and the other in Birmingham, Ala. Metal Blast, Inc., discontinued production of chilled iron shot and grit, but manufacturing capability was maintained. Two new firms started production during 1981. One of the new firms, Jumbo Manufacturing Inc., in Tippecanoe, Ind., produced chilled iron shot and grit and planned to expand into malleable shot and grit in 1982. The other new firm, Metal Tec Steel Abrasives Co., Plymouth, Mich., produced steel shot. Three companies were deleted from the survey because they either only recycled shot and grit or sold only scrap shot.

TECHNOLOGY

A domestic manufacturer developed a proprietary new synthetic mineral for abrasive products based on aluminum oxide and containing unspecified chemicals. The crystalline structure of the mineral was claimed to be more uniform than that of other abrasive minerals produced by conventional fusion processes. It was reported that this material has a toughness factor more than twice that of aluminum oxide. Coated abrasive products made with this new material reportedly increased service life 300% in metal removal operations and improved productivity.[32] The product was being produced in a pilot plant operation, but a new manufacturing plant was under construction in Hastings, Minn., and was scheduled for completion in 1982.

A new energy- and cost-efficient process for manufacturing silicon carbide was being developed by a domestic manufacturer. Tests completed in the pilot plant in 1981 demonstrated the ability to produce granular silicon carbide on a continuous, steady state operating basis. The material was very uniform and was being tested as a metallurgical additive, for the manufacture of abrasives and refractories and other ceramic products.[33]

A domestic synthetic abrasive producer developed a new backing material for coated abrasives. The backing consists of two layers of high-strength polyester yarns that are stitched together rather than woven. The high-strength design is extremely important to the life and performance of belts operating under high bending and impact stresses. Since this backing maintains its strength throughout its life, the abrasive grains are more effectively presented to the workpiece, thereby improving grinding efficiency by as much as 20%.[34]

Because cubic boron nitride (CBN) reacts less with iron than does diamond, it is more applicable for certain engineering materials than diamond. Extensive studies were made on developing a practical method to synthesize the CBN from the hexagonal form under moderate pressure and temperature conditions. Research was undertaken to determine the effects of atmosphere and the additions of aluminum nitride (AlN). AlN was found to act as the catalyst for the synthesis; it lowered the transition temperature and pressure to 1,000° C and 7 gigapascals. Well-crystallized hexagonal boron nitride (BN) could be completely converted to CBN by the addition of 20 mole-percent of AlN at 1,600° C under a 6.5-gigapascals reducing atmosphere. No conversion of hexagonal BN to CBN was observed without added AlN under pressures of less than 7 gigapascals, even if the atmosphere was controlled. A dense CBN-AlN sintered compact, with a density greater than 99% of theoretical, was obtained. Direct bonding between cubic grains occurred. To enhance the catalytic effect of the AlN, the atmosphere in the high-pressure cell should be reducing.[35]

Because CBN has a self-sharpening capability, it cuts the metal cleanly with less frictional heat thereby reducing the possibility of thermal damage to the ground part. Many new machines have been developed to exploit the full productivity potential of CBN wheels. The material removal capabilities of these machines are so high that they may replace conventional lathes and milling machines, as well as grinding machines.[36]

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Table 13.—Crude artificial abrasives manufacturers in 1981

Company	Location	Product
Carborundum Electro Minerals Co., Div. of Standard Oil of Ohio.	Niagara Falls, N.Y	Fused aluminum oxide (high purity) and silicon carbide.
	Vancouver, Wash	Silicon carbide.
	Niagara Falls, Ontario, Canada	Fused aluminum oxide (regular).
	Shawinigan, Quebec, Canada	Silicon carbide.
ESK Corp	Hennedin, Ill	Do.
The Exolon Co	Thorold, Ontario, Canada	Fused aluminum oxide (regular), aluminum-zirconium oxide, silicon carbide.
Ferro Corp. Speciality Ceramics Group	Cape-de-la-Madeleine, Quebec, Canada	Silicon carbide.
General Abrasives, Div. of Dresser Ind	Niagara Falls, N.Y	Fused aluminum oxide (regular and high purity) and silicon carbide.
	Niagara Falls, Ontario, Canada	
Norton Co	Huntsville, Ala	Aluminum-zirconium oxide.
	Worchester, Mass	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.
Unicorn Abrasives of Canada Ltd., Div. of Fusion du Saguenay.	Arvida, Quebec, Canada	Fused aluminum oxide (regular).
Washington Mills Abrasives Co	Niagara Falls, Ontario, Canada	Do.

Table 14.—Producers of metallic abrasives in 1981[1]

Company	Location	Product (shot and/or grit)
Abrasive Materials, Inc	Hillsdale, Mich	Cut wire.
Durasteel Co	Pittsburg, Pa	Steel.
Ervin Industries, Inc	Adrian, Mich	Do.
Do	Butler, Pa	Do.
Globe Steel Abrasives Co	Mansfield, Ohio	Do.
Jumbo Manufacturing Co	Tippecanoe, Ind	Chilled iron.
Metal Tec Steel Abrasives Co	Plymouth, Mich	Steel.
National Metal Abrasive Co	Wadsworth, Ohio	Do.
The Pangborn Co	Butler, Pa	Do.
Pellets, Inc	Tonawanda, N.Y	Cut wire.
Steel Abrasives, Inc	Fairfield, Ohio	Chilled iron.
Wheelabrator-Frye Inc	Mishawaka, Ind	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	1977	1978	1979	1980	1981
Silicon carbide[1]	192	182	[e]196	170	156
Value	$53,814	$51,371	[e]$62,702	$64,346	$68,839
Aluminum oxide (abrasive grade)[1]	185	142	[e]225	193	203
Value	$48,819	$46,633	[e]$67,511	$63,881	$73,712
Aluminum-zirconium oxide	20	23	28	19	W
Value	$11,281	$14,668	$14,893	$8,438	W
Metallic abrasives[2]	243	204	264	[r]233	228
Value	$72,740	$59,882	$84,918	[r]$80,281	$82,952
Total	640	551	[e]713	[r]615	[3]587
Value	$186,654	$172,554	[e]$230,024	[r]$216,946	[3]$225,503

[e]Estimated. [r]Revised. 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) as reported by producers

Use	1980			1981		
	Quantity (short tons)	Value	Yearend stocks (short tons)	Quantity (short tons)	Value	Yearend stocks (short tons)
SILICON CARBIDE						
Abrasives	51,573	$19,370,719	2,640	58,920	$28,394,648	4,883
Metallurgical	78,275	27,622,033	13,171	68,440	25,865,816	6,576
Refractories	38,174	16,553,260	2,334	23,596	12,896,158	1,319
Other	2,000	800,000	1,000	4,957	1,682,808	1,881
Total	170,022	64,346,012	19,145	155,913	68,839,430	14,659
ALUMINUM OXIDE						
Regular:						
Abrasives	NA	NA	NA	140,447	45,995,409	9,501
Refractories	NA	NA	NA	25,715	9,800,617	1,668
Other	NA	NA	NA	--	--	--
Total	158,947	49,082,840	10,484	166,162	55,796,026	11,169
High purity	34,091	14,798,018	4,012	37,003	17,916,188	5,339
Grand total	193,038	63,880,858	14,496	203,165	73,712,214	16,508

NA Not available.

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

Product	Production		Sold or used		Annual capacity[2] (short tons)
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	
1980:					
Chilled iron shot and grit	r30,494	r$8,012	r31,241	r$8,774	r41,600
Annealed iron shot and grit	XX	XX	115	36	XX
Steel shot and grit	r207,462	r62,169	r201,152	r70,708	r373,000
Other[3]	251	549	279	763	r1,200
Total	r238,207	r70,730	r232,787	r80,281	XX
1981:					
Chilled iron shot and grit	16,375	4,394	13,606	3,672	19,500
Annealed iron shot and grit	5,162	1,591	5,216	1,610	7,300
Steel shot and grit	206,832	65,700	208,638	76,520	273,000
Other[3]	342	845	377	1,150	1,800
Total	228,711	72,530	227,837	82,952	XX

rRevised. XX Not applicable.
[1]Excludes secondary (recycle) producers.
[2]Total quantity of the various types of metallic abrasives that a plant could have produced during the year, working three 8-hour shifts per day, 7 days per week, allowing for usual interruptions, and assuming adequate fuel, labor, and transportation.
[3]Includes cut wire, aluminum, and stainless steel shot.

Aluminum

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

Primary aluminum production in the United States fell to 4.95 million short tons after a record production high of 5.13 million tons in 1980. Production was cut back significantly in the last half of 1981 from a high operating level at the beginning of the year because of weak demand. The annual demand, as measured by net shipments of ingot and mill products to the domestic industry, remained at 6.0 million tons. Inventories of ingot, mill products, and scrap aluminum reached a new record high of 3.3 million tons at the end of the year. Exports of crude, semifabricated, and scrap aluminum were reduced 42% while imports increased 31%. The value of net exports declined to about $100 million in 1981.

World production fell slightly in 1981. Major shifts in production were from countries that were dependent on external energy sources to countries with abundant supplies of low-cost energy. Japan showed the largest decrease in production followed by Venezuela, Poland, and the United Kingdom. Countries with the largest increase in production were Australia, Dubai, Canada, the U.S.S.R., and Egypt. World demand for primary and secondary aluminum metals declined.

Legislation and Government Programs.—New contracts between the Bonneville Power Administration (BPA) and the six aluminum smelters in the Pacific Northwest, represented by the Direct Service Industries, were challenged by public utilities in the area as being invalid, and legal action was initiated. The new 20-year contracts that guaranteed power to the aluminum smelters were initiated as a result of the Pacific Northwest Power Planning and Conservation Act, Public Law 96-501, which was signed into law in December 1980.

Suits were filed in November 1981 in the Federal District Court of Portland, Oreg., and in the U.S. Circuit Court of Appeals in San Francisco, Calif., by the National Wildlife Federation, the Washington State Sportmen's Council, and electric-rate payers to invalidate a contract between Alumax, Inc., and BPA for power for a proposed aluminum smelter near Umatilla, Oreg. The suits claim that the contract was illegally written.

Table 1.—Salient aluminum statistics

(Thousand short tons and thousand dollars unless otherwise specified)

	1977	1978	1979	1980	1981
United States:					
Primary production	4,539	4,804	5,023	5,130	4,948
Value	$4,683,949	$5,191,064	$6,130,302	$7,346,410	$7,520,841
Price: Producer list, ingot, average cents per pound	51.6	54.0	61.0	71.6	76.0
Secondary recovery	1,271	1,323	1,401	1,389	1,656
Exports (crude and semicrude)	411	520	773	1,483	867
Imports for consumption (crude and semicrude)	836	1,080	840	713	935
Aluminum industry shipments[1]	6,136	6,839	r6,922	r6,003	p5,999
Consumption, apparent	5,492	6,045	5,888	r5,065	5,137
World: Production	r15,189	r15,581	r16,061	17,006	p16,613

pPreliminary. rRevised.
[1]To domestic industry.

DOMESTIC PRODUCTION

Primary.—Production of primary aluminum decreased after a record production in 1980. Production capacity decreased as a result of the permanent closing in September of the Lake Charles, La., smelter of Consolidated Aluminum Corp. (Conalco). The smelter was closed owing to the lack of natural gas for the company-owned powerplant. The smelter, 100% owned by Swiss Aluminium Ltd. (Alusuisse), began production in 1971 using alumina imported from Suriname.

During 1981, 810,650 tons of annual primary aluminum production was shut down owing to a weak aluminum market. Contributing to this decline in production were consumers and fabricators who were taking advantage of short delivery schedules to lower their inventories, thereby controlling their carrying costs during a period of high interest rates. Production declined slowly during the first half of 1981, but the lack of metal orders about midyear and a 40% decline in exports during the first half caused a rapid cutback in primary production during the final half. In the period July through October, 598,069 tons of annual primary aluminum production was shut down. Excluding the Lake Charles plant closing, primary production was cut back at the Aluminum Co. of America (Alcoa) smelters at Badin, N.C., Vancouver, Wash., Rockdale, Tex., and Wenatchee, Wash., and at the Reynolds Metals Co. plants at Corpus Christi, Tex., Listerhill, Ala., Troutdale, Oreg., Longview, Wash., and Jones Mills, Ark. Kaiser Aluminum & Chemical Corp. cut back production at plants in Ravenswood, W. Va., and Chalmette, La., and Revere Copper and Brass Co. cut back its primary production at Scottsboro, Ala. Conalco cut back production at its New Johnsonville, Tenn., primary aluminum smelter. Unusual in the overall 1981 world slowdown of aluminum production was that U.S. producers cut back a larger percentage of their production than producers in other countries.

Aluminum producers in the Pacific Northwest negotiated new 20-year contracts with BPA, which were being contested as discussed under "Legislation and Government Programs." The new contracts were expected to provide the producers a greater assurance of obtaining "non-firm" power, but at increased costs in the years to come. Under the new contracts, electricity costs to the aluminum producers rose from 6 mills per kilowatt-hour to about 17.3 mills starting October 1. Further increases in power costs were expected during 1982.

In June, Alcoa and Reynolds signed new contracts with the New York State Power Authority (NYSPA), reportedly extending until the year 2013 the availability of electric power to the two aluminum smelters located in Massena, N.Y. The contracts immediately increased the power rates from 4 mills per kilowatt-hour to 7.6 mills for Alcoa, and to 4.3 mills for Reynolds. The agreements also stipulated a gradual increase in the rates to 16 mills by 1986 for Alcoa and by 1987 for Reynolds. An option in the old Alcoa contract that authorized the NYSPA to withdraw one-half the power supplied to the Alcoa plant in 1986 and beyond was deleted in the new contract.

Secondary.—Production and shipments of secondary aluminum alloys by independent smelters increased slightly in 1981 (table 5), but in general remained weak owing to a decline in automotive markets.

Consumption of used can scrap increased dramatically by about 210,000 tons in 1981 with the primary producers utilizing about 65% of the total amount of can scrap consumed. Used beverage cans toll-treated for primary producers were tabulated by the Bureau of Mines as consumed by secondary smelters. Of all domestic purchased aluminum scrap consumed in 1981, 25% was from used beverage cans.[3] Of the 43 billion aluminum beverage cans produced in the United States in 1981, 54%, or slightly more than 500,000 tons of used aluminum cans, was recycled, based on an average rate of 23 cans to the pound. In 1980, the recycling rate of used aluminum cans was about 38%.

Reynolds acquired a secondary aluminum plant in Benton Harbor, Mich., which when refurbished will have a scrap melting capacity of 35,000 tons per year. Alreco Metal Co., a wholly owned subsidiary of Reynolds, was expected to begin operating the plant in the summer of 1982. Reynolds announced it will convert a plantsite in Sheffield, Ala., to a dross processing facility. Plans call for the plant to have the capability to recover more than 30,000 tons of aluminum from dross generated at various operations of Reynolds. In addition, the plant will process nonferrous shredded scrap from automobiles, using a heavy-media separation technique.

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

(Short tons)

Class	Consumption	Calculated recovery	
		Aluminum	Metallic
1980			
Secondary smelters	884,255	705,345	760,263
Primary producers	541,771	462,402	495,251
Fabricators	143,915	125,940	134,601
Foundries	81,830	69,525	74,887
Chemical producers	41,862	23,902	24,401
Total	1,693,633	1,387,114	1,489,403
Estimated full industry coverage	1,982,000	1,619,000	1,738,000
1981			
Secondary smelters	976,348	784,169	845,049
Primary producers	730,736	620,836	664,992
Fabricators	167,703	144,748	154,878
Foundries	99,903	84,170	90,541
Chemical producers	37,733	21,004	21,469
Total	2,012,423	1,654,927	1,776,929
Estimated full industry coverage	2,333,000	1,913,000	2,055,000

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

Table 3.—Aluminum recovered from purchased scrap processed in the United States, by kind of scrap and form of recovery

(Short tons)

	1980	1981
KIND OF SCRAP		
New scrap:		
Aluminum-base	[1]850,260	[2]947,714
Copper-base	[r]63	[e]70
Zinc-base	204	[e]230
Magnesium-base	394	210
Total	[r]850,921	948,224
Old scrap:		
Aluminum-base	[1]536,854	[2]707,213
Copper-base	[r]96	[e]80
Zinc-base	860	[e]870
Magnesium-base	319	31
Total	[r]538,129	708,194
Grand total	[r]1,389,050	1,656,418
FORM OF RECOVERY		
Unalloyed	4,815	1,167
Aluminum alloys	1,327,372	1,606,550
In brass and bronze	159	[e]150
In zinc-base alloys	1,064	[e]1,100
In magnesium alloys	713	241
Dissipative forms[3]	54,927	47,210
Total	[r]1,389,050	1,656,418

[e]Estimated. [r]Revised.
[1]The amount of aluminum alloys recovered from aluminum-base scrap in 1980, including all constituents, was 907,471 tons from new scrap and 581,932 tons from old scrap and sweated pig, a total of 1,489,403 tons.
[2]The amount of aluminum alloys recovered from aluminum-base scrap in 1981, including all constituents, was 1,011,553 tons from new scrap and 765,376 tons from old scrap and sweated pig, a total of 1,776,929 tons.
[3]Includes recovery in deoxidizing ingot assuming 85% aluminum content in such ingot.

Table 4.—Stocks, receipts, and consumption of purchased new and old aluminum scrap and sweated pig in the United States in 1981[1]

(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	21,374	284,153	286,627	18,900
Borings and turnings	12,637	154,074	152,799	13,912
Foil	W	W	W	W
Dross and skimmings	8,404	85,978	86,619	7,763
Other[3]	291	14,465	14,462	294
Total	42,706	538,670	540,507	40,869
Old scrap:				
Castings, sheet, clippings	16,849	163,266	167,829	12,286
Aluminum cans	2,924	[4]176,424	[4]177,163	2,185
Other[5]	2,825	24,034	25,128	1,731
Total	22,598	363,724	370,120	16,202
Sweated pig	8,597	68,569	65,721	11,445
Total secondary smelters	73,901	970,963	976,348	68,516
Primary producers, foundries, fabricators, chemical plants:				
New scrap:				
Solids and clippings	24,098	498,460	507,080	15,478
Borings and turnings	648	24,687	25,007	328
Foil	W	W	W	W
Dross and skimmings	521	26,589	26,944	166
Other[3]	4,259	41,340	40,073	5,526
Total	29,526	591,076	599,104	21,498
Old scrap:				
Castings, sheet, clippings	1,226	60,515	60,037	1,704
Aluminum cans	18,738	[4]332,001	[4]331,142	19,597
Other[5]	2,417	25,796	25,638	2,575
Total	22,381	418,312	416,817	23,876
Sweated pig	1,133	20,147	20,154	1,126
Total primary producers, etc	53,040	1,029,535	1,036,075	46,500
Total of all scrap consumed:				
New scrap:				
Solids and clippings	45,472	782,613	793,707	34,378
Borings and turnings	13,285	178,761	177,806	14,240
Foil	1,770	8,975	8,526	2,219
Dross and skimmings	8,925	112,567	113,563	7,929
Other	2,780	46,830	46,009	3,601
Total new scrap	72,232	1,129,746	1,139,611	62,367
Old scrap:				
Castings, sheet, clippings	18,075	223,781	227,866	13,990
Aluminum-copper radiators	2,368	17,829	18,563	1,634
Aluminum cans	21,662	508,425	508,305	21,782
Other	2,874	32,001	32,203	2,672
Total old scrap	44,979	782,036	786,937	40,078
Sweated pig	9,730	88,716	85,875	12,571
Grand total	126,941	2,000,498	2,012,423	115,016

W Withheld to avoid disclosing company proprietary data.

[1]Includes imported scrap. According to reporting companies, 17.75% of total receipts of aluminum-base scrap, or 355,101 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.

[5]Includes data on aluminum-copper radiators.

Table 5.—Production and shipments of secondary aluminum alloys by independent smelters

(Short tons)

	1980		1981	
	Production	Net shipments	Production	Net shipments
Die-cast alloys:				
13% Si, 360, etc. (0.6% Cu, maximum)	77,347	76,021	93,676	93,308
380 and variations	406,260	404,705	391,585	392,672
Sand and permanent mold:				
95/5 Al-Si, 356, etc. (0.6% Cu, maximum)	24,788	24,444	37,610	36,930
No. 12 and variations	W	W	W	W
No. 319 and variations	53,912	53,880	50,652	50,314
F-132 alloy and variations	16,970	16,609	15,751	15,278
Al-Mg alloys	1,948	1,705	1,378	1,529
Al-Zn alloys	6,754	7,180	8,397	7,846
Al-Si alloys (0.6% to 2.0% Cu)	5,901	6,013	5,758	5,567
Al-Cu alloys (1.5% Si, maximum)	2,492	2,400	3,364	3,344
Al-Si-Cu-Ni alloys	4,159	4,130	4,778	4,627
Other	6,687	6,029	4,089	4,790
Wrought alloys: Extrusion billets	94,497	95,510	108,134	106,814
Destructive and other uses: Steel deoxidation:				
Grades 1, 2, 3, and 4	36,500	35,978	30,831	31,508
Miscellaneous:				
Pure (97.0% Al)	4,826	4,815	1,203	958
Aluminum-base hardeners	r3,243	r2,847	1,493	1,857
Other[1]	11,347	11,318	10,066	10,010
Total	r757,631	r753,584	768,765	767,352
Less consumption of materials other than scrap:				
Primary aluminum	34,461	--	43,047	--
Primary silicon	40,697	--	39,996	--
Other	3,691	--	2,778	--
Net metallic recovery from aluminum scrap and sweated pig consumed in production of secondary aluminum ingot[2]	r678,782	--	682,944	--

rRevised. W Withheld to avoid disclosing company proprietary data; included with "Other" under "Sand and permanent mold."

[1]Includes other die-cast alloys and other miscellaneous.

[2]No allowance made for melt-loss of primary aluminum and alloying ingredients.

CONSUMPTION

The apparent consumption of aluminum in end products increased slightly in 1981 to 5.1 million tons (table 6); however, consumption was still considerably below the record high level of over 6 million tons in 1978. The continued low rate of consumption was primarily attributed to continuing weak markets in the automobile production and residential construction industries. An increase in the use of aluminum in the production of beverage cans and other packaging products kept the apparent consumption of aluminum from a larger decline.

The aluminum share of the beverage can market continued to increase. Sheet shipments for use in can production have tripled since 1970, and the beverage can industry has become the largest single user of aluminum sheet. In 1981, the aluminum can market shipments increased 14%[4] with approximately 43 billion aluminum beverage cans used in the United States.[5] Consumption of aluminum for use in foil packaging and semirigid containers also increased in 1981.[6]

The weakness in domestic passenger-car sales continued throughout 1981 and contributed to a large decline in aluminum consumption in the transportation industry. However, according to the Automobile and Truck Committee of the Aluminum Association, Inc., the average 2,250-pound 1982 U.S. automobile contained about 133 pounds of aluminum. Estimates of about 200 pounds of aluminum were forecast for use in the average automobile by 1990.[7]

Table 6.—Apparent aluminum supply and consumption in the United States

(Thousand short tons)

	1977	1978	1979	1980	1981
Primary production	4,539	4,804	5,023	5,130	4,948
Change in stocks:[1]					
Aluminum industry	-3	+106	+184	r+25	-765
Government	--	--	--	--	--
Imports	836	1,080	840	713	935
Secondary recovery:[2]					
New scrap	1,074	1,098	1,163	1,058	1,169
Old scrap	531	575	614	680	886
Total supply	6,977	7,663	7,824	r7,606	7,173
Less total exports	411	520	773	1,483	867
Apparent aluminum supply available for domestic manufacturing	6,566	7,143	7,051	r6,123	6,306
Apparent consumption[3]	5,492	6,045	5,888	r5,065	5,137

rRevised.

[1]Positive figure indicates a decrease in stocks; negative figure indicates an increase in stocks.

[2]Metallic recovery from purchased, tolled, or imported new and old aluminum scrap expanded for full industry coverage.

[3]Apparent aluminum supply available for domestic manufacturing less recovery from purchased new scrap (a measure of consumption in manufactured end products).

Table 7.—Distribution of end-use shipments of aluminum products, by industry

Industry	1979		1980		1981p	
	Quantity (thousand short tons)	Percent of total	Quantity (thousand short tons)	Percent of total	Quantity (thousand short tons)	Percent of total
Building and construction	r1,522	20.5	1,310	18.5	1,260	18.8
Transportation	r1,539	20.7	1,123	15.8	1,069	16.0
Containers and packaging	1,612	21.6	1,667	23.5	1,755	26.3
Electrical	787	10.6	689	9.7	665	9.9
Consumer durables	511	6.9	440	6.2	488	7.3
Machinery and equipment	r475	6.4	416	5.8	418	6.3
Other markets	r322	4.3	300	4.2	318	4.8
Statistical adjustment	r+154	2.1	+58	.8	+26	.4
Total to domestic users	r6,922	93.1	6,003	84.5	5,999	89.8
Exports	512	6.9	1,097	15.5	685	10.2
Grand total	r7,434	100.0	7,100	100.0	6,684	100.0

pPreliminary. rRevised.

Source: The Aluminum Association, Inc.

Table 8.—Net shipments of aluminum wrought[1] and cast products by producers

(Short tons)

	1979	1980	1981[p]
Wrought products:			
Sheet, plate, foil	[r]3,591,612	3,346,305	3,423,935
Rolled and continuous-cast rod and bar; wire	618,080	606,368	521,593
Extruded rod, bar, pipe, tube, shapes; drawn and welded tubing	1,263,261	1,164,827	1,103,337
Powder, flake, paste	62,782	58,285	52,638
Forgings (including impacts)	[r]79,433	66,635	69,501
Total	[r]5,615,168	5,242,420	5,171,004
Castings:			
Sand	142,821	120,516	120,620
Permanent mold	241,131	192,822	172,253
Die	634,596	443,357	478,290
Other	21,714	12,140	18,909
Total	1,040,262	768,835	790,072
Grand total	[r]6,655,430	6,011,255	5,961,076

[p]Preliminary. [r]Revised.

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

Source: U.S. Department of Commerce.

Table 9.—Distribution of wrought products

(Percent)

	1979	1980	1981[p]
Sheet, plate, foil:			
Non-heat-treatable	[r]51.2	51.4	54.4
Heat-treatable	4.9	4.5	3.6
Foil	7.9	7.9	8.2
Rolled and continuous-cast rod and bar; wire:			
Rod, bar, wire	3.5	4.3	3.3
Cable and insulated wire	7.5	7.3	6.8
Extruded products:			
Rod and bar	.9	1.1	1.0
Pipe and tubing	1.4	1.3	1.1
Shapes	18.6	18.1	17.4
Tubing:			
Drawn	.9	.8	.7
Welded	.7	.9	1.1
Powder, flake, paste	1.1	1.1	1.0
Forgings (including impacts)	[r]1.4	1.3	1.4
Total	100.0	100.0	100.0

[p]Preliminary. [r]Revised.

Source: U.S. Department of Commerce.

STOCKS

Inventories of aluminum ingot, mill products, and scrap at reduction and other processing plants as reported by the Bureau of Industrial Economics, U.S. Department of Commerce, increased from 2,538,002 tons (revised) at the end of 1980 to 3,303,325 tons at the end of 1981.

PRICES

The producers' list price for 99.5% pure aluminum ingot was 76 cents per pound. The average spot price, or U.S. market price, as published by Metals Week (McGraw-Hill, Inc.), was 67.6 cents per pound at the beginning of the year. In March, the spot price rose slightly to 68 cents per pound, then steadily declined to a low of 48.9 cents per pound in November. At yearend, the average spot price was 50.6 cents per pound. Prices on the London Metal Exchange began the year at 64.9 cents per pound, rose slightly in the first quarter, then declined by yearend to 57.3 cents per pound.

The price of secondary smelter alloyed aluminum ingot ranged from 82 to 96 cents per pound throughout most of the year, according to the American Metal Market. Prices of aluminum-base scrap began the year with a price range of 22 to 47 cents per pound depending on the type of scrap and its location. By yearend, the prices dropped to a range of 13 to 31 cents per pound.

FOREIGN TRADE

Crude and semicrude aluminum exports, including scrap, declined after a record high level of exports in 1980. Most of the large decrease in exports was in the form of ingot and scrap usually exported to Western European and Far Eastern countries.

U.S. tariff rates in effect during 1981 for wrought and unwrought aluminum products included the following: Unwrought aluminum (other than aluminum silicon), 0.7 cents per pound; wrought aluminum (bars, plates, sheets, strip), 3.1% ad valorem; and aluminum waste and scrap, 2% ad valorem.[8] The U.S. International Trade Commission investigated and made a preliminary determination that secondary aluminum alloys in unwrought form from the United Kingdom were not materially injuring or likely to injure the recycling industry of the United States.

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

Class	1980 Quantity (short tons)	1980 Value (thousands)	1981 Quantity (short tons)	1981 Value (thousands)
Crude and semicrude:				
Ingots, slabs, crude	714,906	$1,107,398	344,161	$526,646
Scrap	444,681	483,138	241,161	236,204
Plates, sheets, bars, etc.	306,214	715,899	263,672	625,181
Castings and forgings	7,496	30,626	8,930	40,482
Semifabricated forms, n.e.c	9,914	43,686	9,250	49,017
Total	1,483,211	2,380,747	867,174	1,477,530
Manufactures:				
Foil and leaf	43,625	76,929	36,368	47,324
Powders and flakes	8,023	16,928	3,384	9,259
Wire and cable	16,683	36,007	9,832	23,429
Total	68,331	129,864	49,584	80,012
Grand total	1,551,542	2,510,611	916,758	1,557,542

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

Country	1980						1981					
	Ingots, slabs, crude		Plates, sheets, bars, etc.[1]		Scrap		Ingots, slabs, 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	5,227	$7,823	1,972	$5,767	982	$1,346	920	$1,784	2,669	$9,250	870	$1,230
Belgium-Luxembourg	7,714	12,569	3,093	9,064	12,618	14,688	5	23	1,109	5,348	1,634	1,430
Brazil	27,300	41,148	5,478	14,855	12,362	13,515	4,562	7,453	1,623	6,155	2,636	2,707
Canada	19,761	32,355	109,922	270,665	17,026	14,404	14,874	25,821	125,396	286,470	16,931	14,326
Chile	1,521	2,333	530	1,688	265	400	1,612	3,433	505	1,663	251	402
China	9,433	14,894	101	331	(2)	1	4,300	8,113	24	134	--	--
France	18,916	32,324	9,200	25,302	4,425	3,997	4,870	7,309	3,218	15,682	175	179
Germany, Federal Republic of	22,451	32,091	10,738	30,365	31,827	31,425	381	1,065	5,199	21,065	5,626	4,777
Hong Kong	7,457	13,799	4,066	10,100	1,750	2,652	1,226	2,142	1,386	5,801	63	114
India	28,789	44,920	24,677	40,775	1,283	1,338	18	33	1,780	3,107	1,799	2,874
Israel	1,295	2,872	3,149	10,229	27	34	302	1,103	4,739	16,940	71	82
Italy	19,456	29,911	8,944	32,322	16,878	17,340	239	1,008	4,784	23,110	1,311	1,124
Japan	338,482	503,092	19,007	50,999	269,356	321,214	240,219	349,328	17,658	45,116	175,536	170,809
Korea, Republic of	43,748	70,112	4,358	10,058	1,876	2,262	6,121	9,401	1,107	3,783	1,236	1,246
Malaysia	2,707	3,687	311	656	82	123	1,080	1,574	94	234	--	--
Mexico	38,754	65,591	33,698	69,026	28,526	19,803	34,034	56,936	50,926	107,096	15,598	19,224
Netherlands	34,373	54,775	9,580	24,038	16,288	16,991	100	528	2,231	8,438	2,349	2,027
Pakistan	1,873	2,974	4,754	8,577	2,367	1,307	102	149	425	728	223	198
Philippines	4,782	8,081	236	780	168	269	282	429	383	799	209	258
Saudi Arabia	1,914	4,232	3,867	11,334	18	29	791	1,931	2,780	9,944	90	285
Singapore	2,046	3,167	1,049	2,814	264	410	1,261	1,882	549	1,966	154	201
South Africa, Republic of	221	368	2,460	5,824	1,794	2,315	46	144	2,796	6,570	6,100	6,722
Spain	13	67	3,865	10,106	4,130	3,038	2	14	1,674	6,873	2,362	997
Sweden	53	108	1,447	3,646	1,143	1,189	208	441	3,274	7,870	20	191
Switzerland	3,871	6,195	438	2,146	6	51	1,233	1,735	949	3,508	15	55
Taiwan	30,109	46,353	1,833	6,139	14,706	7,613	6,578	9,756	1,001	5,507	4,664	3,039
Thailand	6,416	10,669	400	1,117	135	208	8,943	13,112	454	1,097	11	2
United Kingdom	9,751	15,931	15,659	42,724	2,521	2,836	1,367	2,833	14,859	36,690	516	648
Venezuela	368	726	16,275	33,716	195	303	107	478	15,675	35,165	12	16
Other	26,105	44,231	22,517	55,048	1,663	2,037	8,378	16,688	12,585	38,571	700	1,041
Total	714,906	1,107,398	323,624	790,211	444,681	483,138	344,161	526,646	281,852	714,680	241,162	236,204

[1]Includes castings, forgings, and unclassified semifabricated forms.
[2]Less than 1/2 unit.

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

Class	1980 Quantity (short tons)	1980 Value (thousands)	1981 Quantity (short tons)	1981 Value (thousands)
Crude and semicrude:				
Metals and alloys, crude	580,515	$777,606	710,656	$990,869
Circles and disks	3,879	8,721	5,837	12,954
Plates, sheets, etc., n.e.c	59,783	123,959	118,393	235,642
Rods and bars	8,571	17,274	17,699	57,438
Pipes, tubes, etc	490	2,182	583	2,643
Scrap	59,802	59,718	81,994	79,141
Total	713,040	989,460	935,162	1,378,687
Manufactures:				
Foil	4,550	27,219	6,715	34,562
Leaf	(1)	137	(1)	131
Flakes and powders	6,114	11,827	1,694	3,501
Wire	728	1,665	1,029	2,721
Total	11,392	40,848	9,438	40,915
Grand total	724,432	1,030,308	944,600	1,419,602

[1] 1980—Aluminum leaf not over 30.25 square inches in area, 1,772,837 leaves, and aluminum leaf over 30.25 square inches in area, 82,489,898 square inches; 1981—aluminum leaf not over 30.25 square inches in area, 1,033,500 leaves, and aluminum leaf over 30.25 square inches in area, 175,206,746 square inches.

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

Country	1980 Metals and alloys, crude: Quantity (short tons)	1980 Metals and alloys, crude: Value (thousands)	1980 Plates, sheets, bars, etc.[1]: Quantity (short tons)	1980 Plates, sheets, bars, etc.[1]: Value (thousands)	1980 Scrap: Quantity (short tons)	1980 Scrap: Value (thousands)	1981 Metals and alloys, crude: Quantity (short tons)	1981 Metals and alloys, crude: Value (thousands)	1981 Plates, sheets, bars, etc.[1]: Quantity (short tons)	1981 Plates, sheets, bars, etc.[1]: Value (thousands)	1981 Scrap: Quantity (short tons)	1981 Scrap: Value (thousands)
Argentina	--	--	--	--	--	--	472	$650	663	$1,072	--	--
Australia	--	--	12,235	$20,869	23	$33	--	--	17,125	29,456	318	$317
Austria	--	--	2,026	4,066	--	--	--	--	1,836	4,012	--	--
Belgium-Luxembourg	11	$28	2,559	6,313	358	475	263	330	13,349	24,963	230	215
Brazil	--	--	190	431	--	--	20	32	1,815	2,903	--	--
Canada	485,620	638,184	17,587	32,535	54,019	55,309	537,450	739,561	24,392	51,463	66,880	65,895
France	425	1,039	4,489	12,687	--	--	7,997	9,595	9,407	21,733	21	8
Germany, Federal Republic of	3,905	9,504	1,133	3,928	--	--	7,101	13,406	2,235	5,648	141	142
Ghana	84,894	118,665	--	--	178	68	94,211	144,459	--	--	--	--
Hong Kong	--	--	1,070	2,004	--	--	--	--	1,513	2,979	2	13
Israel	--	--	436	1,829	14	28	--	--	677	2,904	454	320
Italy	4	8	2,449	4,680	40	45	1,642	1,640	6,284	11,770	--	--
Japan	49	224	9,841	19,004	27	33	38	403	21,534	43,439	24	17
Mexico	348	375	194	489	3,466	2,327	298	216	181	428	2,850	2,156
Netherlands	118	324	8,209	12,172	4	74	1,896	2,375	4,029	18,691	127	141
Norway	2,189	4,327	1,096	2,316	--	--	14,694	19,477	8,793	14,611	--	--
Romania	--	--	836	1,082	--	--	555	581	3,036	4,674	--	--
Spain	--	--	1,243	2,448	--	--	1,357	1,528	1,125	2,012	--	--
Suriname	--	--	--	--	--	--	13,076	18,294	--	--	--	--
Sweden	6	62	375	1,242	--	--	190	252	686	2,190	--	--
Switzerland	419	1,289	187	550	45	63	1,548	2,451	598	1,342	--	--
U.S.S.R	11	101	--	--	--	--	639	613	--	--	3,067	2,996
United Kingdom	2,516	3,476	1,950	5,713	143	174	10,616	12,831	2,082	5,887	5,710	5,344
Venezuela	--	--	4,123	6,591	483	318	16,250	21,677	12,766	45,922	--	--
Yugoslavia	--	--	5,155	10,396	--	--	--	--	7,723	14,750	--	--
Other	--	--	340	791	1,002	771	343	498	668	1,328	2,170	1,577
Total	580,515	777,606	72,723	152,136	59,802	59,718	710,656	990,869	142,512	308,677	81,994	79,141

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

WORLD REVIEW

As demand weakened in many of the industrialized countries, stocks of primary aluminum held by members of the International Primary Aluminum Institute (IPAI) increased sharply. IPAI member stocks, which represent the bulk of inventories held outside the centrally planned economies, increased 49% over 1980 levels.

Significant plant expansions were completed in Bahrain, Canada, and the Republic of South Africa. New primary aluminum smelters began production in China and Yugoslavia.

Australia.—Alcan Australia Ltd. postponed indefinitely its proposed 220,000-ton-per-year smelter planned for Bundaberg, Queensland. However, Alcan Australia still planned to expand its Kurri-Kurri, New South Wales, smelter to 150,000 tons per year by completion of the second-stage expansion from 75,000 tons to 100,000 tons per year. The third-stage expansion to 150,000 tons per year was scheduled to come onstream in 1983.

Alcoa of Australia Ltd. decided in December to continue construction of the 145,000-ton-per-year Portland, Victoria, smelter, scheduled to come onstream in 1984. Construction was delayed earlier in the year because of increased electricity rates.

Gladstone Aluminium Ltd., the consortium that was building the 227,000-ton-per-year smelter at Gladstone, Queensland, changed its name to Boyne Smelters Ltd. Comalco Ltd., Kaiser Aluminum & Chemical Corp., and five Japanese companies comprise the consortium.

Reynolds Metals Co., Colonial Sugar Refining Ltd., and Shell of Australia Ltd. decided against building a smelter in Western Australia because of high electricity costs. However, Alcoa, International Construction Corp. (a Korean company), and the government of Western Australia began discussions on building a smelter near Bunbury, Western Australia.

Alumax withdrew from the proposed 260,000-ton-per-year smelter at Lochinvar, New South Wales. The remaining two participants, Broken Hill Proprietary Co. Ltd. and Alfarl Pty. Ltd., a Japanese consortium, were seeking a new partner for the project.

The New South Wales government gave final approval for the construction of the Tomago smelter. The first 121,000-ton-per-year potline was scheduled to come onstream in 1983; the second, in 1984.

Comalco (Bell Bay) commissioned the second half of the fourth potline at its Bell Bay, Tasmania, smelter. Capacity was increased 6,000 tons per year to 129,000 tons per year.

Bahrain.—Aluminium Bahrain Co. increased its capacity by 55,000 tons to 187,000 tons per year at its Knuff primary smelter.

Brazil.—The Government of Brazil accepted a bid from the West German firm Vereinigte Aluminium-Werke AG to build a 242,000-ton-per-year primary smelter at Recife. Initial capacity of 120,000 tons per year was scheduled to come onstream in mid-1985, with full capacity scheduled for 1988. Total cost was estimated at $800 million.

Consorcio de Aluminio de Maranhão-Alumar was formed to own and operate a $1.2 billion alumina-aluminum complex under construction at São Luis, Maranhão. Alcoa Aluminio S.A. would own 60% and Shell Brasil Billiton Metais S.A. would own 40%. Startup was scheduled for 1984.

Cía. Vale do Rio Doce (CVRD), the Brazilian state mining company, reportedly sold part of its majority interest in the 95,000-ton-per-year Valesul aluminum smelter under construction at Santa Cruz to Shell Brasil Billiton (9%) and Abranfe, the Brazilian Nonferrous Metals Association, (12%). Partners in the project include CVRD (40%), Shell Brasil Billiton (44%), Abranfe (12%), and Reynolds (4%).

Canada.—Alcan Aluminium Ltd. completed construction of a second 63,000-ton-per-year potline at its Grande Baie, Quebec, primary aluminum smelter. Startup of the new potline was delayed until the demand for aluminum increased. Construction of a third potline was underway and scheduled for completion in 1982. Alcan and the government of Manitoba reportedly signed a letter of intent to begin a feasibility study for construction of a 220,000-ton-per-year primary aluminum smelter in Manitoba.

Canadian Reynolds Metals Co. Ltd. and the government of Quebec reached an agreement on a power contract that would allow Reynolds to increase capacity to 300,000 tons per year by 1985 at its Baie Comeau, Quebec, primary smelter.

The Anaconda Aluminum Co. and the government of Newfoundland reportedly were to begin a feasibility study for construction of an aluminum smelter in Newfoundland.

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

(Thousand short tons)

Continent and country	1977	1978	1979	1980	1981[p]
North America:					
Canada	1,073	1,156	948	1,184	1,238
Mexico	47	48	48	48	[e]47
United States	4,539	4,804	5,023	5,130	4,948
South America:					
Argentina	55	[r]59	138	152	145
Brazil	184	205	262	287	283
Suriname	64	61	71	51	[e]45
Venezuela	48	[r]82	251	361	[e]300
Europe:					
Austria	101	101	102	104	104
Czechoslovakia	40	41	41	42	42
France	[r]440	431	435	476	480
German Democratic Republic[e]	72	[r]72	66	66	66
Germany, Federal Republic of	818	816	817	806	803
Greece	143	159	155	161	161
Hungary	79	79	79	81	82
Iceland	82	81	80	81	82
Italy	287	298	297	321	302
Netherlands	266	288	284	289	289
Norway	686	704	727	718	701
Poland[2]	115	110	106	105	73
Romania[3]	230	235	239	266	277
Spain	233	234	286	426	437
Sweden	91	90	90	107	91
Switzerland	88	88	91	95	91
U.S.S.R.[e]	1,810	1,840	1,930	1,940	1,973
United Kingdom	386	382	396	413	374
Yugoslavia	195	194	185	182	195
Africa:					
Cameroon	61	54	48	48	[e]50
Egypt	98	111	85	132	[e]160
Ghana	169	123	186	207	[e]210
South Africa, Republic of	86	89	95	95	[e]95
Asia:					
Bahrain	134	135	139	139	[e]155
China[e]	385	400	400	400	[e]400
India	[r]197	[r]236	233	204	235
Iran	23	28	15	11	6
Japan[2]	1,310	1,166	1,113	1,203	849
Korea, North[e]	11	11	11	11	11
Korea, Republic of	20	22	24	23	20
Taiwan	33	56	62	70	[e]40
Turkey	57	35	35	38	[e]45
United Arab Emirates: Dubai	--	--	--	28	117
Oceania:					
Australia	273	290	298	334	418
New Zealand	160	167	170	171	173
Total	[r]15,189	[r]15,581	16,061	17,006	16,613

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Output of primary unalloyed ingot unless otherwise specified. Table includes data available through May 21, 1982.
[2]Includes secondary unalloyed ingot.
[3]Includes primary alloyed ingot.

China.—The first 44,000-ton-per-year potline of a new 88,000-ton-per-year primary smelter in the southwestern Province of Guizhou reportedly came onstream in December. Full capacity was expected to be completed in 1982.

Germany, Federal Republic of.—Kaiser Aluminum purchased the remaining 50% interest in the 79,000-ton-per-year primary smelter at Voerde from Preussag A.G.

Hungary.—Plans were under consideration for construction of a 110,000-ton-per-year primary aluminum smelter near Inota.

Japan.—The Industrial Structural Council of the Ministry of International Trade and Industry considered plans to reduce Japan's total smelting capacity to 772,000 tons per year. Actual capacity at yearend was 1,252,000 tons per year, excluding about 190,000 tons per year of decommissioned capacity. Mitsubishi Light Metal Industry Ltd. announced the shutdown of its 178,000-ton-per-year smelter at Naeotsu at the end of October, and Showa Light Metal Co. announced it would shut down its 24,000-ton-per-year smelter at Ohmachi by June 1982.

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

(Thousand short tons)

Continent and country	1979	1980	1981
North America:			
Canada	1,175	1,238	1,299
Mexico	50	50	50
United States	5,282	5,503	5,467
South America:			
Argentina	154	154	154
Brazil	295	306	306
Suriname	73	73	73
Venezuela	446	446	446
Europe:			
Austria	101	101	101
Czechoslovakia	r66	r66	66
France	r470	r490	490
German Democratic Republic	94	94	94
Germany, Federal Republic of	r820	r811	804
Greece	160	160	160
Hungary	r78	r78	78
Iceland	r83	95	95
Italy	r315	r315	315
Netherlands	293	293	293
Norway	r780	r780	785
Poland	127	127	61
Romania	220	275	275
Spain	439	439	439
Sweden	94	94	94
Switzerland	104	r95	95
U.S.S.R	3,230	r3,450	3,450
United Kingdom	r412	r412	421
Yugoslavia	r226	r276	410
Africa:			
Cameroon	68	68	88
Egypt	110	147	183
Ghana	220	220	220
South Africa, Republic of	94	94	190
Asia:			
Bahrain	132	132	187
China	r312	r312	356
India	r380	r380	386
Iran	55	55	55
Japan	r1,658	r1,443	1,443
Korea, North	22	22	22
Korea, Republic of	20	20	20
Taiwan	r92	r92	92
Turkey	66	66	66
United Arab Emirates: Dubai	149	149	149
Oceania:			
Australia	309	r380	410
New Zealand	r165	r165	165
Total	r19,439	r19,966	20,353

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 I of "Primary Aluminum Plants, Worldwide," details location, ownership, and production capacity for 1978-85 and sources of energy and aluminum raw materials for foreign and domestic primary aluminum plants, including those in centrally planned economies. Part II summarizes production capacities for 1978-85 by smelter and country.

Sumitomo Aluminium Smelting Co. increased its high-purity aluminum production capacity to 5,732 tons per year at its Kikumoto smelter, making it the largest facility in the world for this type of production.

New Zealand.—Construction reportedly began on a third 104,000-ton-per-year potline at the 165,000-ton-per-year primary smelter of New Zealand Aluminium Smelters Ltd. at Bluff. The $200 million expansion was scheduled to come onstream in late 1982.

Alusuisse withdrew its 25% share in South Pacific Aluminium, the consortium planning to build a 220,000-ton-per-year primary smelter at Dunedin, South Island. Fletcher Holdings of New Zealand (50%) and Gove Alumina Ltd. (25%), the two remaining partners, were seeking another partner to replace Alusuisse.

Norway.—Aardal og Sunndal Verk AS (ASV) began modernization of a potline at its Höyanger smelter, increasing capacity to

25,000 tons per year. Capacity was expected to be increased to 74,000 tons per year by 1982. ASV also considered plans to increase the capacity by 11,000 tons per year each at its Aardal and Sunndalsora smelters.

Norsk Hydro AS primary smelter at Karmöy was closed in November when power was knocked out by a storm and metal froze in the pots. Production was expected to resume in mid-1982. An additional 55,000 tons per year of expanded capacity was also expected to come onstream in 1982.

The Ministry of Industry was considering plans to rebuild and expand the state-owned Det Norske Nitridaktieselskap AS primary smelter at Tyssedal. The proposed expansion would increase capacity to 66,000 tons per year.

Paraguay.—The Government of Paraguay was considering building a 165,000-ton-per-year aluminum smelter in a joint venture with Japan.

Philippines.—Discussions continued between Reynolds and the Philippine Government for construction of a 154,000-ton-per-year primary smelter to be located on Mindanao Island at Misamis, Oriental. The proposed smelter was estimated to cost $463 million.

Poland.—The Government of Poland permanently closed the 66,000-ton-per-year primary smelter at Skawina owing to pollution problems. Reportedly, a smelter to replace the Skawina facility would be built in Konin, where a 61,000-ton-per-year primary smelter already existed.

South Africa, Republic of.—Alusaf Pty. Ltd. reportedly increased capacity to 190,000 tons per year at its Richards Bay primary smelter. Dismantled equipment from the closed Nippon Light Metal Co. Ltd.'s smelter at Niigata, Japan, was shipped to the Richards Bay facility in 1981.

Taiwan.—Taiwan Aluminium Corp. reportedly closed its 46-year-old, 36,000-ton-per-year smelter at Kaoshuing and may eventually scrap the plant.

Turkey.—Plans were announced to double primary aluminum smelting capacity to 132,000 tons per year and alumina refining capacity to 287,000 tons per year at the Seydisehir complex. The U.S.S.R. reportedly was to provide a $200 million loan.

U.S.S.R.—Construction of a 550,000-ton-per-year primary smelter was underway at Sayansk, Siberia. Startup was scheduled for 1984.

United Kingdom.—On December 31, British Aluminium Co. Ltd. closed its 110,000-ton-per-year primary smelter at Invergordan, Scotland, owing to high power costs and low demand for aluminum. Reportedly, British Aluminium would maintain the smelter for 6 months while it attempted to find a buyer. After the 6-month period, the smelter would be dismantled and sold.

British Aluminium completed modernization of its Lochaber smelter, increasing capacity 10,000 tons to 41,000 tons per year.

Venezuela.—The Government of Venezuela acquired majority interest in the 138,000-ton-per-year primary aluminum smelter, Aluminio del Caroni, S.A., through an additional capital investment of $51.5 million by the Venezuelan State Investment Fund. The 50% interest held by Reynolds was reduced to 27.9%. Reportedly, Reynolds would continue to operate the smelter.

Venezolano de Aluminio had to shut down about 110,000 tons per year of production at its 308,000-ton-per-year smelter at Cindad as a result of severe potline damage reportedly caused by poor maintenance and inadequate operational supervision.

Yugoslavia.—Capacity at the Sibenik primary aluminum smelter was reportedly increased by 33,000 tons to 116,000 tons per year.

Production began at the new, 101,000-ton-per-year primary smelter at Bacevici, near Mostar. Péchiney Ugine Kuhlmann provided technical assistance for the smelter.

Zaire.—A consortium of nine companies headed by Alusuisse discussed plans to build a 165,000- to 220,000-ton-per-year primary smelter to be located near Banana. Feasibility studies reportedly were underway.

TECHNOLOGY

New developments in aluminum smelting technology initiated during the past 20 years were reviewed.[9] Two improvements of particular importance to the Hall-Heroult process were computer control of anodes, which permitted closer interelectrode distances, and larger anode surface areas, which decreased current density and voltage for a given cell amperage. Other improvements included the design of cells that can accommodate currents up to 250,000 amperes, the development of higher quality carbons for both anodes and cathodes, and the use of additives in the cryolite-alumina electrolyte, which permit lower operating temperatures and increase the conductivity and current efficiency of the molten salt. Mechanical improvements included the automation of all phases of potroom operations. The major result of all these changes has been a decrease in the energy requirements from about 7.7 kilowatt-hours per pound (17 kilowatt-hours per kilogram) to 5.9 kilowatt-hours per pound (13 kilowatt-hours per kilogram) in modern plants. Basic science investigations have increased the knowledge of electrolyte densities, surface tensions, vapor pressures, and electrical conductivities. Phase diagrams of the electrolyte system have been better established, and thermodynamic data were becoming more consistent.

A review of work on the development of inert anodes was published.[10] The advantages of inert anodes include the reduction in the use of carbon and the use of a fixed anode with a constant interelectrode distance. The major disadvantage is the increased reaction voltage of 1.05 volts required to reduce alumina to aluminum metal. The physiochemical property requirements of inert anodes include (1) the insolubility of the material in molten fluoride salts and molten aluminum, (2) a resistance to anode oxygen, (3) thermal stability and resistance to thermal shock, (4) low specific resistivity and conductor bar contact resistance, (5) low overvoltage of the aluminum reactions, (6) high overvoltage of undesired anode reactions such as the discharge of fluorine, and (7) production of uncontaminated aluminum. Proposed materials for inert anodes are pressed and sintered oxides, metals, and refractory metal materials. The most feasible inert anodes appear to be those made of a metallic oxide; however, many technical problems require solving prior to commercial use.

Japan's MITI and six aluminum producers will build a small pilot plant to test a direct-reduction method for smelting aluminum.[11] The pilot plant, to be built at Tsukuba, outside Tokyo, based on Mitsui Alumina Co., Ltd., technology, reportedly will use less energy than the Hall-Heroult process. A direct-reduction process eliminates the alumina refining step. In the process, alumina-rich clay is reduced by coke in a blast furnace at 2,000° C forming an aluminum-silicon alloy containing some iron, which is refined into aluminum ingots during a second-stage smelting operation. MITI claims that the process will use only one-half to one-third the amount of electricity required for conventional smelters, and should reduce the oil consumption used in aluminum smelting by 71%.

Mitsui Alumina Co., Mitsui Mining and Smelting Co., and Mitsui Aluminium Co. announced a blast-furnace aluminum smelting method that uses molten lead to absorb the aluminum.[12] The process prevents bridging of aluminum vapor at the top of the furnace. The process is similar to the direct-reduction smelting process being developed by MITI and six aluminum producers.[13] In the Mitsui process a mixture of pulverized alumina-rich clay or bauxite and coking coal are carbonized in a coking oven and fed into the lower section of the furnace. Molten lead absorbs a molten alloy of aluminum, silicon, and iron. The lead-aluminum alloy mixture is transferred to a furnace where the lead is removed for recycling. The final alloy mixture is refined by vacuum distillation to a reported purity of 99.9%.

An important feature of the new technology is the generation of carbon monoxide gas. It was estimated that enough carbon monoxide may be generated for electric power and other chemical processes to pay for the smelting costs. Studies were also in progress to determine if the carbon could be utilized for a carbothermic reduction of aluminum ores.

Mitsubishi reported development of a low-cost process to produce a high-purity aluminum.[14] The process, based on fractional solidification, will produce aluminum with a purity of 99.999% to 99.9999%. The fractional solidification process deposits the high-purity aluminum through forced cooling of molten ingots and consumes less power than conventional three-layer electrolysis or the Hoopes process. The ultrapure aluminum can be utilized for semiconductors and other electronic applications. Mitsubishi was constructing a new production facility of 200 to 250 metric tons per month utilizing the Hoopes process.

Aluminum and manganese can be utilized as replacements for chromium and nickel, respectively, in austenitic steel to form an Fe-Mn-Al alloy that is considered ideal for cryogenic applications, such as liquid gas pipelines.[15] The addition of carbon and silicon to the Fe-Mn-Al system contribute to the alloys' good ductility at low temperatures and impart excellent mechanical properties at both room and subzero temperatures. Studies indicated the oxidation resistance of these alloys could be sufficient for most cryogenic applications.

A thermomechanical process was developed at the Rockwell International Science Center that imparts superplasticity to aluminum alloys.[16] The process creates a fine-grained structure necessary for superplasticity in aluminum alloy 7475 and other high-strength aluminum alloys. Deformation of several hundred percent can be tolerated without rupturing the alloys.

The Rockwell process, prior to superplastic forming, consists of three steps: (1) Extreme overaging from a solution-treated condition introduces large intermetallic particles. (2) Cold or warm working, depending on the alloy, introduces localized deformation around the intermetallic particles. The particles do not deform during working. (3) The metal grains are recrystallized at solution-treatment temperature for the particular alloy. The intermetallic particles inhibit further grain growth and form the nuclei for new grains. Upon completion of the three-step process, the alloy is given a normal heat treatment.

Both British Aluminium [17] and Alcan[18] have developed special aluminum alloys for superplastic forming by adding grain-stabilizing metals. The British Aluminium alloy known as Supral 100 (6% Cu, 0.5% Zr) and the Alcan alloy, designated 08050 (4.8% Ca, 4.8% Zn) are not regarded as structural alloys because of their lower strength. Structural aircraft parts can be formed with the 7475 high-strength alloy, and toys, automobile panels and instrument housings can be fabricated from lower strength alloys. For both types of alloys, complex components are formed by heating the fine-grained alloy to its superplastic temperature, then applying gas pressure on the alloys and blowing it into female cavities or over male formers.

The Bureau of Mines investigated the use of used potlining recovered from aluminum reduction cells as a substitute for the flux fluorspar in ferrous foundry operations.[19] No adverse effects were found in ferrous cupola performance. Use of these potlinings would reduce the problem of waste disposal. Fluorine recovery is equal to or higher than that of fluorspar.

Over 40 papers reporting studies on aluminum reduction, carbon, and cast-shop technologies were published. Other studies published included new developments on environment and health and energy conserving technology in the North American aluminum industry.[20]

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[1]Physical scientist, Division of Nonferrous Metals.

[2]Statistical assistant, Division of Nonferrous Metals.

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Antimony

By Patricia A. Plunkert[1]

Domestic mine production increased in 1981 compared with that of 1980 owing to the absence of strikes. A new plant, located near Memphis, Tenn., began producing antimony products during 1981. The General Services Administration (GSA) was granted authority to sell antimony metal from the Government stockpile. Bolivia, China, and the Republic of South Africa remained the major sources of imported antimony materials. Prices for antimony metal decreased steadily during the year as the economic slowdown continued.

Legislation and Government Programs.—GSA reported that at yearend the Government stocks of antimony totaled 40,728 short tons of stockpile-grade material. The Government stockpile goal remained at 36,000 tons.

The Omnibus Budget Reconciliation Act of 1981 (Public Law 97-35), signed by the President on August 13, 1981, authorized the disposal of 3,000 tons of antimony metal from the Government stockpile surplus at the rate of 1,000 tons per year, effective October 1, 1981. This metal is to be used for domestic consumption only. No carryover authority for disposal of any unsold quantities from one year to another is authorized. By yearend, GSA had not yet issued an invitation to bid on this material; therefore, no sales were made during 1981.

Table 1.—Salient antimony statistics

(Short tons unless otherwise specified)

	1977	1978	1979	1980	1981
United States:					
Production:					
Primary:					
Mine	610	798	722	343	646
Smelter[1]	12,827	14,110	15,062	16,062	17,761
Secondary	30,601	26,456	24,155	19,893	19,856
Exports of metal and alloys	742	556	485	453	324
Imports for consumption (antimony content)	13,335	17,516	22,141	17,996	17,970
Reported consumption, primary antimony[1]	13,823	13,152	11,753	11,239	11,592
Stocks: Primary antimony, all classes (antimony content), Dec. 31	8,591	8,201	7,144	8,411	9,158
Price: New York, average cents per pound	178.00	[2]175.00	[2]196.00	[2]200.00	[2]200.00
World: Production	[r]74,600	[r]68,662	[r]71,384	[p]71,727	[e]65,246

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Includes primary antimony content of antimonial lead produced at primary lead refineries.
[2]Antimony price in alloy, cents per pound.

DOMESTIC PRODUCTION

MINE PRODUCTION

Domestic mine production of primary antimony in 1981 by two companies increased compared with that of 1980. The 1980 production figure was unusually low owing to a work stoppage at the Sunshine Mine that lasted more than 8 months. In 1981, the Sunshine Mining Co., which operates the Sunshine Mine in the Coeur d'Alene district of Idaho, produced 432 tons of antimony compared with 83 tons in 1980. 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, Idaho, area. The United States Antimony Corp. (USAC) produced antimony from the stibnite mined at the Babitt, Bardot, and Black Jack Mines at Thompson Falls, Mont. In 1981, USAC produced 214 tons of antimony compared with 260 tons in 1980.

Antimony was also produced as a byproduct in 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
1977	610	534
1978	798	863
1979	722	701
1980	343	382
1981	646	590

SMELTER PRODUCTION

Primary.—Production of primary antimony products in 1981 was 17,761 tons. A new plant, which uses a leaching process to produce sodium antimonate and antimony oxide from imported antimony ore, started production during 1981. The plant, Mineral Processes JV, which is located near Memphis, Tenn., has a capacity of about 150 tons per month. Bernuth, Lembcke Co. Inc. of Houston, Tex., is marketing the products from this new operation. ASARCO Incorporated announced that it has increased its antimony oxide capacity by one-third to about 2,500 tons per year by installing a 55-ton-per-month kettle at its Omaha, Nebr., lead refinery. Asarco also produced some antimony metal at its new smelter in El Paso, Tex. The other major producers of antimony products were Anzon America Inc., Laredo, Tex.; Harshaw Chemical Co., Gloucester City, N.J.; McGean Chemical Co., Inc., Cleveland, Ohio; M & T Chemicals Inc., Baltimore, Md.; PPG Industries, Inc., La Porte, Tex.; Sunshine Mining Co., Kellogg, Idaho; and USAC at Thompson Falls, Mont.

Secondary.—Production of antimony from secondary sources continued to decline in 1981. 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. RSR Corp. has patented a hydrometallurgical process to recover pure lead, pure antimony, and pure tin from scrap.[2]

Table 3.—Primary antimony produced in the United States

(Short tons of antimony content)

Year	Class of material produced				Total
	Metal	Oxide	Residues	Byproduct antimonial lead	
1977	1,877	9,907	277	766	12,827
1978	1,108	12,117	184	701	14,110
1979	2,642	12,141	--	279	15,062
1980	507	15,461	64	30	16,062
1981	790	16,425	--	546	17,761

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
1977	7,557	598	168	134	900	11.9
1978	5,518	539	162	82	783	14.2
1979	3,750	208	71	20	299	8.0
1980	971	18	12	--	30	3.1
1981	3,922	361	185	9	555	14.1

[1]Includes primary residues and a small quantity of antimony ore.
[2]Includes foreign base bullion and small quantities of foreign antimony ore.

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)

	1980	1981
KIND OF SCRAP		
New scrap:		
Lead-base	2,679	2,103
Tin-base	16	2
Total	2,695	2,105
Old scrap:		
Lead-base	17,191	17,744
Tin-base	7	7
Total	17,198	17,751
Grand total	19,893	19,856
FORM OF RECOVERY		
In antimonial lead[1]	16,968	16,371
In other lead alloys	2,910	3,476
In tin-base alloys	15	9
Total	19,893	19,856
Value (millions)	$79.6	$79.4

[1]Includes 9 tons of antimony recovered in antimonial lead from secondary sources at primary plants in 1981.

CONSUMPTION AND USES

Domestic consumption of primary antimony metal continued to decline in 1981. In recent years, improved technology that has lowered the average antimony content of the antimonial lead alloy used in the manufacture of starting-lighting-ignition (SLI) batteries and the increased use of maintenance-free batteries, which contain a lead-calcium-tin alloy, have resulted in a decline in the use of antimony metal. The Battery Council International reported an increase of 6% in SLI battery shipments in 1981 compared with those of 1980. A joint venture set up last year by the Department of Energy (DOE), the Electric Power Research Institute, the Rural Electrification Authority, and two Michigan utilities—Wolverine and Northern Electric Cooperatives—to build a lead-acid battery load-leveling facility has been canceled. DOE has withdrawn funding from the project as a result of changes in Government energy policies.

Antimony alloyed with lead also finds industrial use in chemical pumps and pipes, tank linings, roofing sheets, and cable sheaths. In these alloys, antimony increases strength and inhibits chemical corrosion.

Nonmetallic antimony was used in plastics both as a stabilizer and as a flame retardant. Antimony trioxide in an organic solvent is 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						
	Ore and concentrate	Metal	Oxide	Sulfide	Residues	Byproduct antimonial lead	Total
1977	160	2,625	9,959	36	277	766	13,823
1978	131	2,709	9,399	28	184	701	13,152
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

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

(Short tons of antimony content)

Product	1977	1978	1979	1980	1981
Metal products:					
Ammunition	138	133	253	362	409
Antimonial lead	2,936	2,832	1,300	748	1,257
Bearing metal and bearings	265	279	235	223	206
Cable covering	16	21	16	31	24
Castings	13	15	14	10	11
Collapsible tubes and foil	16	17	24	18	9
Sheet and pipe	56	39	36	29	36
Solder	220	206	199	134	105
Type metal	83	81	37	21	19
Other	104	113	99	74	69
Total	3,847	3,736	2,213	1,650	2,145
Nonmetal products:					
Ammunition primers	13	13	23	20	25
Fireworks	9	5	6	4	4
Ceramics and glass	1,547	1,259	1,127	1,303	782
Pigments	400	410	399	499	341
Plastics	1,503	1,456	1,580	1,636	1,551
Rubber products	473	254	182	325	232
Other	266	165	140	107	111
Total	4,211	3,562	3,457	3,894	3,046
Flame retardant:					
Plastics	3,972	4,063	4,262	3,874	4,509
Pigments	149	33	35	56	40
Rubber	219	196	146	189	174
Adhesives	246	298	302	461	585
Textiles	997	990	1,143	942	962
Paper	182	274	195	173	131
Total	5,765	5,854	6,083	5,695	6,401
Grand total	13,823	13,152	11,753	11,239	11,592

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

(Short tons of antimony content)

Stocks	1977	1978	1979	1980	1981
Ore and concentrate	1,869	1,610	1,757	2,743	2,529
Metal	1,359	1,119	1,184	680	916
Oxide	4,576	4,906	3,398	3,855	4,707
Sulfide	24	19	17	13	25
Residues and slags	516	457	730	1,116	864
Antimonial lead[1]	247	90	58	4	117
Total	8,591	8,201	7,144	8,411	9,158

[1]Inventories from primary sources at primary lead refineries only.

PRICES

The price of antimony in alloy remained at $2 per pound in 1981. The New York dealer price for antimony metal that began the year at $1.47 to $1.51 per pound decreased steadily throughout most of the year to finish at $1.20 to $1.24 per pound. The industry price quotation for antimony trioxide increased from $1.50-$1.80 to $1.60-$1.80 per pound in May owing to a slight surge in demand. In August, Asarco began trimming its price for antimony trioxide so that by yearend its price stood at $1.40 to $1.50 per pound owing to a continual fall in demand. Most of the other producers continued to publish a price of $1.80 per pound through the end of the year, but there were reports of discounting owing to the lower prices quoted by Asarco and to the availability of lower priced imported material. In February, the European market quotation for lump ore, on a 60% antimony basis, was placed at $21 to $23 per metric ton unit (equivalent to $19 to $21 per short ton unit), but by yearend, the price decreased to $20 to $22 per metric ton unit (equivalent to $18 to $20 per short ton unit).

Table 9.—Antimony price ranges in 1981, by type

Type	Price per pound
Domestic metal[1]	$2.00
Foreign metal[2]	$1.20-1.52
Antimony trioxide[3]	1.40-1.80

[1]Based on antimony in alloy.
[2]Duty-paid delivery, New York.
[3]Producer price.

FOREIGN TRADE

Total imports of antimony (antimony content) in 1981 were at the same level as those of 1980. Imports of antimony ore and concentrates, antimony metal, and antimony oxide were virtually unchanged from those of 1980.

In 1981, approximately 80% of the antimony metal imports came from Bolivia. Bolivia also provided most of the imported antimony ore and concentrates. The Republic of South Africa remained the largest single source for imports of antimony oxide, followed by Bolivia and China.

Exports of antimony metal, alloys, and scrap decreased in 1981 from those of 1980. Approximately 50% of the total was shipped to Mexico; the balance was shipped in small parcels to 19 countries. Exports of antimony oxide dropped to 452 tons (gross weight), a decrease of 51% from that of 1980. Mexico, Canada, the Federal Republic of Germany, Italy, and Australia, in descending order of receipts, received over 80% of the total oxide exports. Exports of antimony oxide (gross weight) for the following years were not previously reported: 1977, 257 tons; 1978, 238 tons; 1979, 688 tons; and 1980, 918 tons.

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

Item	Number	Most favored nation (MFN) January 1, 1981	Most favored nation (MFN) January 1, 1980	Non-MFN January 1, 1981
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	0.8 cent per pound	0.9 cent per pound	2 cents per pound.
Antimony oxide	417.50	0.2 cent per pound	0.3 cent per pound	2 cents per pound.

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

Class and country	1980		1981	
	Gross weight (short tons)	Value (thousands)	Gross weight (short tons)	Value (thousands)
Antimony metal:				
Belgium-Luxembourg	172	$458	175	$408
Bolivia	1,625	4,366	2,086	5,114
Canada	25	397	3	176
Chile	117	235	61	107
China	457	1,231	176	460
Dominican Republic	--	--	4	8
Germany, Federal Republic of	(1)	38	(1)	2
Japan	--	--	(1)	2
Mexico	139	412	55	102
Netherlands	--	--	19	51
Taiwan	--	--	33	86
United Kingdom	--	--	19	53
Uruguay	55	140	--	--
Total	2,590	7,277	2,631	6,569
Antimony oxide:				
Belgium-Luxembourg	214	651	470	1,222
Bolivia	927	2,088	2,311	4,884
Brazil	--	--	110	256
Canada	19	64	--	--
Chile	--	--	220	422
China	2,388	6,092	2,085	5,233
France	1,055	2,861	1,864	4,856
German Democratic Republic	23	67	--	--
Germany, Federal Republic of	20	54	22	53
Hong Kong	20	50	33	86
Italy	20	54	88	220
Japan	35	92	--	--
Mozambique	19	6	--	--
Netherlands	20	55	40	111
South Africa, Republic of	7,047	2,137	4,602	1,613
Switzerland	19	120	--	--
United Kingdom	398	1,380	325	966
Total	12,224	15,771	12,170	19,922
Antimony sulfide:[2]				
Austria	2	14	12	35
Belgium-Luxembourg	8	27	6	17
China	--	--	72	138
France	8	27	14	36
Germany, Federal Republic of	--	--	(1)	2
United Kingdom	16	148	2	21
Total	34	216	106	249

[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	1980			1981		
	Gross weight (short tons)	Antimony content (short tons)	Value (thousands)	Gross weight (short tons)	Antimony content (short tons)	Value (thousands)
Bolivia	3,543	2,336	$6,608	4,089	2,656	$4,916
Canada	1,624	1,017	2,073	186	86	162
Chile	79	56	131	458	302	593
China	--	--	--	55	36	56
Germany, Federal Republic of	--	--	--	124	88	186
Guatemala	107	64	127	809	517	931
Honduras	27	6	2	--	--	--
Hong Kong	--	--	--	217	119	183
Mexico	4,771	1,252	1,501	3,951	883	1,318
Peru	--	--	--	33	21	38
South Africa, Republic of	694	397	996	587	297	454
Thailand	199	107	208	275	150	226
Zimbabwe	--	--	--	29	13	32
Total	11,044	5,235	11,646	10,813	5,168	9,095

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)
1979	15,745	7,732	$11,860	50	34	$255	3,022	$7,011	13,679	11,353	$17,921
1980	11,044	5,235	11,646	34	23	216	2,590	7,277	12,224	10,148	15,771
1981	10,813	5,168	9,095	106	70	249	2,631	6,569	12,170	10,101	19,922

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

WORLD REVIEW

Belgium.—Metallurgie Hoboken-Overpelt S.A. has announced plans to recover sodium antimonate, copper, impure nickel sulfate, arsenic trioxide, and sulfuric acid from the byproducts of its lead and copper operations. The company's research department has developed a new process that employs hydrometallurgical techniques to separate the various compounds. The plant, which is expected to have the capacity to treat 6,600 short tons of byproducts per year, will be located at Olen.

Bolivia.—The Comite Boliviano de Productores de Antimonio (CBPA), a committee of Bolivian antimony producers, invited the world's antimony producers to attend the initial meeting of the Organizacion Internacional de Antimonio (OIA) at La Paz, Bolivia, in late October to discuss the future of the antimony industry. The meeting was attended by producers from Bolivia, Peru, Thailand, and Turkey. As yet, the organization has no formal rules or bylaws. The OIA announced that it would, however, hold a second meeting of antimony producers in October 1982 to which consumers and end users would also be invited. The CBPA has initiated the funding of the Antimony Research Institute at Battelle Columbus Laboratories in Ohio to develop, investigate, and promote new uses and current applications of antimony metal and antimony trioxide.

Canada.—Consolidated Durham Mines and Resources Ltd. halted its antimony mining and milling operations at Lake George, New Brunswick, in May 1981 as proven ore reserves were exhausted. Exploration work continues to outline a new zone of antimony-bearing ore discovered near the existing mine. As yet, a decision to reopen the operation has not been made.

In October, construction work on the leaching plant at Equity Silver Mines Ltd. in British Columbia was completed. The plant, which is expected to be fully operational during 1982, will remove antimony and arsenic from a complex silver-gold-copper ore. The leached concentrate will be shipped to Dowa Mining Co., Ltd., of Japan for further processing, and byproduct sodium antimonate will be sold to consumers.

France.—Société Nationale Elf-Aquitaine, S.A., was granted a permit by the French Industry Ministry to prospect for lead, zinc, copper, silver, antimony, and gold in Brittany. The permit covers a 47.5-square-kilometer area at Stival in the Morbihan Department.

During the year, Compagnie Française des Mines began production at a small antimony deposit near Quimper, France.

South Africa, Republic of.—Consolidated Murchison Ltd. reduced its milling rate of antimony ore by approximately one-third compared with the 1980 level of production. During the year, approximately 60% of the antimony concentrates was treated by Antimony Products (Proprietary) Ltd. and converted to a crude antimony oxide. Most of this oxide was exported to the United Kingdom, Europe, and North America.

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[1]Physical scientist, Division of Nonferrous Metals.

[2]Prengaman, R. D., and H. B. McDonald (assigned to RSR Corp., Dallas, Tex.). Method of Recovering Lead Values From Battery Sludge. U.S. Pat. 4,229,271, Oct. 21, 1980.

———. Process for Reducing Lead Peroxide Formation During Lead Electrowinning. U.S. Pat. 4,230,545, Oct. 28, 1980.

———. Stable Lead Dioxide Anode and Method for Production. U.S. Pat. 4,236,978, Dec. 2, 1980.

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

(Short tons)

Continent and country	1977	1978	1979	1980[p]	1981[e]
North America:					
Canada[e 2]	3,500	3,310	3,256	2,600	1,600
Guatemala	1,010	254	728	613	441
Honduras	[r]77	[r]86	51	25	22
Mexico[3]	2,974	2,708	3,166	2,399	1,984
United States[4]	610	798	722	343	[5]646
South America:					
Bolivia	18,012	14,702	14,351	17,047	[5]16,861
Brazil	289	216	74	72	72
Peru (recoverable)	903	821	840	1,157	1,213
Europe:					
Austria	564	561	629	730	694
Czechoslovakia	[e]330	[e]330	450	452	452
Italy	891	1,026	1,047	786	772
Spain	[r]365	487	552	689	661
U.S.S.R.[e]	8,700	8,700	9,000	9,000	9,000
Yugoslavia	2,478	2,950	2,245	2,315	2,205
Africa:					
Morocco	1,553	2,437	2,175	606	606
South Africa, Republic of[6]	12,715	10,024	12,815	14,413	[5]10,744
Zimbabwe	[r]607	[r]133	174	165	165
Asia:					
Burma	[r]584	[r]650	750	485	386
China	11,000	11,000	11,000	11,000	11,000
Malaysia (Sarawak)	[r]291	[r]290	338	147	254
Pakistan	21	23	7	11	11
Thailand	2,705	3,167	3,235	3,214	1,764
Turkey	2,118	[r]2,315	2,083	2,153	2,370
Oceania: Australia[7]	2,303	1,674	1,696	1,305	1,323
Total	[r]74,600	[r]68,662	71,384	71,727	65,246

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through May 12, 1982.
[2]Partly estimated on the basis of reported value of total production.
[3]Antimony content of ores for export plus antimony content of antimonial lead and other smelter products produced.
[4]Production from antimony mines; excludes a small amount produced as a byproduct of domestic lead ores.
[5]Reported figure.
[6]As reported by the Government of the Republic of South Africa; differs slightly from data reported by the Nation's only significant producer, Consolidated Murchison Ltd. Official figures apparently represent content of hand-cobbed ores and antimony concentrates, apparently excluding antimony content of arsenical concentrates reported as follows by Consolidated Murchison in short tons: 1977—1,337; 1978—1,173; and 1979 and 1980—nil.
[7]Antimony content of antimony ore and concentrates, lead concentrates, and lead and zinc middlings.

Asbestos

By R. A. Clifton[1]

Shipments of asbestos (all chrysotile) in 1981 from mines in the United States decreased 6% from those in 1980. Imports in 1981 were 3% higher than those in 1980.

U.S. apparent consumption declined 3% in 1981. Canadian shipments in 1981 were 14% lower than those for 1980. Shipments from Canada to the United States rose slightly during 1981. Imports from Canada were 94% of total U.S. imports in 1981, and those from the Republic of South Africa accounted for 5%.

Table 1.—Salient asbestos statistics

	1977	1978	1979	1980	1981
United States:					
Production (sales) metric tons	92,256	93,097	93,354	80,079	75,618
Value thousands	$25,267	$27,987	$28,925	$30,599	$30,685
Exports and reexports (unmanufactured) metric tons	34,896	45,380	r43,291	r48,671	64,419
Value thousands	$12,075	$20,533	r$17,381	r$21,067	$21,508
Exports and reexports of asbestos products (value) do	$62,665	$119,915	r$137,690	r$141,653	$145,130
Imports for consumption (unmanufactured) metric tons	550,693	570,020	513,084	327,296	337,618
Value thousands	$145,146	$154,351	$135,210	$91,809	$103,893
Released from stockpile (unmanufactured) metric tons	188	--	1	--	--
Consumption, apparent[1] do	609,157	618,706	560,600	358,700	348,800
World: Production do	r4,793,451	r4,693,221	4,884,732	p4,887,215	e4,725,533

eEstimated. pPreliminary. rRevised.
[1]Measured by quantity produced, plus imports, plus stockpile releases, minus exports.

Legislation and Government Programs.—Regulatory agency procedures, proposals, and regulations, including asbestos related ones, were under review in 1981 to bring about conformance with Supreme Court decisions and new administration policy. Even prior to establishment of the Cabinet level Presidential Task Force on Regulatory Relief, Federal Register (F.R.) Jan. 30, 1981, the agencies had begun some changes. For example, the Occupational Safety and Health Administration (OSHA), in the January 19th F.R., published some final rule changes in the general cancer policy, and further changes were prepared in the January 23d F.R. The significant change proposed in the January 23d issue was that OSHA must consider all relevant evidence in making its determinations.

In the February 6th F.R., a Presidential memorandum postponing the promulgation of all regulations for 60 days was announced, and in the February 19th F.R., Executive Order 12291 requiring cost benefit analyses of all new and existing regulations was promulgated.

The Asbestos Information Association/North America presented to the Task Force on Regulatory Relief the following as those regulatory initiatives that most threaten the asbestos industry: (1) A proposal outstanding at OSHA since 1975 to reduce the permissible workplace exposure level from 2.0 to 0.5 fibers per cubic centimeter, and outstanding recommendations by the National Institute for Occupational Safety and Health to reduce that standard even further to 0.1 fiber; (2) announcement by advance notice of proposed rulemaking in 1979 at the Environmental Protection

Agency (EPA), under Section 6 of the Toxic Substances Control Act (TSCA), to consider the possibility of banning all industrial and commercial uses of asbestos; (3) announcement by advance notice of proposed rulemaking in 1979 at the Consumer Product Safety Commission (CPSC) to consider the possibility of banning all uses of asbestos in consumer products; (4) outstanding water-quality criteria for asbestos issued by EPA under the Clean Water Act that, although they do not yet have formal regulatory impact, have already created marketing problems for asbestos-cement pipe manufacturers; (5) a proposal by EPA under TSCA Section 8(a) to collect enormous amounts of information on asbestos in support of numerous efforts to regulate asbestos more stringently; (6) a proposal by EPA to identify asbestos in schools; and (7) plans by EPA to reassess the existing National Emission Standard for a Hazardous Air Pollutant asbestos regulation with the possibility of tightening its requirements.

On June 17, the U.S. Supreme Court handed down a decision in the cotton dust case. Interpretations of the decision vary as the AFL-CIO says that the ruling flatly cuts out cost benefit analyses, while OSHA contends that only the mandatory nature of such analyses is removed.

In the July 21st F.R., the EPA clarified which asbestos exports must be reported under the TSCA. EPA considers three categories of asbestos exports to be reportable: (1) bulk shipments of raw fiber; (2) an asbestos-containing mixture that assumes the shape of its container—for example, asbestos-containing paints; and (3) an asbestos-containing mixture that is formed to a shape that must be fundamentally changed before use. Given as examples of types of products that are not subject to the rule are asbestos-cement pipe, brake linings, sheet gasketing, unfinished asbestos textiles, floor tiling, and rolls of asbestos paper.

On December 7, the Supreme Court refused to review the separate rulings of Federal Appellate Courts that held that any insurer would be liable for health impairment claims during the period of exposure to asbestos as well as during manifestation of the disease.

Environmental Impact.—It is practically impossible to separate the large drop in 1980 in asbestos consumption into economic environmental parts. It would seem to be mainly economic, but the very large number of lawsuits about asbestos exposure-related diseases and their coverage in the media are bound to have some effect on the market. The scope of these effects was discussed by Senator Hart and printed in the Congressional Record. The Senator introduced into the Record an article from the National Law Journal (Oct. 19, 1981) entitled "The Asbestos Case Explosion" by James Granelli.[2] Mr. Granelli says that two recent Federal Appellate Court rulings and a recent medical study could radically expand the size and number of the asbestos-related disease lawsuits. These lawsuits are already the largest type of product-liability case in the country. Any "radical expansion" of the 12,000 to 15,000 cases pending (5,000 in California alone) could overwhelm the courts.

Seamen and shipyard workers, the largest group of plaintiffs, have been deemed by an October ruling of the 4th U.S. Circuit Court of Appeals to come under admiralty law; their suits can be tried in Federal courts, thereby avoiding the statute of limitations that bind many State courts.

On October 1, Judge David Bazelon, writing for the District of Columbia Circuit Court of Appeals, settled the hard-fought question of the "moment of liability" so important to the insurance carriers. He ruled that the insurance coverage was triggered both at the time of exposure and manifestation and also while the asbestos fibers were in residence.

The Johns Manville Corp. had 8,000 cases pending involving 13,500 plaintiffs and had settled 1,000 cases. The plaintiffs have won 56% of the cases that went to trial and were awarded amounts ranging from $16,000 to $1,857,600.

The disposal of 395 cases in 1980 by trial or settlement resulted in an average award of $76,000 to the plaintiffs. In the first 9 months of 1981, 302 cases were disposed of with an average cost of $58,500 per case to the defendant. A business publication suggested that in the long run, these cases may be a social rather than a legal problem.[3] It suggested that the huge scope of potential liabilities from asbestos and other latent diseases may be too great for an industry or group of industries to bear. The Government may have to step in. The inclusion of the tobacco industry and the Government itself as codefendants in many suits may influence congressional decisions.

According to one of its journals, the medical profession apparently thinks that environmental regulations are sometimes based on incomplete, inaccurate, or misinterpreted data.[4] Affairs of the American Medical Association (AMA) in their report on "Carcinogen Regulations" gave the following as major conclusions: (1) Although such carcinogens as asbestos and chromates have been identified in the workplace, there is no definitive epidemiologic evidence that the United States has experienced an overall increase in the incidence of cancer related to high levels of pollutants or contaminants in the environment; (2) much more research relating the development of cancer in animals to a parallel development in humans is needed before that relationship can be used to mandate regulating substances in the human environment; (3) the AMA should continue to encourage Federal regulatory agencies to use an independent review processs for full scientific assessment—one that will objectively consider experimental biases and define the limits of testing accuracy before a formal proposal is made to regulate a potential carcinogen; and (4) the AMA should advise Federal regulatory agencies of the importance of providing a comment period of at least 90 days after the proposal of a regulation so that there may be indepth peer review of the proposed policy or rule.

In 1981, the first drafts of the long awaited reports on the National Toxicology Program animal feeding study became available. They give no indication of carcinogenicity from ingested asbestos.

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

(Metric tons)

	Stockpile goals	Total inventories 1979	Total inventories 1980	Total inventories 1981	Sales of excesses, 1981
Amosite	15,422	38,587	38,587	38,587	--
Chrysotile	2,722	9,034	9,034	9,034	--
Crocidolite	--	2,163	2,163	754	1,409
Total	18,144	49,784	49,784	48,375	1,409

DOMESTIC PRODUCTION

Mines in the United States shipped about 6% less asbestos in 1981 than in 1980, but the value was practically identical. Three States produced asbestos; California was the leader, followed by Vermont and Arizona. Total output was 75,618 tons valued at $30.7 million.

Calaveras Asbestos Corp. was California's and the Nation's leading producer from its Copperopolis Mine. One other mine was also active in California. On the Joaquin Ridge near Coalinga, in San Benito County, Union Carbide Corp. operated its Santa Rita Mine.

The Vermont Asbestos Group's Lowell Mine in Orleans County, Vt., is second in the country in production.

Arizona production in 1981 was below the 1980 level. The Jaquays Mining Corp. in Gila County had the only active asbestos mine in the State. This mine will probably be closed in 1982.

Employment in U.S. asbestos mines and mills averaged about 450 persons during 1981.

Table 3.—Asbestos producers in the United States in 1981

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

CONSUMPTION AND USES

Total U.S. asbestos consumption decreased 3% from 1980 to 1981. Chrysotile was 90% of that consumed; crocidolite, 9%. Small amounts of both amosite and anthophyllite were reported used.

Asbestos-cement pipe decreased its share of the asbestos used from 40% in 1980 to 37% in 1981. Chrysotile was 76% of that

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

(Metric tons)

	Chrysotile								Crocido-lite	Amosite	Antho-phyllite	Total asbestos
	Grades 1 and 2	Grade 3	Grade 4	Grade 5	Grade 6	Grade 7	Grade 8	Total chrysotile				
1980	400	3,600	86,900	89,500	19,900	132,300	--	332,600	24,400	1,700	--	358,700
1981:												
Asbestos-cement pipe	--	--	71,300	26,100	1,100	--	--	98,500	31,300	--	--	129,800
Asbestos-cement sheet	--	100	300	2,500	2,500	12,300	--	17,700	1,400	200	--	19,300
Flooring products	--	--	--	400	--	67,800	--	68,200	--	--	--	68,200
Roofing products	--	100	400	1,100	7,300	22,900	--	31,800	--	--	--	31,800
Packing and gaskets	--	1,000	1,600	5,200	100	11,400	--	19,300	--	--	--	19,300
Insulation:												
Thermal	--	--	200	--	--	5,800	--	6,000	--	--	--	6,000
Electrical	--	300	--	--	--	300	--	600	--	--	--	600
Friction products	--	--	1,100	14,200	5,800	26,900	--	48,000	--	--	100	48,100
Coatings and compounds	--	--	100	300	1,100	11,600	--	13,100	--	--	--	13,100
Plastics	100	100	--	300	--	600	--	1,100	--	--	--	1,100
Textiles	--	1,700	--	--	--	--	--	1,700	--	--	--	1,700
Paper	--	100	--	400	900	300	--	1,700	200	--	--	1,900
Other	--	100	200	100	200	6,200	--	6,800	--	1,100	--	7,900
Total	100	3,500	75,200	50,600	19,000	166,100	--	314,500	32,900	1,300	100	348,800

used in asbestos-cement pipe and crocidolite the rest. Flooring products with 20%, friction products with 14%, roofing products with 9%, and asbestos-cement sheet and packing and gaskets with 6% each, were the other major uses.

One percent of the chrysotile used was spinning grades 1, 2, or 3. Of the rest, the grade 7's were the most used at 53%, the 4's next at 24%, the 5's at 16%, and the 6's at 6%.

PRICES

Cassiar Resources, Inc., started the year optimistically with price increases that averaged 12% higher than those of 1980. Most other Western Hemisphere producers raised their published prices by varying amounts. The depressed markets and high producer inventories, though, made for a buyer's market with much selling below the listed prices. Because most of the asbestos used in the United States came from Canada, Quebec prices set the pattern. Quebec prices are given below.[5]

Quotations for Asbestos Corp. (Quebec) chrysotile, f.o.b. mine, as of January 1, 1981, follow:

Grade	Description	Value per metric ton
3Z to 3F	Spinning fiber	Can$1,325-$2,199
4T to 4A	Asbestos-cement fiber.	937- 1,384
5Z to 5D	Paper fiber	548- 757
6D	Paper and shingle fiber.	450- 470
7TS to 7D	Shorts	138- 278

African asbestos producers privately negotiate sales, thereby ruling out market quotations. The following tabulation shows the average value per metric ton of imports from the Republic of South Africa, regardless of grade, calculated from 1981 and previous U.S. Department of Commerce data:

Type	1977	1978	1979	1980	1981
Amosite	$589	$569	$577	$902	$725
Crocidolite	582	624	686	689	676
Chrysotile	485	451	679	692	595

FOREIGN TRADE

There was a 2% increase in the value of asbestos and asbestos products exported from the United States in 1981 over that of 1980. The fiber share of the export dollar remained at 13% in 1981. All of the gain was accounted for by a 2.4% increase in the value of manufactured asbestos products. There was a 23% decrease in the unit value of imported fibers to $430 in 1981.

In 1981, the United States recovered 160% of the cost of imported asbestos by exporting and reexporting fibers and products.

Canada remained the largest user of U.S. asbestos and products accounting for 34% of the value of exports of these products in 1981, followed by Mexico, 14%, and Saudi Arabia, 7%. Other major buyers of U.S. asbestos and products were, in descending order, Japan, Venezuela, Australia, the United Kingdom, the Federal Republic of Germany, Colombia, and the Netherlands.

Canada provided 94% of the asbestos fiber imported into the United States in 1981, and the Republic of South Africa provided 5%. Several countries provided the remainder. Chrysotile again dominated the imported types with 98% of the total. The dollar value of imported fiber in 1981 was 13% higher than that of 1980.

Table 5.—Countries importing U.S. asbestos fibers and products, by type and country

(Thousand dollars)

Country	1980			1981		
	Unmanufactured fibers	Manufactured products	Total	Unmanufactured fibers	Manufactured products	Total
Australia	68	3,231	3,299	117	4,480	4,597
Canada	951	60,182	61,133	1,029	55,754	56,783
Colombia	168	1,638	1,806	55	1,867	1,922
Germany, Federal Republic of	1,146	3,618	4,764	713	3,098	3,811
Japan	4,233	3,840	8,073	4,246	4,171	8,417
Mexico	4,410	8,980	13,390	5,267	18,344	23,611
Netherlands	--	3,288	3,288	14	1,680	1,694
Saudi Arabia	67	13,362	13,429	118	11,717	11,835
United Kingdom	373	4,258	4,631	206	3,627	3,833
Venezuela	239	3,202	3,441	222	4,951	5,173
Other	9,082	35,700	44,782	9,362	34,842	44,204
Total	20,737	141,299	162,036	21,349	144,531	165,880

Table 6.—U.S. exports and reexports of asbestos and asbestos products

Product	1979		1980		1981	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
EXPORTS						
Unmanufactured:						
Crudes, fibers, and stucco ... metric tons	31,635	[r]$12,868	36,426	$17,044	50,131	$17,328
Sand and refuse ... do	10,501	3,642	11,793	3,693	13,995	4,021
Total ... do	[r]42,136	[r]16,510	[r]48,219	[r]20,737	64,126	21,349
Products:						
Asbestos fibers ... do	2,559	6,784	2,695	8,610	3,840	9,544
Shingles and clapboard ... do	7,323	3,875	4,535	2,560	21,771	3,686
Other articles of asbestos ... do	17,758	13,301	16,646	14,236	17,504	14,292
Gaskets ... do	4,203	4,556	438	3,542	451	4,144
Packing and seals ... do	2,405	14,497	2,118	15,661	1,598	18,179
Insulation ... do	NA	4,524	NA	6,151	NA	8,185
Other articles, n.s.p.f ... do	NA	22,806	NA	25,442	NA	23,660
Brake linings and disk brake pads ... do	NA	55,270	NA	55,471	NA	50,058
Clutch facings and linings ... number	NA	9,334	NA	9,626	NA	12,783
Total	XX	[r]134,947	XX	[r]141,299	XX	144,531
REEXPORTS						
Unmanufactured:						
Crudes and fibers ... metric tons	1,039	851	383	307	240	150
Sand and refuse ... do	116	20	69	23	53	9
Total ... do	1,155	871	452	330	293	159
Products:						
Asbestos fibers ... do	--	--	--	--	6	34
Shingles and clapboard ... do	--	--	477	78	34	20
Gaskets ... do	--	--	--	--	1	7
Packing and seals ... do	4	109	1	5	1	2
Insulation ... do	--	--	NA	1	NA	17
Other articles, n.s.p.f ... do	NA	68	NA	14	NA	120
Brake linings and disk brake pads ... do	NA	2,492	NA	219	NA	149
Clutch facings and linings ... number	NA	52	NA	24	NA	234
Other articles of asbestos ... metric tons	NA	22	3	13	1	16
Total	XX	2,743	XX	354	XX	599

[r]Revised. NA Not available. XX Not applicable.

Table 7.—U.S. imports for consumption of asbestos fibers by type, origin, and value

Type	Canada		Republic of South Africa		Other		Total	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
1979	495,914	$123,673	16,328	$11,135	842	$402	513,084	$135,210
1980:								
Chrysotile:								
Crude	129	20	--	--	29	32	158	52
Spinning fibers	5,424	4,571	360	338	567	578	6,351	5,487
All other	309,886	78,371	2,041	1,379	899	721	312,826	80,471
Crocidolite (blue)	[1]52	12	7,545	5,201	--	--	7,597	5,213
Amosite	[1]49	302	315	284	--	--	364	586
Total	315,540	83,276	10,261	7,202	1,495	1,331	327,296	91,809
1981:								
Chrysotile:								
Crude	--	--	957	554	--	--	957	554
Spinning fibers	4,450	4,124	471	175	90	91	5,011	4,390
All other	313,917	86,704	7,802	4,762	1,875	2,000	323,594	93,466
Crocidolite (blue)	--	--	7,376	4,988	--	--	7,376	4,988
Amosite	--	--	506	367	174	128	680	495
Total	318,367	90,828	17,112	10,846	2,139	2,219	337,618	103,893

[1]Transshipment from the Republic of South Africa.

WORLD REVIEW

A wide-ranging survey of asbestos-cement use was reported at an industry meeting and described in a trade publication.[6] The trends are detailed in figure 1, which shows a decline in use in Western Europe and North America and increases in the rest of the world after 1970. These curves illustrate what has become increasingly apparent in the last decade. The growth areas for asbestos consumption are in the less developed portions of the world.

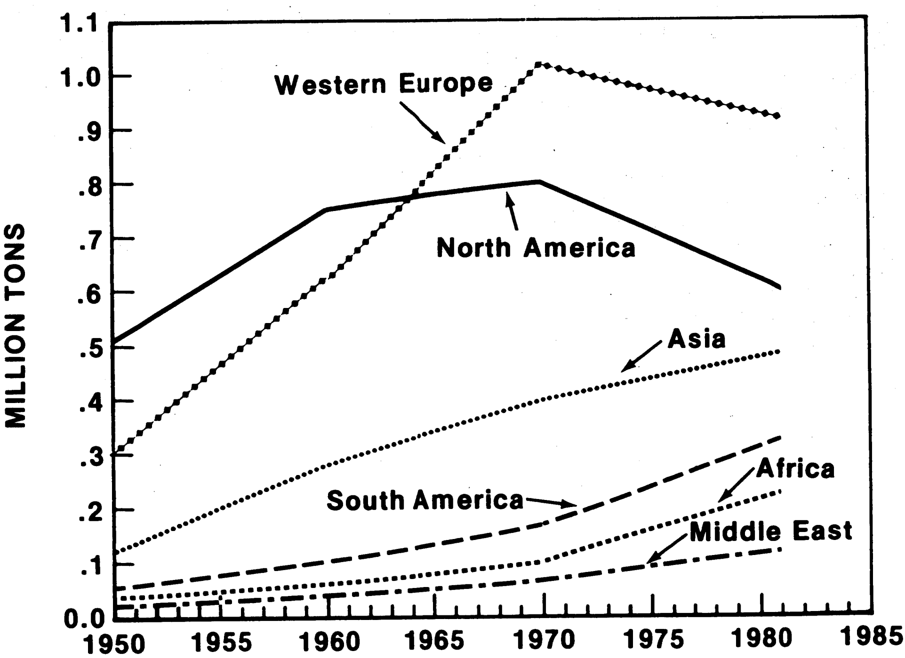

Figure 1.—Asbestos consumption by geographical area.

Australia.—Woodsreef Mines, Ltd., in Barraba received enough funds from its parent company, Trans Pacific Asbestos, Ltd., of Canada, to retire its bank loan and come out of receivership. It still owes large amounts to the Australian Federal Government and the New South Wales government. In midsummer, the recession forced reduction in work from a normal 3 shifts per day 5 days per week to 1 shift per day 5 days per week.

Canada.—As of October, the Quebec asbestos producers had inventories of about 200,000 tons. This was in spite of many layoffs and temporary mine and/or mill closures. In late November, a Canadián mining paper described the past 12 months as harder on the asbestos industry than any previous period in its history.[7] The article cited an 11% downturn in sales for the first 7 months of 1981 when compared with the already low sales of 1980 and saw no apparent improvement for later in the year. An anomaly during the first part of the year saw sales of the short fibers (40% by weight of the production) grow by 0.8% while the others declined by 15.1%.

In November, the Quebec government and General Dynamics Corp. finally agreed to the terms under which control of the Asbestos Corp. would be transferred from the latter to the former.[8] The first phase, effective immediately, called for the transfer of 51% of the voting stock of General Dynamics Canada, Ltd., which owned 54.65% of Asbestos Corp., to the Quebec government. The price was Can$16 million. The agreement allows further acquisition at 2- and 5-year intervals.

After a temporary closure in August, Advocate asbestos mine near Baie Verte in Newfoundland was scheduled for permanent closure on December 31, 1981. The principal owners, Johns Manville Canada, Inc., and Compagnie Financiere Eternit S.A. of Belgium, said that the decision to close was mainly a problem of cash flow and the economics of an overburden-to-ore ratio of 6 to 1 compared with that in Quebec of 3 to 1. Trans Pacific Asbestos, Ltd., showed late-year interest in acquiring Advocate to showcase their Woodsreef wet milling process. The Newfoundland government, interested in maintaining the more than 500 jobs, said that at least three other firms were interested in the acquisition of Advocate.

Greece.—On April 17, 1981, the asbestos mill at Kozani and mine at nearby Zidani were officially opened. Full production at a 100,000-metric-ton-per-year capacity was expected in 1981 with production of grades 4, 5, 6, and 7.

South Africa, Republic of.—General Mining Union Corp. (Gencor) made an offer for the former Cape Asbestos, Ltd., asbestos properties acquired in 1979 by Transvaal Consolidated Land and Exploration, Ltd. Gencor was already South Africa's largest asbestos producer through its 31% ownership of Griqualand Exploration and Finance Co. and Msauli Asbestos, Ltd.

Turkey.—A recent report cited in an international magazine from the Union of Chambers projected the value of Turkey's asbestos production to rise 37% from 1979 to $1.7 million in 1981.[9]

U.S.S.R.—The U.S.S.R. reported that the second stage of the Lenin asbestos plant in the Tuva Autonomous Soviet Socialist Republic reached full production. Design capacity was 120,000 tons per year.

A translation from the Russian gave a thumbnail sketch of the Uralasbest combine.[10] It produced 62.4% of the Soviet asbestos output. It also provided all the asbestos exported from the Soviet Union. The combine incorporated 20 sections and subsections, including two asbestos mines, three asbestos milling plants, anthophyllite asbestos mining, an asbestos millboard factory, mechanical works, and factories for large building panels and other structural building materials. The total personnel numbered about 19,000, including 15,000 of labor force.

Zimbabwe.—Data on the production of asbestos and other minerals during the years of unilaterally declared independence (UDI) became available. For the UDI years 1966-79, inclusive, asbestos was the primary revenue-producing mineral with a value 32% above the next highest revenue producer (gold) and 23% of the total mineral value. Asbestos production maintained a healthy growth rate during that period.

Amiantos of Switzerland closed, in April of 1981, its Pangani, Vanguard, and Buss Mines. The no-longer-viable mines produced only 5% of Zimbabwean asbestos.

Table 8.—Asbestos: World production, by country[1]

(Metric tons)

Country[2]	1977	1978	1979	1980[p]	1981[e]
North America:					
Canada (shipments)	1,517,360	1,421,808	1,492,719	1,323,053	[3]1,133,000
United States (sold or used by producers)	92,256	93,097	93,354	[3]80,079	[3]75,618
Latin America:					
Argentina	686	1,069	1,371	1,261	1,400
Brazil	92,773	122,815	138,457	169,173	180,000
Europe:					
Bulgaria[e]	500	700	600	652	700
Italy	149,327	135,402	143,931	157,794	142,000
U.S.S.R.[e]	1,900,000	1,945,000	2,020,000	2,150,000	2,220,000
Yugoslavia	9,066	10,360	10,041	12,106	[3]13,591
Africa:					
Egypt	478	349	238	316	325
Mozambique	--	--	789	800	800
South Africa, Republic of	380,164	257,325	249,187	276,759	[3]236,999
Swaziland[4]	38,046	[r]36,957	34,294	32,833	34,000
Zimbabwe	[r]273,194	[r]248,861	259,891	250,949	253,000
Asia:					
Afghanistan	13,000	[e]13,000	[e]4,000	--	--
China[e]	200,000	250,000	250,000	250,000	250,000
Cyprus	36,684	34,342	35,472	34,535	34,000
India	22,177	[r]24,623	32,094	31,253	32,000
Japan	6,307	5,746	3,502	3,897	3,500
Korea, Republic of	6,180	13,616	14,804	9,854	10,000
Taiwan	673	2,031	2,957	683	2,600
Thailand	4	4	--	--	--
Turkey	3,975	13,372	17,210	8,800	10,000
Oceania: Australia	50,601	62,744	79,721	92,418	92,000
Total	[r]4,793,451	[r]4,693,221	4,884,732	4,887,215	4,725,533

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through Apr. 21, 1982.
[2]In addition to the countries listed, Czechoslovakia, North Korea, and Romania also produce asbestos, but output is not officially reported, and available general information is inadequate for the formulation of reliable estimates of output levels.
[3]Reported figure.
[4]Exports.

TECHNOLOGY

Examination of an EPA document published in 1981 left no doubt about that agency's interest in asbestos.[11] It described 49 different asbestos related research projects taking place in 10 laboratories under the guidance of 4 EPA offices. Of further interest is that 19 (39%) of the projects had to do with waterborne asbestos.

Funding from Trans Pacific Asbestos, Ltd., parent company of Australia's Woodsreef Mine, was intended to bring into operation a prototype mill to demonstrate its revolutionary wet milling process. At least one U.S. company was showing great interest in this process.

Substitutes.—A paper at a national glass conference gave some details about the asbestos uses in a glass plant and the hunt for substitutes.[12] The author conceded that to eliminate all asbestos one must be willing to accept lower operating efficiencies and higher operating and maintenance costs. He identified 72 separate kinds of equipment in all parts of the plant that contained asbestos.

Another paper detailed one company's very novel approach to a less hazardous substitute for asbestos.[13] Reasoning that, if condensed phosphates were degradable in cellular enzymes, fibrous condensed phosphates would be biodegradable and less capable of cellular damage and carcinogenicity; they produced such fibers. Analysis of the paper indicates that the following questions were not addressed: (1) Would the fibers that have much larger diameters be compatible with present asbestos manufacturing processes? (2) How would further fiberization to produce smaller fibers affect the physical parameters of the fibers? (3) Could long lasting cement products be made using these "fairly resistant to alkali" fibers?

If asbestos continues to be deemed a controllable hazard, then, because the less costly reinforcement will prevail, asbestos could likely win any economic battle. Figure 2 shows the efficacy of several reinforcing agents in plastic matrices. Asbestos is by far the least costly.

[1]Physical scientist, Division of Industrial Minerals.
[2]Granelli, J. The Asbestos Case Explosion. Nat. Law J., v. 4, No. 6, Oct. 18, 1981, pp. 1-3.
[3]Business Week. Suits That Are Searing Asbestos. No. 2883, Apr. 13, 1981, pp. 166-167.
[4]Journal of the American Medical Association. Council on Scientific Affairs—Carcinogen Regulations. V. 246, No. 3, July 17, 1981, pp. 253-256.
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[6]Dorner, R. The Asbestos Users—World Survey of Asbestos-Cement. Pres. at Asbestos Internat. Assoc. 3d Biennial Conf., London, May 27-28, 1981, Asbestos Bull. (Astex Pub. Co., Surrey, England), v. 22, No. 5, September-October 1981, pp. 94-95 (Abstract).
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[11]Environmental Protection Agency, Office of Research and Development. Asbestos/Asbestiform Research in EPA ORD. Rept. No. EPA 600/7-81-032, March 1981, 80 pp. Single copy available from Center for Environmental Research Information, U.S. Environmental Protection Agency, Cincinnati, OH 45268; also available from National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161. Document No. PB 81-191876.
[12]Haney, J. C. Asbestos Elimination in a Glass Plant. Ceram. Eng. and Sci. Proc., 41st Conf. on Glass Problems, Nat. Inst. of Ceram. Eng., January-February 1981, pp. 30-34.
[13]Griffith, E. J. Crystalline Calcium Polyphosphate Fibers. Pres. at Internat. Symp. on Phosphorous Chemistry, Duke Univ., Durham, N.C., June 1981, 27 pp.

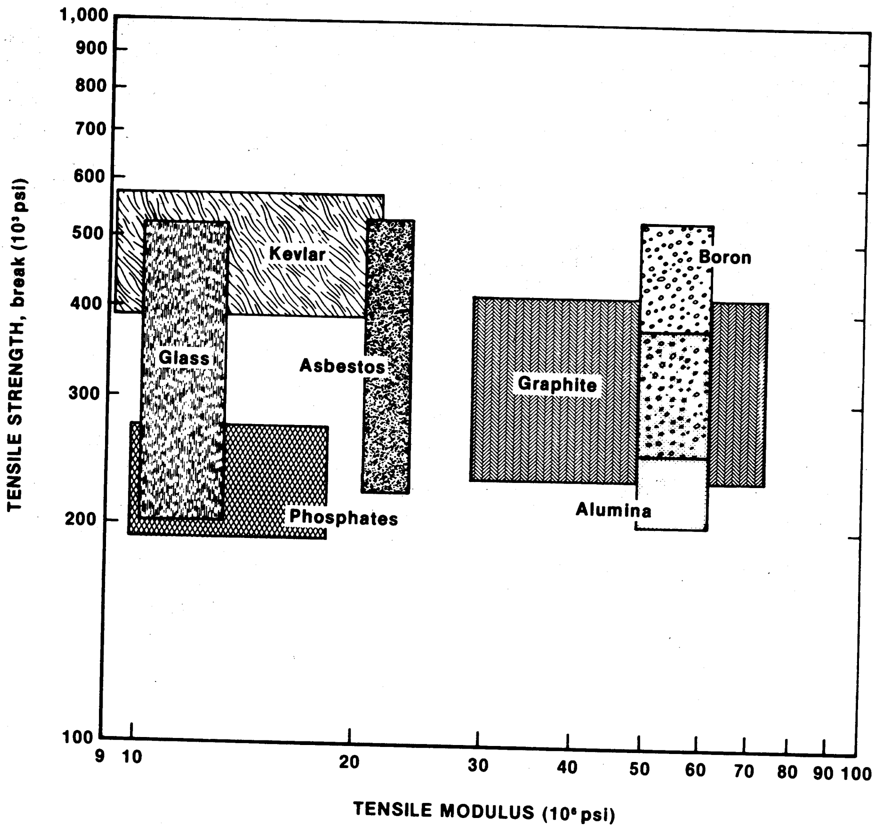

Figure 2.—Strength and modulus of selected fibers.

Barite

By Sarkis G. Ampian[1] and David E. Morse[1]

Domestic production of barite increased 27% to a record 2.85 million tons in 1981 valued at $102 million. Nevada, the leading producer, increased output 29% to 2.48 million tons, the first time that any State has exceeded 2 million tons in annual production. Production from Missouri, the second leading producer, increased substantially in 1981, and was up 58% from that of 1980. Imports for consumption of crude barite continued to increase, reaching 1.93 million tons, which was more than 80,000 tons higher than the previous record of 1.85 million tons imported in 1980. The principal use for barite, as a weighting agent in oil- and gas-well-drilling fluids (muds), accounted for 97% of U.S. consumption in 1981. Demand for barite continued at a record high pace because of the unprecedented high level of oil- and gas-well-drilling activity, which more than offset the decline in demand by other consuming industries that were adversely affected by the downturn in economic activity during the latter half of the year.

Table 1.—Salient barite and barium-chemical statistics

(Thousand short tons and thousand dollars)

	1977	1978	1979	1980	1981
United States:					
Barite, primary:					
Sold or used by producers	1,494	2,170	2,112	2,245	2,849
Value	$30,264	$45,130	$53,581	$65,957	$102,439
Exports	50	r50	109	97	62
Value	$3,436	$2,724	$10,861	$13,794	$9,947
Imports for consumption (crude)	955	1,291	1,489	1,850	1,932
Consumption (apparent)[1]	2,399	r3,411	3,492	3,998	4,719
Crushed and ground (sold or used by processors)[2]	2,593	2,897	3,223	3,649	4,716
Value	$110,409	$132,312	$179,009	$365,632	$406,255
Barium chemicals (sold or used by processers)	56	55	50	40	34
Value	$23,151	$24,018	$26,063	$22,441	$20,670
World: Production	r6,534	r7,508	r7,791	p8,069	e8,715

eEstimated. pPreliminary. rRevised.
[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 32% of total production in 1981 compared with 34% in 1980; other beneficiated material was 64% of the 1981 total compared with 62% in 1980; flotation concentrate, unchanged from 1980, was again 4% of the total 1981 production.

In 1981, reported primary barite production from 38 mines in 8 States increased 27% to the new record high of 2.85 million tons; Nevada with 20 mining operations and Missouri with 10 were the leading States in the number of mines and in barite output. Other producing States in 1981, in descending order were Arkansas, Georgia, Montana, Illinois, Tennessee, and Arizona. Illinois produces barite as a coproduct of fluorspar mining and milling; in all other States barite was the primary product.

The leading domestic barite producers in 1981 were (in alphabetical order) Baroid Div., 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 (in alphabetical order) All Minerals Corp., A. W. Arnold and Associates, Inc., Chromalloy American Corp., Eisenmann Chemical Co. (a subsidiary of Newpark Resources, Inc.), FMC Corp., Old Soldier Mining Co., and T. Norris, Inc. In Missouri, Agers Brothers, Inc., DeSoto Mining Co., and General Barite Co. produced important quantities of barite in 1981.

The domestic barite industry continued its rapid expansion that began in the latter half of the 1970's. Since 1977, domestic primary barite production has increased nearly 100% from 1.5 million to 2.85 million tons. Barite grinding capacity has more than doubled in the same 5-year period with the addition of a large number of plants near the gulf coast and in Oklahoma. Additionally, nine plants that were operating in 1977 have had capacity increases. Barite-grinding capacity, which had been straining to meet demand in 1978, had increased by 1981 to a point of overcapacity.

In 1981, Milchem, Inc., was constructing a flotation plant at its Fancy Hill property near Glenwood, Ark. The company planned to have the mine and flotation plant in operation by late summer 1982.

In Louisiana, Blast Abrasives, Inc., began production from its Houma grinding facility and constructed a second grinding plant at New Iberia; Dowell Fluid Services, a subsidiary of The Dow Chemical Co., purchased a large barite-grinding facility from G. H. Fluid Services; IMCO Services was expanding the capacity of its Houma grinding plant; Magcobar, a subsidiary of Dresser Industries, added a 66-inch mill to its New Orleans grinding plant; and NL Baroid began construction of a new grinding plant at Lake Charles, which was to be onstream in late 1982.

In Nevada, All Minerals was expanding the capacity of its beneficiating plant at its mine in Nye County; Magcobar added a 54-inch mill to its Battle Mountain grinding plant and expanded production from the Graystone Mine; NL Baroid added a second grinding mill to its Dunphy facility.

In Oklahoma, All Minerals and Eisenmann Chemical each completed construction of new grinding plants. Best Barite, Inc., was nearing completion of a new grinding plant at Cyril, southwest of Oklahoma City and near the oil well-drilling activity in the Anadarko Basin. Old Soldier Mining constructed a new grinding plant with a 54-inch mill at Elk City. Oklahoma, which did not have any grinding plants in 1978, was expected to have five in operation by mid-1982.

In Texas, All Minerals began construction of a two-mill grinding plant at Monahans. IMCO increased the capacity of its Brownsville grinding plant, and Magcobar added a 54-inch mill to its Galveston facility.

CE-Minerals, a Division of Combustion Engineering, Inc., began developing its Flagstaff Mountain property in Stevens County, Wash., after completion of a extensive drilling program. Crude ore was to be hauled to a flotation plant at Deep Lake that CE purchased from Washington Resources. Barite production was expected to start in mid-1982.

Table 2.—Primary barite sold or used by producers in the United States, by type and State

(Thousand short tons and thousand dollars)

State	Number of operations	Run of mine		Flotation concentrates		Beneficiated material		Total	
		Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1980:									
Alaska	1	W	W	--	--	--	--	W	W
Arkansas	2	W	W	--	--	W	W	W	W
Georgia	2	--	--	W	W	W	W	W	W
Illinois	2	--	--	W	W	--	--	W	W
Missouri	10	--	--	--	--	117	5,570	117	5,570
Montana	1	W	W	--	--	--	--	W	W
Nevada	16	708	16,319	W	W	1,209	31,481	[1]1,918	47,800
New Mexico	1	--	--	--	--	W	W	W	W

See footnotes at end of table.

Table 2.—Primary barite sold or used by producers in the United States, by type and State —Continued

(Thousand short tons and thousand dollars)

State	Number of operations	Run of mine		Flotation concentrates		Beneficiated material		Total	
		Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1980 —Continued									
Tennessee	2	W	W	--	--	W	W	W	W
Total	37	772	20,444	81	4,607	1,392	40,907	2,245	[1]65,957
1981:									
Arizona	1	--	--	--	--	W	W	W	W
Arkansas	1	--	--	W	W	--	--	W	W
Georgia	2	--	--	W	W	--	--	W	W
Illinois	2	--	--	W	W	--	--	W	W
Missouri	10	--	--	--	--	185	9,725	185	9,725
Montana	1	W	W	--	--	--	--	W	W
Nevada	20	839	21,322	W	W	1,634	58,394	2,482	79,716
Tennessee	1	W	W	--	--	--	--	W	W
Total	38	909	26,347	123	7,011	1,817	69,081	2,849	102,439

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

CONSUMPTION AND USES

Domestic sales of crushed and ground barite reached an alltime high in 1981. Use as a weighting agent in oil- and gas-well-drilling fluids continued to be the dominant end use, accounting for 97% of total sales volume in 1981. The oil- and gas-well-drilling industry had a record year by completing over 78,500 wells and drilling more than 361 million feet of hole. Total footage drilled exceeded 10 million feet in seven States: Texas, 123.6 million feet; Oklahoma, 52.8 million feet; Louisiana, 33.2 million feet; Kansas, 23.2 million feet; Ohio, 19.6 million feet; New Mexico, 13.5 million feet; and Wyoming, 12.0 million feet. Generally, the deeper a hole is drilled, the more barite is used per foot of drilling; thus, the total footage drilled has a larger effect than the number of wells. In the seven States with the greatest footage drilled in 1981, Wyoming had the highest average with nearly 7,200 feet per well and Kansas the lowest with about 3,400 feet per well. The U.S. average was 4,602 feet. An average of 25.1 pounds of barite was consumed per foot of drilling in 1981, compared with 23.8 pounds per foot in 1980.

The data in table 4 are mainly for ground barite but include quantities of crushed barite used by the barium chemical industry and by some glass manufacturers. Other uses of ground barite include filler in paint, paper, plastics, and rubber; flux, oxidizer, and decolorizer in glass manufacture; and miscellaneous uses.

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

State	1980			1981		
	Number of plants	Quantity (thousand short tons)	Value (thousands)	Number of plants	Quantity (thousands short tons)	Value (thousands)
Louisiana	9	1,293	$120,877	13	1,673	$169,188
Missouri	6	179	9,054	4	220	20,711
Nevada	5	610	62,169	6	609	28,888
Oklahoma	--	--	--	4	261	28,132
Texas	10	1,106	129,761	12	1,392	112,823
Utah	6	151	13,817	6	247	19,740
Other[1]	13	310	29,954	13	314	26,773
Total	49	3,649	365,632	58	4,716	406,255

[1]Includes Arkansas, California, Georgia, Illinois, Kansas (1981), Montana, and Tennessee (1980).

Table 4.—Crushed and ground barite sold or used by processors in the United States, by use[1]

(Thousand short tons and thousand dollars)

Use[2]	1980 Quantity	1980 Value	1981 Quantity	1981 Value
Barium chemicals	67	4,472	45	3,945
Filler or extender[3]	119	14,660	86	12,807
Well drilling	3,462	346,500	4,585	389,505
Total[4]	3,649	365,632	4,716	406,255

[1]Includes imported barite.
[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 may not add to totals shown because of independent rounding.

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

Barium chemical	1980				1981			
	Plants[2]	Production (short tons)	Sold or used by processors: Quantity (short tons)	Sold or used by processors: Value (thousands)	Plants[2]	Production (short tons)	Sold or used by processors: Quantity (short tons)	Sold or used by processors: Value (thousands)
Barium carbonate	4	30,000	25,000	$10,000	4	25,000	22,000	$9,400
Barium chloride	2	W	W	W	2	W	W	W
Barium hydroxide	1	W	W	W	--	--	--	--
Black ash	2	W	W	W	1	W	W	W
Blanc fixe	1	W	W	W	1	W	W	W
Other	3	23,546	15,045	12,441	3	11,000	12,000	11,270
Total	5	53,546	40,045	22,441	5	36,000	34,000	20,670

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]: Oil	Gas	Dry holes	Total	Successful wells (percent)	Average depth per well (feet)	Average barite per well (short tons)
1961	942	21.41	5.46	17.38	44.25	60.7	4,285	21.29
1962	934	21.73	5.35	17.08	44.16	61.3	4,408	21.15
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	r38.78	r58.1	4,510	r25.45
1966	1,022	16.78	4.38	15.23	r36.39	58.1	4,478	r28.08
1967	965	15.33	3.66	13.23	r32.22	58.9	4,385	r29.95
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	r27.30	59.5	4,932	r43.33
1973	1,326	9.90	6.39	10.31	r26.60	61.2	5,129	r49.85
1974	1,440	12.78	7.24	11.67	r31.69	63.2	4,750	r45.44
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	r52.73
1978	2,632	17.76	12.93	16.25	r46.94	65.4	4,829	r56.07
1979	2,967	19.38	14.68	15.75	r49.81	68.4	4,791	r59.57
1980	3,385	26.99	15.74	18.09	r60.82	70.3	4,675	55.66
1981	4,526	37.67	17.89	22.97	78.53	70.8	4,602	57.63

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

Source: U.S. Department of Energy. Energy Information Administration.

PRICES

Prices for all grades of barite increased in 1981 according to the Engineering and Mining Journal. The prices listed in table 7 are from trade publications; they serve as a general guide but do not reflect actual transactions.

The total reported value of primary barite in the United States in 1981 was $102 million; the average value per ton was $35.95, f.o.b. plant, an increase of 22% compared with the 1980 average value of $29.38. The average reported value per ton of ground barite from Texas and Louisiana was $92.01; the average value from California, Nevada, and Utah was $58.12 per ton. In 1981, the average customs value of ground barite exported to Canada was about $225 per ton; the customs value of material exported to Mexico and Latin America was nearly $150 per ton.

Table 7.—Barite price quotations

Item	Price per short ton[1]	
	1980	1981
Barite:[2]		
Chemical, filler, glass grades, f.o.b. shipping point, carlots:		
Handpicked, 95% $BaSO_4$, not over 1% Fe	$72.00	$72.00
Magnetic or flotation, 96% to 98% $BaSO_4$, not over 0.5% Fe	$60.00- 70.00	105.00
Water ground, 95% $BaSO_4$, 325 mesh, 50-pound bags	80.00-133.00	$80.00-155.00
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	70.00- 90.00	95.00-115.00
Crude, imported, specific gravity 4.20 to 4.30, f.o.b. shipping point	30.00- 60.00	32.00- 61.00
Barium chemicals:[3]		
Barium carbonate:		
Precipitated, bulk, carlots, freight equalized (per pound)	.206	0.26
Electronics grade, bags	335.00	335.00
Barium chloride:		
Technical crystals, bags, carlots, works	300.00	300.00
Anhydrous, bags, carlots, same basis	400.00	400.00
Barium hydrate: Mono, 55-pound bags, carlots, delivered (100 pounds)	39.50	55.00
Barium sulfate:		
Blanc fixe, technical grade, bags, carlots	430.00	430.00
USP, X-ray diagnosis grade, powder, 250-pound drums, 1,250-pound lots (per pound)	.53- 1.06	--
USP, X-ray diagnosis grade, powder, 25-kilo bags, 10,000 kilo-lots (per pound)	--	.51
Barium sulfide (black ash), drums, carlots, works	150.00	115.00-150.00

[1]Unless otherwise specified.
[2]Engineering and Mining Journal. V. 181, No. 12, December 1980, p. 23, and v. 182, No. 12, December 1981, p. 23.
[3]Chemical Marketing Reporter. V. 218, No. 26, Dec. 29, 1980, p. 27, and v. 220, No. 26, Dec. 28, 1981, p. 29.

FOREIGN TRADE

During 1981, over 62,000 tons of "natural barium sulfate" was exported from the United States. Export data provided by the U.S. Bureau of the Census do not indicate what type or form of barite was exported; however, based on the value of each shipment, it was estimated that 95% of barite exports was ground drilling-mud grade, 1% was crude barite, and 4% was chemical, filler, or glass grade. Mexico and Canada continued as the leading importers of barite from the United States, accounting for 81% of total exports. Barite was exported to 18 countries in 1981.

A record high 1.93 million tons of crude barite was imported by the United States in 1981. Compared with the 1980 figures, imports in 1981 increased 4.4% in quantity and 5.2% in value (c.i.f.). China supplied 80% of ground barite imports during the year, and Mexico supplied nearly 12%. Canada and the Federal Republic of Germany supplied most of the remaining 8%. The average value of imported crude barite increased $0.40 to $55.50 per ton (c.i.f.). The principal source countries, in order of tonnage and average values per ton in 1981, were China, $63.00; Peru, $47.88; Chile, $44.11; Morocco, $63.41; Mexico, $41.75; and Ireland, $39.09.

For the most part, crude barite entered the United States through customs districts located along the gulf coast. This reflects the concentration of grinding plants along the gulf coast and the nearness to the most important drilling mud markets. The import distribution by customs district in 1981 (1980 distribution in parentheses) was New Orleans, La., 56.2% (55%); Galveston, Tex., 18.1% (15%); Houston, Tex., 14.2% (11.9%); Laredo, Tex. (Port of Brownsville, Tex.), 9.3% (12.6%); and Port Arthur, Tex. (Port of

Lake Charles, La.), 2.4% (2%). The United States imported over 13,000 tons of ground barite in 1981.

The United States imported over 22,000 tons of barium chemicals valued at $11.9 million in 1981. The Federal Republic of Germany, China, France, and Italy were the major suppliers of imported barium chemicals in 1981.

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

Country	1980		1981	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Angola	431	$50	600	$87
Argentina	312	141	327	140
Australia	3	2	2	1
Austria	211	17	--	--
Barbados	310	40	732	80
Brazil	1,059	139	110	19
Canada	31,473	5,715	11,002	2,499
Chile	2,550	276	1,400	168
Colombia	5	2	5	58
Costa Rica	2	1	--	--
Dominican Republic	61	26	3,528	431
Guatemala	4,480	459	--	--
Indonesia	3	4	--	--
Jamaica	--	--	500	83
Japan	--	--	61	84
Mexico	50,313	6,030	39,333	5,624
Paraguay	--	--	1,000	150
Philippines	--	--	10	2
Seychelles	250	42	--	--
Sierra Leone	--	--	510	93
United Kingdom	159	64	--	--
Venezuela	3,142	397	3,062	423
Zaire	1,518	241	--	--
Other	536	150	11	4
Total[1]	96,819	13,794	62,187	9,947

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

Source: U.S. Department of Commerce.

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

Country	1980		1981	
	Quantity (short tons)	Value[1] (thousands)	Quantity (short tons)	Value[1] (thousands)
Crude barite:				
Australia	49,629	$2,479	--	--
Canada	111	4	--	--
Chile	174,285	9,468	313,926	$13,848
China	525,055	32,636	735,905	46,360
France	413	36	--	--
Greece	31,748	2,451	17,638	1,479
Guatemala	1,438	51	--	--
India	145,060	7,948	54,902	4,001
Ireland	82,823	2,603	78,287	3,060
Mexico	129,788	5,627	133,550	5,576
Morocco	204,928	12,282	230,328	14,605
Peru	326,908	14,453	317,236	15,188
Thailand	130,427	8,567	23,479	1,361
Total	[2]1,850,334	[2]101,956	[2]1,932,227	[2]107,236
Ground barite:				
Belgium-Luxembourg	17	8	53	16
Canada	397	164	451	248
China	118	20	10,844	771
Colombia	--	--	39	8
Germany, Federal Republic of	35	12	372	129
Mexico	3,224	228	1,561	107
Netherlands	--	--	208	71
Spain	40	13	40	12
Total[3]	3,831	445	13,569	1,363

[1]C.i.f. value.
[2]Includes 47,721 tons valued at $3,351,000 in 1980 and 26,976 tons valued at $1,758,000 in 1981 from Taiwan—not believed to have originated in Taiwan.
[3]Data may not add to totals shown because of independent rounding.

Source: U.S. Department of Commerce

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

Year	Lithopone		Blanc fixe (precipitated barium sulfate)		Barium chloride		Barium hydroxide	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1977	65	$27	8,729	$3,069	5,384	$1,170	2,448	$1,222
1978	142	58	9,424	4,160	5,287	1,173	3,138	1,539
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

Year	Barium nitrate		Barium carbonate, precipitated		Other barium compounds	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1977	899	$197	6,911	$1,391	395	$286
1978	468	123	10,712	2,465	2,987	1,186
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

NA Not available.

Source: U.S. Department of Commerce.

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)
1977	--	--	518	$103
1978	--	--	1,809	387
1979	5	$1	436	105
1980	22,145	713	62	23
1981	7	2	92	85

[1]Barium carbonate.

Source: U.S. Department of Commerce.

WORLD REVIEW

Estimated world production of barite increased 8% to 8.7 million tons in 1981. The United States produced 33% of the world total and imported 22% of the world output.

Belgium.—NL Baroid Minerals, Inc., began operating Belgium's only barite mine at Fleurus near Namur in 1981. The Fleurus barite is relatively expensive because it requires flotation and subsequent cleanup to produce a salable product. The deposit was reported to have reserves of more than 1 million tons.[2]

Canada.—In Newfoundland, Baroid of Canada, Ltd., was assisting ASARCO Incorporated and the Price Co. to both produce and market barite from the tailings of their Buchans lead-zinc-copper operation. A barite plant designed to process 85,000 tons per year of tailings to recover 15,000 tons per year of barite was put into operation in August.[3]

Chile.—Milchem, Inc., entered into a

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

(Thousand short tons)

Country[2]	1977	1978	1979	1980[p]	1981[e]
North America:					
Canada	129	97	74	95	90
Guatemala	--	1	4	5	--
Mexico	298	255	167	297	350
United States[3]	1,494	2,170	2,112	2,245	[4]2,849
South America:					
Argentina	34	[r]50	61	55	54
Bolivia[5]	2	3	2	10	2
Brazil	55	118	119	101	115
Chile	72	[r]204	250	249	247
Colombia	4	4	4	4	[4]4
Peru	[r]479	[r]436	490	457	451
Europe:					
Austria	(6)	(6)	(6)	(6)	(6)
Belgium	--	--	--	[e]33	44
Czechoslovakia	[e]70	[e]70	75	67	67
France	[r]233	248	187	250	230
German Democratic Republic[e]	34	39	40	40	40
Germany, Federal Republic of	293	186	178	193	190
Greece[7]	[r]96	49	53	53	53
Ireland	411	385	362	287	287
Italy	[r]168	261	237	224	[4]192
Poland	98	100	106	106	100
Portugal	1	1	1	1	1
Romania	[e]94	96	97	97	98
Spain	[r]93	79	82	66	70
U.S.S.R.[e]	500	525	550	550	550
United Kingdom	55	60	50	36	45
Yugoslavia	58	47	51	[e]50	51
Africa:					
Algeria	53	81	99	[e]100	100
Egypt	1	1	3	5	5
Kenya	(6)	(6)	(6)	7	7
Morocco	165	195	316	353	360
South Africa, Republic of	3	3	3	3	3
Tunisia	18	18	18	30	[4]25
Zimbabwe	[r]1	(6)	(6)	(6)	(6)
Asia:					
Afghanistan[8]	[r]13	14	3	--	--
Burma	18	39	44	44	33
China[e]	385	440	550	750	850
India	365	428	427	381	390
Iran	204	[r]220	198	165	85
Japan	64	78	61	63	62
Korea, North[e]	130	120	120	120	120
Korea, Republic of	3	[r]1	1	(6)	(6)
Malaysia	12	6	2	--	--
Pakistan	20	21	38	15	26
Philippines	6	6	7	6	6
Thailand	131	303	417	336	330
Turkey	158	35	[e]120	90	100
Oceania: Australia	13	[r]15	12	30	33
Total	[r]6,534	[r]7,508	7,791	8,069	8,715

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through June 16, 1982.
[2]In addition to the countries listed, Bulgaria also produced barite, but available information was inadequate to make reliable estimates of output levels.
[3]Sold or used by producers.
[4]Reported figure.
[5]Series represents exports only; Bolivia also produced barite for domestic consumption, but available data were not adequate for formulation of estimates or levels of production to meet internal needs.
[6]Less than 1/2 unit.
[7]Barite concentrates.
[8]Year beginning Mar. 21 of that stated.

joint venture agreement with a Chilean group to mine and jig barite ores in the Punta Colorado area of central Chile.[4]

China.—China exported nearly 736,000 tons of crude barite and about 11,000 tons of ground barite to the United States in 1981. Based on the volume of exports, China has become the world's second largest producer and the world's largest exporter of barite. In 1980, China exported 520,000 tons to the United States and nearly 90,000 tons to the European Economic Community.

NEI International Combustion, Ltd., of the United Kingdom, manufactured and shipped two Lopulco table and roller milling units, which were installed in a barite plant at Wuchow in 1981. KCA International Ltd. and Feoso Oil Ltd. of Hong Kong established KCA Feoso Ltd., which financed, designed, and built the barite plant. KCA Minerals Ltd. of Hong Kong was to distribute the barite, which was to be ground to drilling-mud specifications.[5]

Peru.—Perubar, S.A., began installing a jig plant at its Graciela Mine northeast of Lima to process low-grade ore that had been previously stockpiled.[6]

United Kingdom.—In Derbyshire, SPO Minerals Ltd. began production of drilling-mud grade barite from its Galconda processing plant.

Venezuela.—Baroid de Venezuela added a Williams roller mill to its Punta Camacho grinding plant.[7]

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[1]Physical scientist, Division of Industrial Minerals.
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[6]Castelli, A. V. Barite: U.S. Production Continues Strong, Sets Record of 2 Million ST. Eng. and Min. J., v. 183, No. 3, March 1982, pp. 135-137.
[7]Work cited in footnote 6.

Bauxite and Alumina

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

The 1981 downturn in world aluminum metal demand was reflected by similar decreases in world bauxite production, down 3.4%, and alumina production, down 2.7% from 1980 levels. Leading bauxite producers, Australia, Jamaica, Guinea, and Suriname, registered a combined output drop of 3.3 million metric tons.[3] A 28% increase in Brazilian bauxite production offset some of the decline in world mine output. The principal sources of crude and dried bauxite imported into the United States in 1981 were Jamaica, Guinea, Brazil, and Suriname. Ninety-eight percent of alumina imports was supplied by Australia (74%), Jamaica (13%), and Suriname (11%).

New bauxite discoveries were reported at Tatunshan, northern Taiwan; Olmeda in Sardinia, Italy; Pula, Yugoslavia; Zabirah District, Saudia Arabia; and Fenyofo, Hungary. Known deposits in West Kalimantan, Indonesia, and Samar, Philippines, were evaluated by further sampling, analytical testing, and economic studies.

Table 1.—Salient bauxite statistics

(Thousand metric tons and thousand dollars)

	1977	1978	1979	1980	1981
United States:					
Production: Crude ore (dry equivalent)	2,013	1,669	1,821	1,559	1,510
Value	$27,555	$23,185	$24,875	$22,353	$26,489
Exports (as shipped)	26	13	15	21	20
Imports for consumption[1]	12,989	13,847	13,780	14,087	12,802
Consumption (dry equivalent)	14,528	14,738	15,697	15,962	13,525
World: Production	[r]81,931	[r]79,810	[r]87,777	[p]88,786	[e]85,729

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

Legislation and Government Programs.—During 1981, no changes were made in stocks of bauxite in the national stockpile which is maintained by the General Services Administration (GSA). At yearend the stockpile contained 14.4 million tons of metal-grade bauxite, comprised of 9.0 million tons of Jamaica-type ore and 5.4 million tons of Suriname-type ore. Stocks of calcined refractory-grade bauxite totaled 177,401 tons. Stockpile goals included 21.3 million tons of Jamaica-type and 6.2 million tons of Suriname-type metal-grade ore, 1.4 million tons of calcined refractory-grade bauxite, and 762,000 tons of calcined abrasive-grade bauxite. There were no stocks or inventory goals for alumina.

In October 1981, GSA awarded a contract to Cometals, Inc., to supply 25,400 tons of Chinese calcined refractory-grade bauxite. Delivery was to be made in January and February 1982 to a Government stockpile at Granite City, Ill. A second bauxite acquisition for the stockpile was ordered by Presidential directive in November 1981. The United States was to acquire from the Jamaican Government approximately 1.6 million metric dry tons of Jamaican metal-grade bauxite to be delivered to a stockpile at Gregory, Tex., during the period from March to September 1982. Payment was to be made by a combination of cash purchase, exchange of excess stockpile commodities, and barter of agricultural commodities.

No import duties on bauxite or alumina have been applied since they were suspended in 1971.

DOMESTIC PRODUCTION

Three States, Arkansas, Alabama, and Georgia, supplied all of the domestic bauxite in 1981. Approximately 75% of the bauxite mined was processed to alumina in Arkansas, while the balance of the ore produced in the three States was used by the chemical and refractory industries. Arkansas production was confined to Saline County where the Aluminum Co. of America (Alcoa), American Cyanamid Co., and Reynolds Metals Co. operated surface mines. Porocel Corp. produced activated bauxite from purchased ore at its Berger plant south of Little Rock.

In Alabama, the second largest producing State, A. P. Green Refractories Co., Harbison-Walker Refractories Co., Didier Taylor Refractories Corp., and Mullite Co. of America mined bauxite in the Eufaula district. Near Andersonville, Ga., Mullite Co. operated the only bauxite mine in the State. All production from both States was calcined in local or out-of-State plants for consumption in refractory and chemical uses.

Domestic alumina production by nine Bayer process refineries, including Martin Marietta's U.S. Virgin Islands plant, was 5.96 million tons, or 12% below 1980 production. The total, expressed as calcined equivalent weight, includes calcined alumina, commercial alumina trihydrate, and activated, tabular, and other specialty alumina forms, but excludes aluminates.

During 1981, primary aluminum plants received an estimated 5.46 million tons of calcined alumina from domestic alumina plants. The chemical, abrasive, ceramic, and refractory industries received the balance of shipments.

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]
1979:						
Alabama and Georgia	501	391	4,320	r649	r616	r18,500
Arkansas	1,685	1,430	20,555	r1,783	r1,512	r25,726
Total	2,186	1,821	24,875	r2,432	r2,128	r44,226
1980:						
Alabama and Georgia	336	260	3,101	r477	r474	r15,240
Arkansas	1,533	1,299	19,252	r1,577	r1,371	r24,405
Total[3]	1,869	1,559	22,353	r2,054	r1,844	r39,645
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

rRevised.
[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
1980	355	179	277
1981	419	187	328

[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)	1977	1978	1979	1980	1981
Less than 8	2	2	1	--	--
From 8 to 15	54	55	55	62	65
More than 15	44	43	44	38	35

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]				
1977	5,580	660	6,230	6,030
1978	5,550	580	6,130	5,960
1979	5,950	700	6,650	6,450
1980	6,310	720	7,030	6,810
1981	5,490	700	6,190	5,960
Shipments:[e]				
1977	5,510	660	6,160	5,960
1978	5,620	580	6,200	6,020
1979	5,970	710	6,680	6,480
1980	6,160	720	6,880	6,660
1981	5,610	715	6,320	6,085

[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	1980	1981
Aluminum Co. of America:		
Bauxite, Ark	325	340
Mobile, Ala	800	800
Point Comfort, Tex	1,325	1,325
Total	2,450	2,465
Martin Marietta Aluminum, Inc.: St. Croix, V.I	508	635
Kaiser Aluminum & Chemical Corp.:		
Baton Rouge, La	930	955
Gramercy, La	726	770
Total	1,656	1,725
Ormet Corp.: Burnside, La	544	545
Reynolds Metals Co.:		
Hurricane Creek, Ark	650	650
Corpus Christi, Tex	1,400	1,400
Total	2,050	2,050
Grand total	7,208	7,420

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

CONSUMPTION AND USES

Over 92% of the bauxite consumed during the year was processed into different forms of alumina. Consumption and production data from the alumina producers indicated that an average of 2.3 tons (dry basis) of bauxite was required to produce 1 ton of calcined alumina. As in previous years, seven domestic refineries processed imported bauxite, one used a blend of Arkansas and foreign ore, and one plant refined Arkansas ore exclusively. Although bauxite consumption increased in 1981 for chemical and refractory uses, overall consumption was 15% below the 1980 total. Approximately 35% of the bauxite consumed by the refractories industry was supplied from Alabama and Georgia mines with the balance coming from foreign sources.

Quantities of abrasive-grade bauxite listed in table 7 include ore consumed in Canada to produce intermediate abrasive materials used by U.S. plants to manufacture a variety of abrasive end products. About 75,000 tons of bauxite was consumed in 1981 by the cement, oil and gas industries, and municipal waterworks.

In 1981, 32 domestic primary aluminum plants consumed 8,588,000 tons of calcined alumina. A considerable quantity of aluminum fluoride and synthetic cryolite made from alumina was consumed by the primary aluminum industry, however, data for this and other uses of alumina were not available.

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

(Thousand metric tons, dry equivalent)

Industry	Domestic	Foreign	Total[1]
1980:			
Alumina	1,681	13,287	14,968
Abrasive[2]	--	277	277
Chemical	[3]64	[3]224	211
Refractory	145	285	430
Other	W	W	77
Total[1] [2]	1,890	14,072	15,962
1981:			
Alumina	1,233	11,277	12,510
Abrasive[2]	--	249	249
Chemical	[3]79	[3]227	232
Refractory	162	298	460
Other	W	W	75
Total[1] [2]	1,474	12,052	13,525

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
1980:			
Crude and dried	1,692	13,523	[1]15,214
Calcined and activated	198	550	748
Total	1,890	[1]14,072	15,962
1981:			
Crude and dried	1,242	11,516	12,758
Calcined and activated	233	534	767
Total	1,475	12,050	13,525

[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 1980

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)	66	1,167	1,079	$123,985
Iron-free (17% Al_2O_3)	17	106	79	8,006
Aluminum chloride:				
Liquid and crystal (32° Bé)[1]	5	19	3	844
Anhydrous (100% $AlCl_3$)	5	67	35	21,613
Aluminum fluoride, technical	5	135	133	90,331
Aluminum hydroxide, trihydrate (100% $Al_2O_3 \cdot 3H_2O$)	7	588	565	116,210
Other inorganic aluminum compounds[2]	XX	XX	XX	32,981

XX Not applicable.
[1]No crystal production or shipments in 1980.
[2]Includes sodium aluminate, light aluminum hydroxide, cryolite and alums.

Source: Data are based upon U.S. 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	1980	1981
Producers and processors	[r]662	900
Consumers	[r]7,681	7,439
Government	14,661	14,661
Total	[r]23,004	23,000

[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	1980	1981
Producers[e]	245	155
Primary aluminum plants	1,283	1,267
Total[e]	1,528	1,422

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

PRICES

Most world trade transactions in bauxite involve long-term contracts or intracompany transfers. Consequently, prices, other than for spot sales or special grades, are not quoted in trade journals as they are for commodities traded on the open market.

The Bureau of Mines estimated an average value of $13.87 per ton for domestic crude bauxite shipments, f.o.b. mine or plant, in 1981. Shipments of domestic calcined bauxite were estimated to average $102 per ton, compared with $101 per ton in 1980. Data used by the Bureau in preparing these estimates were incomplete. Grade differences among producers also affected the estimated values.

The avarage value of imported bauxite consumed at domestic alumina plants could not be estimated because of insufficient data. The following prices per ton of supercalcined, refractory-grade bauxite imported from Guyana were published by Engineering and Mining Journal in 1981. The quotations for carload lots, delivered f.o.b. Baltimore, Md., Mobile, Ala., or Burnside, La., are:

Jan. to Mar. 1981	Apr. to June 1981	July to Oct. 1981	Nov. to Dec. 1981
$208.39	$236.66	$214.90	$203.22

The average value of domestic shipments of calcined alumina was estimated at $236 per ton in 1981. For imported alumina, including a minor amount of hydrate, the average value derived from Bureau of Census reports was $211 per ton at port of shipment (f.a.s.) and $222 per ton at U.S. ports (c.i.f.).

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

(Per metric ton)

Country	1980 Port of shipment (f.a.s.)	1980 Delivered to U.S. ports (c.i.f.)	1981 Port of shipment (f.a.s.)	1981 Delivered to U.S. ports (c.i.f.)
To U.S. mainland:				
Brazil	$23.05	$33.17	$26.70	$36.36
Dominican Republic	31.11	35.34	33.79	42.01
Guinea	25.94	32.67	26.38	36.27
Guyana	31.36	44.64	33.89	48.53
Haiti	24.20	29.46	25.15	31.49
Jamaica	27.25	30.51	27.07	30.63
Sierra Leone	16.59	26.44	19.68	29.54
Suriname	31.61	41.46	41.48	53.42
Weighted average	26.25	32.02	28.30	35.37

[1]Computed from quantity and value data reported to U.S. Customs Service and compiled by the Bureau of the Census, U.S. Department of Commerce. Not adjusted for moisture content of bauxite or differences in methods used by importers to determine value of individual shipments.

Table 13.—Market quotations on alumina and aluminum compounds

(Per metric ton, in bags, carlots, freight equalized)

Compound	Jan. 2, 1981	Dec. 31, 1981
Alumina, calcined	$228.18	$228.18
Alumina, hydrated, heavy	203.93	203.93
Alumina, activated, granular, works	352.74	352.74
Aluminum sulfate, commercial, ground (17% Al_2O_3)	200.62	259.04
Aluminum sulfate, iron-free, dry (17% Al_2O_3)	270.06	270.06

Source: Chemical Marketing Reporter.

FOREIGN TRADE

In 1981, the United States exported 40,900 tons of bauxite, including 21,000 tons in calcined form. Canada and Mexico received 98% of the total exports. U.S. exports of alumina, down 35% from 1980, went primarily to Canada (27%), Norway (19%), and Mexico (17%). Alumina export shipments included 21,000 tons of aluminum hydroxide. About 48,000 tons of material classified as "other aluminum compounds" was distributed to many foreign destinations. A substantial amount of this material was believed to be aluminum fluoride and synthetic cryolite used as a flux in the production of primary aluminum.

Imports of calcined bauxite declined 22% from the adjusted 1980 level. Refractory-grade bauxite accounted for 79% of the 319,000 tons of calcined bauxite imported in 1981. Calcined abrasive-grade bauxite from Australia, Guinea, and Suriname was processed into fused crude aluminum oxide in Canada prior to shipment to U.S. plants for manufacture into abrasive and refractory products.

Imports of Suriname alumina rose by 200,000 tons in 1981, however, this was offset by the 560,000-ton decline in alumina supplied by Australia and Jamaica.

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

(Thousand metric tons and thousand dollars)

Country	1979		1980		1981	
	Quantity	Value	Quantity	Value	Quantity	Value
Argentina	3	1,754	16	4,514	1	501
Australia	3	1,099	4	1,920	2	1,234
Belgium-Luxembourg	(2)	323	1	729	1	1,570
Brazil	1	863	18	5,829	2	1,363
Canada	185	44,954	264	71,488	201	63,940
France	4	2,558	4	4,214	3	3,010
Germany, Federal Republic of	6	5,867	6	7,581	3	6,514
Ghana	94	14,295	151	24,958	76	13,862
Japan	3	4,592	3	9,489	3	10,454
Mexico	131	25,691	125	29,655	127	35,657
Netherlands	2	1,391	2	1,768	1	1,392
Norway	204	30,042	226	36,241	141	21,364
Poland	(2)	80	23	2,570	(2)	26
Spain	(2)	749	(2)	714	20	4,349
Sweden	2	1,585	72	16,749	15	4,358
U.S.S.R.	70	8,462	18	2,124	36	8,570
United Kingdom	5	3,547	6	4,502	6	6,284
Venezuela	128	26,915	189	36,057	94	25,695
Other	8	7,301	10	10,840	7	8,497
Total	849	182,068	1,138	271,942	[3]737	218,640

[1]Includes exports of aluminum hydroxide: 1979—36,800 tons; 1980—38,000 tons; 1981—21,300 tons. Also includes alumina exported from the U.S. Virgin Islands to foreign countries: 1979—264,000 tons; 1980—271,000 tons; 1981—data not reported separately.
[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, by country[1]

(Thousand metric tons)

Country	1979	1980	1981
Brazil	168	777	1,265
Dominican Republic[2]	551	565	449
Greece	10	--	--
Guinea	3,924	4,112	3,546
Guyana	425	585	463
Haiti	572	452	529
Jamaica[2]	6,469	6,146	5,352
Sierra Leone	141	75	108
Suriname	1,520	1,369	1,079
Other	--	6	11
Total	13,780	14,087	12,802

[1]Includes bauxite imported to the U.S. Virgin Islands from foreign countries: 1979—1,051,000 tons; 1980—1,241,000 tons; 1981—data not reported separately.
[2]Dry equivalent of shipments to the United States.

Note: Total U.S. imports of crude and dried bauxite (including U.S. Virgin Islands) as reported by U.S. Bureau of the Census were: 1979—15,274,570 tons; 1980—15,136,854 tons; 1981—13,856,826 tons.

Table 16.—U.S. imports for consumption of bauxite (calcined), by country[1]

(Thousand metric tons and thousand dollars)

Country	1980		1981			
			Refractory grade		Other grade	
	Quantity	Value[1]	Quantity	Value[1]	Quantity	Value[1]
Australia	16	1,147	--	--	15	1,561
China[2]	r142	r14,030	122	14,681	12	1,410
Guyana	199	34,314	101	19,146	35	4,406
Suriname	49	5,420	28	4,575	6	467
Other	3	89	(3)	22	(3)	23
Total	r409	r55,000	251	38,424	68	7,867

rRevised.
[1]Value at foreign port of shipment as reported to U.S. Customs Service.
[2]The 1980 and 1981 data for imports from China have been revised and adjusted to conform to information supplied by industry and the U.S. Bureau of the Census.
[3]Less than 1/2 unit.

Table 17.—U.S. imports for consumption of alumina,[1] by country

(Thousand metric tons and thousand dollars)

Country	1979 Quantity	1979 Value[2]	1980 Quantity	1980 Value[2]	1981 Quantity	1981 Value[2]
Australia	2,938	433,382	3,408	578,031	2,955	574,688
Canada	23	5,704	37	9,380	34	10,222
France	12	21,350	5	14,452	4	13,479
Germany, Federal Republic of	11	8,158	8	8,934	8	9,469
Guyana	18	1,539	17	1,472	4	613
Jamaica	587	106,120	634	113,392	523	124,180
Japan	1	1,080	1	875	1	1,639
Suriname	239	41,245	246	55,440	448	102,486
Other	8	1,844	1	925	1	1,156
Total[3]	3,837	620,422	4,358	782,902	3,978	837,932

[1]Includes aluminum hydroxide; excludes shipments from the U.S. Virgin Islands to the United States: 1979—182,673 tons ($30,730,428); 1980—208,506 tons ($39,199,528); 1981—not available.
[2]Value at foreign port of shipment as reported to U.S. Customs Service.
[3]Data may not add to totals shown because of independent rounding.

WORLD REVIEW

Twenty-six countries produced 86 million tons of bauxite in 1981, a decrease of 3% from 1980 production. Four countries, Australia, Jamaica, Guinea, and Brazil, accounted for 64% of the world bauxite production in 1981. Brazil displaced Suriname as the fourth largest producer.

World alumina production from 26 countries totaled 32.3 million tons in 1981. This was approximately 3% lower than 1980 production. Australian and U.S. refineries produced 40% of the total.

Australia.—A 9-week labor strike at Comalco Ltd.'s bauxite mines at Weipa, Queensland, and a 10-week labor dispute at the Swiss Aluminium Ltd. (Alusuisse). Gove alumina production plant in the Northern Territory were reported to be the principal reasons for the lower bauxite and alumina output.

Queensland Alumina Ltd. (QAL) at Gladstone, Queensland, with a rated annual capacity of about 2 million tons of alumina, announced that it planned to raise the plant capacity to 2.33 million tons by the first half of 1983. The possibility of recovering titanium minerals from the Weipa bauxite at the alumina plant was being studied by QAL.

Nabalco Pty. Ltd. cut production to 50% of capacity at its 1.2-million-ton-per-year Gove alumina plant in October 1981. Reduced demand for alumina was cited by the Alusuisse subsidiary as reason for the decision.

In Western Australia, construction of the Worsley Alumina Pty. Ltd. project was reported to be 23% complete at the end of November 1981. The alumina project was owned by Reynolds Australia Alumina Ltd. (40%), Shell Co. of Australia (30%), Dampier Mining Co. Ltd. (20%), and Kobe Alumina Associates (Australia) Pty. Ltd. (10%), and is scheduled to start production in mid-1983 with an annual capacity of 1 million tons. At Wagerup, a second new alumina plant in Western Australia had been scheduled by Alcoa of Australia (W.A.) Ltd. to open in July 1982 with an initial capacity of 500,000 tons per year. However, in December, Alcoa announced that the startup date had been postponed to 1983 owing to weakened alumina demand, although construction work would continue. Alcoa is reported to have added to its bauxite reserves by acquiring a 17.5% interest in the Mitchell Plateau deposits and a 22.5% interest in the Cape Bougainville deposits of northern Western Australia from Conzinc Riotinto of Australia, Ltd. In February 1981, a suit was filed in a U.S. district court against Alcoa and Reynolds by the Conservation Council of Western Australia in an attempt to curtail further growth of the State's bauxite and alumina industry. The suit was dismissed in July by the U.S. District Court in Pittsburgh on the grounds that it had no jurisdiction in Australian legal matters.

Brazil.—Bauxite production in 1981 again registered a substantial gain, attributable chiefly to increased output by Mineraçâo Rio do Norte S.A.'s (MRN) mining operation near the Trombetas River in the Amazon Basin. During 1981, changes were made in the interests held by MRN partners. Alcan Aluminium Ltd. increased its share to 24% by acquiring the 5% share held by Spain's Alumina Espanola, S.A. Aardal og Sunndal Verk AS's 5% interest was sold to Mineraçâo Rio Xingu, a Royal/Dutch Shell Group subsidiary that originally held a 5% share. Interests held by other partners included 46% by Cía. Vale do Rio Doce (CVRD), 10% by Cía. Brasileira de Aluminio, 5% by Reynolds Metals Co., and 5% by Norsk Hydro AS.

A second bauxite reserve in the Trombetas River region, reported to contain over 250 million tons of ore, was sold by Santa Patricia Mining Co. (a D. K. Ludwig company) to Alcoa Aluminio S.A. (owned 68% by Alcoa and 32% by Hanna Mining Co.). The purchase was followed by the announcement of a new 500,000-ton-per-year alumina plant and a 100,000-ton-per-year smelter to be built at São Luis, Maranhão State. Construction of this $1 billion project, called Consorcio-Alumar, began in 1981 and the first alumina and primary aluminum production was scheduled for 1985.

The Aluminio Brasileiro S.A.-Alumina do Norte do Brasil S.A. project, jointly financed by CVRD and Nippon Amazon Aluminium Co., was designed to include an alumina refinery and primary aluminum smelter with annual capacities of 800,000 tons and 320,000 tons, respectively. The $2.57 billion complex was to be located in Pará State near Belém on the Amazon River, where it would receive bauxite from CVRD's share of MRN production at Trombetas and power from the Tucurui hydroelectric plant on the Tocantins River. Startup of the two plants was scheduled for 1985.

Ghana.—President Hilla Limann announced that Brown & Root, Inc., Houston, Tex., was selected as prime contractor for a feasibility study to develop the Kibi bauxite deposits and to evaluate plans for an 800,000-ton-per-year alumina plant. The $4.5 million study was to include Granges International Mining Co. (Sweden) and Alusuisse as subcontractors. The Kibi deposits are reported to contain 180 to 200 million tons of bauxite reserves.

Guinea.—Most of the 1981 bauxite production came from the Sangaredi Mine in the Boke district operated by Compagnie des Bauxites de Guinée. The balance was from the Fria-Kimbo deposits and the state-owned, Russian-financed, Office des Bauxites de Kindia deposits. The Friguia alumina refinery, owned jointly by the Government of Guinea (49%) and Frialco Co. (51%), produced about 680,000 tons of sandy-type alumina, having converted from a floury-type alumina product during 1980.

Nigeria was reported to have joined the Société Guinée-Arabe d'Alumine et d' Aluminium, a consortium of petroleum-producing countries and the Government of Guinea, organized to mine bauxite from the Ayékoyé deposits.

Guyana.—The Government of Guyana was pursuing numerous avenues in an attempt to increase its bauxite output and recoup a dwindling market. The Inter-American Development Bank agreed to provide $250,000 to fund a 10-month study of port facilities and river-mouth bars which limit both size and frequency of bauxite export shipments. A contract with Green Construction Co., Des Moines, Iowa, to remove overburden at the East Montgomery Mine was completed in midyear, and a second contract was signed authorizing Green to conduct the entire East Montgomery mining operation. U.S. imports of Guyanese calcined bauxite in 1981 were about 30% lower than in 1980.

Indonesia.—The Government announced its decision to build an alumina plant with an annual capacity of 600,000 tons on Bintan Island. Indonesia has awarded letters of intent to Kaiser Aluminum & Chemical Corp., Klöckner Industrie-Anlagen GmbH. of the Federal Republic of Germany, and Kaiser Engineers Inc., a subsidiary of Raymond International Inc., for construction of the $570 million plant.

Jamaica.—About one-half of the bauxite produced was exported to the United States, and the balance was refined in Jamaica. Jamaica was the largest single source (42%) of metal-grade bauxite imported by the United States in 1981. Cutbacks in both bauxite mining and alumina production during the year resulted in reduction of the labor force and the threat of a strike by the National Workers Union, which subsequently agreed to continue negotiations with company and Government representatives. Many of the expected layoffs at the bauxite mines were averted when the United States decided in November 1981 to purchase 1.6 million tons of Jamaican bauxite to be delivered to a Government stockpile in Texas by September 1982. The Jamaican Government planned to supply the bauxite from mines operated by Reynolds Jamaica Mines Ltd. and Kaiser Jamaica Bauxite Co.

Efforts by the Jamaican Government to increase the island's alumina capacity were unsuccessful and by the yearend had failed to reach conclusive agreements with prospective participants. In one plan, Jamaica would be joined by three Norwegian companies in a project to double the annual alumina capacity of the Jamalco plant (Alcoa 94%, Jamaica Bauxite Mining Ltd., 6%) at Clarendon from 500,000 to 1 million tons. The depressed alumina market caused two of the Norwegian firms to withdraw, leaving Norsk Hydro to continue negotiations for a smaller capacity expansion of about 340,000 tons.

A second plan explored by the Government called for the construction of a new 600,000- to 800,000-ton-per-year alumina plant in Manchester Parish to be financed by a consortium that included Iraq, Algeria, and the U.S.S.R. However, by mid-1981, these three prospective participants had withdrawn, causing the Jamaican Government to renew its search for partners.

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

(Thousand metric tons)

Continent and country	1977	1978	1979	1980[p]	1981[e]
North America and Caribbean Islands:					
Dominican Republic[2 3]	576	568	524	510	[4]405
Haiti[5]	588	580	584	477	400
Jamaica[6]	[r]11,390	[r]11,739	11,618	12,054	11,664
United States	2,013	1,669	1,821	1,559	[4]1,510
South America:					
Brazil[e 7]	1,120	1,160	2,388	4,152	5,300
Guyana[e 2]	2,731	2,425	2,312	2,471	1,680
Suriname	4,805	5,188	5,010	4,696	3,728
Europe:					
France[8]	2,059	1,978	1,970	1,892	[4]1,871
Germany, Federal Republic of	(9)	(9)	(9)	(9)	--
Greece	[r]2,885	[r]2,663	2,812	3,286	3,300
Hungary	2,949	2,899	2,976	2,950	[4]2,914
Italy	35	24	26	23	23
Romania	702	708	708	710	712
Spain	10	[r]9	17	8	9
U.S.S.R.[e 10]	4,600	4,600	4,600	6,400	4,600
Yugoslavia	2,044	2,565	3,012	3,138	[4]3,249
Africa:					
Ghana	244	328	214	225	181
Guinea	10,841	10,456	13,700	10,330	12,100
Mozambique	2	--	--	--	--
Sierra Leone	745	716	672	766	610
Zimbabwe	3	5	5	4	4
Asia:					
China[e]	1,500	1,500	1,500	1,500	1,500
India	1,519	1,663	1,934	1,740	2,100
Indonesia	1,301	1,008	1,052	1,249	1,200
Malaysia	616	615	387	920	[4]701
Pakistan	(9)	2	2	2	2
Turkey	[r]567	[r]449	350	546	425
Oceania: Australia	26,086	24,293	27,583	27,178	25,541
Total	[r]81,931	[r]79,810	87,777	88,786	85,729

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through June 23, 1982.
[2]Dry bauxite equivalent of crude ore.
[3]Shipments.
[4]Reported figure.
[5]Dry bauxite equivalent of ore processed by drying plant.
[6]Bauxite processed for conversion to alumina in Jamaica plus kiln-dried ore prepared for export.
[7]Estimated dry bauxite equivalent of crude ore, calculated from reported crude ore, assuming a moisture content of 17.2%.
[8]Includes bauxite identified as "usable for fabrication of alumina" as follows, in thousand metric tons: 1976—2,250; 1977—1,966; 1978—1,875; 1979—1,874; 1980—(estimated) 1,610.
[9]Less than 1/2 unit.
[10]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: 1977—2,500; 1978—2,500; 1979—2,500; 1980—2,500, 1981—2,500, and estimated alunite ore production was as follows, in thousand metric tons: 1977—600; 1978—600; 1979—600; 1980—600, 1981—600. 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] [2] by continent and country

(Thousand metric tons)

Continent and country[3]	1977	1978	1979	1980[p]	1981[e]
North America:					
Canada	1,061	1,054	953	[4]1,202	[4]1,208
Jamaica	[r]2,051	[r]2,117	2,094	2,478	[4]2,550
United States[e]	6,030	5,960	6,450	6,810	5,960
South America:					
Brazil	340	352	449	493	530
Guyana[5]	271	250	200	220	198
Suriname	1,172	1,310	1,325	1,316	1,172
Europe:					
Czechoslovakia[e]	95	100	100	100	100
France	1,081	1,056	1,069	1,173	[4]1,095
German Democratic Republic	39	38	41	43	43
Germany, Federal Republic of	[r]1,556	[r]1,539	1,608	1,422	[4]1,419
Greece	474	[r]477	495	494	500
Hungary	783	782	788	805	[4]799
Italy	788	819	854	900	900
Poland	--	--	--	--	75
Romania[e]	442	449	502	534	540
Spain	--	--	--	58	695
United Kingdom	99	94	88	102	100
U.S.S.R.[e]	2,600	2,600	2,600	2,700	3,100
Yugoslavia	499	496	836	1,056	800
Africa: Guinea	562	610	660	708	679
Asia:					
China[e]	750	750	750	750	750
India	387	480	493	[e]500	500
Japan	1,785	1,502	1,546	1,936	[4]1,344
Taiwan	51	51	58	[e]65	61
Turkey	170	74	70	138	138
Oceania: Australia	6,659	6,776	7,415	7,246	[4]7,079
Total	[r]29,745	[r]29,736	31,444	33,249	32,335

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data through June 23, 1982.
[2]Figures presented generally represent calcined alumina; exceptions are noted individually.
[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 continent and country

(Thousand metric tons, yearend)

Continent and country	1979	1980	1981
North America:			
Canada	1,225	1,225	1,225
Jamaica	2,824	2,824	2,825
United States	7,208	7,208	7,420
South America:			
Brazil	460	540	540
Guyana	354	354	355
Suriname	1,350	1,350	1,350
Europe:			
Czechoslovakia	100	100	100
France	1,320	1,320	1,320
German Democratic Republic	65	65	65
Germany, Federal Republic of	1,729	1,745	1,745
Greece	500	500	500
Hungary	817	895	895
Italy	920	920	920
Poland	--	--	100
Romania	540	540	540
Spain	--	80	800
United Kingdom	138	138	140
U.S.S.R.[e]	3,400	3,400	4,500
Yugoslavia	1,600	1,635	1,635
Africa: Guinea	700	660	700

See footnotes at end of table.

Table 20.—World annual alumina capacity, by continent and country —Continued

(Thousand metric tons, yearend)

Continent and country	1979	1980	1981
Asia:			
China	650	650	650
India	675	675	675
Japan	2,614	2,614	2,615
Taiwan	140	140	140
Turkey	200	200	200
Oceania: Australia	7,044	7,340	7,340
Total	36,573	37,118	39,295

[e]Estimated.

TECHNOLOGY

In 1981, the Bureau of Mines carried out research on kaolin clays, oil shales, and coal ash as potential alternate sources of metal-grade bauxite. The Bureau and five aluminum industry companies continued their participation in the cooperative, cost-sharing miniplant project to evaluate alumina recovery from calcined clay by hydrochloric acid digestion.[4] The mineral dawsonite is another possible source of alumina. Associated with the oil shales of the Piceance Creek Basin in Colorado, dawsonite contains 35% alumina and constitutes a resource estimated at 6.7 billion tons of aluminum oxide. The Bureau conducted laboratory studies on caustic-leaching of retorted oil shale residues to recover alumina and soda ash. Work also was continued on techniques for the extraction of alumina for coal ash using acid leach and lime sinter-acid leach procedures.[5]

In a separate area of research, gibbsite-bearing saprolites from Alabama, North Carolina, and Virginia were mechanically beneficiated and the refractory qualities of the products were tested by the Bureau. Caustic leaching of calcined kaolin clay to reduce the silica content also appeared to be a promising approach in creating a high-alumina refractory raw material. Work on refractories was continued into 1982 and reports are not yet available on this work.

[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]Bengston, K. B., P. Chuberka, R. R. Nunn, A. V. San Jose, G. M. Manarolis, and L. E. Malm (contract JO265048, Kaiser Engineers, Inc.). Alumina Process Feasibility Study and Preliminary Pilot Plant Design. Task 3 Report: Preliminary Design of 25 Ton Per Day Pilot Plant. Volume 1. Process Technology and Costs. BuMines OFR 122(1)-80, 1980, 232 pp.; PB 81-125031.

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[5]Canon, R. M., T. M. Gilliam, and J. S. Watson. Evaluation of Potential Processes for Recovery of Metals From Coal Ash. Electric Power Res. Inst. EPRI CS 1992, v. 1-2. August-November 1982. Prepared by Oak Ridge National Laboratory.

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Beryllium

By Benjamin Petkof[1]

The U.S. beryllium industry was strong in 1981. Low-grade bertrandite ore mined in Utah was the major commercial source of beryllium ore. Imports of beryl have increased annually since 1977 and augmented the domestic supply of beryllium ore concentrates. Beryllium concentrate consumption declined from that of 1979 and 1980. Exports of beryllium materials in 1981 increased in quantity but declined in value. World beryl production showed an upward trend.

Table 1.—Salient beryllium mineral statistics

	1977	1978	1979	1980	1981
United States:					
Beryllium mineral concentrates:					
Shipped from mines[1] ......short tons..	W	W	W	W	W
Imports ......do....	746	1,031	1,037	1,703	2,138
Consumption[1] ......do....	4,165	5,916	9,518	8,508	8,141
Price, approximate, per short ton unit BeO, imported cobbed beryl at port of exportation......	$40	r$40	$47	$69	$94
Yearend stocks[1] ......short tons..	3,557	1,346	835	1,350	2,223
World production of beryl ......do....	r2,844	r2,888	2,644	p2,767	e2,903

eEstimated. pPreliminary. rRevised. W Withheld to avoid disclosing company proprietary data.
[1]Includes bertrandite ore, which was calculated as equivalent to beryl containing 11% BeO.

Legislation and Government Programs.—The strategic stockpile goals for beryllium materials (issued by the Federal Emergency Management Agency on May 2, 1980) were unchanged. No beryllium materials were released from the strategic stockpile.

The Occupational Safety and Health Administration, U.S. Department of Labor, did not finalize its proposed beryllium occupational and health standards, as published in the Federal Register, October 17, 1975.

DOMESTIC PRODUCTION

Brush Wellman, Inc. (Brush), was the only large commercial domestic producer of beryllium concentrates in 1981. Brush mined low-grade bertrandite ore at Spor Mountain, Utah, for processing into beryllium hydroxide. In addition, there was a small domestic output of beryl. Brush has initiated a program to stimulate domestic and foreign beryl mining to extend the life of existing bertrandite ore reserves and to make use of its existing beryl ore processing capacity.

Brush converted beryl and bertrandite ore to beryllium hydroxide at a processing plant north of Delta, Utah. The company announced a program to modify the Delta plant to allow the processing of lower grade beryllium ore. The plant modifications are expected to be completed in mid-1983.

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.

Domestic production of beryllium metal, beryllium oxide, beryllium-copper master alloy, beryllium-copper alloy, and other beryllium alloys was strong in 1981.

CONSUMPTION AND USES

In 1981, the domestic beryllium industry consumed beryllium ore equivalent to 8,141 short tons of beryl containing 11% beryllium oxide (BeO). Ore consumption was well above that of 1978 but below that of 1979 and 1980.

Copper-based beryllium alloys were the most widely used beryllium-containing products. The addition of beryllium to copper provides a commercial copper alloy with greatly improved physical properties that allow the alloy's use for a wide range of applications in cast and wrought forms. Much of the alloy consumption was as thin strip or small-diameter rod. The alloy was 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 (beryllia) ceramics found increasing use in electronics and electrical industries because of its high thermal conductivity, good mechanical hardness and strength, electrical insulation capability, and low dielectric constant. Because of these physical properties, beryllium oxide was used in the manufacture 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, special nuclear applications, and brake components for aircraft and aerospace vehicles.

STOCKS

Consumer stocks of beryllium minerals totaled 2,223 tons (11% BeO equivalent) at yearend. Yearend stocks increased to the highest level since 1977, reflecting increased beryllium mineral production and imports.

PRICES AND SPECIFICATIONS

From January 1 to March 2, 1981, Metals Week quoted the price of beryl ore at $90 to $110 per short ton unit of contained beryllia. From March 2, 1981, to the end of the year, the ore was quoted at $100 to $130 per short ton unit.

At yearend 1981, the American Metal Market quoted the following prices for beryllium materials: Vacuum cast ingot, $173 per pound; metal powder (in 5,000-pound lots), $148 per pound; beryllium-copper master alloy, $121 per pound of contained beryllium; beryllium-copper casting alloy, $4.10 to $4.96 per pound; beryllium-copper in rod, bar, and wire, $6.70 per pound; beryllium-copper in strip, $6.61 per pound; beryllium-aluminum alloy (100,000-pound lots), $201 per pound; and beryllium oxide powder, $37.50 per pound. All beryllium metal quotations were for 97%-purity metal.

FOREIGN TRADE

Exports of wrought and unwrought beryllium alloys and waste and scrap increased in quantity from that of 1980 but declined in total value. About three-fifths of U.S. exports were destined for Switzerland with significant quantities also shipped to Canada, France, and Japan.

Beryl remained the only beryllium mineral ore imported into the United States. The average value per ton of imported ore increased from $686 in 1980 to $936 in 1981. China and Brazil furnished over four-fifths of total U.S. imports. In addition, 746 pounds of wrought, unwrought, and waste and scrap beryllium metal valued at $21,370 was imported from the United Kingdom, the Federal Republic of Germany, and Canada.

Table 2.—U.S. exports of beryllium alloys, wrought or unwrought, and waste and scrap[1]

Country	1980 Quantity (pounds)	1980 Value (thousands)	1981 Quantity (pounds)	1981 Value (thousands)
Argentina	209	$4	931	$119
Australia	1,148	10	2,238	11
Belgium-Luxembourg	34	3	--	--
Brazil	--	--	117	4
Canada	7,829	170	7,057	293
France	12,633	1,128	4,387	605
Germany, Federal Republic of	1,042	267	2,338	144
India	--	--	276	30
Ireland	--	--	528	3
Israel	--	--	194	4
Italy	4,342	35	3,000	92
Jamaica	14	5	--	--
Japan	2,788	366	4,470	882
Korea, Republic of	--	--	84	1
Mexico	--	--	247	3
Netherlands	4,276	126	60	44
Portugal	--	--	54	1
Switzerland	208	23	48,227	589
Taiwan	2,500	12	57	6
Turkey	2,546	13	--	--
United Kingdom	18,582	1,701	3,914	262
Venezuela	--	--	10	1
Other	304	4	--	--
Total	58,455	3,867	78,189	3,094

[1]Consisting of beryllium lumps, single crystals, powder; beryllium-base alloy powder; beryllium rods, sheets, and wire.

Table 3.—U.S. imports for consumption of beryl, by customs district and country

Customs district and country	1980 Quantity (short tons)	1980 Value (thousands)	1981 Quantity (short tons)	1981 Value (thousands)
Philadelphia district:				
Argentina	--	--	30	$27
Belgium-Luxembourg	--	--	22	10
Brazil	328	$260	248	288
China	640	415	337	256
Hong Kong	--	--	33	35
Mozambique	14	10	--	--
Portugal	44	25	--	--
Rwanda	131	74	22	10
South Africa, Republic of	--	--	79	90
United Kingdom	--	--	40	19
Total	1,157	784	811	735
Los Angeles district:				
Argentina	55	33	−49	51
Brazil	243	190	580	573
China	222	147	616	569
Hong Kong	--	--	5	6
Mozambique	--	--	22	11
Portugal	--	--	20	16
South Africa, Republic of	15	6	18	16
Total	535	376	1,310	1,242
New York City district:				
Brazil	--	--	11	13
South Africa, Republic of	11	8	6	9
Total	11	8	17	22
New Orleans district: Belgium-Luxembourg	--	--	([1])	1
Seattle district: Canada	--	--	([1])	2
Grand total	1,703	1,168	2,138	2,002

[1]Less than 1/2 unit.

WORLD REVIEW

World beryl production remained low in 1981 but demonstrated an upward trend because of slightly increased industrial demand for beryl. Brazil and the U.S.S.R. were the major world beryl producers (table 4). However, China must be considered a significant world beryl producer because of its demonstrated ability to export the mineral.

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

(Short tons)

Country	1977	1978	1979	1980[p]	1981[e]
Argentina	182	[r]24	13	34	33
Brazil	547	815	500	[e]550	600
Kenya	--	--	(2)	(2)	--
Madagascar	[e]17	12	11	11	10
Mozambique	NA	NA	31	22	20
Nepal[3]	1	(2)	(2)	(2)	(2)
Portugal	--	(2)	6	21	20
Rwanda	[e]60	64	51	119	100
South Africa, Republic of	3	4	1	(2)	110
Uganda[e]	50	NA	--	--	--
U.S.S.R.[e]	1,870	1,930	2,000	2,000	2,000
United States[4]	W	W	W	W	W
Zimbabwe[e]	114	39	31	10	10
Total	[r]2,844	[r]2,888	2,644	2,767	2,903

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available. 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 output levels. Table includes data available through Apr. 7, 1982.

[2]Less than 1/2 unit.

[3]Fiscal year ending in July of year stated.

[4]Primarily bertrandite ore.

TECHNOLOGY

Tensile property, formability, and stress relaxation data were presented for an improved mill-hardened beryllium-copper alloy strip that was developed for connector applications. This treated alloy reportedly has superior physical properties and was used to manufacture precision formed pin-and-socket and box receptacle contacts and crimp-fastened terminals.[2]

The stress relaxation characteristics for beryllium-copper and beryllium-nickel alloys were studied at room and elevated temperatures. The alloys were stressed at levels up to 100% of yield strength. Test results were given.[3]

[1]Physical scientist, Division of Nonferrous Metals.

[2]Harkness, J. C. Improved Mill Hardened Beryllium Copper Strip for Connector Applications. Proc. 13th Ann. Connector Symp., Philadelphia, Pa., Oct. 8-9, 1980. Electron Connector Study Group Inc., Fort Washington, Pa., 1980, pp. 129-142.

[3]Filer, E. W., and H. T. McClelland. Stress Relaxation of Copper-Beryllium and Nickel-Beryllium Alloys. Proc. 13th Ann. Connector Symp., Philadelphia, Pa., Oct. 8-9, 1980. Electron Connector Group Inc., Fort Washington, Pa., 1980, pp. 179-186.

Bismuth

By James F. Carlin, Jr.[1]

Domestic consumption and imports of bismuth increased slightly in 1981, while exports declined sharply. The price generally declined, remaining in a low range. Worldwide, a significant oversupply situation remained. Australia remained the leading producer, followed by Mexico and Peru.

Legislation and Government Programs.—Government stocks remained at 2,081,298 pounds, including 567,186 pounds in the national stockpile and 1,514,112 pounds in the supplemental stockpile. The stockpile goal remained at 2,200,000 pounds.

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

Table 1.—Salient bismuth statistics

(Pounds unless otherwise specified)

	1977	1978	1979	1980	1981
United States:					
Consumption	2,379,635	2,511,876	2,727,153	2,288,807	2,392,709
Exports[1]	95,334	96,346	427,809	128,732	78,703
Imports, general	2,013,333	2,657,763	2,167,278	2,217,359	2,436,249
Producer price, average per pound (ton lots)	$6.01	$3.38	$3.01	(2)	(2)
Consumer stocks, Dec. 31	436,092	781,868	629,741	673,975	509,003
World: Production[3] thousand pounds	r9,872	r9,412	r7,573	p7,162	e7,159

eEstimated. pPreliminary. rRevised.
[1]Includes bismuth, bismuth alloys, and waste and scrap.
[2]Domestic producers' list price has been suspended since Oct. 1, 1980.
[3]Excludes the United States.

DOMESTIC PRODUCTION

Bismuth was produced almost entirely from the treatment of lead ores and bullion of both foreign and domestic origin. A single primary refinery operated by ASARCO Incorporated at Omaha, Nebr., accounted for all primary production. Small amounts of secondary bismuth were produced from recycled bismuth scrap materials by several firms, one of which was Metal Specialties Inc., Fairfield, Conn. Refinery production statistics are withheld to avoid disclosing company proprietary data.

CONSUMPTION AND USES

While overall domestic consumption in 1981 increased slightly, the trends in specific usage categories varied. The most severe decline occurred in metallurgical additives where the demand for malleable iron castings continued to decline. The most significant increase in usage occurred in the pharmaceutical category, which also includes chemicals and cosmetics.

Various steel companies continued to experiment with and introduce commercially, new bismuth-bearing steel grades for the free-machining bar steel market.

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

(Pounds)

Use	1980	1981
Fusible alloys	650,895	656,956
Metallurgical additives	467,939	307,028
Other alloys	26,484	25,953
Pharmaceuticals[1]	1,115,615	1,387,554
Experimental	1,197	214
Other	26,677	15,004
Total	2,288,807	2,392,709

[1]Includes industrial and laboratory chemicals and cosmetics.

STOCKS

During the year, consumer stocks reached a 4-year low as high interest rates encouraged liquidation of stocks.

PRICES

Asarco continued suspension of its producer list price throughout the year. The list price of a major foreign producer, published in the metals media late in the year, remained at $2.30 per pound from November through yearend. Dealer quotations started the year at $2 to $2.10 per pound, peaked at $2.50 to $2.60 per pound in March, and then generally declined throughout the year to finish at $1.85 to $1.95 per pound.

FOREIGN TRADE

Exports of bismuth again declined sharply, reaching a 5-year low, owing to the world oversupply situation.

Imports were mainly from Peru, Mexico, and the United Kingdom.

Starting January 1, 1981, the tariff rates for bismuth were unwrought metal (TSUS 632.10), free for most favored nations (MFN) and 7.5% ad valorem (non-MFN); alloys (TSUS 632.66), 8.1% ad valorem (MFN) and 45% ad valorem (non-MFN); compounds (TSUS 418.00 and 423.80), 12.3% ad valorem (MFN) and 35% ad valorem (non-MFN).

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

(Pounds, gross weight)

Country	1980		1981	
	Quantity (pounds)	Value (thousands)	Quantity (pounds)	Value (thousands)
Argentina	3,185	$21	2,500	$10
Belgium-Luxembourg	17,630	55	7,444	43
Brazil	--	--	10,586	46
Canada	70,551	444	16,269	171
Colombia	570	6	--	--
Denmark	400	3	430	1
Dominican Republic	400	1	--	--
France	101	4	11,996	55
Germany, Federal Republic of	940	44	459	2
Greece	8,158	28	--	--
Hong Kong	--	--	1,006	6

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

(Pounds, gross weight)

Country	1980 Quantity (pounds)	1980 Value (thousands)	1981 Quantity (pounds)	1981 Value (thousands)
India	3,500	$15	1,789	$14
Ireland	--	--	6,451	37
Israel	784	7	1,508	6
Italy	569	2	579	12
Japan	1,293	6	4,180	23
Korea, Republic of	209	6	287	1
Leeward-Windward Islands	840	2	--	--
Mexico	45	2	1,308	4
Netherlands	4,400	12	--	--
Saudi Arabia	2,460	5	--	--
Singapore	331	7	1,224	6
South Africa, Republic of	5,176	197	4,905	187
Sweden	926	14	--	--
Taiwan	--	--	705	16
Thailand	250	2	3,086	28
United Kingdom	5,345	31	853	7
Venezuela	313	13	429	13
Other	r356	r15	709	20
Total	128,732	942	78,703	708

rRevised.

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

Country	1980 Quantity (pounds)	1980 Value (thousands)	1981 Quantity (pounds)	1981 Value (thousands)
Belgium-Luxembourg	88,224	$31	156,868	$328
Canada	80,640	197	41,740	94
Germany, Federal Republic of	158,778	563	77,162	172
Israel	820	2	--	--
Japan	138,378	339	124,093	262
Korea, Republic of	9,692	21	37,556	72
Mexico	860,363	2,008	724,052	1,309
Peru	619,091	1,416	859,325	1,605
Poland	3	1	--	--
Spain	331	2	--	--
United Kingdom	261,039	784	415,453	1,041
Total	2,217,359	5,364	2,436,249	4,883

[1]General imports and imports for consumption were the same in 1980 and 1981.

WORLD REVIEW

World production of bismuth continued the decline evident since 1977. This was primarily due to planned production reductions in response to the continued decline in the bismuth market price.

Australia.—Australia remained the leading world producer. The main source of bismuth was a gold-bismuth bullion from the Mount Isa Mine in Queensland, which was shipped to Europe for bismuth recovery and refining.

Korea, Republic of.—The principal producer of bismuth metal in Korea was Korea Tungsten Mining Co., Ltd. The firm's bismuth production was a byproduct of tungsten mining from the Sangtong Mine in Kangwong Province. The refinery was located in Daegu.

U.S.S.R.—Bismuth was recovered as a byproduct of lead and zinc smelting in Kazakhstan and other regions, from dust and crude metal at the Balkhash, Kirovgrad, and Mednogorsk complexes, and from tungsten and molybdenum ores. Two copper-bismuth deposits, Taryzkan and Kantarkhana, were under exploitation in Tadzhikistan. The Ustarassy Mine in the Chatkal Mountains was the only enterprise mining bismuth ore, and its concentrates were sent to the Chimkent lead refinery in Kazakhstan for processing.

[1]Physical scientist, Division of Nonferrous Metals.

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

(Thousand pounds)

Country[2]	1977	1978	1979	1980[p]	1981[e]
Australia (in concentrates)	2,054	2,324	[e]2,200	[e]2,000	1,870
Bolivia (in concentrates)	1,435	677	22	24	25
Canada[3]	363	320	301	328	[4]271
China (in ore)[e]	500	530	570	570	570
France (metal)	[r]115	([5])	([5])	([5])	([5])
Germany, Federal Republic of (in ore)[e]	24	20	22	22	22
Japan (metal)[6]	1,538	1,375	1,010	745	990
Korea, Republic of (metal)[3]	293	269	192	271	220
Mexico[7]	1,607	2,156	1,662	1,698	1,390
Peru[7]	[r]1,420	[r]1,347	1,162	950	1,200
Romania (in ore)[e]	180	180	180	180	180
Sweden (in ore)[e]	[r]33	[r]33	31	31	31
Uganda (in ore)[e]	7	2	11	NA	NA
U.S.S.R. (metal)[6] [e]	140	150	160	160	165
United States (in ore)	W	W	W	W	W
Yugoslavia (metal)[6]	163	29	50	183	225
Total	[r]9,872	[r]9,412	7,573	7,162	7,159

[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. 8, 1982.

[2]In addition to the countries listed, Brazil, Bulgaria, 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]France terminated metallic bismuth production in 1977. The solitary French mine that has produced bismuth in prior years continued to operate through 1980 and may have operated in 1981, but whether bismuth was recovered at all, and if so where and in what form is unknown.

[6]Although output reported is at the smelter stage of production rather than at the mine stage, and thus could include metal contained in ores mined in other countries, it is believed that any such production derived from ores from other countries is not duplicative to any significant extent of mine production reported elsewhere in this table.

[7]Bismuth content of refined metal, bullion, and alloys produced indigenously, plus recoverable bismuth content of ores and concentrates exported for processing.

Boron

By Phyllis A. Lyday[1]

Boron compounds and minerals sold or used by primary producers in the United States decreased to 230,000 short tons of boron content during 1981. This was the second consecutive decrease since the 1979 record of 248,000 short tons of boron content.

Domestic availability of boron minerals in Federal land increased during 1981. A moratorium from 1976 to 1980 prohibited surface disturbances in the Death Valley National Monument (DVNM), which has had historical significance as a boron area since 1883 when 20-mule teams carried boron minerals from the Harmony Mine across Death Valley. Two companies were granted permits to drill to delineate reserves in DVNM during 1981. The Lake Meade National Recreation Area (LMNRA), with reserves of 1.5 million tons of colemanite in the Anniversary Mine claim, was opened to hard-rock mining during the year.

Interest in overseas boron also increased as several U.S. companies conducted feasibility studies of South American deposits. The Turkish Government continued to manage the boron mines and sought to establish joint venture mining operations with foreign and domestic companies.

Research has increased the usage of boron as a hardener and grain refiner in specialty steels and alloys. Boron in the form of textile-grade fiberglass has become a lightweight, high-tensile-strength, and noncorrosive replacement for metal. Boron in silicon chips for use in electronics increased because of its magnetic and electrical properties. Research on the use of boron as a fuel continued.

Legislation and Government Programs.— Discharge prior to 1977 from ash ponds of a thermal powerplant in Illinois caused water quality in the Wood River to exceed the 1.0-milligram-per-liter of boron water quality standard.[2] Further studies on rats found growth suppression at levels of boron in water greater than 150 milligrams per liter. A safe tolerance of boron has been suggested to be as low as 0.5 milligram per liter.[3]

The Environmental Protection Agency recommended that an emission standard for borax and boric acid not be developed. Borax and/or boric acid have been identified as having a potential to contribute to air pollution. The proposed regulation would have only affected new and modified boron refining and processing facilities.[4]

Final rules issued for four national recreational areas (NRA) relaxed rules formerly proposed by the Bureau of Land Management (BLM) and the National Park Service (NPS) in December 1980, and kept LMNRA open to hard-rock mining. LMNRA has boron reserves of 1.5 million tons of colemanite averaging 26% B_2O_3 at the Anniversary Mine claim. Areas closed to mining are the same as those in other NRA's. The BLM would need the consent of the NPS regional director before it could grant a lease or permit. Veto of a lease or permit by a regional director would be permitted only if the operation would have a significant adverse effect on the resource or administration of the area.[5]

During 1981, American Borate Co. (ABC) and U.S. Borax & Chemical Corp. (USB) obtained permission from the regional director of the NPS to do exploration drilling on claims in DVNM. The drilling was to explore and delineate borate claims. ABC drilled the Sigma claim, and USB drilled the White Monster claim.

A study of the biological effects of manmade vitreous fiber showed no chronic progressive diseases by inhalation of manmade fibers in animal studies. Therefore, fiberglass is not likely to come under Federal regulations. The dimensions of the manmade fibers overlap the dimensions of the larger asbestos fibers.[6]

Table 1.—Salient statistics of boron minerals and compounds in the United States

(Thousand short tons and thousand dollars)

	1977	1978	1979	1980	1981
Sold or used by producers:					
Quantity:					
Gross weight[1]	1,469	1,554	1,590	1,545	1,481
Boron oxide (B_2O_3) content	735	778	799	783	740
Value	$236,163	$279,927	$310,211	$366,760	$435,387
Exports:					
Sodium borates (refined):[2]					
Quantity	265	304	332	325	228
Value	$64,634	[e]$80,000	[e]$94,000	[e]$65,000	[e]$58,000
Boric acid:[3]					
Quantity	36	46	42	[r]47	46
Value	$12,931	$22,217	$22,938	$23,735	$24,602
Imports for consumption:					
Colemanite:					
Quantity	51	[r 4]104	[r 4]89	[r 4]69	[4]98
Value	$3,695	$9,320	$10,946	$6,218	$15,202
Boric acid:					
Quantity	14	16	8	10	1
Value	$5,596	$8,921	$4,267	$6,393	$763
Consumption: Boron oxide (B_2O_3) content[5]	389	413	410	384	373

[e]Estimated. [r]Revised.

[1]Minerals and compounds sold or used by producers, including both actual mine production and a marketable ore 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 33,100 tons of ulexite in 1978, 11,000 tons in 1979, 5,500 tons in 1980, and 44,000 tons in 1981.

[5]See table 2.

DOMESTIC PRODUCTION

Domestic producers reported that boron minerals, for sales and use, decreased in boria content but increased 19% in value during 1981 compared with those of 1980. The majority of the output continued to come from Kern County, Calif., and to a smaller extent from San Bernardino and Inyo Counties, Calif.

ABC, a wholly owned subsidiary of Owens-Corning Fiberglas Corp. (OCF), completed development of the drifts in the Billie Mine in DVNM. During 1981, production and value of boria increased 17% and 69%, respectively, over those of 1980. The problems associated with water control were solved using surface and underground evaporative lakes that controlled the 50-gallon-per-minute flow of water into the mine. ABC was given approval by the NPS to drill in DVNM to explore and delineate the Sigma 30 and Sigma 31 borate claims. With the increase in mine production, the mill at Lathrop Wells, Nev., was expected to increase production from 2,000 tons per month to 6,300 tons per month during 1982.

During 1981, Corning-Glass Works (CGW), a major producer of borosilicate glass, announced plans to sell 23.9% of OCF. OCF is a major consumer of borates for use in textile-grade fiberglass and fiberglass insulation. An antitrust decree, entered in 1949 and modified in 1978, prohibits CGW from exercising control over OCF. The order also required divestiture of 90% of CGW's stock shares by 1986. CGW was expected to meet the consent decree by exchanging OCF stock shares for CGW stock in a tax-free transaction.

Kerr-McGee Chemical Corp. (KM) produced boron compounds as a byproduct of potash and sodium production in San Bernardino County, Calif. KM operated the Trona and Westend chemical plants at Searles Lake. Mineral-rich brines from borate deposits in the lake are processed into borax, anhydrous borax, and boric acid. Specialty products are produced at Henderson, Nev. During 1981, sales of borates decreased in boria quantity but increased 9% in value over that of 1980. KM owned 6,169 acres of mineral land on Searles Lake and leases an additional 15,000 acres from the U.S. Government.

At Boron, in Kern County, Calif., USB, a member of the Rio Tinto Zinc Corp. Ltd. of London, was the world's primary source of boron. Crude sodium borate, refined sodium borate, boric acid, and their anhydrous varieties are processed at the mine site. High-purity and specialty products continued to be produced at Wilmington, Calif., and Burlington, Iowa. Wilmington also served as the company's warehouse and port of export for bulk shipments.

The 200,000-ton-per-year boric acid plant at Boron reached full production in April. The new process designed by USB could continuously process raw-sodium borate ore (kernite) without the waste disposal problems that plagued the Wilmington plant. The Wilmington plant, in Los Angeles County, stopped producing boric acid in June.

Crude and refined sodium borates continued to be produced from sodium borate ore (tincal). The ore-to-waste ratio increased from 1:4 in 1977 to 1:5.8 in 1980.[7]

USB decreased output and sales of primary borate products in 1981 from that of 1980. Value increased 20% over that of 1980. Output of refined decahydrate, pentahydrate, and anhydrous borax for domestic and foreign customers accounted for about 48% of the company's total sales. Crude sodium borate, Rasorite 46 (a pentahydrate) and its anhydrous derivative, which is produced exclusively for foreign markets, accounted for about 41% of the company's total sales. A large percentage of USB's exports was shipped to Europe via a warehouse and distribution facility at Botlek, near Rotterdam, Netherlands.

At yearend, USB announced preliminary plans to construct a cogeneration plant at Boron in cooperation with Southern California Edison. The plant is scheduled to be in operation by 1984.

Late in 1981, USB obtained permission from the NPS to begin drilling on the White Monster claim in DVNM to delineate reserves. Other exploration included areas in southern California and Nevada.

Duval Corp. conducted a test project to recover colemanite by solution mining near Barstow, Calif. Duval leases some of the land from N. L. Industries, Inc., which mines hectorite on adjacent property. The colemanite is located 1,200 feet below the surface and contains 8% to 14% boria.

The State of California required Great Western Cities, a subsidiary of Hunt International Resources Co., to drill 11 holes near California City to determine if borates existed under land that was being developed for housing. The land in question showed a magnetic anomoly similar to the Boron pit, which is located approximately 7 miles to the south. The holes, drilled from 750 to 1,400 feet deep, failed to prove the presence of boron.

Other U.S. companies were involved in domestic boron programs during 1981. Johns Manville Corp. discontinued its exploration program at yearend. Anaconda Copper Co. conducted a reconnaissance program of the United States and sought joint ventures with existing companies. Occidental Petroleum Corp. continued to hold leases on the shores of Searles Lake but had no plans to process the brines for boron.

CONSUMPTION AND USES

Domestic consumption of boron minerals and compounds are shown in tables 2 and 3. U.S. consumption of boron minerals and compounds during 1981 decreased from that of 1980. Insulation products and textile-grade glass fibers continued to be the most important consuming sectors.

Boron compounds found applications in many areas of industry. In metallurgy, boron is used as a flux and is added to hot metal to reduce grain size and improve metallurgical homogeneity. During 1981, boron was used in the production of 456,251 tons of steel alloys.[8]

The largest growth area is glass fibers used to reinforce plastic, rubber, and paper. Boron fibers are being used in epoxy-based composites for uses previously reserved for steel and reinforced plastics. Fiberglass fabricated applications included mining, petrochemical, and electrical generating industries. Fiberglass tanks are used for metallurgical extraction, processing, environmental control, and storage, and are competitive with stainless steel. Fiberglass fabricated filtration systems in baghouses are used as pollution controls. Glass fibers are used as batts, blankets, and boards in acoustical and heating insulation material. One of the advantages of fiberglass is that it does not generate toxic products when burned.

Boron compounds in cleaning and bleaching have been an important but declining sector of consumption. During 1981, E. I. du Pont de Nemours & Co. (Du Pont) was the sole domestic producer of sodium perborate. FMC Corp. closed its Buffalo, N.Y., plant in August 1980. It was reported that 100 million pounds of sodium perborate tetrahydrate is produced annually at Du Pont's plant in Memphis, Tenn. Imports from Europe are reported to supply 20% of the U.S. market. The detergent market represents approximately 90% of sodium perborate demand in the United States. The remaining 10% is reportedly used in textiles.[9]

Boron nitride (BN) is an unctuous, highly refractory material with excellent thermal insulation properties and chemical stability. It is not wettable by most metals, glass, cryolite, or other materials. Uses include crucibles, chemical equipment and pumps, rocket nozzles, vacuum tube separators, seals and gaskets, and as a neutron absorber. It is also useful as a mold lubricant in glass manufacturing. A cubic form of BN has been made harder than a diamond and is used as an abrasive.[10]

Boron carbide is used in abrasive and abrasive-resistant applications. Boron carbide is second only to the diamond on Moh's scale of hardness and is chemically inert. As an abrasive, boron carbide is used for ultrasonic grinding and drilling and fine polishing. Boron carbide and elemental boron are used for nuclear reactor control elements, radiation shields, and moderators.[11]

Boron compounds find application in the manufacture of biological growth control chemicals for use in water treatment, algicides, fertilizers, herbicides, and insecticides.

Many important end uses for borates and boron-containing chemical derivatives are placed in the miscellaneous category. Another group of borate compounds were sold to chemical distributors, and their ultimate uses are unknown.

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

(Short tons of boron oxide content)[1]

End use	1980	1981
Glass-fiber insulation	89,400	103,500
Fire retardants:		
Cellulosic insulation	50,200	34,300
Other	1,300	2,800
Textile-grade glass fibers	50,400	57,500
Borosilicate glasses	44,800	44,000
Soaps and detergents	26,600	29,100
Enamels, frits, glazes	13,300	11,700
Agriculture	15,700	16,600
Metallurgy	6,600	6,800
Nuclear applications	500	400
Miscellaneous uses	48,300	25,400
Sold to distributors, end use unknown	36,900	40,500
Total	384,000	[2]372,700

[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	1980[r]	1981
Fire retardants:		
Cellulosic insulation[1]	24,960	13,974
Other	1,524	1,284
Textile-grade glass fibers	17,750	17,154
Borosilicate glasses	5,725	9,654
Metallurgy	993	1,485
Soaps and detergents	116	111
Enamels, frits, glazes	793	780
Nuclear applications	459	300
Agriculture	113	84
Miscellaneous uses	14,483	14,188
Sold to distributors, end use unknown	14,792	15,678
Total	81,708	74,692

[r]Revised.
[1]Includes imports of 9,939 and 629 tons in 1980 and 1981, respectively.

PRICES

At the beginning of the year, prices for basic boron compounds rose between 6% and 15%. Specialty compounds increased between 16% and 20%. By yearend, prices were effectively the same. The reason for the price increases was attributed to rising energy, labor, and material costs. Prices for boron minerals and compounds are shown in table 4.

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

Product	Price, Dec. 31, 1981 (rounded dollars)
Borax, technical, anhydrous, 99%, bulk, carlots, works[2]	501-508
Borax, technical, granular, pentahydrate, 99.5%, bulk, carlots, works[2]	186
Borax, technical, granular, decahydrate, 99.5%, bulk, carlots, works[2]	162
Boric acid, technical, granular, 99.9%, bulk, carlots, works[2]	511
Boric acid, technical, granular, 99.9%, bags, carlots, works[2]	571
Boric acid, U.S. Borax & Chemical Corp., anhydrous, 96% B_2O_3, bulk, carlots, Boron, Calif	966
Colemanite, American Borate Co., calcined and screened, minus 70-mesh, 42% B_2O_3, bulk, carlots, Dunn, Calif	414
Colemanite, American Borate Co., flotation concentrate (uncalcined), 37% B_2O_3, bulk, carlots, Dunn, Calif	290
Colemanite, Turkish, 40%-42% B_2O_3, crude, lump, f.o.b. railcars, U.S. east coast port	325-350
Ulexite-probertite, American Borate Co., screened, minus 7-mesh, 21% B_2O_3, bulk, carlots, Dunn, Calif	52

[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. V. 220, No. 26, Dec. 28, 1981, p. 29.

FOREIGN TRADE

In 1978, the U.S. Bureau of the Census discontinued publishing export statistics on refined sodium borate compounds. Export data from a Bureau of Mines canvass are presented in table 5.

U.S. exports of boric acid decreased in quantity but increased in value during 1981. Exports of refined sodium borates decreased 30% in quantity in 1981 over those of 1980. Because there is only one producer of crude sodium borates for export, these data are withheld. During 1981, unusually small quantities of sodium borates were exported to the Netherlands, which is a major transshipment point for Europe. The change was attributed to large industry stocks in Europe that were being used and not replenished. The increased availability of boric acid from the United States and Turkey and a decrease in usage of borates, as a result of a world economic recession, made it uneconomical for companies to maintain large stockpiles of raw borate materials.

During 1981, OCF through ABC imported colemanite and ulexite from Turkey, principally for use in textile-grade and insulation-grade glass fiber. Imports increased 42% in 1981 over those of 1980. The increase was primarily a result of the improved Turkish economy since the 1978 military takeover of the Government, which stopped the frequent strikes that had hampered productivity.

Table 5.—U.S. exports of boric acid and refined sodium borate compounds in 1981, by country

Country	Boric acid[1]		Refined sodium borates[2] (short tons)
	Quantity (short tons)	Value (thousands)	
Argentina	--	--	1
Australia	2,745	$1,740	7,677
Austria	--	--	352
Bangladesh	64	42	--
Belgium-Luxembourg	119	42	6,275
Brazil	3,104	1,377	13,004
Cameroon	--	--	66
Canada	8,505	4,185	19,789
Chile	18	17	351
China	2	2	2
Colombia	473	299	2,305
Costa Rica	8	6	1,106
Czechoslovakia	--	--	2,022
Denmark	170	100	156
Dominican Republic	--	--	11
Ecuador	8	6	137
El Salvador	2	2	44
Finland	21	10	470
France	747	449	14,115
French Polynesia	20	12	--
German Democratic Republic	--	--	2,308
Germany, Federal Republic of	7	14	12,571
Greece	--	--	44
Guatemala	9	7	53
Honduras	24	9	--
Hong Kong	273	160	3,136
India	--	--	3
Indonesia	100	63	3,023
Ireland	--	--	14
Israel	82	42	4,967
Italy	--	--	7,949
Ivory Coast	7	2	--
Jamaica	--	--	6
Japan	15,435	9,215	52,121
Kenya	--	--	1
Korea, Republic of	998	516	7,811
Liberia	52	31	--
Malaysia	59	42	978
Mexico	6,990	3,064	26,431
Morocco	--	--	33
Netherlands	56	74	2,635
New Guinea	326	179	206
New Zealand	967	457	3,556
Nigeria	93	33	55
Norway	--	--	336
Pakistan	101	93	516
Peru	1,000	556	109
Philippines	577	347	1,293
Portugal	--	--	332
Puerto Rico	--	--	53
Saudi Arabia	17	6	--
Sierra Leone	2	(3)	--
Singapore	179	87	1,012
South Africa, Republic of	76	66	6,403
Spain	--	--	2,488
Sri Lanka	495	18	402
Sweden	--	--	332
Switzerland	--	--	1,122
Taiwan	1,028	514	5,979
Tanzania	--	--	3
Thailand	161	95	1,207
Trinidad and Tobago	--	--	2
Tunisia	3	1	--
United Kingdom	--	--	7,495
Uruguay	376	204	118
Venezuela	685	419	1,738
Yugoslavia	--	--	435
Zambia	--	--	143
Zimbabwe	--	--	241
Total	46,184	[4]24,602	227,543

[1]Source: U.S. Bureau of the Census.
[2]Source: U.S. exporters of sodium borates.
[3]Less than 1/2 unit.
[4]Data do not add to total shown because of independent rounding.

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

Country	1980 Quantity (short tons)	1980 Value[1] (thousands)	1981 Quantity (short tons)	1981 Value[1] (thousands)
Argentina	1,210	$708	--	--
Belgium	40	24	--	--
Brazil	60	35	--	--
Canada	41	36	(2)	$1
Chile	6	2	--	--
China	146	86	--	--
France	3,184	2,143	1,123	757
Germany, Federal Republic of	(2)	5	(2)	4
Italy	1,607	1,031	--	--
Japan	--	--	(2)	1
Mexico	(2)	(2)	--	--
Netherlands	40	24	--	--
Romania	66	31	--	--
Singapore	65	40	--	--
Spain	377	219	--	--
Turkey	2,270	1,356	--	--
U.S.S.R	707	587	--	--
United Kingdom	(2)	(2)	(2)	1
Yugoslavia	119	64	--	--
Total[3]	9,938	6,393	1,124	763

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

Source: U.S. Bureau of the Census.

WORLD REVIEW

Chile.—Drilling at Solar de Pedernales, 31 miles north of El Salvador, confirmed deposits of lithium, potassium, and borax. Salt deposits extend between 43 and 92 feet.[12]

At Maria Elena, boric acid is recovered as a byproduct of nitrate and iodine production. Some ores containing borax interfere with iodine purification. Boric acid had been recovered when the price was favorable by acidifying the mother liquor prior to iodine extraction. The extraction of borax directly from solutions, using kerosine as the carrier for a suitably selected extractant, has been studied at a pilot scale, but has not been practiced industrially.[13]

Sociedad Chilena de Litio, Ltda. (SCL), has 12 million short tons of boron reserves at Salar de Atacama in Antofagasta Province. SCL is owned by Corporación de Fomento de la Producción (45%) and Foote Mineral Co. (55%). International tenders were being sought for a 31,000-ton-per-year boric acid plant.[14]

China.—Chaerhan Lake, a 2,000-square-mile dry lake in the Qaidam Basin has a 100-foot thickness of brines that contain boron. Total reserves have been estimated at 67,000 short tons of boron, lithium, and potash. The lake is located 2,500 miles west of Peking in Qinghai Province. Jacobs Engineering Group has received a contract to prepare a study for a facility on the 100-mile-long lake.[15]

Three kinds of borosilicate glass—ampul tubing and laboratory ware, chemical plant piping, and pharmaceutical containers—were produced in the Peking technical glass factory in Peking. The plant has 1,500 workers and uses 6 furnaces fired by gas. The plant operates under the Ministry of Light Industries (MLI).

The Yao-Hua glass works in Shanghai, which operates under the Ministry of Building Materials, produces E glass marbles for fiberglass, draws continous filament glass, spins thread, and weaves fiberglass cloth. The cloth is primarily for electrical laminates. The boron comes from borax mines in western China. There is also a second plant that produces continuous-strand fiber for reinforcing and/or textile operations. The second plant contains a furnace and six machines producing E glass marbles and has an output of 27 tons per day. Glass fiber was produced from 200 bushings having no more than 104 fibers per bushing. A large addition was in the construction stage.

Peking Glass Research Institute operates under the MLI and has 600 workers. One area of research was glass fibers for fiber-optic face plates.[16]

Japan.—Production of glass wool in 1979 was reported to be 299,166 tons. This was a 214% increase in production since 1970. Usage was reported to be in thermal insulation of buildings. Usage of borates for glass wool in 1979 was 29,401 tons of borax and 7,743 tons of boric acid.[17]

The Japanese Government's Nuclear Research Organization set 1987 as the planned date for disposal of high-level radioactive waste encased in borosilicate glass.[18]

Mexico.—In addition to the occurrence of howlite at Magdalina, boron occurrences have been found at other locations in the State of Sonora, including a national reserve area near Tubutama. Drilling for borates in the State of Sonora continued. Under Article 27 of the Mexican mining code, foreign investment in local mining companies is restricted to 49%. Foreign ownership in mining ventures involving national reserve lands is restricted to 34%.

Netherlands.—In February, Van Geldera-pier (Amsterdam) joined with OCF to form Van Gelder Owens-Corning VOP (VGOC). In September, OCF acquired full ownership of the joint venture agreement. VGOC will manufacture nonwoven glass-fiber mat for the European market. Annual capacity of some million square yards will be operational by mid-1982.[19]

Imports of borates from the United States totaled 418,000 short tons in 1979 and 454,000 short tons in 1980. Imports from Turkey during 1979 and 1980 was 5,000 and 14,000 short tons, respectively.[20]

Peru.—A deposit of ulexite, a sodium-calcium borate, occurs in Laguna Salinas, 53 miles east of Arequipa. The occurrence is located 14,000 feet above sea level and was first claimed in 1883. Borax Consolidated, Ltd., mined the deposit from 1926 until 1974. Boratos del Peru S.A. began mining in 1975. Barex, Ltd., has acquired the mining rights. Another company, Boroquimica S.A., also produces ulexite at Laguna Salinas. The ulexite is used locally for glass production and for export.

The borate in the deposit is found in discontinuous beds of variable thickness ranging from 40 centimeters to 1 meter. Part of the lake is underwater year round because of the impermeability of the borate beds. The deposit contains 10% to 23% boria. Mining is done by a backhoe and the ore is handpicked to upgrade it to 35% boria.

Romania.—A 2,700-short-ton glass-fiber plant was under construction. No further details were available.[21]

Switzerland.—Borax, S.A., and Minmet Financina traded boron minerals at Lausanne during 1981. During 1980, it was reported that 57,000 short tons of borates was imported and 11,300 short tons was exported.[22]

Turkey.—The most significant chemical feedstocks produced in Turkey were boron materials. Turkey continued to be the world's second largest producer of boron minerals and the world's largest resource base. Etibank, a State Economic Enterprise responsible for Government boron activities, ran three colemanite and one tincal mine.

The Turkish Government offered compensation to the boron mine operators for their investments, which were nationalized in a 1978 decree and put under Government management in 1979. The compensation did not include the value of the mineral reserves, which have long been considered Government property.

The Council of Ministers decreed on June 9, 1980, that the nationalized mines would be returned to the original operators. On June 27, 1980, the Supreme Administrative Court (Danistay) issued an order to halt the Council of Ministers decree. Private sector participation was limited to exports of boron ore.

During 1981, Etibank sought to establish joint-venture mining operations with both domestic and foreign companies. Foreign capital participation must be at least 10% but cannot exceed 49%, and minimum participation should be $1.0 million.

U.S.S.R.—The 14,000-short-ton glass-fiber plant in Polotsk near Minsk continued in the planning stage. The process was being planned by Bishop.[23]

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

(Thousand short tons)

Country	1977	1978	1979	1980[p]	1981[e]
Argentina	[r]91	140	147	172	180
Chile	5	29	3	4	3
China[e]	30	30	30	30	30
Peru[e]	[r]6	[r]7	13	23	18
Turkey	1,211	1,455	1,036	1,097	1,320
U.S.S.R.[e]	200	220	220	220	220
United States[2]	1,469	1,554	1,590	1,545	[3]1,481
Total	[r]3,012	[r]3,435	3,039	3,091	3,252

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through May 5, 1982.
[2]Minerals and compounds sold or used by producers, including both actual mine production and a marketable ore equivalent of brine products.
[3]Reported figure.

TECHNOLOGY

A fiberglass composite was introduced that used a combination of fiberglass strands, swirled strands, and a resin. There is a potential for reduced waste and improved in-house cleaning because the process involves no chopped fibers.[24]

Growth of textile-grade glass fibers for manufacturing high-tensile-strength glass-fiber composites continued for use in a range of products that include a large segment of vehicles for transportation. The desire to lower vehicle weight and increase gasoline mileage has contributed to the demand in the automotive sector. An advantage to the fiberglass composite is the use of injection molding. The injection molded plastic is polished once by polishing the mold. Chrome can be plated onto the reinforced plastic to give a look equivalent to a metal.[25]

A 70% continuous-strand glass-fiber spring in General Motors' Corvette automobile won the Materials Engineering Grand Design Award. The 8-pound spring achieved an 80% savings over the steel version.[26] The fiberglass-reinforced car has brought electric-powered transportation a step closer to reality. The lightweight vehicle uses a fiber-reinforced composite fifth wheel that serves as a power link between two electric motors and the car's rear axle.[27]

A plastic bicycle, injection-molded of glass-filled polyester, was planned for production in Sweden. Iter Development Center (Sweden) planned to manufacture the components, which included wheels, frame, forks, handlebars, package carriers, pedal crank arms, and fenders. The bicycles are easy to maintain and are 20% lighter than steel bicycles.[28]

Epoxy resins and fibers of boron, aramid, and graphite comprise the entire structure of a new jet plane, the Lear Fan. By using composites, weight savings of 30% to 40% of the equivalent use of metals can be achieved. The prop jet can transport eight people 2,300 miles at speeds up to 400 miles per hour.[29]

OCF entered into an agreement with the Ohio Transportation Department of test road signs made of glass-fiber reinforced composites. Advantages of the glass-fiber components over conventional aluminum are the ability to withstand damages from collision and corrosion.

Fiberglass yarns coated with Teflon resins were being used in high-temperature fluid-sealing components. The yarns exhibit characteristics of strength, durability, resilience, conformability, and absorption.[30]

Fiber-optics research continued for use in communication cables. Optical fiber conveys signals by light rather than by electricity. The fiber optics take less space than a copper cable, but costs are too high to replace commonly used copper wire. A pair of glass fibers can carry as many as 672 voice messages simultaneously. Copper wire can carry only one voice message per wire, or two per pair. A single strand of optical fiber can transmit signals in two directions at the same time. The light used with the signals is invisible; therefore, stray light does not interfere with signals.[31]

A glass-fiber cloth that can be used up to 1,000° F as a welding curtain, slow cool blanket, and heat shield was developed. The nontoxic cloth meets or exceeds the Occupational Safety and Health Administration requirements and is reported to be six times stronger than asbestos cloth.[32]

The Columbia Space Shuttle used borosilicate glazed tiles to protect the vehicle during reentry. Various special glasses are reported to make up a total of 70% of the Columbia's outer surface area. The thermal protection system (TPS) of the space shuttle Orbiter differs from previous metallic shields in that it is reusable. The TPS uses reinforced boron carbon and silicon dioxide tiles with borosilicate glass coating. The TPS is a high temperature surface insulation and a heat radiator. The black high temperature reusable surface insulation and the white low temperature reusable surface insulation both use an amorphous silica-fiber composite structure with a borosilicate glass coating system. The three main engines in the aft are attached to a titanium thrust structure that is reinforced with boron-epoxy composites; the titanium structure distributes thrust load to an aluminum structure.[33]

Studies continued on using boric acid as a smolder retardant glass fiber in flame retardant uses. Boric acid is a conventional smolder-retardant additive. Studies at the National Bureau of Standards continued on the smoldering capability of cellulosic, loose-fill insulation. About 80% of residential fires involve deaths due to smoke inhalation.

Chemical companies continued research to develop a fire-resistant mattress and box springs to reduce deaths attributable to smoke inhalation. The U.S. Fire Administration reported that 40% of all residential deaths occur from fires that ignite in and around mattresses. OCF, Burlington Industries, and Martin Galex have introduced a nonflammable ticking fabric called Sandel that does not ignite or smoke when exposed to flames. The Sandel is made of glass-fiber yarn and is waterproof and stain-resistant.

A new family of flame-retardant glass-reinforced nylons was developed for use in electrical and electronic applications.[34]

A hetrocyclic boron-containing molecule inhibits lipopolysaccharide synthesis of gram negative bacteria. The molecule acts as an antibacterial agent that blocks the biosynthesis of the bacteria.[35]

Rapid production of solidified alloys was achieved by spraying liquid metal into high-speed jets of helium gas or dropping a thin column of liquid on a spilling, water-cooled wheel. Metallic glasses can withstand cyclic stress, high temperatures, intensive neutron bombardment, and helium gas damage and can be magnetized easily with low magnetic losses. Rapid solidification technology is an important part of the Government's strategic material program. Metallic glass alloys have demonstrated an ability to reduce U.S. dependency on imports of cobalt, chromium, tantalum, and other critical elements.[36]

Ductile glassy ribbons of ferrous alloys, incorporating boron and known as metallic glasses, have been found to combine outstanding strength and toughness, biaxial strength, high corrosion resistance, very low accoustical attenuation, high electrical resistivity, great ease of magnetization, and inexpensive processing into wires and strips as well as ribbons. Direct quench casting on a continuous basis makes it possible to produce large quantities quickly. Long life expectancy of key parts is an important cost element in its manufacture. Resistance is only by the viscosity of the liquid metal, which reduces the energy consumption by a factor of four to five.

Because metallic glass resists chloride and sulfate solution, it is attractive for marine cables, naval aircrafts, control cables, chemical filters, reactors, electrodes, and other chemical engineering components. Ferrous glasses are easily magnetized and manufactured and should be suitable for motors, generators, transformers, amplifiers, switches, memory recording heads, etc.[37]

Dopants were added to silicon chips for use in random access memory for electronics. Boron (one of the dopants) was added in the form of gases (diborane), liquids (boron tribromide), and solids (boron nitride).[38]

Addition of boron in the form of KBF_4 and titanium in the form of K_2TiF_6 as a grain refinement in aluminum alloys was studied. The master alloy contains up to 1% boron and 5% titanium. The addition of boron and titanium makes it possible to obtain a suitably strong grain refining effect.[39]

Boron was chosen for a precipitation-hardening component in alloys containing nickel and chrome. Boron reduces the swelling tendencies when the alloy is used in a liquid metal fast-breeder reactor.[40]

Research was conducted on adding boron in an attempt to change the charge-carrier concentrations of silicon carbides. Reaction-bonded silicon carbides have found extensive application in wear-resistant parts. They are also prime candidates for ceramic gas-turbine components because of good oxidation resistance at high temperatures. At room temperature, the addition of boron to silicon carbide reduces thermal conductivity significantly and increases the electric conductivity by a factor of 100. At high temperatures, the material converges to the undoped thermal and electrical conductivity values.[41]

Titanium-boron was used to coat multistrand graphite filament. Studies deposited titanium-diboride by a chemical-vapor-deposition process. The coating provided excellent erosion resistance.[42]

Borides were tested by the Bureau of Mines Research Center at Tuscaloosa, Ala., as a structural material for gas turbines. New techniques to prepare the powder involve chemical preparation, vapor-phase techniques, and salt decomposition.

A nickel catalyst containing boron was used to promote the conversion of carbon monoxide into methane. The advantage of using this new catalyst over other catalysts was greater resistance against poisoning by sulfur compounds.[43]

A suitable barrier for high-level radioactive waste has been intensively researched. Certain liquid military waste will be solidified into either glass or ceramic. Borosilicate glass was one of the two processes that were considered the most effective. In the glass process, water components and glass-forming additives, such as boron oxide and silicon oxide, are smeltered together. The glass process is tolerant of a wide variety of waste forms.[44]

A fiberglass nuclear-fallout shelter that absorbs blast and seismic shocks was manufactured. The shelter provided 100 times more protection from residual radiation than an average house.[45]

Carborundum combines the mechanical properties of stainless steel with the neutron absorption properties of boron carbide. Spent nuclear fuel is now stored in pools of borated stainless steel or boron carbide. Boron carbide must be used as a matrix in tougher materials because of its brittle failure mode. Carborundum shows high thermal neutron capture cross section, a high melting point, chemical stability, high boron-10 content, and low density.[46]

Neutron logs can measure porosity and can be used to make a qualitative analysis of boron, if the lithology is known. When a high energy neutron collides with a particle of approximately the same size, such as boron, they are slowed through inelastic collisions. The neutron is captured by hydrogen and a captured gamma ray is emitted. The population of thermal neutrons is proportional to the hydrogen content, which is usually a direct measure of porosity.[47]

Research continued on boron as an addition to a variety of propulsion systems. Boron has a high heat value and low density and is attractive as a large volumetric heat substance. The size, shape, surface area, and purity of the boron affects the propulsion capabilities. Powdered samples of amorphous boron were studied. The samples were supplied by two producers and manufactured by two processes (an electric arc process and the commercial "Thermit" process) to produce amorphous boron powder.[48]

Environmental problems related to the use and disposal of geothermal fluid containing toxic levels of boron were studied. In California, the geysers in the north and the Salton Sea in the southeast have high boron concentrations. Fluid releases could reach harmful levels in soil water if sufficient geothermal fluids percolate into the soil. Boron concentrations must be kept below 5 milligrams per liter to protect crops such as tomatoes, wheat, and cotton. An ion-exchange process could remove boron selectively from condensates if it were necessary to reduce it to below 5 milligrams per liter.[49]

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Bromine

By Phyllis A. Lyday[1]

Domestic producers sold or used 378 million pounds of elemental bromine valued at $86 million during 1981. Demand for ethylene dibromide (EDB) was down. Consumption of methyl bromide (MB), calcium bromide, and flame retardants increased.

During 1981, the Internal Revenue Service (IRS) began collecting a tax on bromine production as outlined in the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (Superfund).

Debate continued over the use of bromine in compounds for use in agriculture. The Occupational Safety and Health Administration (OSHA) and the Environmental Protection Agency (EPA) continued to discuss changes in the regulation of EDB.

Legislation and Government Programs.—After the Teamster Union in California submitted a petition, OSHA set up a task force to investigate exposure of workers to EDB. A request by the union for a temporary emergency standard was refused by OSHA.[2] Approximately 15 million pounds of EDB are used each year in Texas, Florida, California, and Hawaii. The risk of

Table 1.—Salient bromine and bromine compound statistics

(Thousand pounds and thousand dollars)

	1977	1978	1979	1980	1981
United States:					
Bromine sold:[1]					
Quantity	59,000	53,200	r67,600	52,100	60,800
Value	$12,800	$11,300	$15,100	$12,500	$11,000
Bromine used:					
Quantity	374,800	393,400	429,700	325,978	317,500
Value	$86,900	$88,700	$98,200	$83,100	$75,100
Exports:					
Elemental bromine:					
Quantity	5,400	6,400	10,100	8,100	W
Value	$1,100	$1,300	$2,100	$1,700	W
Bromine compounds:[2]					
Gross weight	64,400	106,000	92,800	85,400	36,500
Contained bromine	54,100	87,900	77,600	70,400	30,900
Value	$27,300	$38,500	$35,500	$35,900	$12,100
Imports:[3]					
Elemental bromine:					
Quantity	517	669	34	1	(4)
Value	$102	$102	$5	$5	(4)
Ethylene dibromide:					
Quantity	79	589	193	861	644
Value	$22	$102	$33	$165	$139
Potassium bromide:					
Quantity	89	119	794	667	107
Value	$56	$84	$536	$457	$80
Sodium bromide:					
Quantity	106	320	2,190	310	20
Value	$60	$175	$1,056	$201	$12
World: Production	r772,270	r795,917	r888,785	p760,569	e760,597

eEstimated. pPreliminary. rRevised. 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]Exports reported to Bureau of Mines by primary producers.
[3]Source: U.S. Bureau of the Census.
[4]Negligible.

EDB contamination to the consumer is reduced to safe levels 4 to 8 days after fumigation. Current Federal standards permit EDB in ambient air at 20,000 parts per million per 8-hour, time-weighted, average.[3] On September 23, California set the State standard for workers exposed to EDB at 130 parts per million.[4]

At yearend, OSHA amended its 1978 lead exposure standard to extend the compliance time for gasoline additives for the petroleum industry as well as several other industries.[5] Bromine is used primarily in EDB as a scavenger for lead in gasoline.

EPA has also affected the use of EDB in gasoline by regulation designed to decrease the concentration of lead in the atmosphere. An EPA position document on EDB proposed regulatory actions to reduce the human health risk of the compound by the following actions: (1) Allow registration to continue for preplant soil fumigation; (2) cancel registration for use on stored grains and spot fumigation of grain milling machinery; (3) cancel registration for postharvest fumigation of citrus, tropical fruits, and vegetables on July 1, 1983; (4) cancel the registration for fumigation of felled logs; (5) defer the decision on use for termite control; and (6) allow the remaining uses to continue only if certain restrictions are implemented and additional data requirements are fulfilled.[6]

A 14-month infestation by the Mediterranean fruit fly (medfly) in California caused controversy over the use of the pesticide EDB during the late spring and early summer. It was estimated that 35,000 pounds of EDB are used annually to fumigate fruits and vegetables.[7] On November 12, the U.S. Department of Agriculture (USDA) announced eradication of the pest.

"Solibrom" 90, an EDB-based nematicide and the only liquid nematicide on the market, was approved by EPA as a planting-time soil fumigant. Solibrom replaces dibromochloropropane (DBCP), a pesticide that has been banned in the United States.[8] EPA exempted the use of DBCP in Hawaiian pineapple fields to control ground worms.[9]

EPA granted an exemption to USDA for MB used as a fumigant on imported food and feed commodities for the control of the khapra beetle. Provisions, until June 4, 1982, included the wearing of masks and monitoring of the ambient air levels.[10]

Other EPA activities during the year included the publication of a comprehensive bibliography of published literature on bromoethylene. The bibliography was to be used as partial support for the preparation of a preliminary risk assessment of bromoethylene (593-60-2).[11] EPA also published a list of 129 priority pollutants which included MB, bromoform, bromodichloromethane, dibromochloromethane, and 4-bromophenylphenyl ether.[12]

On April 1, IRS began to collect tax on bromine production at the rate of $4.91 per ton. The 1954 Internal Revenue Code was amended to provide for the environmental taxes, which were required by Superfund. Chemical companies will provide 87.5% of a special tax to clean up abandoned waste sites of hazardous chemicals.[13]

The National Toxicology Program found polybrominated biphenyl (PBB) to cause liver and bile cancer in rats and mice at five levels of exposure.[14] Use of PBB has virtually ceased since the 1973 accident that mixed PBB, a fire retardant, with animal feed. A comprehensive medical examination was conducted on workers from a plant that manufactured decabromodiphenyl and decabromodiphenyl oxide (DBDPO). Exposed employees showed higher serum levels, higher primary hypothyroidism, and reduced motor velocities. No significant dermatological, neurological, or other adverse health effects were clinically demonstrated.[15] Tests on 25 chemical workers with high concentration of PBB's in adipose tissue showed no evidence of memory dysfunction.[16] EPA issued a final ruling requiring submission of notice of manufacture or import of PBB's.[17]

The Dow Chemical Co. was one of several companies that sued EPA over the testing requirements for deep reinjection wells. Dow extracts bromine from subterranean brines and returns the residue to the same geologic formation. EPA at first considered the brine as an industrial waste. As a consequence of the suit, requirements for reinjection were eased.[18]

Tougher enforcement of local building codes increased the need for bromine in flame-retardant building materials. The Consumer Product Safety Commission and other State agencies have not developed a fire-retardant standard to test the use of bromine compounds in consumer products, and flame retardants containing bromine have to pass the EPA's test for toxicity and mutagenicity.[19]

The American Society for Testing and Materials' Committee E-15 was requested by bromine producers to study the handling of bromine. Standards proposed by the committee could aid producers in following Federal agency regulations on bromine.[20]

A study in New Jersey showed contamination of ground water to be at least 78% of the average concentration of contaminates in the surface water. Dichlorobromoethane, dibromochloromethane, 1,2-dibromoethane, bromoform, dibromomethane, and bromodichloromethane were some of the 56 toxic substances sampled.[21]

The Department of the Interior's Bureau of Land Management commissioned a study by the National Academy of Sciences on the environmental effects of drilling mud discharges during offshore oil and gas drilling operations. Calcium bromide is used in drilling-completion activities in offshore wells to improve the well production.[22]

On July 17, the office of the U.S. Trade Representative (USTR) announced the acceptance of a petition limited to tetrabromobisphenol-A (TBBA) by Ameribrom, Inc. TBBA is a brominated hydrocarbon that is used as a flame retardant primarily in epoxies and polycarbonates for electrical applications and contains approximately 60% bromine by weight. Ameribrom, the U.S. marketing group of Bromine Compounds, Ltd., an organization that is 80% owned by the Government of Israel, receives duty-free preference in the European and Japanese markets. U.S. producers of bromine felt that lower Generalized System of Preference (GSP) would adversely affect U.S. production of bromine. On September 15, hearings were held by the USTR. On November 3, the International Trade Commission held hearings on TBBA to gather information to prepare a recommendation to the USTR. The USTR planned to publish a final ruling on GSP for TBBA in the Federal Register in March 1982.

DOMESTIC PRODUCTION

Domestic production of elemental bromine during 1981 increased 2% over that of 1980. The increase was a result of increased use of bromine in flame retardants and well-drilling fluids.

In 1981, there were six companies that operated nine plants in two States. Four companies operated six elemental bromine and compound facilities. One company produces only elemental bromine for distribution to another bromine producer and to a compound producer. One company produced bromine for compounds only. One plant produced only elemental bromine to make compounds used in another plant. Bromine production from the leading State, Arkansas, decreased 2%. The decrease was attributed to a decline in usage of EDB. Arkansas production of EDB decreased 22% in production for domestic use and 38% in production for exports.

Michigan experienced a 25% increase in production primarily for use in well-drilling fluids. Dow continued to expand the Dowell Div. In 1981, Dow acquired G-H Fluid Services Div. for $44 million in cash. This is the third drilling fluids company that Dow has acquired.

At yearend, Ethyl Corp. announced plans to build a $7 million plant in Magnolia, Ark. The plant will produce a flame retardant for use in plastic bottles and was planned to be completed by January 1983. The flame retardant to be produced is Saytec 102, DBDPO. The new plant will double Ethyl's capacity to produce DBDPO. Ethyl is a major producer of DBDPO at its Sayreville, N.J., plant. Capacity is also being increased at Sayreville for other brominated flame retardants.[23]

Great Lakes Chemical Corp. (GLCC) announced an agreement in March to purchase Velsicol Chemical Corp., a unit of Northwest Industries, Inc., for $29.7 million in cash.[24] Velsicol bought the bromine facilities of Michigan Chemical Corp. in 1977. The Federal Trade Commission filed a restraining order based on an antitrust violation in the flame-retardant market. The merger was approved in the district and appellate courts in July. With the merger, GLCC became the sole producer of TBBA flame retardant. GLCC signed a tolling agreement with E. I. du Pont de Nemours & Co. for Halon 1301 fire extinguishant and purchased technology from Onoda Cement (Japan) and Japan Halon for the construction of a Halon facility. Halogenated fire extinguishants are used in computer facilities, record storage areas, museums, pipelines, drilling platforms, military applications, and power-generation stations. A significant feature of Halon is that people can live in the halogenated hydrocarbon atmosphere required to extinguish a fire.[25]

Table 2.—Bromine-producing plants in the United States

State and company	County	Plant	Production source	Elemental bromine capacity[1]
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

[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.

Table 3.—Bromine compounds sold by primary U.S. producers[1]

(Million pounds and million dollars)

	1980			1981[p]		
	Quantity		Value	Quantity		Value
	Gross weight	Bromine content		Gross weight	Bromine content	
Ethylene dibromide	212.9	180.9	54.1	157.1	134.3	42.1
Methyl bromide	38.9	27.7	25.3	W	W	W
Other compounds[2]	225.3	167.7	177.8	247.7	196.4	216.4
Total[3]	477.1	376.3	257.2	404.8	330.6	258.4

[p]Preliminary. W Withheld to avoid disclosing company proprietary data.
[1]Includes exports.
[2]Includes hydrobromic acid, tetrabromobisphenol-A, ethyl, calcium, ammonium, sodium, potassium, and other bromides, plus some methyl bromide exports.
[3]Data may not add to totals shown because of independent rounding.

CONSUMPTION AND USES

Consumption of EDB decreased during 1981. Since 1972, production of EDB has decreased 42%. The primary reason for the decrease has been a mandated phasedown by EPA to decrease the amount of lead in the atmosphere. EDB is used as a scavenger for lead in gasoline. With a lower lead content in gasoline, the demand for a scavenger is also reduced. EDB also is used as a preplant soil fumigant. Usage of EDB as a space fumigant has been banned, except for use on citrus crops.

MB consumption increased during 1981. Because only two companies manufacture this product, the production figures are proprietary and cannot be revealed.

Oilfield chemicals were the most promising products of the bromine industry. Calcium bromide consumption was estimated to have increased to 89 million pounds of bromine content during 1981. Clear fluids were used in drilling, drill-in, redrill, completion, packer, workover, and gravel-pack under reaming. Clear fluids assure maximum formation protection, wellbore stability, and down-hole pressure control. Chemicals in the clear-fluid classification include calcium chloride, calcium bromide, and zinc bromide-calcium bromide blends.[26] Densities between 8.35 and 19.2 pounds per gallon are possible. Clear fluids can produce drilling rates double or triple that of a mud system, if used without solids. Clear fluids keep clay hydration and dispersion to a minimum; small amounts of solids can reduce a well's production potential from 10% to 85%. Legislation enacted in 1981 established a phase reduction sequence that will lower the impost on new oil by 1986.[27] With the new tax policy, the expected exploration for oil and gas will translate into consumption of more bromine chemicals.

Approximately 58 million pounds of bromine was used to produce flame retardants. During 1980, flame retardants were incorrectly reported as a combination of flame retardants and well-drilling fluids.

PRICES

The average price for bulk elemental bromine sold or used, f.o.b. plant, as reported by producers in 1981 was 22.78 cents per pound, a decrease compared with the revised 1980 average price of 25.31 cents per pound. In July, domestic producers increased prices of bromine and bromine derivatives. The four major producers posted a 1.5 cent per pound increase. The average list price of bromine compounds in 1981 increased 7% over 1980 prices.

Velsicol increased the drum deposit on bromine from $550 to $625 per drum. The detention fee for tank cars was changed from $75 after 4 days to the new fee of $30 per day on 60,000-pound cars and $45 per day on 100,000-pound cars after 15 days.[28] Industry sources explained the deposit cost to be attributed to the nickel-copper "monel" containers.

Table 4.—Prices for elemental bromine and selected compounds

Product	Value per pound (cents)
Bromine, purified:	
Carlots, truckloads, delivered	75
Drums, carlots, truckloads, delivered east of the Rocky Mountains[1]	55- 69
Bulk tank car, tank trucks (45,000-pound minimum), delivered east of the Rocky Mountains[1]	28- 29.5
Ammonium bromide, national formulary (N.F.), granular, drums, carlots, truckloads, freight equalized	106
Bromochloromethane, drums, carlots, f.o.b. Midland	107
Bromoform, pharmaceutical grade, 5-gallon drums, f.o.b. works	270
Calcium bromide, 53%, bulk	25
Ethyl bromide, technical, 98%, drums, carlots, freight allowed, East	72
Ethylene dibromide, drums, carlots, freight equalized	38
Hydrobromic acid, 48%, drums, carlots, truckloads, f.o.b. works	39- 41
Hydrogen bromide, anhydrous, cylinders, 130 pounds, f.o.b. works	700
Methyl bromide, distilled, tanks, 140,000-pound minimum, freight allowed	57
Potassium bromate, granular, powdered, 200-pound drums, carlots, f.o.b. works	106
Potassium bromide, N.F. granular, drums, carlots, f.o.b. works	103
Sodium bromide, 99% granular, 400-pound drums, freight, f.o.b. works	97

[1]Delivered prices for drums and bulk shipped west of the Rockies, 1 cent per pound higher. Bulk truck prices 1 cent per pound higher for 30,000-pound minimum and 2 cents per pound higher for 15,000-pound minimum. Price f.o.b. Midland and Ludington, Mich., freight equalized, 1 cent per pound lower.

Source: Chemical Marketing Reporter. Current Prices of Chemicals and Related Materials. V. 220, No. 6, Dec. 28, 1981, pp. 28-37.

FOREIGN TRADE

Exports of bromine contained in compounds as reported by producers was 30.9 million pounds during 1981. Approximately 82% of the contained bromine exports were EDB. Other compounds exported included compounds for use in well completions, flame retardants, and agriculture.

In 1981, approximately 84% of U.S. imports of bromine and bromine compounds reported by the U.S. Bureau of the Census were from Israel. The closer proximity of Israel to overseas markets gave Israeli producers an advantage in transportation cost compared with U.S. exporters. Other countries from which bromine and bromine compounds were imported by the United States were the United Kingdom, 12%; France, 3%; and Japan, 1%. Imports reported by the U.S. Bureau of the Census included potassium bromide, 11%; sodium bromide, 2%; EDB, 69%; potassium bromate, 18%; and negligible amounts of elemental bromine. Because imports of bromine compounds are classified into multiproduct categories, some bromine compounds imported by the United States are not easily identified.

WORLD REVIEW

France.—Rhone-Poulenc, Inc. (RP), the U.S. selling agent and major shareholder of Potasse et Produits Chimiques (PPC), was undergoing plans at yearend to be nationalized. PPC is Europe's largest producer of inorganic and organic bromine compounds.

During 1981, bromine produced in Israel was imported into France where PPC manufactured bromine products, some of which were exported to the United States.[29]

In 1978, RP acquired an interest in Morton-Norwich (MN), one of five domestic producers of bromine. Under a 10-year agreement, RP gave MN the option to develop and market all pharmaceutical compounds of RP and its subsidiaries. At yearend, RP owned 20.3% of MN and was the largest shareholder. In 1981, RP announced an intent to sell its 2.75 million shares.[30]

Société Octel-Kuhlman was reported to operate a seawater plant for the extraction of bromine at Port-de Bouc, near Marseilles. The company is a joint venture of Associated Octel, Ltd. (50%) (United Kingdom), and Pechiney Ugine-Kuhlman (50%) (France). Capacity was estimated to be 30 million pounds per year. The EDB produced at Port-de Bouc is transported to Paimboeuf for the manufacture of lead alkyls.

At Mines de Potasse D'Alsace, S.A., bromine was reported to be produced as a byproduct of potash production. Production of bromine was estimated to be 19 million pounds per year.

Germany, Federal Republic of.—Kali und Salz, A.G., reported bromine production as a coproduct in the processing of potash at the Wintershall Mine near Herfa and the Siegfried-Giesen Mine near Hannover.[31] Production capacity was estimated to be 8 million pounds per year.

Israel.—Dead Sea Bromine, Ltd., completed its capacity expansion to 154 million pounds in 1981.[32] No plans were under study to increase this capacity.[33] The production is exported through Eurobrom.

Italy.—S.p.A. Ing. Luigi Conti-Vecchi S.p.A. Sarramin operated a bromine-from-seawater plant with a capacity of 2 million pounds at South Gilla, Gagliari, Sardinio. The bromine was a coproduct of solar salt and magnesium production. SAIBI produced 702,000 tons per year at Margherita de Savoia. The seawater plant operated by Montedison in southern Italy was reported closed several years ago.[34]

Netherlands.—The prosecution of a bromine-derivatives producer accused of disposal of industrial waste in a municipal sewer began in 1981. Because the statute of limitations had expired, the case went into civil litigation.[35]

Gasoline-grade tertiary butyl alcohol (GTBA), 5% to 7% by volume, is produced in Europe by Oxirane 6, Botelek. GTBA is used as a substitute for EDB and lead in gasoline as an octane booster.[36]

MB for use as a soil decontaminant had been banned from use except by special permit in the Netherlands. A proposal by a Dutch member of the European Economic Community (EEC) would ban all EEC uses of the compound.[37]

Spain.—Derivados del Etilo, S.A., (Etilo), which is located at Almería, had a bromine capacity of 2.2 million pounds per year and was the sole producer of bromine. All of the bromine was consumed by Etilo for the production of brominated compounds for use in fumigants, fire extinguishing agents, and flame-resistant resins. Nueva Compañía Arrendataria de las Salinas de Torrevieja, S.A., in Alicante, closed bromine production in 1977. During 1978, 100,000 pounds of bromine and 330,000 pounds of compounds were imported and 6,700 pounds of compounds were exported.[38]

Tunisia.—Société Nationale des Industries Chimiques, a state-controlled company, was formed to exploit bromine deposits associated with magnesium and potassium in brackish water in the Zarzis area of southern Tunisia.[39]

United Kingdom.—Associated Octel operated a seawater plant to produce bromine at Amlwch, Anglesey, in North Wales. The bromine was converted into EDB for use as a lead scavenger in gasoline. Production capacity was estimated at 60 million pounds.

An increase in the use of bromine in flame retardants was expected as a result of the United Kingdom introducing safety regulations on upholstered furniture in 1980. The regulation is expected to result in increased use of bromine in reactive flame retardants for use in polyurethane foams.[40]

The United Kingdom announced a reduction of lead in gasoline from 0.4 gram per liter to 0.15 gram per liter by 1985. EDB, a lead scavenger, will be affected by the decision.[41] Already, substitutes such as methyl tertiary butyl ether (MTBE), tertiary butyl alcohol, methanol, and ethanol are being considered. MTBE capacity in Europe was 530,000 tons in 1980 and was planned to be 740,000 tons by 1982.[42]

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

(Thousand pounds)

Country[2]	1977	1978	1979	1980[p]	1981[e]
France	34,326	35,714	41,888	[e]44,000	42,000
Germany, Federal Republic of	8,236	8,583	8,862	[e]8,800	8,800
India	1,124	1,014	660	736	770
Israel	69,450	76,170	101,000	97,133	[3]97,047
Italy	[r]1,380	[e]1,300	[e]1,300	[e]1,300	1,280
Japan[e]	26,500	26,500	26,500	26,500	26,500
Spain[e]	900	900	900	900	900
U.S.S.R.[e]	[r]142,000	[r]144,000	146,000	148,000	150,000
United Kingdom	54,454	55,336	64,375	55,100	55,100
United States[4]	433,900	[r]446,400	497,300	378,100	[3]378,200
Total[4]	[r]772,270	[r]795,917	888,785	760,569	760,597

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

[1]Table includes data available through Apr. 14, 1982.

[2]In addition to the countries listed, several other nations produce bromine, but output data are not reported and available general information is inadequate for formulation of reliable estimates of output levels.

[3]Reported figure.

[4]Sold or used by producers.

TECHNOLOGY

Research involving flame and fire retardants included projects by United States and Japanese research groups. Dow completed animal studies on its dibromoneopentyl flame retardant for unsaturated polyester resins and polyurethane foams. Rats ingesting 5 milligrams per kilogram of body weight per day experienced no adverse effects. Rats ingesting 100 milligrams per kilogram per day showed minor toxic effects but no increase in tumors.[43] In addition, Dow commercialized a "brominated aliphatic compound with a little phosphorus" to use as a fire retardant in rigid urethane foams. The bromine additive becomes part of the molecular structure (reactive), which increases the flame retardant's stability. Another brominated aliphatic reactive compound was being tested in rigid urethane foams.[44]

The CF_2Br_2 microstructure data was studied to determine the mechanism of Halon[45] inhibition of methane flames. Halon, a bromofluorochloromethane, exhibits properties of low toxicity, quick fire extinquisher, and no residue. The study supported the concept of a region of inhibition preceding the primary reaction zone, although the reaction of the inhibitor is not simple or limited in one region.[46]

Studies were conducted in Japan to synthesize vinyl-type monomers containing bromine and/or phosphorus as flame retardants. The flame retardants for thermally stable polymers are comparable to the base polymer when heated.[47]

Studies conducted by the Maryland Environmental Service and Dow demonstrated that bromine chloride offers advantages over other disinfectants in treating activated sludge waste water. Bromine chloride is more soluble than chlorine and reacts more quickly. The bromoamines formed by the reaction of bromine and chlorine with ammonia are hydrolized to a harmless salt in less than 1 hour. Because one-half the amount of bromine chloride is required for disinfecting, the cost is lower.

Studies on sickle cell diseases revealed that polarized groups, such as bromine substituents on aromatic rings, endowed nonpermeating compounds with the ability to penetrate the red cell membrane and to increase binding by hemoglobin. A substantial decrease in the number of abnormally shaped cells other than the sickle form was produced with dibromoaspirin. The presence of bromine substituents increased the membrane permeability.[48]

Other areas of research included an information release by Exxon Corp. concerning the cost and reliability of a zinc-bromide battery.[49] Research and development on hydrogen production from water by a continuous HBr reactor using the iron-bromine family cycle was being studied.[50] A study on the solar chemistry investigated the oxidation reduction reactions that store chemical energy. Two classes of metal complexes are being studied for hydrogen production from aqueous solution.[51] Experiments to detect reactions that proceeded single-electron transfer used 1-bromo-2,2-dimethyl-5-hexene.[52]

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Cadmium

By Robert Reese[1]

Domestic production of cadmium in all forms except cadmium sulfide increased in 1981. Apparent consumption of cadmium metal was also up significantly in 1981 despite increasing stocks held by producers, chemical manufacturers, and distributors. Foreign trade increased during 1981 with both export and import levels being greater than those in 1980. Domestic prices for cadmium in 1981 fell from a published price of $2.50 per pound to $1.40 per pound at yearend. The lower prices were believed to have led to purchases of cadmium by consumers for future needs and to the use of cadmium in some applications where cadmium substitutes had been used.

Legislation and Government Programs.—Review of the Clean Air Act of 1970 was begun by Congress during 1981 with hearings being held concerning control standards for hazardous air pollutants. Addition of at least 37 substances, including cadmium, to the lists of hazardous air pollutants was proposed. Regulations require industry to prove that a listed substance is not hazardous. Final action on a revised Clean Air Act was not taken during the year.

The Occupational Safety and Health Administration (OSHA) postponed the issuance of new standards on worker exposure to cadmium and the decision on whether or not medical surveillance and exposure monitoring should be included in the standards. The existing OSHA standards set limits on exposure to airborne cadmium averaged over an 8-hour day. Medical surveillance and individual exposure monitoring are not included in the existing standards.

The strategic stockpile goal remained at 5,307 metric tons. No net inventory acquisitions or sales were made during the year, and as of December 31, 1981, the stockpile inventory consisted of 2,871 metric tons.

Table 1.—Salient cadmium statistics

	1977	1978	1979	1980	1981
United States:					
Production[1] metric tons	1,999	1,653	1,823	1,578	1,603
Shipments by producers[2] do	1,837	1,957	2,468	1,271	1,382
Value thousands	$7,072	$5,906	$9,498	$5,219	$3,838
Exports metric tons	107	326	211	236	239
Imports for consumption, metal do	2,332	2,881	2,572	2,617	3,090
Apparent consumption do	3,818	4,510	r5,099	r3,534	4,442
Price: Average per pound[3]	$2.96	$2.45	$2.76	$2.84	$1.93
World: Production metric tons	r18,288	r17,446	r18,883	p18,130	e17,721

eEstimated. pPreliminary. rRevised.
[1]Primary and secondary cadmium metal. Includes equivalent metal content of cadmium sponge used directly in production of compounds.
[2]Includes metal consumed at producer plants.
[3]Average quoted price for cadmium sticks and balls in lots of 1 to 5 tons.

DOMESTIC PRODUCTION

Domestic production of cadmium metal increased slightly in 1981 despite the closure of The Bunker Hill Co.'s zinc smelter in Kellogg, Idaho, near the end of the year. Although metal production was up in 1981, the tonnage produced was less than the average production for the previous 5 years. Peak domestic production of 5,736 metric tons of cadmium metal occurred in 1969. Since then, the production trend has been declining. The closing of The Bunker Hill Co. left only four companies as active domestic cadmium producers at the end of 1981.

Production of cadmium compounds other than cadmium sulfide (cadmium content), which includes both electroplating salts and cadmium oxide, increased in 1981 over 1980 levels, but remained essentially the same as the average for the previous 5 years. The production of cadmium sulfide including cadmium sulfoselenide and lithopone was significantly lower in 1981 when compared with both the production of the previous year and the average for the previous 5 years.

Table 2.— Primary cadmium producers in the United States in 1981

Company	Plant location
AMAX Lead & Zinc, Inc	Sauget, Ill.
ASARCO Incorporated	Corpus Christi, Tex. and Denver, Colo.
The Bunker Hill Co	Kellogg, Idaho.
Jersey Miniere Zinc Co	Clarksville, Tenn.
National Zinc Co	Bartlesville, Okla.

Table 3.—U.S. production of cadmium compounds other than cadmium sulfide[1]

(Metric tons)

Year	Quantity (cadmium content)
1977	695
1978	708
1979	912
1980	826
1981	885

[1]Includes plating salts and oxide.

Table 4.—Cadmium sulfide[1] produced in the United States

(Metric tons)

Year	Quantity (cadmium content)
1977	639
1978	698
1979	[r]813
1980	801
1981	527

[r]Revised.
[1]Includes cadmium lithopone and cadmium sulfoselenide.

CONSUMPTION AND USES

Apparent consumption of cadmium was up significantly over that of 1980, but was lower than that of 1979. The increase was possibly due to a perceived bottoming of cadmium prices and subsequent early purchases for future needs, the development of new uses for cadmium, and to a switching back to the use of cadmium in some applications where substitutes previously had been developed to replace cadmium.

Although the Bureau of Mines does not collect actual consumption data, the distribution of apparent consumption has been estimated by industry sources for the following categories: Coating and plating 34%, batteries 16%, pigments 27%, plastics and synthetic products 15%, and alloys and other uses 8%. 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)

	1979	1980	1981
Stocks, Jan. 1	[r]2,258	[r]1,343	1,768
Production	1,823	1,578	1,603
Imports, metal	2,572	2,617	3,090
Total supply	[r]6,653	[r]5,538	6,461
Exports	211	236	239
Stocks, Dec. 31	[r]1,343	[r]1,768	1,780
Apparent consumption[1]	[r]5,099	[r]3,534	4,442

[r]Revised.
[1]Total supply minus exports and yearend stocks.

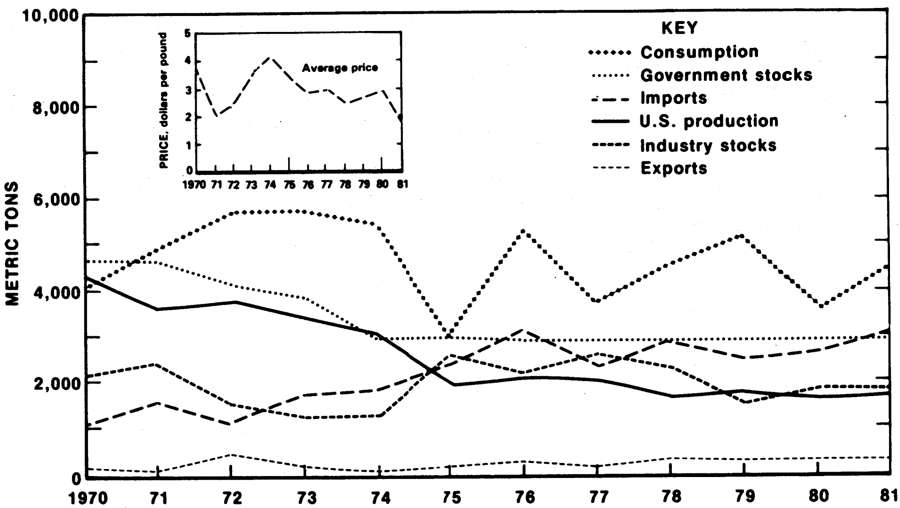

Figure 1.—Trends in production, consumption, yearend stocks, exports, imports, and average price of cadmium metal in the United States.

STOCKS

During 1981, producer and compound manufacturers' stocks fluctuated minimally; however, their inventory levels were higher, especially for metal producers, than those of 1980.

Although 1981 stock levels for metal producers and compound manufacturers were up compared with 1980 levels, they were significantly lower than metal producer inventories at the end of 1978 and compound manufacturer inventories at the end of 1977.

In table 6, distributor-held stocks show a significant decrease because a few large distributors altered their market positions during 1981. If these special cases are disregarded, the remaining distributors show an 8% increase in stocks held at the end of 1981 when compared with their stocks held at the end of 1980.

Table 6.—Industry stocks, December 31

(Metric tons)

	1980		1981	
	Cadmium metal	Cadmium in compounds	Cadmium metal	Cadmium in compounds
Metal producers	841	W	1,077	W
Compound manufacturers	r42	r441	45	447
Distributors	r439	r5	203	8
Total	1,322	r446	1,325	455

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

PRICES

On January 1, 1981, ASARCO Incorporated withdrew its published producer price for cadmium and began selling the metal on a daily basis. The National Zinc Co. stopped publishing a producer price on January 21, 1981, leaving Amax Lead & Zinc, Inc., and The Bunker Hill Co. as the only domestic producers with a listed price. With the announcement of the suspension of operations by Bunker Hill in late 1981, the company was no longer considered a major factor in the market.

Published producer prices were $2.50 per pound at the beginning of the year. In mid-January, they were reduced to $2 per pound, responding to a softer demand for the metal. As the economy slowed, prices dropped to $1.75 per pound in early July, $1.60 per pound in October, and finally $1.40 per pound in early December where it remained at yearend. Daily prices of cadmium generally were 5 to 30 cents below the published price throughout 1981.

Dealer prices in January were listed at $2 per pound. They fell steadily throughout the early months to $1.70 per pound near the end of March. Prices then began climbing, reaching $2 per pound in mid-May. For the remainder of 1981 dealer prices declined steadily, closing the year in the range of $1.25 to $1.35 per pound.

FOREIGN TRADE

Exports of cadmium metal and cadmium in alloys, dross, flue dust, residues, and scrap increased slightly over that exported in 1980. The three largest recipient countries, Finland, Belgium-Luxembourg, and Switzerland, received approximately 86% of U.S. cadmium exports.

Cadmium metal imports increased significantly in 1981, being only slightly less than the 3,094 metric tons imported in 1976, the peak for the last 20 years. Although there are yearly fluctuations, 1981 imports continued the general trend started in 1960 of increasing import tonnages. Primary supplying countries in 1981 were Canada, Australia, the Republic of Korea, and the Federal Republic of Germany.

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 15 cents 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)
1979	211	$550
1980	236	464
1981	239	332

Table 8.—U.S. imports for consumption[1] of cadmium metal, by country

Country	1980 Quantity (metric tons)	1980 Value (thousands)	1981 Quantity (metric tons)	1981 Value (thousands)
Australia	573	$3,197	693	$2,571
Belgium-Luxembourg	42	292	60	225
Canada	825	4,494	843	3,759
China	16	94	80	270
Cocos Islands	9	46	--	--
Finland	119	616	50	185
France	37	177	86	326
Germany, Federal Republic of	10	57	231	748
India	50	267	6	29
Italy	--	--	36	103
Japan	9	45	18	73
Korea, Republic of	175	907	p367	p3,006
Mexico	339	1,801	188	674
Netherlands	110	557	[2]89	300
Norway	31	161	5	17
Peru	142	735	166	532
South Africa, Republic of	--	--	16	74
Spain	50	272	121	375
Sweden	5	35	--	--
United Kingdom	5	29	--	--
Yugoslavia	70	399	5	24
Zaire	--	--	30	78
Total	2,617	14,181	p3,090	p13,369

pPreliminary.
[1]General imports and imports for consumption were the same in 1980 and 1981.
[2]Includes waste and scrap (gross weight).

WORLD REVIEW

Production began at the Cajamarquilla zinc refinery of Empresa Minera del Perú (Minero Peru) during 1981. The plant produced high-grade zinc, sulfuric acid, and metallic cadmium.

A new zinc reduction plant was scheduled for construction in mid-1982 at Belledune, New Brunswick, Canada, and was expected to begin production in late 1984. In addition to zinc, cadmium and sulfuric acid will also be produced. Feedstock for the plant will be provided by mines in New Brunswick, which are currently shipping concentrates to Europe for smelting.

Stemming from the general pollution controls imposed in 1979, the Swedish Government issued the final ordinance on exceptions from the ban on the use of cadmium for surface treatment, as a stabilizer, or as a coloring agent. Although the rule was to apply to both imports and exports beginning July 1, 1982, most product areas were expected to have exemptions for pigments and stabilizers through 1985 and for surface coatings through 1987.

In the Federal Republic of Germany, initial steps were taken to tighten air pollution regulations in general as well as controls on the production and use of cadmium. Final decisions were still pending.

The International Organization for Standardization issued two new standards affecting cadmium. One dealt with permissible limits on the release of lead and cadmium from ceramic foodware, and the other was related to testing procedures. The objectives of these standards were to preserve the ceramic markets for these metals while protecting public health. The permissible limits specified by the standard for the release of lead and cadmium include (1) ceramic flatware, 1.7 milligrams per square decimeter for lead and 0.17 milligram per square decimeter for cadmium, (2) small ceramic hollowware, 5 parts per million for lead and 0.5 part per million for cadmium, and (3) large ceramic hollowware, 2.5 parts per million for lead and 0.25 part per million for cadmium. These standards have been accepted by most countries participating in the multilateral negotiations, although a number of countries reportedly wanted more stringent limits.

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

(Metric tons)

Continent and country	1977	1978	1979	1980[p]	1981[e]
North America:					
Canada (refined)	1,185	[r]1,265	1,460	1,033	[2]1,274
United States[3]	1,999	1,653	1,823	1,578	[2]1,603
Latin America:					
Argentina	40	22	36	18	20
Brazil	10	10	21	41	45
Mexico (refined)	908	897	830	778	860
Peru	182	169	190	163	180
Europe:					
Austria	26	33	34	36	55
Belgium	[r]1,440	1,164	1,440	1,527	1,070
Bulgaria[e]	200	210	210	210	210
Finland	527	611	590	581	580
France	790	689	792	791	660
German Democratic Republic[e]	18	18	15	15	16
Germany, Federal Republic of	1,336	1,182	1,266	1,197	[2]1,192
Italy	[r]448	378	527	568	600
Netherlands[e]	302	402	416	455	540
Norway	97	120	115	130	115
Poland	754	761	773	698	630
Romania[e]	90	90	90	[r]85	85
Spain	303	253	222	309	310
U.S.S.R.[e]	2,750	2,800	2,850	2,850	2,900
United Kingdom	295	291	424	375	[2]278
Yugoslavia	189	187	289	290	285
Africa:					
Algeria	133	175	185	150	200
Namibia	88	79	81	69	[2]--
Zaire	246	186	212	168	[2]230
Zambia	4	--	--	1	1
Asia:					
China[e]	200	220	225	225	225
India	44	113	166	89	80
Japan	2,844	2,531	2,597	2,173	[2]1,977
Korea, North[e]	150	150	150	150	150
Korea, Republic of	20	40	50	365	300
Oceania: Australia (refined)	[r]670	747	804	1,012	1,050
Total	[r]18,288	[r]17,446	18,883	18,130	17,721

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

[1]This table gives unwrought metal 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 recorded in this table to avoid double counting. Table includes data available through Mar. 31, 1982.

[2]Reported figure.

[3]Includes secondary.

TECHNOLOGY

A laboratory process has been developed for catalytically splitting hydrogen sulfide into its components using visible light and an aqueous transparent suspension of colloidal cadmium sulfide particles and ruthenium dioxide.[2] As the visible light passes through the solution, water is reduced to hydrogen and hydroxide ions by photo-induced electrons in the cadmium sulfide particle. The hydroxide ions then strip hydrogen from the hydrogen sulfide to reform water, leaving negatively charged sulfide ions that are then oxidized to elemental sulfur. Significantly, because no oxygen is produced, a gas separation phase to recover the hydrogen is not needed. In addition to offering a potentially simple alternative to conventional methods of removing hydrogen sulfide from waste gases, the process offers two other potential bonuses. The hydrogen generated has a positive fuel value, and the precipitated sulfur can be used or sold without further treatment.

Ametek Inc. reported laboratory development of a low-cost, simple-to-make solar photovoltaic cell using cadmium telluride and other materials.[3] Ametek reported that its solar cells in converting solar energy to electricity have achieved efficiency in excess of 8% with the theoretical efficiency equal to 26%.

Researchers at the Bureau of Mines reported laboratory research on development of a multistage hydrometallurgical process for recovering or recycling zinc, cadmium, copper, cobalt, and nickel from electrolytic zinc industrial copper filter cake.[4] The stages involved are (1) wet sizing, (2) sulfuric acid leaching of undersized material, (3) sulfuric acid-manganese dioxide leaching of the sulfuric acid leach residues, (4) selective precipitation of arsenic, copper, and cobalt-nickel products, and (5) precipitation of manganese for recycling to the leach circuit.

Developments in cadmium technology were abstracted in Cadmium Abstracts, a quarterly publication available through the Cadmium Association, 34 Berkeley Square, London W1X 6AJ, England. Progress reports of the projects supported by the International Lead Zinc Research Organization, Inc., were published in the Cadmium Research Digest.

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[1]Physical scientist, Division of Nonferrous Metals.
[2]Chemical and Engineering News. Visible Light Cleaves Hydrogen Sulfide. July 27, 1981, pp. 40-42.
[3]Chemical Week. Apr. 15, 1981, p. 54.
[4]Hebble, T. L., V. R. Miller, and D. L. Paulson. Recovery of Principal Metal Values From Electrolytic Zinc Waste. BuMines RI 8582, 1981, 12 pp.

Calcium and Calcium Compounds

By J. W. Pressler[1]

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 two companies in Louisiana, one company in New York, and two companies in Washington.

DOMESTIC PRODUCTION

Pfizer Inc. produced calcium metal at Canaan, Conn., by the Pidgeon process—an aluminothermic process in which high-purity quicklime and aluminum powder are briquetted and heated in vacuum retorts. At 1,300° C, the calcium oxide is reduced to calcium metal, which vaporizes and is subsequently collected as "crowns" in a water-cooled condenser at the other end of the retort at about 700° C.

National Chloride Co. of America, Leslie Salt Co., and Hill Bros. Chemical Co. produced calcium chloride from dry-lake brine wells in San Bernardino County, Calif. Output increased 23% in 1981 compared with that of the previous year. The Dow Chemical Co. and Wilkinson Chemical Corp. recovered calcium chloride from brine in Lapeer, Mason, and Midland Counties, Mich. Average output in Michigan increased 21% in 1981 compared with that of the previous year. Total production of natural calcium chloride in 1981 was 704,700 tons, an increase of 21% compared with 1980 production.

Allied Chemical Corp. recovered synthetic calcium chloride as a byproduct of soda ash production at its Solvay plant near Syracuse, N.Y., and as a byproduct at its Baton Rouge, La., plant using excess hydrochloric acid and limestone; Texas United Chemical Corp. produced calcium chloride 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, Wash.; and Hooker Chemicals & Plastics Corp. manufactured calcium chloride at Tacoma using limestone and hydrochloric acid. Total output of synthetic calcium chloride in 1981 was 212,300 tons, an 8% decrease compared with the 1980 level.

W. R. Grace & Co. of New York, N.Y., announced plans to build a calcium nitrite plant in Wilmington, N.C., scheduled to come onstream in early 1983. The plant is the first of its kind in North America.[2] The product will be used as a concrete additive to prevent steel reinforcing bar corrosion in bridges, as described in the Technology section of the 1978-79 Calcium and Calcium Compounds chapter of the Minerals Yearbook.

Allied Chemical of Morristown, N.J., built a new plant for the production of 38% liquid calcium chloride at its Baton Rouge, La., complex in 1981. The heavy liquid completion fluid market for the oil and gas drilling industry will be the principal use.[3]

PPG Industries, Inc., announced that it will construct a multimillion-dollar facility for the production of calcium hypochlorite, scheduled for completion in late 1983. To be constructed in either Natrium, W. Va., or Barberton, Ohio, the facility will more than quadruple PPG's nameplate capacity to 36,500 tons per year. Principal markets include swimming pool sanitization, municipal water facilities sanitization, controlling algae, and as a general disinfectant.[4]

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)
1977	710,385	$45,048	257,231	$17,683	967,616	$62,731
1978	773,138	53,868	257,763	21,172	1,030,901	75,040
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

CONSUMPTION AND USES

Calcium metal was used as an aid in removing bismuth in the refining of lead; as a desulfurizer and deoxidizer in steel refining; to form alloys with metals such as aluminum, lead, and silicon; as a reducing agent to recover refractory metals such as tantalum, uranium, and zirconium from their oxides; and in the manufacture of calcium hydride used in the production of chromium, titanium, and zirconium. Some minor, but interesting, uses were in the preparation of vitamin B and chelated calcium supplements, and as a cathode coating in some types of photo tubes.

A high growth rate was forecast for the use of calcium in the battery sector, particularly in the maintenance-free (MF) automotive storage battery that uses lead-calcium (0.1% Ca) and lead-tin calcium alloys. As with nickel-cadmium batteries, the lead batteries were completely sealed, and replacement of the electrolyte is not necessary. They were sold particularly on their merit of being of long life. The weak economy in 1980-81 resulted in reduced demand for MF batteries.

In the refining of crude lead bullion, calcium metal consumption in the debismuthizing step was more than used in MF batteries for 1981.

In addition to its use in the refining of steel, calcium was used as an additive to high-tensile steels, such as those used in oil pipelines. Research has pointed to possibilities of using calcium additives in other high-quality steels.

The uses of calcium chloride in 1981 were principally for road and pavement deicing (35%); dust control and road base stabilization (20%); industrial uses, including coal and other bulk material thawing (20%); oil and gas drilling (12%); concrete-set acceleration (5%); and tire ballasting and miscellaneous (4% each). The most rapidly growing end use of calcium chloride and bromide was as a completion fluid 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 is mainly used 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.

Sales of calcium chloride and calcium bromide as a packer and completion solids-free fluid for oil and gas wells increased 15% in 1981 compared with that of 1980. Dow Chemical with two calcium bromide plants in Midland, Mich., and Magnolia, Ark.; Great Lake Chemical Corp. in El Dorado, Ark.; and Velsicol Chemical Corp.'s two plants in Beaumont, Tex., and El Dorado, Ark., were the principal producers.

PRICES AND SPECIFICATIONS

The price of calcium metal crowns increased from $2.78 per pound to $3.05 per pound on October 15, 1981. The price of calcium-silicon alloy increased from 76.3 cents per pound to 82 cents per pound on January 2, 1981, maintaining that level for the remainder of 1981. Yearend published prices and specifications for 1981 were as follows:

	Value per pound	
	1980	1981
Calcium metal, 1-ton lots, 50-pound full crowns, 10 by 18 inches, Ca+Mg 99.5%, Mg 0.7%	$2.78	$3.05
Calcium-silicon alloy, 32% calcium, carload lots, f.o.b. shipping point	.763	.82

Source: Metals Week. V. 50, No. 52, Dec. 29, 1980, p. 7; Metals Week. V. 52, No. 52, Dec. 28, 1981, p. 5.

Calcium metal is usually sold in the form of crowns, broken pieces, or billets, shipped in 55-gallon metal containers with a maximum content of 300 pounds, and gasketed to provide an airtight condition, with argon atmosphere provided if desired. The value for imported calcium metal in 1981 ranged from \$2.19 to \$6.55 per pound, and averaged \$3.19 per pound for the year. This did not include the assessed tariff, which was 6.4% ad valorem for most-favored-nation status and 25% ad valorem for non-most-favored-nation status. The price of calcium metal crowns increased 10% in 1981 compared with that of 1980, and calcium-silicon alloy increased 7% in 1981 compared with that of 1980.

Calcium chloride is usually sold either as solid flake or pellet averaging about 75% $CaCl_2$, or as a concentrated liquid averaging about 40% $CaCl_2$. The company-reported value of flake calcium chloride increased 55%, and liquid formulations of $CaCl_2$ increased 10% in 1981 compared with that of 1980. Yearend published prices and specifications for 1981 were as follows:

	Value per ton[1] [2]
Calcium chloride, regular grade, 77% to 80%, flake, bulk, carload, works	\$99.00-\$114.00
Calcium chloride, liquid, 40% to 45%, tank car or tank truck, works	38.75- 45.00

[1]Differences between high and low price are accounted for by differences in quantity, quality, and location.
[2]1980 price quotations were same as 1981. See Source.

Source: Chemical Marketing Reporter. V. 218, No. 26, Dec. 29, 1980, p. 27; Chemical Marketing Reporter. V.220, No. 26, Dec. 28, 1981, p. 29.

As reported by producers on an f.o.b. warehouse basis, with conversions of all products to a 75% $CaCl_2$ basis, the average value in 1981 for natural calcium chloride was \$87.54 per ton; the average value for synthetic calcium chloride was \$127.58 per ton. Combining natural and synthetic products, the average value of solid 75% $CaCl_2$ for the year was \$120.57 per ton, and the average value of liquid 40% $CaCl_2$ was \$34.64 per ton.

FOREIGN TRADE

Exports of calcium phosphates in 1981 were 55,862 tons valued at \$33.4 million compared with 43,314 tons valued at \$27.6 million in 1980; leading destinations were Canada, Venezuela, Colombia, and Mexico. Exports of calcium chloride in 1981, mainly to Canada and Mexico, were 32,794 tons valued at \$13.0 million compared with 49,215 tons valued at \$9.8 million in 1980. Exports of other calcium compounds in 1981, including precipitated calcium carbonate, mainly to the Netherlands, Canada, and Mexico, totaled 25,659 tons valued at \$11.7 million compared with 25,068 tons valued at \$15.6 million in 1980.

Total imports of calcium and calcium compounds in 1981 were 366,600 tons valued at \$48.3 million compared with 266,200 tons valued at \$31.1 million in 1980. Imports of calcium metal from Canada, China, and France were 118 tons valued at \$751,000. Imports of calcium chloride, mainly from Canada and Mexico, were 86,865 tons valued at \$4.1 million. Substantial increases in calcium chloride imports from Mexico through the Laredo, Tex., customs district occurred in 1981. They were consumed principally in the oil and gas drilling industry as a heavy-liquid completion fluid. Imports of other calcium compounds, mainly from Norway, Turkey, Belgium, Canada, and the United Kingdom, totaled 277,700 tons valued at \$43.4 million.

Imports of other calcium compounds in 1981 included 153,443 tons of calcium nitrate, mainly from Norway; 78,396 tons of calcium borate, mainly from Turkey; 15,569 tons of chalk whiting, mainly from Belgium; 10,065 tons of precipitated calcium carbonate, mainly from France, the United Kingdom, and Japan; 7,117 tons of calcium carbide, mainly from Canada; 5,280 tons of calcium hypochlorite and chlorinated lime, mainly from Japan and India; 1,391 tons of calcium cyanamide, mainly from Canada; and 6,563 tons of miscellaneous calcium compounds and salts, mainly from the Netherlands, the United Kingdom, and the Republic of South Africa.

Table 2.—U.S. exports of calcium chloride, by country of destination

(Short tons)

Country	1980 Quantity	1980 Value[1]	1981 Quantity	1981 Value[1]
Brazil	753	$117,288	801	$453,967
Canada	20,027	3,130,233	8,819	1,483,424
Mexico	15,777	2,283,642	10,270	2,219,076
Netherlands	212	30,351	3,140	346,542
Sweden	4,039	799,291	44	23,620
Trinidad	1,097	227,439	1,356	433,107
United Arab Emirates	2,125	1,496,949	1,313	674,830
United Kingdom	404	122,984	706	201,460
Other	4,781	1,546,202	6,345	7,167,978
Total	49,215	9,754,379	32,794	13,004,004

[1]U.S. Customs declared value, generally representing value at U.S. port of export and therefore, excluding U.S. export duties, freight, insurance, and other charges incurred in shipping merchandise overseas.

Table 3.—U.S. imports for consumption of calcium and calcium chloride

Year	Calcium: Quantity (pounds)	Calcium: Value[1]	Calcium chloride: Quantity (short tons)	Calcium chloride: Value[1]
1977	458,319	$705,634	19,708	$1,002,386
1978	523,835	825,008	42,523	2,101,794
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

[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

(Short tons)

Country	1980 Quantity	1980 Value[1]	1981 Quantity	1981 Value[1]
Canada	28,010	$1,261,488	28,956	$1,407,143
Germany, Federal Republic of	79	70,057	68	68,807
Mexico	18,321	717,261	57,833	2,335,440
Other	29	22,657	8	276,971
Total	46,439	2,071,463	86,865	4,088,361

[1]U.S. Customs import value. See detailed explanation in footnote 1 of table 3.

WORLD REVIEW

The market economy world annual production of calcium metal is estimated to be between 1,400 and 1,600 short tons.

Canada.—Chromasco Corp. Ltd. produced calcium metal at its Haley smelter near Renfrew, Ontario. Canada continued to lead all other countries in the production of calcium metal in 1981, producing about 550 short tons. Most of it was exported to the United States (21%), with the balance to Mexico, the Republic of South Africa, the Federal Republic of Germany, and Australia.

Canada was the second leading source of U.S. imports of calcium chloride in 1981. U.S. imports from Canada increased slightly from 28,010 tons in 1980 to 28,956 tons in 1981.

U.S. exports of calcium chloride to Canada decreased from 20,027 tons in 1980 to 8,819 tons in 1981.

China.—China exported its first calcium metal to the United States in 1981; 28,219 pounds of metal was imported through the Los Angeles, Calif., customs district.

France.—Planet Wattohm S.A., a subsidiary of Compagnie de Mokta, produced calcium metal by the Pidgeon process. The calcium metal division was sold to Nobel Bozel S.A. in late 1981. France exported 11,444 pounds of metal to the United States in 1981.

U.S.S.R.—Substantial quantities of calcium metal was produced in the U.S.S.R. in 1981. None was exported, and all metal produced was allocated for domestic consumption.

TECHNOLOGY

Calcium bromide and its mixtures with calcium chloride and zinc bromide to produce high-density, solids-free liquids in the completion of oil and gas wells continued its strong demand pattern in 1981. The number of multiple-completion wells drilled in 1981 increased 29% compared with that of 1980, and consumption of calcium chloride and bromide high-density liquids increased commensurately. Dow Chemical increased its Ludington, Mich., plant capacity, thus facilitating increased shipments within its nameplate capacity. More facilities were established to recycle used fluids for refining and reuse, and to provide fluid services more efficiently. Heretofore mostly used for land-based wells and some in inland waters, more extensive use of high-density liquids was experienced in offshore wells. Deeper wells also required denser fluids compared with the traditional use, thereby requiring more zinc bromide consumption in the higher densities above 15 pounds per gallon.[5]

Modern injection metallurgy's biggest advantage is maximum refining (deoxidation and desulfurization) in the ladle in a very short period of time using limited amounts of energy and materials. Technology now has advanced to the point of computer controlling of ladle facilities, such as the newly commissioned plant in 1980 at the Swedish Steel AB works in Lulea, Sweden.[6]

Ladle injection's principal objective is the production of high-performance steel with minimal sulfur content and sulfide inclusions. Calcium metal, or its calcium-silicon (CaSi) alloys, continue to be a preferred additive because in the presence of manganese it will prevent the deleterious formation of manganese sulfides by the preferential formation of complex calcium sulfides, which do not cause ingot cracking and hot shortness upon rolling. Because of its higher affinity for oxygen, calcium also prevents formation of detrimental alumina inclusions by the alternate formation of an innocuous complex calcium aluminate. CaSi also facilitates the removal of macroslag inclusions and reduces the sulfur level at the same time.

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[1]Physical scientist, Division of Industrial Minerals.
[2]Chemical Engineering. CPI News Briefs. V. 89, No. 4, Feb. 22, 1982, p. 28.
[3]———.CPI News Briefs. V. 88, No. 10, May 18, 1981, p. 58.
[4]Chemical Marketing Reporter. Calcium Hypochlorite Plant is Scheduled. V. 220, No. 5, Aug. 3, 1981, pp. 4, 23.
[5]Dowell Division of The Dow Chemical Co. (Houston, Tex.), Private Communication, Mar. 15, 1982.
[6]33 Metal Producing. Ladle Injection Metallurgy: Where It's At, Where It's Going, and Why. V. 19, No. 4, April 1981, pp. 53-59.

Cement

By Sandra T. Absalom[1]

U.S. cement consumption and production slumped in 1981 to the lowest levels since 1975. Cement demand, which declined for the second successive year, reflected reduced activity in the construction industry and general weakness in the U.S. economy. For example, total value of construction, in terms of constant (1977) dollars, decreased 3.5% to $155 billion, according to data published by the U.S. Department of Commerce. Housing starts decreased 16% to 1.1 million units.

Imports, a sensitive indicator of domestic cement demand, declined 24% to 4 million tons and accounted for 5% of consumption, compared with 7% in 1980. Clinker imports were 31% of the total, compared with 36% in 1980. Anticipating a recovery in cement demand, several terminals for transshipment of imported cement began operations in California, Maine, and New York.

Shipments of portland and masonry cement from U.S. plants, excluding Puerto Rico, at 71.7 million tons, were 6% less than 1980 shipments and 16% less than 1979 shipments. No regional shortages occurred during 1981. Shipments decreased by at least 5% to all geographical regions except New England (up 1%), and the West South Central and Mountain regions (up 2% each). Shipments declined most severely to the East North Central (down 13%) and Pacific regions (down 12%).

Table 1.—Salient cement statistics

(Thousand short tons unless otherwise specified)

	1977	1978	1979	1980	1981
United States:[1]					
Production[2]	78,647	83,986	84,491	75,224	71,710
Shipments from mills[2 3]	80,247	86,557	85,747	76,242	71,748
Value[2 3 4] thousands	$2,932,403	$3,543,996	$3,991,580	$3,886,488	$3,723,095
Average value per ton[2 3 4]	$36.54	$40.94	$46.55	$50.98	$51.89
Stocks, Dec. 31 at mills[2]	6,041	5,320	6,600	6,825	7,372
Exports	236	55	149	186	300
Imports for consumption	3,989	6,577	9,393	5,244	3,963
Consumption, apparent[5 6]	81,537	87,619	87,799	77,599	73,321
World: Production	r878,635	r940,249	r959,283	p974,825	e978,919

eEstimated. pPreliminary. rRevised.
[1]Excludes Puerto Rico and the Virgin Islands.
[2]Portland and masonry cement only.
[3]Includes imported cement shipped by domestic producers.
[4]Value received, f.o.b. mill, excluding cost of containers.
[5]Quantity shipped, plus imports, minus exports.
[6]Adjusted to eliminate duplication of imported clinker and cement shipped by domestic cement manufacturers.

Two new plants in Alabama and Utah collectively added more than 2 million tons per year to domestic cement production capacity in 1981. Seven other plants completed modernization programs that added approximately 3.5 million tons to U.S. capacity. Most of these plant expansions occurred in California, and all of them were west of the Mississippi River.

Despite these capacity additions, total

U.S. portland cement capacity declined 2% to 103 million tons in 1981. A number of plants closed temporarily or permanently because of poor market conditions and uneconomic operating parameters. Other plants were sold to companies capable of making capital investments to improve efficiency and realize economies of scale.

The trend continued toward acquisition of U.S. cement capacity by foreign firms. Companies based in Canada, France, Italy, the Netherlands, Sweden, Switzerland, and the United Kingdom acquired whole or partial interests in U.S. plants. At yearend, foreign ownership of U.S. clinker production capacity and finish-grinding capacity was 23% and 22%, respectively.

DOMESTIC PRODUCTION

During 1981, one State agency and 47 companies operated 155 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 tables show statistical data 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 have, on some tables, been divided to provide additional 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, decreased 2% to 66.6 million tons in 1981, and clinker imports reported by U.S. cement producers decreased 40% to 1.3 million tons. A total of 68.9 million tons of portland cement was ground in the United States in 1981. Stocks at mills increased by 500,000 tons to 6.9 million tons at yearend.

Production Capacity.—By yearend 1981, multiplant operations were being run by 26 companies. The size of individual companies, as a percentage of total U.S. clinker production capacity, ranged from 8.9% to 0.18%. The five largest producers provided 34% of the total 1981 production; the 10 largest producers provided a combined 54%. The 10 largest companies, in terms of 1981 clinker production, were (1) Lone Star Industries, Inc., (2) Ideal Basic Industries, Inc., (3) General Portland, Inc., (4) Martin Marietta Corp., (5) Gifford Hill & Co., Inc., (6) Lehigh Portland Cement Co., (7) Dundee Cement Co., (8) Kaiser Cement Corp., (9) Southwestern Portland Cement Co., and (10) Marquette Cement Co.

At yearend 1981, 318 kilns located at 142 plants were being operated by 42 companies and one State agency in the United States, excluding Puerto Rico. Annual clinker production capacity at yearend was 89.4 million tons, compared with 89.7 million tons in 1980. An average of 56 days' downtime was reported for kiln maintenance and replacing refractory brick. The industry operated at 75% of its apparent capacity, compared with 76% in 1980. Average annual clinker capacity of U.S. kilns was 281,000 tons, average plant capacity was 629,000 tons, and average company capacity was about 2.1 million tons. Six plants produced white cement. In addition, seven plants operated grinding mills using only imported or purchased clinker, or interplant transfers of clinker. Of these, six produced portland cement only, and one ground clinker for both masonry and portland cement. Based on the fineness necessary to grind Types I and II cements and making allowance for downtime required for maintenance, the U.S. cement industry had an estimated annual grinding capacity of 103 million tons of cement, about 2% less than that of 1980.

During 1981, clinker was produced by wet-process kilns at 68 plants and by dry-process kilns at 66 plants; 8 additional plants operated both wet and dry kilns. Most new plants that came onstream in 1981 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. Cement producers reported the addition of 4 suspension and 13 grate preheaters in 1981, bringing the yearend totals to 58 suspension and 19 grate preheaters.

Capacity Added in 1981.—Alamo Cement Co.'s new $50 million plant near San Antonio, Tex., was designed to produce about 500,000 tons of clinker annually and reportedly was expected to increase Alamo's production capacity to about 1 million tons of cement per year. Alamo Cement is wholly owned by Cementwerke Vigier A.G. of Switzerland and Presa S.p.A. Cementaria di Robilante of Italy.

California Portland Cement Co. completed a $112 million modernization and expansion of its plant in Mojave, Calif. The expansion increased annual plant capacity to 1 million tons. Pending the results of a preliminary engineering study, the company was considering doubling plant capacity to 2 million tons per year.

Genstar Cement and Lime Co. completed a $42 million modernization and expansion of its Redding, Calif., plant from 290,000 to 600,000 tons per year. This project was begun in 1979 when the plant was owned by The Flintkote Co.

Ideal Basic Industries, Inc., began operation of its new Cris Dobbins plant at Theodore, Ala., in September. Design capacity was 1.5 million tons per year. Ideal's expansion and complete renovation of its plant in Boettcher, Colo., was completed in July. Design capacity was increased from 325,000 tons to 460,000 tons per year.

Kaiser Cement Corp.'s $112 million modernization of its 1.5-million-ton-per-year cement plant at Permanente in northern California was completed and the new coal-fired kiln was started. The 16- by 250-foot kiln replaced six oil-fired units. The plant was converted from wet to dry process.

Lone Star Industries' expansion and modernization of its plant at Davenport near Santa Cruz, Calif., was completed in September. Capacity was approximately doubled to 775,000 tons per year. New equipment included a four-stage preheater plus precalciner, a 13- by 184-foot rotary kiln, a grate cooler, a raw mill, homogenizing kiln-feed silos, finish-grinding mills, electrostatic precipitators, and a computerized central control system.

Marquette Cement Co. completed a $102 million modernization and expansion of its plant at Cape Girardeau, Mo. The new 1-million-ton-per-year dry-process plant replaced the old 300,000-ton-per-year wet-process plant. The new plant was designed to require only 3 million British thermal units (Btu) of energy to produce 1 ton of clinker, whereas older plants use as much as 10 million Btu per ton.

Martin Marietta's $80 million expansion and conversion from wet to dry process at Buffalo near Davenport, Iowa, was completed. Capacity of the plant was increased from 500,000 to 850,000 tons per year. Martin Marietta's new $85 million, 650,000-ton-per-year plant at Leamington, Utah, started operations in November.

Capacity Additions Scheduled To Be Completed in 1982.—Ash Grove Cement Co. was expanding the capacity of its Louisville, Nebr., plant by adding a new production line designed to produce 600,000 tons per year. The new system was designed to have a suspension preheater, precalciner, 12.5- by 164-foot rotary kiln, and grate cooler. The process control and monitoring system was expected to feature the latest design in digital process control and programmable motor control.

Atlantic Cement Co., Inc., scheduled for spring 1982 the opening of its slag cement plant at Bethelehem Steel Corp.'s complex at Sparrows Point, Md. The plant was expected to consume about 800,000 tons annually of water-granulated blast-furnace iron slag. The process was claimed to use six times less energy than that required to manufacture portland cement. The comminuted product was to be blended with portland cement at the point of use.

Florida Mining and Materials Corp. planned to double the capacity of its plant in Brooksville, Fla., to 1.1 million tons per year. Startup was scheduled for early 1982.

Monolith Portland Cement Co.'s expansion and conversion from wet to dry process at its Monolith, Calif., plant was designed to double capacity to 1.0 million tons per year. Plant operation was scheduled for mid-1982.

Santee Portland Cement Corp., a subsidiary of Dundee Cement Co., announced plans for a new clinker grinding, storage, and handling system, to be operational by mid-1982.

Southwestern Portland Cement Co. reported capital expenditures of $1.3 million for process modifications to be completed in the second quarter of 1982 at its Amarillo, Tex., plant. These modifications were expected to increase annual clinker capacity by 25,000 tons to about 233,000 tons and improve fuel efficiency. The plant was also converting to coal as the primary kiln fuel at a cost of $2.3 million.

Capacity Additions Scheduled for After 1982.—Centex Corp. announced that it would double annual capacity of its Texas Cement Co. plant in Buda, Tex., to 1.1 million tons of cement by 1983.

Columbia Cement Corp. had plans to conduct an estimated $75 million expansion of its plant at Bellingham, Wash. Cement capacity was to be approximately doubled to 750,000 tons per year. No schedule was announced. The firm also planned to modernize equipment at its Zanesville, Ohio, plant at a cost of $3.3 million.

Genstar Cement and Lime Co. announced plans to modernize and expand its San Andreas, Calif., cement plant to 1 million tons per year.

Kaiser Cement Corp.'s $135 million expansion and conversion from wet to dry process of its Cushenbury plant at Lucerne Valley, Calif., was scheduled for completion in early 1983. Annual capacity was designed to be 1.5 million tons.

Las Vegas Portland Cement, Inc., a private firm started by local businessmen, announced plans to build a $272 million cement manufacturing complex near Jean, Nev. The 2-million-ton-per-year plant was scheduled to go onstream in 1983. It was to be the first cement plant in southern Nevada and the second plant in the State. The site of the complex, of which 12,320 acres are Federally controlled, contains reserves of limestone, shale, silica, and iron ore.

Lone Star Industries was considering the construction of a $75 million, 750,000-ton-per-year clinker plant at Concrete, Wash., to replace older capacity. The clinker would be shipped to the firm's Seattle plant for finish grinding.

Louisville Cement Co. announced plans to spend $16 million over 4 years to modernize its Bessemer, Pa., plant. The resulting capacity expansion was expected to be about 18%.

Oregon Portland Cement Co. was exploring the possibility of building additional capacity for cement production in its Northwestern U.S. market area.

Southwestern Portland Cement Co. scheduled a $100 million modernization and expansion of its Victorville, Calif., plant, to be completed in late 1984. Annual clinker capacity was planned to increase from 1.1 million tons to 1.4 million tons.

Plant Closings.—Alpha Portland Cement Co. closed its plants in Birmingham, Ala., and St. Louis, Mo., in 1981 following closure of its Jamesville, N.Y., plant in December 1980.

Ideal Basic Industries closed its Mobile, Ala., cement plant upon completion of its new Cris Dobbins plant at Theodore, Ala. At yearend, the company announced that its Houston, Tex., white and gray cement plants would discontinue production in early 1982 to become a terminal for distribution of cement manufactured at the new Alabama facility.

Marquette Co. suspended operations of its two cement plants in Cowan and Nashville, Tenn., in 1980 in anticipation of the initial operations in 1981 of its new Cape Girardeau, Mo., facility. Toward yearend 1981, Marquette ceased production at its Rockmart, Ga., plant, but continued to ship from the plant's inventory.

Medusa Cement Co. discontinued production of gray cement at its York, Pa., plant. The plant's white cement production was to continue, however.

Missouri Portland Cement Co. closed its St. Louis, Mo., cement manufacturing facility in December but continued to operate its shipping terminal on the property.

Corporate Changes.—Alpha Portland Cement Co. sold its Orange, Tex., cement manufacturing plant to River Cement Co., which is owned by Instituto Finanziario Industriale (IFI) S.p.A. of Turin, Italy. At yearend, the facility was operating as a grinding plant and distribution terminal. Alpha Portland also leased its previously closed Birmingham, Ala., plant to Allied Products Co. Allied was expected to reactivate the plant in 1982.

General Portland was acquired by Canada Cement Lafarge, Ltd., in December. The Canadian firm is 55% owned by Lafarge Coppee S.A. of France. Earlier in the year, General Portland purchased Whitehall Cement Co. Under the terms of a consent decree with the Federal Trade Commission (FTC), the new owner of General Portland must divest itself of its Chattanooga, Tenn., cement plant or, secondarily, its Demopolis, Ala., plant.

Table 2.—Portland cement production, capacity, and stocks in the United States, by district[1]

District	1980					1981				
	Plants active during year	Production[2] (thousand short tons)	Capacity[3]		Stocks[4] at mills, Dec. 31 (thousand short tons)	Plants active during year	Production[2] (thousand short tons)	Capacity[3]		Stocks[4] at mills, Dec. 31 (thousand short tons)
			Finish grinding (thousand short tons)	Percent utilized				Finish grinding (thousand short tons)	Percent utilized	
New York and Maine	9	3,648	5,399	67.6	472	7	3,645	4,559	80.0	434
Pennsylvania, eastern	11	4,036	6,586	61.3	480	10	3,840	5,846	65.7	456
Pennsylvania, western	4	1,435	2,155	66.6	181	4	1,262	2,345	53.8	190
Maryland and West Virginia	4	2,148	2,850	75.4	175	4	1,945	2,811	69.2	236
Ohio	5	1,693	2,380	71.1	130	6	1,571	2,500	62.8	161
Michigan	7	4,767	7,686	62.0	397	6	3,931	7,126	55.2	356
Indiana	5	2,033	3,402	59.8	319	4	1,752	3,188	55.0	305
Illinois	4	1,768	2,818	62.7	255	4	1,701	2,588	65.7	361
Tennessee	6	1,328	2,447	54.3	97	4	1,049	2,017	52.0	105
Kentucky, North Carolina, Virginia	3	1,640	2,482	66.1	203	3	1,626	2,482	65.5	228
South Carolina	3	1,780	3,268	54.5	95	3	1,789	3,130	57.2	114
Florida	6	3,336	4,055	82.3	129	6	3,367	4,057	83.0	204
Georgia	3	1,227	1,753	70.0	76	3	1,167	1,750	66.7	101
Alabama	7	2,520	3,769	66.9	279	6	2,218	3,408	65.1	287
Louisiana and Mississippi	4	1,657	1,993	83.1	108	3	1,363	1,485	91.8	57
Nebraska and Wisconsin	5	820	1,741	47.1	126	3	707	1,580	44.7	111
South Dakota	1	464	1,806	25.7	50	1	464	1,806	25.7	64
Iowa	5	2,058	3,121	65.9	310	4	1,713	2,734	62.7	340
Missouri	7	3,606	5,164	69.8	496	7	3,621	5,844	62.0	460
Kansas	5	1,968	2,308	85.3	191	5	1,843	2,318	79.5	294
Oklahoma and Arkansas	5	2,752	3,620	76.0	244	5	2,819	3,620	77.9	235
Texas	19	9,151	11,601	78.9	504	20	9,952	11,950	83.3	551
Wyoming, Montana, Idaho	4	998	1,194	83.6	117	4	1,118	1,575	71.0	196
Colorado, Arizona, Utah, New Mexico	8	3,521	5,270	66.8	203	9	3,589	6,047	59.4	211
Washington	4	1,572	2,103	74.8	136	4	1,679	2,104	79.8	127
Oregon and Nevada	3	1,025	1,775	57.7	75	3	1,011	1,775	57.0	103
California, northern	4	2,608	3,188	81.8	278	4	2,297	3,797	60.5	235
California, southern	8	6,241	8,199	76.1	208	8	5,581	7,990	69.8	304
Hawaii	2	372	560	66.4	39	2	311	560	55.5	48
Total or average	161	72,172	104,693	68.9	6,373	152	68,931	102,992	66.9	6,874
Puerto Rico	2	1,485	2,209	67.2	40	2	1,222	2,209	55.3	36

[1]Includes Puerto Rico. Includes data for 6 white cement facilities: Texas (2); Pennsylvania (2); California (1); Wisconsin (1 in 1980 only); and Utah (1 in 1981 only). Includes data for 7 grinding plants in 1981 and 9 in 1980 as follows: Florida (1); Indiana (1 in 1980 only); New York (1); Michigan (2); Pennsylvania (2 in 1980 and 1 in 1981); Wisconsin (2 in 1980 and 1 in 1981); and Texas (1 in 1981 only).

[2]Includes cement produced from imported clinker (1980—2,111,000 tons; 1981—1,276,000 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, by district, as of December 31, 1981[1]

District	Active plants: Process used: Wet	Active plants: Process used: Dry	Active plants: Process used: Both	Active plants: Total	Number of kilns	Daily capacity (thousand short tons)	Average number of days for maintenance	Apparent annual capacity[2] (thousand short tons)	Production[3] (thousand short tons)	Percent utilized
New York and Maine	4	2	--	6	9	13.1	53	4,084	3,433	84.1
Pennsylvania, eastern	3	6	--	9	24	17.3	42	5,591	3,716	66.5
Pennsylvania, western	3	1	--	4	8	5.9	39	1,922	1,274	66.3
Maryland and West Virginia	2	2	--	4	10	8.2	47	2,610	1,925	73.8
Ohio	2	3	1	6	10	7.9	65	2,371	1,583	66.8
Michigan	2	2	--	4	13	17.1	89	4,724	3,536	74.9
Indiana	2	2	--	4	9	9.7	34	3,212	1,642	51.1
Illinois	--	4	--	4	8	9.4	38	3,072	1,750	57.0
Tennessee	3	1	--	4	6	4.5	52	1,408	1,008	71.6
Kentucky, North Carolina, Virginia	1	2	--	3	8	6.8	75	1,974	1,616	81.9
South Carolina	2	1	--	3	7	7.4	37	2,429	1,891	77.9
Florida	4	1	--	5	11	11.3	39	3,679	3,006	81.7
Georgia	--	1	1	2	4	4.0	40	1,298	1,150	88.6
Alabama	--	5	--	5	6	12.7	44	4,073	2,406	59.1
Louisiana and Mississippi	3	--	--	3	4	4.5	55	1,397	1,147	82.1
Nebraska and Wisconsin	1	--	1	2	6	3.1	79	886	600	67.7
South Dakota	--	--	1	1	4	3.3	192	571	474	83.0
Iowa	2	2	--	4	10	8.3	33	2,754	1,737	63.1
Missouri	3	3	--	6	10	16.5	57	5,089	3,813	74.9
Kansas	3	2	--	5	15	7.4	53	2,307	1,783	77.3
Oklahoma and Arkansas	3	2	--	5	12	9.5	59	2,907	2,780	95.6
Texas	10	7	2	19	45	35.0	54	10,888	9,418	86.5
Wyoming, Montana, Idaho	4	--	--	4	6	4.0	46	1,276	1,092	85.6
Colorado, Arizona, Utah, New Mexico	3	6	--	9	22	18.6	50	5,858	3,547	60.5
Washington	3	1	--	4	7	3.7	23	1,267	1,180	93.1
Oregon and Nevada	1	2	--	3	6	4.1	48	1,301	1,076	82.7
California, northern	1	2	1	4	6	11.3	72	3,316	2,245	67.7
California, southern	2	5	1	8	30	22.5	68	6,676	5,474	82.0
Hawaii	1	1	--	2	2	1.8	122	437	312	71.4
Total or average	68	66	8	142	318	288.9	56	89,377	66,614	74.5
Puerto Rico	2	--	--	2	9	7.4	100	1,962	1,101	56.1

[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, December 31[1]

Short tons per 24-hour period	Number: Plants	Number: Kilns[2]	Total capacity (short tons)	Percent of total capacity
1980:				
Less than 600	3	4	1,530	0.5
600 to 1,150	31	54	28,175	9.3
1,150 to 1,700	44	100	64,305	21.2
1,700 to 2,300	33	79	65,344	21.5
2,300 to 2,800	15	36	37,376	12.3
2,800 and over	26	95	106,686	35.2
Total	152	368	303,416	100.0
1981:				
Less than 600	2	3	728	0.3
600 to 1,150	22	34	18,698	6.3
1,150 to 1,700	40	82	57,275	19.3
1,700 to 2,300	29	64	57,441	19.4
2,300 to 2,800	21	47	51,850	17.5
2,800 and over	30	97	110,286	37.2
Total	144	327	296,278	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	1979	1980	1981
Calcareous:			
Limestone (includes aragonite, marble, chalk)	[r]81,106	[r]78,289	73,026
Cement rock (includes marl)	30,987	24,991	26,627
Oystershell and coral	[r]3,398	[r]3,388	3,090
Argillaceous:			
Clay	7,016	6,220	5,742
Shale	4,289	4,193	3,649
Other (includes staurolite, bauxite, aluminum dross, pumice, alumina, volcanic material, other)	362	313	212
Siliceous:			
Sand and calcium silicate	2,128	1,994	1,794
Sandstone, quartzite, other	808	668	734
Ferrous: Iron ore, pyrites, millscale, other iron-bearing material	1,063	1,175	1,144
Other:			
Gypsum and anhydrite	4,324	3,859	3,600
Blast furnace slag	483	132	95
Fly ash	509	601	757
Other, n.e.c	6	171	162
Total	136,479	125,994	120,632

[r]Revised.
[1]Includes Puerto Rico.

Gulf Coast Portland Cement Co. was sold twice in 1981. The company was originally a subsidiary of McDonough Co., which was sold early in the year to Hanson Industries, Inc., a British-owned firm. At midyear, Bernard P. McDonough, founder of McDonough Co., reacquired two units of his former company, including Gulf Coast. At yearend, the cement company was under Mr. McDonough's ownership as a subsidiary of Marmac Corp.

Lehigh Portland Cement sold its Hannibal, Mo., cement plant plus three distribution terminals to Continental Cement Co., a newly formed, foreign-owned company. Continental is 51% owned by the Swedish concern Industri AB Euroc, which is the parent company of the Swedish cement firm Cementa AB; the balance of Continental is owned by four other foreign-based companies. Lehigh divested itself of the Hannibal plant in compliance with an FTC consent decree that resulted from Lehigh's 1980 purchase of United States Steel Corp.'s Universal Atlas Cement Div.

Penn Dixie Industries, Inc., which filed for reorganization in 1980 under Chapter 11 of the Federal Bankruptcy Act, sold its remaining cement operations during 1981. Information follows on the yearend status of these plants: (1) Dundee Cement Co., a subsidiary of the Swiss firm Holderbank Financière Glaris S.A., was using the Petoskey, Mich., plant for storage and distribution only; (2) Martin Marietta was operating the Des Moines, Iowa, plant; (3) Moore

McCormack Cement, Inc., was operating the Kingsport and Richard City, Tenn., plants under the name Dixie Cement Co.; (4) Penn-West Cement Co., Inc., a new corporation, was operating the West Winfield, Pa., plant.

MASONRY CEMENT

Production of masonry cement totaled 2.8 million tons, a decrease of 9% from that of 1980. At yearend, 100 plants were manufacturing masonry cement in the United States. Three plants producing masonry cement exclusively were Cheney Lime & Cement Co., Allgood, Ala.; Genstar Stone Products Co., Frederick, Md.; and Riverton Corp., Riverton, Va. Masonry cement was not produced at cement plants in some parts of the country because many masons preferred to use portland cement and add clay or lime on the job as needed for the necessary plasticity.

Table 6.—Masonry cement production and stocks in the United States, by district

District	1980			1981		
	Plants active during year	Production (thousand short tons)	Stocks[1] at mills, Dec. 31 (thousand short tons)	Plants active during year	Production (thousand short tons)	Stocks[1] at mills, Dec. 31 (thousand short tons)
New York and Maine	4	83	16	3	71	12
Pennsylvania, eastern	8	226	28	7	228	41
Pennsylvania, western	4	96	15	4	85	17
Maryland and West Virginia	3	117	10	4	102	14
Ohio	4	129	21	4	112	27
Michigan	5	205	71	4	181	72
Indiana	2	W	W	3	261	59
Illinois	1	W	W	1	W	W
Tennessee	5	144	22	3	64	9
Kentucky, North Carolina, Virginia	4	199	25	4	164	21
South Carolina	2	W	W	2	W	W
Florida	4	299	17	5	286	22
Georgia	3	88	15	3	87	15
Alabama	6	246	35	5	195	25
Louisiana and Mississippi	3	39	7	2	W	W
Nebraska and Wisconsin	2	W	W	1	W	W
South Dakota	1	5	2	1	6	2
Iowa	3	45	11	3	42	18
Missouri	3	72	19	4	96	22
Kansas	5	63	17	5	72	33
Oklahoma and Arkansas	5	107	10	5	100	8
Texas	13	220	23	13	229	22
Wyoming, Montana, Idaho	3	7	2	3	9	4
Colorado, Arizona, Utah, New Mexico	6	116	7	6	112	9
Washington	2	W	W	3	17	5
Oregon and Nevada	--	--	(2)	--	--	(2)
Hawaii	2	13	2	2	12	3
Other	--	533	77	--	248	38
Total	103	[3]3,052	452	100	[3]2,779	498

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes imported cement.
[2]Less than 1/2 unit.
[3]Includes 2,621,000 tons produced from clinker and 431,000 tons produced from cement (1980); 2,445,000 tons produced from clinker and 334,000 tons produced from cement (1981).

ALUMINOUS CEMENT

Aluminous cement, also known as calcium aluminate cement, high-alumina cement, and Ciment Fondu, is a nonportland hydraulic cement. It was produced at the following three plants in the United States: Lehigh Portland Cement Co., Buffington, Ind.; Lone Star Lafarge, Inc., Chesapeake, Va.; and Aluminum Co. of America, Bauxite, Ariz.

ENERGY

Energy conservation continued to be a major focus for reducing cement production costs. Most new or modernized plants in 1981 featured coal burning, dry-process systems with preheaters and precalciners to promote efficiency in fuel consumption.

In 1981, 81% of the energy consumed in cement production was in the form of fuel for kiln firing to produce clinker. Average energy consumption per ton of clinker was reduced 3.7% to 5.3 million Btu.

The average consumption of electrical energy increased 2% to 144.5 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. Average fuel consumption for kiln firing plus electrical energy (primarily for finish grinding) was approximately 6.5 million Btu per ton in 1981.

Average fuel consumption in kiln firing in wet-process plants, 6.0 million Btu per ton, was 33% higher than average fuel consumption in dry-process plants, 4.5 million Btu per ton. Approximately 50% of clinker production in 1981 was by the dry process, compared with 45% in 1980.

Kilns without preheaters averaged 5.6 million Btu per ton of clinker produced; those with suspension preheaters averaged 4.3 million Btu per ton, and those with grate-type preheaters averaged 5.4 million Btu per ton.

In 1981, coal accounted for 84% of kiln fuel consumption, compared with 77% in 1980; natural gas accounted for 12%, compared with 16% in 1980; and oil accounted for 4%, compared with 7% in 1980. On the average, 1 ton of clinker produced in 1981 consumed 369 pounds of coal, 643 cubic feet of natural gas, and 1.35 gallons of oil.

Interest increased in energy-saving additives such as fly ash and iron and steel slag as Atlantic Cement neared completion of a slag cement plant in Baltimore, Md. Use of fly ash in cements increased 26% to 757,000 tons in 1981. However, use of slags decreased 28% to 95,000 tons.

Table 7.—Clinker produced in the United States, by fuel[1]

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)
1980:						
Coal	38	16,719	23.9	3,751	--	--
Oil	3	1,623	2.3	--	1,634	--
Natural gas	4	1,596	2.3	--	--	8,551,904
Coal and oil	19	8,848	12.7	1,536	820	--
Coal and natural gas	52	22,352	32.0	4,488	--	23,773,914
Oil and natural gas	7	3,802	5.5	--	660	16,827,953
Coal, oil, natural gas	30	14,881	21.3	2,449	995	11,529,607
Total	153	69,821	100.0	12,224	4,109	60,683,378
1981:						
Coal	32	14,539	21.5	3,251	--	--
Oil	2	1,100	1.6	--	1,185	--
Natural gas	4	1,568	2.3	--	--	11,067,620
Coal and oil	27	11,849	17.5	2,219	281	--
Coal and natural gas	56	25,285	37.3	4,924	--	19,717,338
Oil and natural gas	5	1,292	1.9	--	122	6,171,226
Coal, oil, natural gas	22	12,082	17.9	2,095	581	6,635,182
Total	148	67,715	100.0	12,489	2,169	43,591,366

[1]Includes Puerto Rico.
[2]Includes 95.6% bituminous and 4.4% petroleum coke in 1980; 96.9% bituminous and 3.1% petroleum coke in 1981.

Table 8.—Clinker produced and fuel consumed by the portland cement industry in the United States, by process[1]

Process	Clinker produced			Fuel consumed		
	Plants active during year	Quantity (thousand short tons)	Percent of total	Coal[2] (thousand short tons)	Oil (thousand 42-gallon barrels)	Natural gas (thousand cubic feet)
1980:						
Wet	85	36,116	51.7	6,605	2,709	40,424,076
Dry	60	29,417	42.1	4,915	1,197	15,408,815
Both	8	4,288	6.2	704	203	4,850,487
Total	153	69,821	100.0	12,224	4,109	60,683,378
1981:						
Wet	72	31,257	46.1	6,466	1,455	24,490,040
Dry	68	31,800	47.0	5,296	616	12,134,282
Both	8	4,657	6.9	727	98	6,967,044
Total	148	[3]67,715	100.0	12,489	2,169	43,591,366

[1]Includes Puerto Rico.
[2]Includes 95.6% bituminous and 4.4% petroleum coke in 1980; 96.9% bituminous and 3.1% petroleum coke in 1981.
[3]Data do not add to total shown because of independent rounding.

Table 9.—Electric energy used at portland cement plants in the United States, by process[1]

Process	Electric energy used: Generated at portland cement plants: Active plants	Generated at portland cement plants: Quantity (million kilowatt-hours)	Purchased: Active plants	Purchased: Quantity (million kilowatt-hours)	Total: Quantity (million kilowatt-hours)	Total: Percent	Finished cement produced (thousand short tons)	Average electric energy used per ton of cement produced (kilowatt-hours)
1980:								
Wet	1	4	85	5,037	5,041	48.2	38,365	131.4
Dry[2]	3	448	70	4,321	4,769	45.6	31,132	153.2
Both	--	--	8	657	657	6.2	4,160	157.9
Total	4	452	163	10,015	10,467	100.0	73,657	142.1
Percent of total electric energy used	--	4.3	--	95.7	--	--	--	--
1981:								
Wet	--	--	72	4,424	4,424	43.7	32,928	134.4
Dry[2]	4	366	74	4,634	5,000	49.3	32,487	153.9
Both	--	--	8	710	710	7.0	4,738	150.0
Total	4	366	154	9,768	10,134	100.0	70,153	144.5
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.

TRANSPORTATION

U.S. shipments of portland cement to consumers were primarily in bulk (94%), by truck (92%), and made directly from cement manufacturing plants (74%) 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 and waterways. Each of these transportation modes accounted for 44% of shipments from plants to terminals. Transportation by truck accounted for 9%.

The increasingly favorable economics for transporting cement on water were realized with Ideal Basic Industries' purchase of two 8,900-ton oceangoing barges. These barges were acquired to haul cement from the company's new Alabama plant to its Houston, Tex., plant, which was undergoing a $1.6 million conversion to a distribution center.

Table 10.—Shipments of portland cement from mills in the United States, in bulk and in containers, by type of carrier[1]

(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	
1980:							
Railroad	7,519	159	438	7	4,572	r188	r5,205
Truck	1,190	178	16,769	767	46,163	4,140	67,839
Barge and boat	7,336	76	71	1	614	6	692
Unspecified[2]	2	--	58	14	795	r71	r938
Total	16,047	413	17,336	789	52,144	r4,405	[3]74,674
1981:							
Railroad	7,582	140	412	3	3,451	98	3,964
Truck	1,442	115	16,883	591	43,346	3,720	64,540
Barge and boat	7,527	75	120	--	645	9	774
Unspecified[2]	478	--	261	21	638	30	950
Total	17,029	330	17,676	615	48,080	3,857	[3]70,228

rRevised.
[1]Includes Puerto Rico.
[2]Includes cement used at plant.
[3]Bulk shipments were 93.0% (69,480,000 tons) and container (bag) shipments were 7.0% (5,194,000 tons) for 1980. Bulk shipments were 93.6% (65,756,000 tons), and container (bag) shipments were 6.4% (4,472,000 tons) for 1981.

CONSUMPTION AND USES

Cement consumption in the United States, excluding Puerto Rico, decreased 5.5% in 1981 to 73.3 million tons. The decline in cement demand reflected reduced activity in the construction industry and general weakness in the U.S. economy. Domestic producers shipped 71.7 million tons in 1981, a 6% decrease from that of 1980. This included 2.1 million tons of cement and clinker imported and sold or used by domestic producers. Additional imports of 1.6 million tons net of cement imported by certain other importers accounted for the difference between consumption and domestic shipments.

Domestic shipments decreased by more than 5% to all regions of the United States except the New England, Mountain, and West South Central regions, where receipts increased 2% or less. Oklahoma showed the largest consumption gain, 12%, of any State. Shipments to destinations in the East North Central and Pacific regions were particularly depressed, decreasing 13% and 12%, respectively, compared with those of 1980. No significant cement shortages occurred in the United States during 1981.

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 miscellaneous.

According to the U.S. Department of Commerce, the value of U.S. construction put in place in 1981 decreased 3.5% from that of 1980 in terms of constant (1977) dollars to $155 billion, although current-dollar value showed an increase of 2.8% to $237 billion.[2] Of this total value 36% was in private housing, 41% was in private industrial and commercial building (including farms), 8% was in public buildings, 6% was in highways, and 9% was in other public construction.

Total private construction put in place decreased 2.4% in real value to $120 billion, of which residential units decreased 9.4% to $55 billion and industrial-commercial construction increased 4.4% in real value to $65 billion. Total public construction put in place decreased 7.0% in real value to $35 billion, of which public buildings decreased 6.7% to $12 billion, highway construction decreased 2.1% to $8.3 billion, and other public construction decreased 10% to $15 billion.

Housing starts decreased 16% to 1.1 million units, consisting of 705,000 single units and 379,000 multiunits, according to the U.S. Department of Commerce. Single housing starts decreased 17%. On a regional basis, housing starts decreased 13% in the South to 562,000 units, 6% in the Northeast to 117,000 units, 22% in the West to 240,000 units, and 24% in the North Central region to 165,000 units. The ratio of cement consumption to housing unit starts was 60% greater in the North Central region than in the South and 43% greater than in the West, reflecting the relatively greater influence of construction other than housing on cement consumption in certain regions.

Table 11.—Portland cement shipped by producers in the United States, by district[1]

District	1980			1981		
	Quantity (thousand short tons)	Value (thousands)	Average per ton	Quantity (thousand short tons)	Value (thousands)	Average per ton
New York and Maine	3,550	$134,855	$37.99	3,369	$130,690	$38.79
Pennsylvania, eastern	4,066	167,855	41.28	3,860	162,122	42.00
Pennsylvania, western	1,504	69,829	46.43	1,290	53,760	41.67
Maryland and West Virginia	2,079	91,159	43.85	1,894	85,316	45.05
Ohio	1,625	77,696	47.81	1,461	69,517	47.58
Michigan	4,651	224,685	48.31	3,871	180,641	46.67
Indiana	1,769	73,049	41.29	1,538	59,344	38.59
Illinois	1,649	75,315	45.67	1,574	61,536	39.10
Tennessee	1,304	58,827	45.11	974	39,378	40.43
Kentucky, North Carolina, Virginia	1,588	72,910	45.91	1,562	72,325	46.30
South Carolina	1,704	74,539	43.74	1,765	79,407	44.99
Florida	3,574	182,590	51.09	3,518	199,064	56.58
Georgia	1,231	55,463	45.06	1,149	45,423	39.53
Alabama	2,491	108,438	43.53	2,270	89,216	39.30
Louisiana and Mississippi	1,621	95,752	59.07	1,317	75,859	57.60
Nebraska and Wisconsin	842	44,136	52.42	746	39,944	53.54
South Dakota	459	23,042	50.20	450	23,290	51.76
Iowa	1,998	101,008	50.55	1,779	92,099	51.77
Missouri	3,515	156,368	44.49	3,732	168,567	45.17
Kansas	1,835	86,103	46.92	1,641	81,792	49.84
Oklahoma and Arkansas	2,726	127,483	46.77	2,703	138,336	51.18
Texas	9,517	535,690	56.29	10,262	567,391	55.29
Wyoming, Montana, Idaho	1,004	56,106	55.88	1,120	68,673	61.32
Colorado, Arizona, Utah, New Mexico	3,647	207,740	56.96	3,697	234,404	63.40
Washington	1,546	89,208	57.70	1,560	100,845	64.64
Oregon and Nevada	960	57,277	59.66	897	54,671	60.95
California, northern	2,556	151,156	59.14	2,413	152,933	63.38
California, southern	6,241	391,331	62.70	5,483	366,033	66.76
Hawaii	358	23,722	66.26	302	23,024	76.24
U.S. total or average[2] [3]	71,613	3,613,332	50.46	68,197	3,515,600	51.55
Foreign imports[4]	1,580	83,718	52.99	805	44,691	55.52
Puerto Rico	1,482	102,872	69.41	1,226	105,420	85.99
Grand total or average[3]	74,674	3,799,923	50.89	70,228	3,665,711	52.20

[1]Includes Puerto Rico. Includes data for 6 white cement facilities: Texas (2); Pennsylvania (2); California (1); and Wisconsin (1 only in 1980); and Utah (1 only in 1981). Includes data for 9 grinding plants in 1980 and 7 in 1981 as follows: Florida (1); Indiana (1 in 1980 only); New York (1); Michigan (2); Pennsylvania (2 in 1980 and 1 in 1981); Wisconsin (2 in 1980 and 1 in 1981); and Texas (1 in 1981 only).

[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, by district[1]

District	1980 Quantity (thousand short tons)	1980 Value (thousands)	1980 Average per ton	1981 Quantity (thousand short tons)	1981 Value (thousands)	1981 Average per ton
New York and Maine	79	$3,813	$48.27	78	$4,317	$55.35
Pennsylvania, eastern	221	14,482	65.53	207	11,619	56.13
Pennsylvania, western	103	5,816	56.47	86	3,180	36.98
Maryland and West Virginia	121	6,733	55.64	111	6,518	58.72
Ohio	126	8,549	67.85	105	7,129	67.90
Michigan	206	14,292	69.38	173	10,584	61.18
Indiana	W	W	W	252	10,972	43.54
Illinois	W	W	W	W	W	W
Tennessee	132	7,241	54.86	67	3,209	47.90
Kentucky, North Carolina, Virginia	193	10,191	52.80	168	8,570	51.01
South Carolina	W	W	W	W	W	W
Florida	285	22,074	77.45	288	20,757	72.07
Georgia	89	5,464	61.39	89	4,392	49.35
Alabama	242	13,012	53.77	193	10,721	55.55
Louisiana and Mississippi	48	2,980	62.08	W	W	W
Nebraska and Wisconsin	W	W	W	W	W	W
South Dakota	6	377	62.83	6	454	76.67
Iowa	48	3,340	69.58	41	3,227	78.71
Missouri	62	3,117	50.27	103	5,495	53.35
Kansas	60	3,310	55.17	51	2,835	55.59
Oklahoma and Arkansas	107	6,031	56.36	101	6,295	62.33
Texas	241	18,310	75.98	229	15,699	68.55
Wyoming, Montana, Idaho	7	490	70.00	7	525	75.00
Colorado, Arizona, Utah, New Mexico	119	8,444	70.96	109	8,684	79.67
Washington	W	W	W	15	1,284	85.60
Oregon and Nevada	1	41	41.00	([2])	25	78.00
Hawaii	13	960	73.85	10	807	80.70
Other	531	29,389	55.35	249	14,521	58.32
U.S. total or average	3,040	188,456	61.99	2,738	161,819	59.10
Foreign imports[3]	10	982	98.20	8	985	123.13
Grand total or average	3,050	189,438	62.11	2,746	162,804	59.29

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Does not include quantities produced on the job by masons.
[2]Less than 1/2 unit.
[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] 1979	Portland cement[2] 1980	Portland cement[2] 1981	Masonry cement 1979	Masonry cement 1980	Masonry cement 1981
Destination:						
Alabama	1,270	1,133	988	116	93	76
Alaska[3]	90	94	137	--	W	--
Arizona	1,808	1,457	1,479	W	W	W
Arkansas	892	758	668	62	49	39
California, northern	3,813	3,012	2,535	1	([4])	--
California, southern	5,734	5,226	4,733	13	([4])	--
Colorado	1,515	1,404	1,532	40	28	27
Connecticut[3]	766	614	590	16	16	16
Delaware[3]	155	132	124	8	7	6
District of Columbia[3]	126	117	116	5	4	2
Florida	4,602	5,412	5,335	396	408	389
Georgia	2,100	2,050	1,882	189	159	151
Hawaii	422	365	302	12	13	10
Idaho	471	362	311	2	2	2
Illinois	3,378	2,664	2,323	133	90	70
Indiana	1,713	1,323	1,146	114	85	71
Iowa	1,779	1,294	1,147	28	19	16
Kansas	1,294	1,207	1,086	29	24	22
Kentucky	1,231	954	915	116	80	75
Louisiana	2,755	2,735	2,597	91	73	70
Maine	242	221	227	12	9	9
Maryland	1,358	1,290	1,165	122	115	97
Massachusetts[3]	1,005	959	997	42	35	36
Michigan	2,874	1,993	1,729	169	109	86
Minnesota	1,714	1,447	1,238	58	43	38

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] 1979	Portland cement[2] 1980	Portland cement[2] 1981	Masonry cement 1979	Masonry cement 1980	Masonry cement 1981
Destination —Continued						
Mississippi	947	861	841	76	65	51
Missouri	1,863	1,430	1,426	51	38	34
Montana	335	292	300	4	2	2
Nebraska	1,053	828	667	19	14	12
Nevada	610	565	574	(4)	--	--
New Hampshire[3]	307	221	242	11	10	10
New Jersey[3]	1,727	1,486	1,267	69	57	57
New Mexico	583	600	661	10	11	11
New York, eastern	776	669	542	29	24	24
New York, western	885	788	809	41	34	34
New York, metropolitan[3]	916	905	1,061	35	35	36
North Carolina	1,656	1,463	1,455	227	184	173
North Dakota[3]	371	271	318	9	6	6
Ohio	3,202	2,659	2,334	208	151	124
Oklahoma	1,699	1,626	1,827	69	56	55
Oregon	976	831	626	1	1	1
Pennsylvania, eastern	1,797	1,583	1,458	71	55	48
Pennsylvania, western	1,105	920	832	94	72	64
Rhode Island[3]	159	126	118	6	5	4
South Carolina	926	883	905	123	107	89
South Dakota	411	257	239	8	6	4
Tennessee	1,515	1,369	1,192	172	134	108
Texas	8,745	8,839	9,202	251	224	219
Utah	921	799	699	2	2	2
Vermont[3]	138	125	125	5	4	5
Virginia	1,973	1,788	1,531	191	147	130
Washington	1,846	1,374	1,292	11	8	8
West Virginia	580	546	478	51	41	34
Wisconsin	1,766	1,544	1,331	64	46	41
Wyoming	462	478	503	4	3	3
U.S. total	83,357	74,349	70,157	3,686	3,003	2,697
Foreign countries[5]	160	296	593	109	86	84
Puerto Rico	1,343	1,414	1,151	--	--	--
Total shipments	84,860	76,059	71,901	3,795	3,089	2,781
Origin:						
United States[6]	78,978	71,610	68,197	3,749	3,044	2,738
Puerto Rico	1,406	1,482	1,226	--	--	--
Foreign:[7]						
Domestic producers	3,006	1,580	805	14	10	8
Others	1,470	1,387	1,673	32	35	35
Total shipments	84,860	76,059	71,901	3,795	3,089	2,781

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 (1979—425,000 tons; 1980—283,000 tons; 1981—192,000 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, by region and subregion[1]

Region and subregion[2]	Portland cement				Masonry cement			
	Thousand short tons		Percent of total		Thousand short tons		Percent of total	
	1980	1981	1980	1981	1980	1981	1980	1981
Northeast:								
New England	2,266	2,299	3.0	3.3	79	80	2.7	3.0
Middle Atlantic	6,351	5,969	8.6	8.5	277	263	9.2	9.7
Total	8,617	8,268	11.6	11.8	356	343	11.9	12.7
South:								
Atlantic	13,681	12,991	18.4	18.5	1,172	1,071	39.0	39.7
East Central	4,317	3,936	5.8	5.6	372	310	12.4	11.5
West Central	13,958	14,294	18.8	20.4	402	383	13.4	14.2
Total	31,956	31,221	43.0	44.5	1,946	1,764	64.8	65.4
North Central:								
East	10,183	8,863	13.7	12.7	481	392	16.0	14.5
West	6,734	6,121	9.1	8.7	150	132	5.0	4.9
Total	16,917	14,984	22.8	21.4	631	524	21.0	19.4
West:								
Mountain	5,957	6,059	8.0	8.6	48	47	1.6	1.8
Pacific	10,902	9,625	14.6	13.7	22	19	.7	.7
Total	16,859	15,684	22.6	22.3	70	66	2.3	2.5
Grand total	74,349	70,157	100.0	100.0	3,003	2,697	100.0	100.0

[1]Includes imported cement shipped by domestic and Canadian cement manufacturers and other importers.
[2]Geographic regions as designated by the U.S. Department of Commerce, Bureau of the Census.

Table 15.—Portland cement shipments in 1981, 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 (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	170	5.1	384	11.4	2,529	75.1	34	1.0	85	2.5	1	(2)	166	4.9	3,369
Pennsylvania, eastern	424	11.0	793	20.5	2,493	64.6	56	1.5	52	1.3	13	.3	29	.8	3,860
Pennsylvania, western	140	10.9	174	13.5	832	64.5	97	7.5	42	3.2	--	--	5	.4	1,290
Maryland and West Virginia	87	4.6	304	16.0	1,390	73.4	30	1.6	64	3.4	2	.1	17	.9	1,894
Ohio	65	4.5	329	22.5	986	67.5	51	3.5	27	1.8	--	--	3	.2	1,461
Michigan	151	3.9	543	14.0	2,841	73.4	173	4.5	146	3.8	--	--	17	.4	3,871
Indiana	85	5.6	180	11.7	1,176	76.4	67	4.3	29	1.9	1	.1	--	--	1,538
Illinois	48	3.0	163	10.4	1,220	77.5	109	6.9	23	1.5	--	--	11	.7	1,574
Tennessee	63	6.5	210	21.6	645	66.2	37	3.8	12	1.2	3	.3	4	.4	974
Kentucky, North Carolina, Virginia	93	5.9	155	9.9	1,199	76.8	40	2.6	53	3.4	1	.1	21	1.3	1,562
South Carolina	48	2.7	307	17.4	1,226	69.5	130	7.4	53	3.0	1	(2)	--	--	1,765
Florida	205	5.8	427	12.2	2,340	66.5	272	7.7	236	6.7	24	.7	14	.4	3,518
Georgia	106	9.2	175	15.2	654	56.9	187	16.3	21	1.8	3	.3	3	.3	1,149
Alabama	177	7.8	408	18.0	1,408	62.0	120	5.3	68	3.0	10	.4	79	3.5	2,270
Louisiana and Mississippi	96	7.3	94	7.1	675	51.3	103	7.8	271	20.6	51	3.9	27	2.0	1,317
Nebraska and Wisconsin	34	4.5	84	11.3	525	70.4	59	7.9	27	3.6	2	.3	15	2.0	746
South Dakota	18	4.0	24	5.3	282	62.7	54	12.0	26	5.8	--	--	46	10.2	450
Iowa	56	3.1	315	17.7	1,235	69.4	143	8.0	26	1.5	1	.1	3	.2	1,779
Missouri	117	3.1	347	9.3	2,938	78.7	224	6.0	83	2.2	20	.6	3	.1	3,732
Kansas	79	4.8	100	6.1	1,205	73.4	28	1.7	151	9.2	2	.1	76	4.7	1,641
Oklahoma and Arkansas	120	4.4	238	8.8	1,848	68.4	69	2.6	353	13.0	14	.5	61	2.3	2,703
Texas	563	5.5	680	6.6	6,123	59.7	386	3.8	1,858	18.1	117	1.1	535	5.2	10,262
Wyoming, Montana, Idaho	29	2.6	53	4.7	758	67.7	28	2.5	235	21.0	--	--	17	1.5	1,120
Colorado, Arizona, Utah, New Mexico	181	4.9	442	12.0	2,567	69.4	134	3.6	241	6.5	3	.1	129	3.5	3,697
Washington	57	3.7	122	7.8	1,272	81.5	40	2.6	34	2.2	3	.2	32	2.0	1,560
Oregon and Nevada	39	4.4	41	4.6	602	67.1	99	11.0	85	9.5	2	.2	29	3.2	897
California, northern	217	9.0	316	13.1	1,633	67.7	82	3.4	128	5.3	1	(2)	36	1.5	2,413
California, southern	316	5.8	766	14.0	3,967	72.3	102	1.9	309	5.6	11	.2	12	.2	5,483
Hawaii	18	6.0	36	11.9	237	78.5	--	--	8	2.6	--	--	3	1.0	302
Imports[3]	25	3.1	39	4.9	724	89.9	16	2.0	1	.1	--	--	--	--	805
Total or average	3,827	5.5	8,249	12.0	47,530	68.9	2,970	4.3	4,747	6.9	286	.4	1,393	2.0	69,002
Puerto Rico	505	41.2	84	6.8	528	43.1	--	--	23	1.9	8	.6	78	6.4	1,226

[1]Includes Puerto Rico.
[2]Less than 1/2 unit.
[3]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, by type[1]

Type	1980			1981		
	Quantity (thousand short tons)	Value[2] (thousands)	Average per ton	Quantity (thousand short tons)	Value[2] (thousands)	Average per ton
General use and moderate heat (Types I and II)	67,536	$3,378,495	$50.03	62,543	$3,192,940	$51.05
High-early-strength (Type III)	2,488	125,705	50.52	2,567	135,214	52.67
Sulfate-resisting (Type V)	245	15,136	61.78	200	12,633	63.17
Oil well	2,513	146,766	58.40	3,272	203,990	62.34
White	309	43,280	140.06	332	42,721	128.68
Portland slag and portland pozzolan	839	44,426	52.95	683	38,189	55.91
Expansive	85	5,446	64.07	55	3,648	66.33
Miscellaneous[3]	659	40,671	61.72	576	36,376	63.15
Total or average	74,674	3,799,925	50.89	70,228	3,665,711	52.20

[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 cement and low-heat (Type IV).

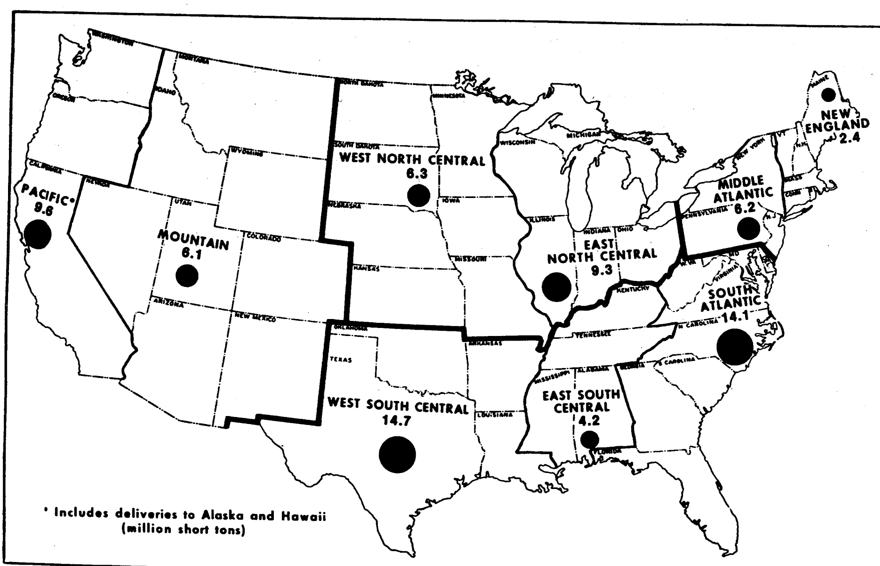

Figure 1.—Shipments of cement by geographic region of destination in 1981.

PRICES

The average mill value of all types of portland cement increased 2.6% in 1981. From 1977 to 1980, the average mill value had increased at an average annual rate of 12%. The average mill value of masonry cement prepared at cement plants declined 4.5% in 1981, following an 11% average annual rate of increase from 1977 to 1980.

According to Engineering News-Record (ENR), yearend prices of bulk portland cement for 20 U.S. cities averaged $62.10 per ton.[3] This was 18% above the average U.S. mill value obtained from the Bureau of Mines canvass of cement producers. The lowest ENR market quotation was $51 per ton for Chicago, and the highest was $78.50 per ton for Seattle. The median per ton price was $61.78.

Civil antitrust suits, originally filed in 1976 by the attorneys general of California, Arizona, and Colorado against the Portland Cement Association and several cement producers, and alleging a conspiracy to fix, maintain, and stabilize cement prices, were not resolved during 1981. The plaintiffs in the multidistrict litigation, reportedly had increased from the orignal 3 States to at least 15 States, with the addition of 29 private plaintiffs. The defendants included a majority of U.S. cement producers. In each of these suits, plaintiffs claimed treble damages based on alleged violations of Federal antitrust laws, sought injunctive relief, costs, and attorneys' fees, and in some instances, claimed damages under State antitrust laws as well. Most of the Federal cases have been consolidated in Arizona for pretrial discovery purposes.

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
1977	$36.36	$45.03	$36.76
1978	40.70	50.53	41.17
1979	46.24	54.59	46.61
1980	50.89	62.11	51.32
1981	52.20	59.29	52.46

[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 cement clinker increased 62% in 1981. Of 303,000 tons exported, 69% was shipped to Canada, 23% to Mexico, and 8% to 60 other countries. These exports accounted for 0.41% of shipments from U.S. and Puerto Rican mills, compared with 0.24% in 1980.

Imports of hydraulic cement and clinker decreased 24% to 4.0 million tons; of this 31% by weight was clinker, compared with 36% in 1980. Canada supplied 58% of the total, followed by Japan (14%), Spain (8%), France (6%), Norway (4%), and 15 other countries (10%). U.S. net import reliance (excluding Puerto Rico and the Virgin Islands) equaled 4% of apparent consumption.

Imports of white nonstaining portland cement increased to 117,000 tons, 3% above 1980 imports. White cement imports had nearly quadrupled since 1977. Canada was the primary source in 1981, providing 38% of the total, followed by Spain (27%), Japan (15%), the French West Indies (11%), Belgium-Luxembourg (7%), and five other countries (2%). White cement imports from Canada were about two-thirds of those in 1980.

Several companies began operating new terminals for transshipment of imported cement during the year:

1. Delta Cement Co., a subsidiary of the Federal Republic of Germany's trading company Stinnes AG, opened a 33,000-ton terminal at Stockton, Calif. The source of cement was Nihon Cement Co. of Japan.
2. Independent Cement Corp., a subsidiary of St. Lawrence Cement Co. of Canada, opened cement distribution terminals at Oswego, N.Y., and Portland, Maine, and announced plans for terminals at Duluth, Minn., and Willington, Conn.
3. Pacific Coast Cement Corp. began operating its 50,000-ton terminal at Long Beach, Calif. Bulk cement from Australia was the source of supply.

Table 18.—U.S. exports of hydraulic cement and cement clinker, by country

Country	1979		1980		1981	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Bahamas	15,904	$351	1,073	$180	3,126	$300
Bolivia	--	--	244	41	1,327	197
Canada	88,965	8,034	[r]123,283	9,571	208,278	18,251
Guinea	--	--	--	--	1,072	96
Leeward and Windward Islands	533	32	603	53	1,422	160
Mexico	38,785	4,334	54,658	4,927	69,968	7,374
Peru	2	1	22	9	1,575	347
Saudi Arabia	450	183	944	332	4,157	1,429
Venezuela	566	253	329	74	2,528	699
Other[1]	5,641	1,383	5,249	1,812	9,324	2,711
Total[2]	150,846	[r]14,571	186,404	16,997	302,777	31,564

[r]Revised.
[1]Includes 40 countries in 1979, 49 in 1980, and 53 in 1981.
[2]Data may not add to totals shown because of independent rounding.

Source: U.S. 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	1979			1980			1981		
	Quantity	Value		Quantity	Value		Quantity	Value	
		Customs	C.i.f.[1]		Customs	C.i.f.[1]		Customs	C.i.f.[1]
Bahamas	487	19,929	22,728	298	12,108	13,279	4	195	223
Canada	4,440	137,975	151,247	2,635	90,597	100,330	2,338	83,660	97,390
France	405	14,425	16,052	251	13,699	14,274	239	12,614	13,351
Japan	1,523	52,605	57,822	619	20,822	25,757	569	20,944	26,032
Mexico	525	19,531	22,471	329	13,841	15,924	83	4,623	4,625
Norway	281	7,182	9,760	225	6,193	8,463	146	4,295	5,613
Spain	548	16,144	21,344	479	22,458	28,461	322	12,357	15,800
Sweden	--	--	--	94	3,942	4,222	--	--	--
United Kingdom	759	26,249	31,636	202	6,797	10,382	103	4,840	5,237
Other	445	8,318	18,104	131	5,116	6,914	193	7,713	10,988
Total	9,413	302,358	351,164	5,263	195,573	228,006	3,997	[2]151,240	179,259

[1]Cost, insurance, and freight.
[2]Data do not add to total shown because of independent rounding.

Source: U.S. Bureau of the Census.

Table 20.—U.S. imports for consumption of clinker, by country

(Thousand short tons and thousand dollars)

Country	1979			1980			1981		
	Quantity	Value		Quantity	Value		Quantity	Value	
		Customs	C.i.f.[1]		Customs	C.i.f.[1]		Customs	C.i.f.[1]
Australia	160	3,670	5,430	--	--	--	--	--	--
Canada	1,887	50,531	54,684	800	25,787	27,998	578	19,421	21,570
France	385	13,931	15,262	249	13,554	14,114	239	12,605	13,336
Japan	1,384	40,849	49,594	506	16,797	20,838	374	12,938	16,442
Peru	105	2,866	3,631	--	--	--	--	--	--
Spain	398	9,980	12,159	298	16,270	18,629	34	1,152	1,359
United Kingdom	341	9,911	11,721	--	--	--	--	--	--
Other	8	135	186	64	1,523	2,163	1	331	435
Total	4,668	131,873	152,667	1,917	73,931	83,742	1,226	46,447	53,142

[1]Cost, insurance, and freight.

Source: U.S. 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	1980			1981		
	Quantity	Value		Quantity	Value	
		Customs	C.i.f.[1]		Customs	C.i.f.[1]
Anchorage: Canada	19	1,377	1,498	14	1,124	1,633
Baltimore:						
Japan	([2])	5	5	--	--	--
Germany, Federal Republic of	--	--	--	([2])	1	3
Yugoslavia	([2])	18	27	1	131	139
Total[3]	([2])	23	32	1	132	143
Buffalo:						
Canada	604	17,973	20,783	690	23,713	26,732
Ecuador	--	--	--	2	61	68
Italy	--	--	--	([2])	1	1
Total	604	17,973	20,783	692	23,775	26,801
Chicago:						
Canada	53	1,842	1,842	--	--	--
United Kingdom	--	--	--	([2])	([2])	2
Total	53	1,842	1,842	([2])	([2])	2
Cleveland: Canada	99	3,097	3,506	26	864	1,004
Detroit:						
Belgium-Luxembourg	--	--	--	([2])	1	3
Canada	603	18,565	20,135	492	17,298	18,990
Total[3]	603	18,565	20,135	492	17,300	18,992
Duluth: Canada	28	951	1,078	5	148	238
El Paso:						
Germany, Federal Republic of	--	--	--	([2])	([2])	1
Mexico	11	587	586	1	61	61
Total	11	587	586	1	61	62
Galveston:						
Canada	--	--	--	27	1,065	1,331
Mexico	93	3,391	4,276	--	--	--
Spain	37	1,064	1,283	34	1,142	1,340
Total[3]	130	4,455	5,559	60	2,207	2,671
Great Falls: Canada	1	347	414	4	568	670
Honolulu:						
Canada	6	250	346	--	--	--
Japan	17	668	755	([2])	6	11
Total	23	918	1,101	([2])	6	11
Houston:						
Canada	([2])	4	5	--	--	--
France	([2])	64	66	--	--	--
Germany, Federal Republic of	--	--	--	([2])	6	9
Spain	176	12,994	14,460	--	--	--
United Kingdom	([2])	59	68	([2])	148	190
Total[3]	176	13,121	14,599	([2])	155	198
Laredo:						
Canada	--	--	--	([2])	23	23
Mexico	100	5,177	5,178	80	4,364	4,366
Total[3]	100	5,177	5,178	81	4,388	4,389
Los Angeles:						
Australia	--	--	--	67	W	W
Canada	64	3,592	3,896	([2])	W	W
Colombia	35	956	1,291	--	--	--
Germany, Federal Republic of	([2])	11	11	([2])	W	W
Japan	273	8,497	10,608	([2])	W	W
Spain	([2])	53	101	1	W	W
Yugoslavia	([2])	55	130	([2])	W	W
Total	372	13,164	16,037	68	2,888	4,311
Miami:						
Bahamas	255	10,304	11,219	4	195	223

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	1980			1981		
	Quantity	Value		Quantity	Value	
		Customs	C.i.f.[1]		Customs	C.i.f.[1]
Miami —Continued						
Belgium-Luxembourg	3	219	303	1	71	116
Canada	--	--	--	10	299	339
Colombia	54	1,839	2,535	47	1,226	2,129
Denmark	24	944	1,041	52	1,801	2,265
France	1	66	69	--	--	--
Italy	--	--	--	([2])	3	3
Mexico	113	3,799	4,851	--	--	--
Norway	24	941	942	--	--	--
Spain	122	3,422	4,879	211	6,536	8,577
Total[3]	596	21,534	25,839	325	10,131	13,653
Milwaukee: Canada	60	1,953	2,256	--	--	--
New Orleans:						
Canada	25	802	1,221	43	1,312	2,012
Germany, Federal Republic of	([2])	23	30	([2])	14	19
Spain	28	762	940	4	102	158
United Kingdom	93	3,024	4,219	([2])	10	12
Total[3]	146	4,611	6,410	46	1,438	2,200
New York City:						
Italy	([2])	([2])	([2])	--	--	--
Norway	175	4,586	6,578	70	1,836	2,643
Total	175	4,586	6,578	70	1,836	2,643
Nogales: Mexico	([2])	42	42	1	62	62
Norfolk:						
France	44	4,427	4,559	45	4,602	4,739
Germany, Federal Republic of	([2])	1	1	([2])	1	1
United Kingdom	([2])	2	2	--	--	--
Total	44	4,430	4,562	45	4,603	4,740
Ogdensburg: Canada	140	4,129	4,495	72	2,330	2,582
Pembina: Canada	92	4,184	4,711	85	4,189	4,758
Philadelphia: Germany, Federal Republic of	([2])	7	9	([2])	6	7
Port Arthur: Spain	30	743	990	--	--	--
Portland, Maine: Canada	14	393	395	13	387	389
Portland, Oregon:						
Canada	12	477	503	10	498	529
Japan	24	803	842	--	--	--
Total	36	1,280	1,345	10	498	529
St. Albans:						
Canada	275	8,164	7,933	396	11,404	14,859
South Africa, Republic of	([2])	([2])	1	([2])	2	2
Yemen Arab Republic	([2])	1	1	--	--	--
Total	275	8,165	7,935	396	11,406	14,861
San Diego:						
Japan	--	--	--	65	3,197	3,409
Mexico	2	191	191	1	136	136
United Kingdom	109	3,712	6,093	72	3,666	3,839
Total[3]	111	3,903	6,284	139	6,999	7,384
San Francisco:						
Australia	1	67	113	--	--	--
Canada	50	2,055	2,588	--	--	--
Finland	--	--	--	([2])	28	45
Japan	172	6,820	8,503	112	4,038	5,404
Total	223	8,942	11,204	112	4,066	5,449
San Juan, Puerto Rico:						
Belgium-Luxembourg	10	822	1,234	7	753	1,116
Canada	--	--	--	3	297	462
Colombia	2	147	178	1	101	122
France	([2])	9	15	([2])	4	8

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	1980 Quantity	1980 Value Customs	1980 Value C.i.f.[1]	1981 Quantity	1981 Value Customs	1981 Value C.i.f.[1]
San Juan, Puerto Rico —Continued						
Spain	7	639	1,309	8	891	1,426
Total[3]	19	1,617	2,736	19	2,047	3,134
Seattle:						
Canada	265	11,646	12,571	108	5,099	5,352
Italy	(2)	(2)	(2)	--	--	--
Japan	131	4,030	5,044	391	13,258	16,584
Mexico	(2)	464	532	--	--	--
Total	396	16,140	18,147	499	18,357	21,936
Tampa:						
Bahamas	44	1,804	2,060	--	--	--
Canada	225	8,797	10,156	340	13,040	15,485
Denmark	--	--	--	1	230	290
France	206	9,133	9,565	194	W	W
Mexico	10	191	268	--	--	--
Norway	25	666	943	76	2,459	2,970
Spain	78	2,780	4,499	64	W	W
Sweden	94	3,942	4,223	--	--	--
United Kingdom	--	--	--	30	1,016	1,195
Total	682	27,313	31,714	705	28,265	32,537
Virgin Islands of the United States:						
Dominican Republic	--	--	--	2	115	170
French West Indies	--	--	--	13	890	1,099
Total	--	--	--	15	1,005	1,269
Grand total[3]	5,263	195,573	228,006	3,997	151,240	179,259

W Withheld to avoid disclosing company proprietary data; included with "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: U.S. Bureau of the Census.

Table 22.—U.S. imports for the consumption of cement

(Thousand short tons and thousand dollars)

Year	Roman, portland, other hydraulic cement Quantity	Roman, portland, other hydraulic cement Value (customs)	Hydraulic cement clinker Quantity	Hydraulic cement clinker Value (customs)	White nonstaining portland cement Quantity	White nonstaining portland cement Value (customs)	Total Quantity	Total Value (customs)
1977	2,394	62,920	1,613	29,224	31	1,861	4,038	94,005
1978	3,589	119,048	2,968	69,264	40	2,330	6,597	190,642
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

Source: U.S. Bureau of the Census.

WORLD REVIEW

World cement production did not increase significantly in 1981. Many of the industrialized nations of North America, Europe, and Asia experienced a decline in production associated primarily with depressed economic conditions. During the past decade, these countries had declined in production and consumption as a percentage of world totals. To maintain growth in sales and earnings, major producers in industrialized countries with saturated domestic markets have penetrated markets in Africa, Asia, and South America, where cement demand traditionally exceeds supply. Leading exporting nations in 1980 (the most recent year for which data were available) were, in decreasing order of exports, Spain, Japan, Greece, the Republic of Korea, the U.S.S.R., France, Canada, Romania, Belgium, the Federal Republic of Germany, and the United Kingdom. Leading importers, in decreasing order of imports, were Saudi Arabia and its neighbors on the Persian Gulf, Nigeria, the United States, the Netherlands, Hong Kong, India, Singapore, and the Federal Republic of Germany. Many of the major importing countries, however, were building or expanding their domestic production capacities, and competition for cement markets was expected to intensify in the long term as new capacity comes onstream.

Argentina.—Cement demand in Argentina had been rising steadily during the previous 5 years, creating shortages and resulting in increased imports. To reduce cement imports and also the expense of long-distance transportation of domestic cement, J. Minetti S.A. was planning to build a 790,000-ton-per-year cement plant at Puesto Viejo in Jujuy Province. The project complemented the Argentine Government's objective to decentralize industry into the less developed, interior regions of the country. The plant, which was Minetti's second major expansion in 3 years, was designed to increase the firm's total annual capacity to 1.8 million tons. Part of the plant's cement production was expected to be used for international infrastructure projects assisted by the World Bank and Inter-American Development Bank.[4]

Australia.—Adelaide Brighton Cement Ltd. began exporting cement to the United States in September 1981. The firm contracted with Pacific Coast Cement Co., of Long Beach, Calif., to supply 660,000 tons per year.[5]

Benin.—Although Benin had been developing its minerals, cement was the only mineral product produced on a commercial scale. Two state enterprises, Société des Ciments du Benin and Société Nationale des Ciments, each operated a clinker grinding plant. These plants, which had combined annual capacity of 350,000 tons in 1981, relied on imported clinker supplies. A new plant of 550,000 tons annual capacity was under construction and scheduled to come onstream in 1982. The new Onigbolo plant was to be located in the Pobe region, which has substantial limestone deposits to supply raw material for the plant. A joint Beninese-Nigerian enterprise was building the $125 million project. The per-ton price of cement rose to $90 in 1981 from $59 in 1980, but this increase was not expected to dampen demand because Nigeria was considered a growth market for the Beninese product.[6]

Brazil.—Cement production capacity was targeted to increase at an average annual rate of 5.4% between 1980 and 1985, reaching 39.3 million tons in 1985, according to the Sindicato Nacional da Industria do Cimento. Of the 60 cement plants in operation in 1981, at least 10 had expansion projects in progress or in the planning stage. Most of the increased output was expected to be consumed domestically to reduce Brazil's foreign exchange outlays for cement imports.[7]

Burma.—In an effort to promote local cement and ceramic industries and to become self-sufficient in certain key minerals, Burma began to develop its nonmetallic minerals after 1962. This effort had been successful over the long term in increasing production of raw materials for Burma's fledgling cement industry. However, major increases in limestone and gypsum supplies were expected to be required within the next 2 years when a new French-financed, 220,000-ton-per-year cement plant was to be completed at Paan in Karen State. The Industrial Planning Department of the Ministry of Industry was considering building another cement plant in the Maymyo area with financial assistance from the World Bank.[8]

Canada.—The slow economy and attendant rise in interest rates combined to restrict Canadian building activity and, therefore, demand for cement. For example, housing unit starts, which fell 20% in 1980, increased only slightly in 1981. In addition, the depressed export market for cement to the United States, Canada's principal export market, continued to reduce Canadian cement sales. Exports of finished cement to the United States in 1981 declined 4% to 1.8 million tons, and exports of clinker declined 28% to 578,000 tons.

The trend of the past few years continued toward direct involvement of Canadian cement producers in the U.S. cement industry by establishing cement distribution terminals in the United States and purchasing U.S. cement firms. St. Lawrence Cement Co. announced plans to build a distribution center in Willington, Conn., consisting of two steel silos to hold 1,500 tons of cement and two concrete silos to hold 5,000 tons, and Canada Cement Lafarge, Ltd., purchased one of the largest U.S. cement manufacturers, General Portland, Inc.

Chile.—To keep pace with forecast domestic cement demand, the Chilean cement industry was expected to require considerable expansion and possibly a temporary increase in imports. Chile had four cement producers, one owned by Blue Circle Industries, Ltd., of the United Kingdom, one owned primarily by the Holderbank Group of Switzerland, and two owned by the Chilean Government. The privately owned plants were in the process of doubling their combined annual capacity to 1.4 million tons by 1983. This increase in capacity was planned to help satisfy demand for cement resulting from the current boom in housing and industrial expansion and the longer term needs of the Colbun hydroelectric project.[9]

Denmark.—AS Aalborg Portland-Cement-Fabrik centralized all cement production at its Rordal works near Aalborg. Three of the firm's other plants were closed because of shrinking cement markets and increased energy costs. A fourth cement plant at Dania was converted to production of calcined bauxite for refractory use, although it retained the capability of producing masonry cement. The company, Denmark's sole cement producer, had production capacity of 2.5 to 2.8 million tons per year.[10]

France.—Société des Ciments Francais, which operated 14 cement plants, 6 grinding mills, and 13 distribution centers, maintained a 33% share of the French cement market in 1981. A new white cement plant at Cruas began production in February. The firm's expansion into international markets was advanced by its 1976 acquisition of Coplay Cement Co. in the United States.

Ciments Lafarge France, with 21 cement plants, increased its usage of coal in cement production to 70% of total fuel consumed. In 1978, coal usage was only 4% of the total.[11]

Greece.—Cement output had grown steadily at an average annual rate of about 8% since 1976. In 1981, exports accounted for 50% of total production. Titan Cement Co. S.A., the country's largest producer with over 40% of Greek cement capacity, increased its clinker production capacity by adding a second preheater with precalciner at the Patras plant, and began operating a new cement mill, storage silos, and ship-loading facilities. All four of Titan's plants were being converted to coal firing.[12]

India.—Cement capacity utilization declined to 67% during Indian fiscal year 1980-81 because of infrastructural bottlenecks, particularly coal shortages. Most of the production came from the private sector, which accounted for about 85% of the total annual capacity of 30.6 million tons. The shortfall in domestic cement supply in 1980-81 resulted in a 550,000-ton increase in imports to 2.1 million tons. Principal suppliers included North Korea, the Republic of Korea, the Philippines, and Indonesia.

In view of the gap between supply and demand, steps were being taken to increase cement output as well as quality. The Ministry of Industry was looking into labor requirements, use of pozzolan additives, and cement technology and machinery with the objective of expanding the industry to meet long-term demand. By fiscal year 1984-85, Indian cement capacity was scheduled to reach 47 million tons per year, with the public sector share of capacity rising to 22%. More than eight plants of 1.1-million-ton annual capacity each were expected to come onstream. In addition, miniplants were being established to take advantage of smaller limestone deposits. Four miniplants ranging in daily capacity from 33 to 220 tons were to be commissioned in 1981, and two additional miniplants were planned for 1982. Furthermore, public sector units were assigned a major program of utilizing slag from Indian steel plants for cement production.[13]

Indonesia.—Demand for cement had escalated in recent years, thereby promoting dramatic growth in the cement industry throughout Indonesia. Construction of a 66,000-ton-annual-capacity cement plant in Kupang, West Nusatenggera, and several small production units in Maluku, Irian Jaya, and South Kalimantan, plus several scheduled plant expansions were expected to raise annual production to 19 million tons by fiscal year 1984-85 and to 22 million tons by 1989-90.[14]

Iraq.—The Iraqi Government contracted for construction of a 2.2-million-ton-per-year cement plant in the southwestern part of the country. The first of two production lines was scheduled to begin operating in 1984. KHD Humboldt Wedag AG was the contractor.[15]

Japan.—Ranked as the second largest cement producer in the world, Japan had an expanded network of cement plants, made possible in part by the widespread occurrence and easy availability of high-purity limestone. To produce 1 ton of Japanese cement, the average quantity of raw materials consumed was 1.2 tons of limestone, 0.24 ton of clay, 0.034 ton of silica stone, and 0.024 ton of slag.[16]

Oil consumption by Japan's industrial sector decreased 20.8% in fiscal year 1980, which ended March 31, 1981.[17] The decrease was primarily the result of energy conservation and fuel substitution from oil to coal by the cement and steelmaking industries. By the end of the fiscal year, 83.6% of the heat used in calcining cement raw materials was derived from coal.[18] Some firms relied entirely on coal for calcination, including Ube Industries Ltd. (three plants), Chichibu Cement Co. Ltd. (three plants), and Mitsui Mining Co. Ltd. (two plants).

Jordan.—Cement demand in 1981 of 1.9 million tons was expected to increase to 3.2 million tons by 1984. To meet this large increase in demand, the National Planning Council awarded a second contract to the Mitsubishi Corp.-Kobe Steel consortium for construction of a cement plant on a turnkey basis. The second plant, which was scheduled to go onstream in 1984, was designed with an annual capacity of 2.2 million tons. The first cement plant, which was under construction, was expected to begin operating in late 1982 to produce 1.1 million tons annually.[19]

Korea, North.—A new calcining method at the Chonnaeri cement plant quadrupled cement output while reducing fuel consumption 50%. The North Korean cement industry set a national target of 22 million tons of annual production by the end of the 1980's. This goal was planned to meet domestic demand and also offer potential for export.[20]

Korea, Republic of.—The South Korean cement industry began expanding for exports in the 1960's. In 1980, South Korea exported 5.2 million tons valued at $235 million. Primary export markets were the Middle East (31%), Southeast Asia (32%), and South Asia (33%). In 1981, the cement industry's nine producers were using about 75% of capacity because of domestic recession and increased overseas competition. Rising fuel and electricity costs and local inflation increased the industry's costs of production in 1980 by 60% compared with those of 1979. By 1981, the domestic price of cement had risen 40% above the export price. Moreover, some Asian countries such as Thailand and Indonesia, which had been traditional markets for South Korean cement, were developing their own cement industries. Despite these problems, South Korea set a target of expanding its annual cement-manufacturing capacity 30% to about 33 million tons by 1986.[21]

Lebanon.—Cement production has been Lebanon's principal industry. All three of the country's plants are located in the northern coastal region. In 1981, domestic sales amounted to 85% of production. Export markets were primarily neighboring Arab countries. After several years of poor performance because of the 1975-76 civil war and subsequent hostilities, the Lebanese construction sector and, concomitantly, cement demand revived in 1980 and 1981. Construction activity indicators exceeded pre-civil war levels of the early 1970's. Building activity was concentrated in the coastal regions north of Beirut and was characterized by rising demand for residential and recreational facilities.[22]

Malaysia.—Kedah Cement Sdn. Bhd. announced plans for a new cement plant having production capacity of 4,400 tons per day. Ishikawajima-Harima Heavy Industries Co. Ltd. of Japan was selected to build the plant.[23]

Mexico.—Chronic shortages of cement in northwestern Mexico were expected to be alleviated when the new Hermosillo plant of Cementos Portland Nacional S.A. begins production in 1982. Production capacity was designed to be approximately 1 million tons per year.[24]

In recent years, strong domestic cement demand had led to a significant increase in imports and decrease in exports. For example, exports of Mexican cement to the United States decreased from 329,000 tons in 1980 to 83,000 tons in 1981. Scheduled growth in Mexican cement capacity was not expected to keep pace with domestic demand in the near term.

Norway.—AS Norcem, Norway's sole cement producer, announced its intention to reduce annual production capacity of its three plants by about 660,000 tons. Plans to modernize the Kjopsvik plant were continuing, however.[25]

Oman.—Krupp Polysius AG of the Federal Republic of Germany was awarded a $135 million contract to build a 2,200-ton-per-day cement plant in Rusayal. The plant, which would be Oman's first cement producer, was scheduled to begin operations in

1983.[26]

Spain.—With 54 cement producing facilities, Spain continued to be the world's leading exporter of cement. In 1981, approximately 40% of total production was exported.[27]

Sweden.—Capacity of Cementa AB, Sweden's only cement producer, was reduced to 3.5 million tons per year from 4.4 million tons per year. Each of the firm's three plants was converted to dry process, and annual fuel consumption was reduced 30%. Cementa's largest plant (2.4 million tons annual capacity) began operating a new production line that featured preheating, precalcining, and computer control from limestone quarrying to cement storage in silos. It was claimed to be the most advanced cement facility in the world.[28]

In 1981, Cementa purchased from Lehigh Portland Cement Co. of the United States a cement plant in Hannibal, Mo., and three distribution terminals.

Switzerland.—During the past decade, virtually all Swiss cement plants converted to dry-process kilns to save energy. The industry was also reverting to use of coal instead of oil or natural gas to fire the kilns.[29]

In 1981, 11 of the country's 13 cement producers were members of Eingetragene Genossenschaft Portland, which set production quotas and prices. The largest producer, Holderbank AG, with over one-third of the Swiss market, had interests in more than 50 cement facilities worldwide, including the 3 plants of Dundee Cement Co. and its subsidiary Santee Portland Cement Corp. in the United States.

Thailand.—For the previous 2 years, high local demand and supply shortages had prevented Thai exports of cement. However, in 1981, the Siam Cement Co., Ltd., was authorized to export 11,000 tons of cement to neighboring Malaysia.[30]

The Tabkwang-Saraburi plant of Siam City Cement Co., Ltd., was scheduled for a preheater-kiln system modification to increase its capacity from 1,900 tons to 3,900 tons per day. Completion of the project was planned for January 1983.[31]

U.S.S.R.—Cement production in the U.S.S.R., the world's largest producer, was targeted to reach approximately 155 million tons by 1985. New automated operations with capacities to exceed 3 million tons per year and reconstructed existing works were planned to increase the country's total output. By 1990, even bigger cement manufacturing facilities capable of producing up to 25 different types of cement were planned to go into operation[32]

United Kingdom.—British cement producers, concerned about competition from low-priced European imports, delayed previously announced price increases of 7.5% until 1982. It was reported that Blue Circle Industries Ltd., which maintained a 60% share of the domestic cement market, suspected that sharp increases in domestic prices might attract a European producer to install a bulk import terminal somewhere along the Thames estuary. Although cement imports had been negligible, precast concrete manufacturers expressed interest in importing cement supplies if domestic prices increased significantly.[33]

Blue Circle, which had about 12,800 employees, announced plans to lay off 1,100 workers in 1982 because of the "continuing recession in construction" that resulted in a 20% decline in cement deliveries in 1981.[34]

Rio Tinto Zinc Corp. (RTZ) was in the process of acquiring Thomas K. Ward Ltd. as 1981 ended. A successful bid would enable RTZ to become the United Kingdom's second largest cement producer by gaining control of Ward's associated companies, Tunnel Cement Ltd. and Ribblesdale Cement Ltd.[35]

Zimbabwe.—Owing to the underutilization of existing cement manufacturing capacity in 1981, Zimbabwe's two cement companies had no immediate plans for expansion. Priority projects included replacing obsolete quarry equipment and increasing comminution and bagging capacities. Both companies, Salisbury Portland Cement Ltd. (SPC) and United Portland Cement Co. Ltd. (Unicem), had production capacities of about 440,000 tons per year. SPC, a subsidiary of the United Kingdom's Blue Circle Industries Ltd., marketed high-quality portland cement and two slag cements, one having 15% and the other 50% blast-furnace slag. Little competition existed between SPC and Unicem because their respective markets were limited to local demand in the vicinity of Zimbabwe's two widely dispersed major cities, Salisbury and Bulawayo.[36]

Table 23.—Hydraulic cement: World production, by continent and country[1]

(Thousand short tons)

Continent and country	1977	1978	1979	1980[p]	1981[e]
North America:					
Bahamas	77	364	496	573	660
Canada	10,626	[r]11,374	12,969	11,571	11,430
Costa Rica	447	[r]540	582	610	550
Cuba	2,928	2,989	2,879	3,241	3,585
Dominican Republic	950	956	977	1,119	1,080
El Salvador	413	[r]502	642	573	550
Guatemala	541	568	632	627	500
Haiti	267	274	298	268	275
Honduras	276	298	685	700	550
Jamaica	367	324	249	159	165
Mexico	14,580	15,494	16,731	17,924	18,740
Nicaragua	249	219	95	170	110
Panama	298	331	562	623	660
Trinidad and Tobago	237	243	236	202	220
United States (including Puerto Rico)	80,058	85,480	85,904	76,709	72,932
South America:					
Argentina	[r]6,616	[r]6,962	7,349	7,863	8,270
Bolivia	294	280	277	280	280
Brazil	[r]23,284	[r]24,559	27,419	29,975	31,415
Chile	1,237	[r]1,297	1,491	1,746	1,765
Colombia	3,635	4,578	4,693	4,796	5,730
Ecuador	687	919	1,211	1,531	1,600
Paraguay	220	183	171	195	210
Peru	[r]2,126	2,226	[e]2,756	[e]3,300	3,395
Suriname	[r]47	66	68	76	70
Uruguay	[r]752	743	757	755	760
Venezuela	3,457	3,777	4,386	5,338	5,400
Europe:					
Albania[e]	827	[r]882	926	1,102	1,100
Austria	[r]6,205	[r]6,482	6,185	6,013	5,950
Belgium	8,558	8,351	8,491	8,247	8,270
Bulgaria	5,142	5,676	5,954	5,984	6,000
Czechoslovakia	10,746	11,248	11,307	11,624	11,735
Denmark	2,545	2,895	2,659	2,205	1,700
Finland	1,887	1,878	1,928	1,976	1,975
France	31,779	30,892	31,774	32,082	31,115
German Democratic Republic	13,340	13,802	13,529	13,717	13,780
Germany, Federal Republic of	36,826	[r]38,915	40,415	39,183	[2]36,408
Greece	11,667	12,434	13,336	14,495	14,880
Hungary	5,093	5,251	5,354	5,137	5,110
Iceland	153	147	139	134	135
Ireland	1,742	1,991	2,278	2,059	1,950
Italy	[r]42,113	[r]42,144	43,309	46,046	46,300
Luxembourg	321	343	351	358	330
Netherlands	4,293	[r]4,319	4,080	4,128	4,190
Norway	2,551	3,460	2,422	2,307	[2]1,964
Poland	23,479	23,920	21,138	20,330	15,680
Portugal	4,736	[r]5,644	5,664	6,336	6,280
Romania	15,295	16,191	17,194	17,208	16,260
Spain (including Canary Islands)[3]	30,859	33,326	30,768	31,372	31,525
Sweden	[r]2,883	[r]2,592	2,631	2,778	2,560
Switzerland	4,022	4,075	4,336	4,687	4,740
U.S.S.R	[r]140,055	139,945	135,605	137,843	140,000
United Kingdom	17,037	17,544	17,791	16,320	14,620
Yugoslavia	8,826	9,588	8,908	10,268	[2]10,779
Africa:					
Algeria	1,959	2,973	4,153	4,410	4,630
Angola[e]	330	440	440	265	275
Cameroon	400	[e]390	540	250	300
Cape Verde Islands[e]	4	17	17	17	18
Egypt	3,590	3,307	3,260	3,338	3,910
Ethiopia	[e]80	95	102	198	220
Gabon	209	[e]210	106	121	120
Ghana	672	551	441	265	265
Kenya	1,262	1,240	938	1,402	1,430
Liberia	110	146	150	117	110
Libya	2,756	3,527	3,527	3,527	3,530
Madagascar	58	73	77	66	70
Malawi	104	[r]114	114	101	110
Mali	39	38	29	22	22
Morocco	3,164	3,107	3,611	3,915	3,970
Mozambique	356	360	301	303	550
Niger	44	[e]45	42	[e]45	45
Nigeria	1,587	1,693	1,918	2,205	2,200
Senegal	364	[r]394	420	426	425
South Africa, Republic of	7,245	7,522	7,606	7,937	8,800
Sudan	[r]166	207	203	204	200
Tanzania	287	255	309	1,213	1,325
Tunisia	631	972	1,524	1,962	2,210
Uganda	[r] [e]88	[r] [e]88	55	11	9
Zaire	539	520	496	449	440
Zambia	440	136	220	176	175
Zimbabwe	542	450	437	[e]440	440

See footnotes at end of table.

Table 23.—Hydraulic cement: World production, by continent and country[1] —Continued

(Thousand short tons)

Continent and country	1977	1978	1979	1980[p]	1981[e]
Asia:					
Afghanistan[4]	150	140	155	[e]55	65
Bangladesh	338	[r]373	355	370	380
Burma	297	280	431	426	420
China	61,343	71,914	81,461	88,030	92,600
Cyprus	1,181	1,220	1,251	1,359	1,325
Hong Kong	1,134	[r]1,362	1,410	1,641	1,660
India	[r]21,010	[r]21,561	20,133	19,511	22,885
Indonesia	[r]2,922	[r]4,072	5,179	6,413	6,945
Iran	7,998	13,227	9,921	8,818	8,820
Iraq	3,494	5,070	5,622	6,063	6,170
Israel	2,165	2,200	2,116	2,302	2,545
Japan	80,621	[r]93,566	96,787	96,956	93,510
Jordan	624	622	882	882	1,100
Kampuchea[e]	55	11	--	--	--
Korea, North	[r]7,717	[r]7,717	8,818	8,818	8,800
Korea, Republic of	15,648	16,681	18,092	17,230	17,215
Kuwait	363	685	[e]695	[e]700	700
Lebanon	1,499	1,522	2,239	[e]2,425	2,425
Malaysia	1,959	2,421	2,497	2,589	2,865
Mongolia	[r]110	183	202	196	200
Nepal	46	40	24	34	35
Pakistan	3,489	3,420	3,768	3,677	3,860
Philippines[5]	[r]4,626	[r]4,784	4,354	4,941	5,070
Qatar	[r]187	229	261	230	285
Saudi Arabia	1,397	1,984	2,425	3,858	5,510
Singapore[e]	[r]1,488	[r]1,488	1,488	2,152	2,200
Sri Lanka	392	634	653	629	660
Syria	1,538	[r]1,580	2,036	2,199	2,370
Taiwan	11,392	12,633	13,115	15,501	15,810
Thailand	5,633	[r]5,612	5,793	5,883	6,615
Turkey	15,248	[r]16,914	15,194	14,192	15,430
United Arab Emirates	220	220	220	551	770
Vietnam[e]	930	929	804	937	720
Yemen	66	69	99	89	90
Oceania:					
Australia	5,536	5,504	5,779	5,938	5,840
Fiji Islands	85	90	106	93	95
New Caledonia	56	61	62	62	62
New Zealand	1,003	880	833	827	830
Total	[r]878,635	[r]940,249	959,283	974,825	978,919

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through June 23,1982.
[2]Reported figure.
[3]Excludes natural cement.
[4]Year beginning Mar. 21 of that stated.
[5]Converted from officially reported data provided in terms of bags of cement. Conversion factor used assumes the bags reported are bags of 94 pounds, but this may be in error for at least a part of the total.

TECHNOLOGY

Cement.—The Bureau of Mines published a report of investigations on its research into replacing a portion of the portland cement in mine backfill (waste) with pozzolan (fly ash) and lime.[37] Unconfined compression tests on various ratios of fly ash to cement in 84 samples produced compressive strength curves that can be used to estimate the best backfill mix for any particular mine. Returning mine waste underground in the form of a low-strength concrete provides benefits in waste disposal, ground control, ventilation, and fire control; however, the support potential gained by adding portland cement to the mine waste is often offset by the cost of cement. Partial substitution of fly ash as a cementing agent not only reduces the material costs of backfilling but also alleviates the waste disposal problems of power generation from coal.

The University of Surrey, United Kingdom, initiated a research program to improve understanding of the processes involved in the setting of portland cement, and the ways in which these processes relate to the subsequent mechanical performance and strength of cement.[38] Essential to the research was an electron microscope purchased for use in a detailed series of experiments to study the developing microstructures of cement during hydration and the variability of these structures relative to chemical composition, temperature, and the presence of gypsum or other additives. A parallel study was planned to address the relationship of changes in cement microstructure to mechanical properties. The researchers' objective was to expand on current knowledge of basic principles in order to develop new types of cement for special applications.

Use of solid fuels such as coal and coke to fire a cement kiln presents problems related to the variability from batch to batch of the fuel constituents. Because of the variability in solid fuels, regular chemical analyses are necessary to determine the proper quantities required for complete combustion of the cement raw materials. The traditional thermogravimetric analysis requires several hours to determine calorific value plus fixed carbon, water, volatiles, and ash content of a coal sample. In 1981, a Texas cement company, Capitol Aggregates, Inc., installed a computer-controlled thermogravimetric system that reduced the time for fuel sample analysis to 20 minutes.[39]

Researchers at Brookhaven National Laboratory have successfully completed laboratory experiments on substituting commercial-grade portland cement for limestone in fluidized-bed coal combustion reactors. The cement sorbent solved most of the problems for the removal of sulfur dioxide (SO_2) gas arising from the combustion. Type III portland cement was introduced directly into the reactor in pellet form, then regenerated to reform the sorbent and produce a concentrated stream of SO_2 which could be reduced to sulfur for disposal or sale. Advantages of using cement sorbent included (1) little loss of reactivity over consecutive cycles of absorption and regeneration, (2) effectiveness at high pressures and at temperatures above 1000° C, (3) removal of 90% of the sulfur from high-sulfur coal, and (4) superiority to natural limestone in consistency of composition, reactivity, and SO_2 removal.[40]

It was reported that cement kiln dust has an agricultural benefit that could raise the value of quality-controlled material to $30 to $35 per ton. Research at Pennsylvania State University determined that cement kiln dust can promote the most efficient use of herbicides in growing no-till corn.[41]

The Environmental Protection Agency (EPA) funded a $500,000 research demonstration at the San Juan Cement Co., Puerto Rico, to study the efficacy of hazardous chemical waste disposal through burning in a cement kiln. EPA officials reportedly believe that if a cement kiln can safely destroy toxic chemicals during the normal cementmaking process, then progress will be made toward allaying public apprehension about toxic waste disposal, particularly by incineration. The San Juan kiln was to be used 3 days per week to burn about 160,000 gallons of low-to-medium-toxicity chemical waste during the 12-week demonstration. The only modification in the plant's wet-process system was to be the addition of a second burner to the kiln. Notwithstanding the questions concerning successful incineration of chemical wastes, the test was also expected to address the possibility of cement contamination that might render the product inappropriate for some uses.[42]

Concrete.—Polymer concretes, made by combining aggregate with resins such as epoxy, polyester, and methyl methacrylate, have been used for years as rapid-patching materials, but had not found wide acceptance for local road and bridge repair because of their high cost compared with hydraulic cements and asphalt. Brookhaven National Laboratory has developed two less expensive polymer concretes, based on furfuryl alcohol and polyester-styrene, respectively, that show promise for ordinary roadway repair as well as more demanding applications.[43] Unlike products now on the market, Brookhaven's polymer concretes can be combined with wet aggregate and applied under virtually all weather conditions. They cure in less than an hour over a wide temperature range with compressive strengths above 2,000 pounds per square inch. These characteristics attracted the U.S. Air Force, which had been searching for a strong, fast-setting concrete for runway repair under hostile conditions.[44] The Brookhaven formulations were expected to be tested in 1982 at the Tyndall Air Force Base (Florida) outdoor explosive crater facility.

The high cost of cement and archaic methods of moving and placing mass concrete in dam construction had become deterrents to building concrete gravity dams. For example, the constant-dollar cost of placing a cubic yard of mass concrete nearly quintupled from 1970 to 1980. To address this problem, U.S., British, and Japanese researchers developed an innovation called roller-compacted concrete that reduces the volume of cement required and employs earthmoving equipment superior to conventional cranes and cableways in size, speed, and efficiency. Roller-compacted concrete, which is placed in thin, continuous, horizontal lifts, was scheduled to be applied for the first time in the United States in construction of the Willow Creek Dam near Hepner, Oreg. Compared with the 1981 cost of $65 for placing a cubic foot of concrete by conventional methods, the new technique lowers the cost to a range of $18 to $24.[45]

SRI International of Menlo Park, Calif., was studying the potential for use of glass-reinforced concrete in solar collectors and wind turbine blades. In solar collectors, the glass-reinforced concrete was being considered for service as both a structural material and a reflector substrate. The material consists of sand-portland cement concrete reinforced with 1.5-inch-long alkali-resisting glass fibers. Fabricators succeeded in making very thin (3/16 inch), strong, and resilient concrete sections using 5% by weight of the glass fibers. Although the material was more expensive than conventional concrete and heavier than more expensive materials that offer similar performance (for example, foamed glass and glass fiber-reinforced plastic), it appeared to offer advantages over these materials in renewable-energy-resource applications.[46]

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Chromium

By John F. Papp[1]

Consumption of chromium decreased in 1981 for the second consecutive year, falling to its lowest level since 1975. After rising slightly during the first two quarters, demand dropped sharply in the latter half of the year. The greatest decline in demand was in ferrochromium, where consumption decreased steadily throughout the year. By yearend, ferrochromium consumption had dropped 60% compared with that at the beginning of 1981, reflecting the sharp downturn in the steel industry, ferrochromium's major consumer. Imports of chromite declined and were at their lowest level since 1946. Imports of ferrochromium continued to rise, following the pattern of the last several years, and were at a record high in 1981, about 31% above the previously recorded high of 327,000 short tons in 1978. As a result of increased imports and low demand, domestic ferrochromium production was at its lowest record level.

Table 1.—Salient chromite statistics

(Thousand short tons)

	1977	1978	1979	1980	1981
United States:					
Exports	187	23	27	6	71
Reexports	61	29	28	44	67
Imports for consumption	1,293	1,013	1,024	982	898
Consumption	1,000	1,010	1,209	968	879
Stocks, Dec. 31: Consumer	1,338	1,301	907	675	663
World: Production	r10,415	r10,210	r10,676	p10,746	e10,225

eEstimated. pPreliminary. rRevised.

Legislation and Government Programs.—No new stockpile goals for chromium materials were set in 1981 by the Federal Emergency Management Agency. Current goals and inventories are shown in table 2. There were no stockpile acquisitions or disposals of chromium material in 1981.

The Committee of High-Carbon Ferrochromium Producers petitioned the International Trade Commission (ITC) in May for an extension of 3 years of the penalty duty on ferrochromium imported below a specified floor price. The current 4-cent-per-pound penalty duty applied at a floor price of $38.01 per pound was set in 1978. After hearings were held in July, the ITC determined that high-carbon ferrochromium imports represented a substantial threat of serious injury to domestic producers. In November, the President proclaimed (Proclamation 4884) an extension of the current import relief provisions on high-carbon ferrochromium for 1 year. A rate of duty of 4.625 cents per pound on chromium content is to be applied to ferrochromium, containing 3% by weight of carbon, valued at less than 38 cents per pound of chromium content.

In a related action, the Ferroalloy Association, representing domestic ferroalloy producers, filed an application in August with the U.S. Department of Commerce (DOC) requesting an investigation to determine the effect on the national security of various ferroalloy imports, including ferrochromium. The investigation by DOC was being conducted under Section 232 of the Trade Expansion Act of 1962. DOC has 1 year to make its recommendations.

A 4% duty was applied to imported South African ferrochromium effective in March. The duty was applied as a result of the Court of International Trade ruling that preferential railroad freight rates in the Republic of South Africa constitute a bounty or grant. The 4% duty was lifted in June, and duty deposits were refunded after DOC found that the South African Government had made its rail rate retroactive to January.

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

(Thousand short tons)

Material	Stockpile goals	Inventory: Stockpile grade	Inventory: Nonstockpile grade
Chromite, metallurgical	3,200	1,957	531
Chromite, chemical	675	242	--
Chromite, refractory	850	391	--
High-carbon ferrochromium	185	402	1
Low-carbon ferrochromium	75	300	19
Ferrochromium-silicon	90	57	1
Chromium metal	20	4	--

DOMESTIC PRODUCTION

The major marketplace chromium products are chromite, alloys, chemicals, and metal. In 1981, the United States produced chromium alloys, chemicals, and metal from imported chromite. No chromite was mined domestically.

The principal domestic chromium materials producers are listed in table 3 by industry. Union Carbide Corp. completed the sale in June of its two ferrochromium alloy plants to a Norwegian group led by Elkem AS. Elkem Metals Co., a subsidiary of Elkem AS, will operate the plants. These facilities are located at Marietta, Ohio, and Alloy, W. Va.

Private companies continued exploration of chromite deposits in California, Oregon, and Alaska. California Nickel Corp. contracted with Kaiser Engineers, Inc., to carry out a final feasibility study for surface mining lateritic deposits in northern California. The deposits contain 1% to 2% chromite, which would be recovered as a byproduct, with cobalt and nickel as the principal products. UOP, Inc., has tested the recovery system, which was developed and patented by the Bureau of Mines (BOM), on a pilot plant scale. Another company, American Chromium Ltd., continued drilling in the same area; it has confirmed previous reserves indicated by BOM and identified an additional mineralized zone. Exploration has also taken place on the Kenai Peninsula in Alaska in areas previously mined for chromite.

Continued weak demand and increased imports of ferrochromium forced domestic producers to close or operate at reduced levels during various periods of the year. Macalloy, Inc., the major high-carbon producer, halted production at its two Charleston, S.C., furnaces in November. Production was scheduled to resume in the first quarter of 1982. Ferrochromium consumption decreased for the second consecutive year, and domestic ferrochromium producers continued to lose a greater share of the domestic market to imported ferrochromium.

Domestic chromium metal production capacity increased in 1981, as Elkem Metals increased its metal production capacity by 50% to 4,500 tons at its Marietta plant.

Table 3.—Principal producers of chromium products

Company	Plant
Metallurgical industry:	
Chromasco, Ltd	Woodstock, Tenn.
Elkem Metals Co	Marietta,Ohio, and Alloy,W.Va.
Foote Mineral Co	Keokuk, Iowa, and Graham, W. Va.
Interlake, Inc	Beverly, Ohio.
Macalloy, Inc	Charleston, S.C.
Satralloy Corp	Steubenville, Ohio.
Shieldalloy Corp., a division of Metallurg, Inc	Newfield, N.J.
SKW Alloys, Inc	Calvert City, Ky., and Niagara Falls, N.Y.
Refractory industry:	
Basic, Inc	Maple Grove, Ohio.
Corhart Refractories Co., Inc	Pascagoula, Miss.
Davis Refractories, Inc	Jackson, Ohio.
General Refractories Co	Baltimore, Md., and Lehi, Utah.
Harbison-Walker Refractories	Hammond, Ind., and Baltimore, Md.
Kaiser Aluminum & Chemical Corp	Moss Landing, Calif., and Columbiana, Ohio.
North American Refractories, Co., Ltd	Womelsdorf, Pa.
Chemical industry:	
Allied Chemical Corp	Baltimore, Md.
American Chrome & Chemical, Inc	Corpus Christi, Tex.
Diamond Shamrock Corp	Castle Haynes, N.C.

Table 4.—Production, shipments, and stocks of chromium ferroalloys and chromium metal

(Short tons)

Year and alloy	Production: Gross weight	Production: Chromium content	Shipments	Producer stocks, Dec. 31
1980:				
Low-carbon ferrochromium; High-carbon ferrochromium	184,408	115,380	185,480	31,510
Ferrochromium-silicon; Other[1]	54,207	26,935	51,987	12,410
Total	238,615	142,315	237,467	43,920
1981:				
Low-carbon ferrochromium; High-carbon ferrochromium	164,933	99,208	148,425	45,680
Ferrochromium-silicon; Other[1]	62,319	28,365	58,852	14,322
Total	227,252	127,573	207,277	60,002

[1]Includes chromium metal, exothermic chromium additives, and other miscellaneous chromium alloys.

CONSUMPTION AND USES

Domestic consumption of chromite ore and concentrate was 879,000 tons in 1981. Of the total chromite consumed in 1981, the metallurgical industry used 57%; the refractory industry, 16%; and the chemical industry, 27%. The metallurgical industry consumed 501,000 tons of chromite to produce 227,000 tons of chromium ferroalloys and metal.

Chromium has a wide range of uses in the three primary consumer groups. In the metallurgical industry, its principal use in 1981 was in stainless steel. Of the total chromium ferroalloys consumed, 434,000 tons, stainless steel accounted for 70%; full-alloy steel, 18%; high-strength low-alloy and electrical steels, 3%; and carbon steel, 2%. Total chromium alloy consumption increased 2% above that of 1980.

The refractory industry used chromium in the form of chromite primarily to make refractory bricks to line metallurgical furnaces. Chromite consumption by the refractory industry decreased 10% compared with that of 1980.

The chemical industry consumed chromite for manufacturing pigments, chromic acid, and sodium and potassium bichromate. Sodium and potassium bichromate are base materials used to make a wide range of chromium chemicals. Chromite consumption by the chemical industry decreased less than 1% compared with that of 1980.

Table 5.—Consumption of chromite and tenor of ore used by primary consumer groups in the United States

Year	Metallurgical industry: Gross weight (thousand short tons)	Metallurgical industry: Average Cr_2O_3 (percent)	Refractory industry: Gross weight (thousand short tons)	Refractory industry: Average Cr_2O_3 (percent)	Chemical industry: Gross weight (thousand short tons)	Chemical industry: Average Cr_2O_3 (percent)	Total: Gross weight (thousand short tons)	Total: Average Cr_2O_3 (percent)
1977	578	41.3	208	36.0	214	44.7	1,000	40.9
1978	534	39.8	237	36.6	239	45.3	1,010	39.9
1979	774	39.9	193	36.2	242	44.9	1,209	40.2
1980	573	37.5	155	34.8	240	45.4	968	39.3
1981	501	36.2	139	34.9	239	44.6	879	38.3

Table 6.—U.S. consumption of chromium ferroalloys and metal in 1981, by end use

(Short tons, gross weight)

End use	Low-carbon ferrochromium	High-carbon ferrochromium	Ferrochromium silicon	Other	Total
Steel:					
Carbon	2,275	5,554	1,307	52	9,188
Stainless and heat-resisting	16,100	271,233	13,966	294	301,593
Full-alloy	16,401	54,910	4,424	2,969	78,704
High-strength low-alloy and electric	2,611	4,151	2,307	2,545	11,614
Tool	558	3,927	125	--	4,610
Cast irons	946	8,978	198	512	10,634
Superalloys	3,718	3,085	W	2,478	9,281
Welding materials (structural and hard-facing)	737	805	--	164	1,706
Other alloys[1]	1,041	780	12	1,849	3,682
Miscellaneous and unspecified	2,034	328	144	23	2,529
Total	46,421	353,751	22,483	[2]10,886	433,541
Chromium content	30,769	207,122	8,258	7,199	253,348
Stocks, Dec. 31, 1981	5,198	46,601	1,801	[3]2,468	56,068

W Withheld to avoid disclosing company proprietary data; included with "Miscellaneous and unspecified."
[1]Includes magnetic and nonferrous alloys.
[2]Includes 3,835 tons of chromium metal.
[3]Includes 744 tons of chromium metal.

STOCKS

Reported consumer stocks of chromite declined for the fourth successive year in 1981, from 0.68 to 0.66 million tons, with most of the decline occurring in the metallurgical industry. Because of continued low demand and high interest rates, maximum efforts were made by consumers to reduce their inventories in 1981. Yearend producer stocks of ferroalloys rose 37% compared with those at yearend 1980, while consumer stocks declined 7%. A considerable tonnage of chromium alloys was in the hands of traders at yearend.

Stocks of chromium chemicals (sodium bichromate equivalent) at producer plants increased from 11,924 tons in 1980 to 14,151 tons in 1981.

Table 7.—Consumer stocks of chromite, December 31

(Thousand short tons)

Industry	1977	1978	1979	1980	1981
Metallurgical	900	755	416	219	174
Refractory	174	185	161	134	119
Chemical	264	361	330	322	370
Total	1,338	1,301	907	675	663

Table 8.—Consumer stocks of chromium ferroalloys and chromium metal, December 31

(Short tons, gross weight)

Product	1977	1978	1979	1980	1981
Low-carbon ferrochromium	6,247	6,455	6,683	5,432	5,198
High-carbon ferrochromium	66,114	69,196	45,465	50,258	46,601
Ferrochromium-silicon	4,777	3,492	3,701	2,578	1,801
Other[1]	2,228	2,618	2,465	1,935	2,468
Total	79,366	81,761	58,314	60,203	56,068

[1]Includes chromium briquets, chromium metal, exothermic chromium additives, and other miscellaneous chromium alloys.

PRICES

There was no price movement of chromite in 1981. The published price of South African Transvaal chromite was $51 to $55 per metric ton ($46 to $50 per short ton), f.o.b. South African ports. Turkish chromite was $110 per metric ton ($100 per short ton), f.o.b. Turkish ports.

There was no significant price increase for the various chromium ferroalloys. The small increases that did occur were attributed to increased operating costs, inflation, and increased power costs in particular. There was little pressure to increase prices of chromite ore because of slow demand and large stocks. The lack of demand by the steel industry kept ferrochromium prices from rising significantly. Price cutting was apparent in many sales of chromite and ferrochromium materials during the latter part of the year. Chromium alloy and chromium metal prices as published in Metals Week are shown in table 9.

Table 9.—Price quotations for chromium materials at beginning and end of 1981

Material	January	December
	Cents per pound of chromium	
U.S. charge chromium (50% to 55% chromium)	46.25- 47.5	47.5
Imported charge chromium (50% to 55% chromium)	45 - 46.25	46.5- 47.5
Imported charge chromium (60% to 65% chromium)	46 - 50	48 - 49.5
U.S. charge chromium (66% to 70% chromium)	48.5 - 52	52 - 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)	95	100
	Cents per pound of product	
Ferrochromium-silicon	34.5	35.3
Electrolytic chromium metal	425	375

FOREIGN TRADE

Reported exports of chromium and chromium containing compounds from the United States included chromite, ferrochromium, chromium metal, pigments, and chemicals. Reported U.S. imports of chromium and chromium-containing compounds included chromite, chromium metal and alloys, ferrochromium, pigments, chemicals, and carbides. Within the categories for which both imports and exports are reported (all except carbide), only chromium chemicals were exported in excess of imports.

Exports of chromite in 1981 were over 1,000% greater than those of 1980, exceeding combined total exports of the previous 3 years. In 1981, exports were valued at $5.9 million. Reexports were the highest since

1976, valued at $9.6 million.

Ferrochromium exports of 14,098 tons, down 56% from those of 1980, were valued at $15.9 million. Exported ferrochromium went primarily to Canada (74%) and Mexico (24%).

Chromium metal alloys (wrought and unwrought), waste, and scrap exports totaling 395 tons were valued at $5.2 million. These exports went principally to Mexico (26%) and Venezuela (22%) among the 37 recipients.

Exports of chromium-containing pigments totaling 2,604 tons were valued at $8.6 million. Of the 46 countries receiving pigments, Japan (21%) and Canada (20%) were the principal recipients.

Chromium-containing chemical (excluding pigments) exports totaling 23,121 tons were valued at $21 million. Of the 55 recipients, these exports went principally to China (27%) and Mexico (28%).

Imports of chromite decreased for the third consecutive year. Ore grading less than 40% Cr_2O_3 was supplied primarily by the Philippines (33%) and the Republic of South Africa (28%); more than 40% but less than 46% ore by the Republic of South Africa (89%); and greater than 46% ore by the Republic of South Africa (44%) and the U.S.S.R. (39%).

Ferrochromium imports continued to increase, rising to their highest recorded level. Low-carbon ferrochromium imports increased 85%, while high-carbon ferrochromium imports increased 41% compared with those of 1980. The Republic of South Africa was the principal supplier of low-carbon (35%) and high-carbon (64%) ferrochromium. Ferrochromium-silicon was imported principally from Zimbabwe (75%). Ferrochromium alloy imports totaled 440,770 tons valued at $220 million; high-carbon ferrochromium totaled 387,637 tons ($174 million); low-carbon ferrochromium totaled 40,602 tons ($40 million); and ferrochromium-silicon totaled 11,435 tons ($6 million).

Imports of chromium metal (wrought and unwrought), alloys, scrap, and waste totaling 3,539 tons were valued at $3.5 million. Principal suppliers were the United Kingdom (44%) and Japan (41%). The average value of imports was $3.48 per pound.

Imports of pigments totaling 6,484 tons were valued at $14 million. Chromium oxide green was the main chromium pigment import (38%), coming principally from the United Kingdom and Japan. Pigments containing zinc yellow (23%) were imported principally from Poland.

Chromium carbide imports totaling 243 tons were valued at $2 million. Of the three countries supplying chromium carbide, the Federal Republic of Germany supplied 79%, Japan 15%, and the United Kingdom 6%.

Tariff rates for chromium materials as of January 1, 1981, and as established for January 1, 1987, as published in the Tariff Schedules of the United States, Annotated (1981), are shown in table 13.

Table 10.—U.S. exports and reexports of chromite ore and concentrates

(Thousand short tons and thousand dollars)

Year	Exports		Reexports	
	Quantity	Value	Quantity	Value
1977	187	10,105	61	4,913
1978	23	2,767	29	2,574
1979	27	2,514	28	2,860
1980	6	1,447	44	8,544
1981	71	5,893	67	9,575

Table 11.—U.S. imports for consumption of chromite, by year, grade, and country

(Thousand short tons and thousand dollars)

Year and country	Less than 40% Cr_2O_3			More than 40% but less than 46% Cr_2O_3			46% or more Cr_2O_3			Total		
	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
1980:												
Albania	18	7	1,454	41	18	2,944	27	13	2,420	86	38	6,818
Finland	30	8	1,074	17	8	1,075	--	--	--	47	16	2,149
Madagascar	--	--	--	33	15	2,419	10	5	806	43	20	3,225
Philippines	138	45	11,740	--	--	--	--	--	--	138	45	11,740
South Africa, Republic of	44	17	1,779	276	122	12,783	85	39	4,498	405	178	19,060
Turkey	52	19	2,707	23	10	1,623	18	8	1,794	93	37	6,124
U.S.S.R	80	30	3,791	35	15	1,899	55	31	1,719	170	76	7,409
Total	362	126	22,545	425	188	22,743	195	96	11,237	982	410	56,525
1981:												
Albania	11	4	979	3	1	237	(1)	(1)	5	14	5	1,221
Finland	65	18	3,016	13	6	830	--	--	--	78	24	3,846
Madagascar	--	--	--	8	4	432	10	5	624	18	9	1,056
New Guinea	(1)	(1)	2	--	--	--	--	--	--	(1)	(1)	2
Philippines	134	46	11,236	--	--	--	11	6	507	145	52	11,743
South Africa, Republic of	112	42	4,017	302	135	15,485	68	34	4,274	482	211	23,776
Turkey	30	11	1,408	13	6	1,035	6	3	633	49	20	3,076
U.S.S.R	50	19	2,456	--	--	--	61	29	2,773	111	48	5,229
Total[2]	403	140	23,115	339	151	18,018	156	77	8,815	898	368	49,948

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

Table 12.—U.S. imports for consumption of ferrochromium, by year and country

Year and country	Low-carbon ferrochromium (less than 3% carbon) Gross weight (short tons)	Low-carbon ferrochromium Chromium content (short tons)	Low-carbon ferrochromium Value (thousands)	High-carbon ferrochromium (3% or more carbon) Gross weight (short tons)	High-carbon ferrochromium Chromium content (short tons)	High-carbon ferrochromium Value (thousands)
1980:						
Brazil	--	--	--	5,303	2,855	$2,170
France	248	177	$265	--	--	--
Germany, Federal Republic of	4,846	3,410	6,056	278	187	291
Italy	19	14	28	--	--	--
Japan	2,632	1,800	3,634	--	--	--
Korea, Republic of	56	37	61	--	--	--
South Africa, Republic of	6,381	4,222	6,023	219,476	123,473	98,797
Spain	--	--	--	2,756	1,485	1,225
Sweden	7,145	5,163	8,527	2,237	1,471	1,267
Turkey	--	--	--	5,485	3,588	3,093
Yugoslavia	55	39	57	20,172	13,157	11,103
Zimbabwe	610	430	677	19,519	12,589	10,213
Total	21,992	15,292	25,328	275,226	158,805	128,159
1981:						
Belgium	26	19	31	--	--	--
Brazil	--	--	--	20,673	11,152	8,601
China	--	--	--	2,767	1,799	1,385
France	2,448	1,695	2,452	--	--	--
Germany, Federal Republic of	4,482	3,134	5,405	341	232	351
Italy	722	528	892	--	--	--
Japan	1,404	944	2,123	--	--	--
Norway	1,246	778	1,042	556	356	539
Philippines	--	--	--	2,315	1,447	1,224
South Africa, Republic of	14,204	9,026	11,479	246,358	130,483	102,865
Spain	--	--	--	1,383	922	701
Sweden	7,959	5,681	9,047	3,308	1,819	1,428
Turkey	231	165	209	7,984	5,122	3,936
Yugoslavia	--	--	--	47,466	30,642	23,527
Zimbabwe	7,875	5,482	7,402	54,486	35,986	28,971
Total[1]	40,602	27,453	40,082	387,637	219,961	173,529

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

Table 13.—U.S. import duties on chromium containing materials

Item	Number	Most favored nation (MFN) Jan. 1, 1981	Most favored nation (MFN) Jan. 1, 1987	Non-MFN Jan. 1, 1981
Ore and concentrate	601.15	Free	Free	Free.
Low-carbon ferrochromium	606.22	4% ad valorem	3.1% ad valorem	30% ad valorem.
High-carbon ferrochromium	606.24	1.9% ad valorem[1]	No change	25% ad valorem.
Ferrosilicon chromium	606.42	10% ad valorem	10% ad valorem	Do.
Sodium chromate and dichromate	420.98	2.8% ad valorem	2.4% ad valorem	8.5% ad valorem.
Potassium chromate and dichromate	420.08	1.6% ad valorem	1.5% ad valorem	3.5% ad valorem.
Chromium carbide	422.92	5.8% ad valorem	4.2% ad valorem	25% ad valorem.
Chrome metal (wrought, unwrought, and waste and scrap)	[2]632.18	4.7% ad valorem	3.7% ad valorem	30% ad valorem.
Pigments:				
Chrome green	473.10	5% ad valorem	5% ad valorem	Do.
Chrome yellow	473.12	do	do	Do.
Chromium oxide green	473.14	4.8% ad valorem	3.7% ad valorem	Do.
Hydrated chromium oxide green	473.16	do	do	Do.
Molybdenum orange	473.18	5% ad valorem	5% ad valorem	Do.
Strontium chromate	473.19	4.8% ad valorem	3.7% ad valorem	Do.
Zinc yellow	473.20	5% ad valorem	5% ad valorem	Do.
Chromic acid	423.0092	4.7% ad valorem	3.7% ad valorem	Do.

[1]Total duty of 4.625 cents per pound on material valued at less than 38 cents per pound of chromium through Nov. 15, 1982.
[2]Temporarily suspended.

WORLD REVIEW

World chromite production in 1981 decreased to 10.2 million short tons from 10.7 million tons in 1980. Chromite mining is expected to increase in Greece and the Philippines, where new mines are planned or came into production in 1981. Future chromite mining appears likely in Papua New Guinea, where exploration has revealed reserves greater than previously expected.

The greatest activity in the world chromium industry is the vertical integration of the industry in chromite-producing countries. Integration takes the form of installing ferrochromium production facilities to process chromite concentrates from local chromite mines. Such upgrading permits the producing country to increase export revenues by the added value of the processed product. Developing countries have the advantages of lower personnel, energy, and transportation costs, compared with those of developed countries such as the United States or Japan. In 1981, new ferrochromium production commenced in Zimbabwe. In addition, construction of new ferrochromium plants was announced in Greece, India, and Zimbabwe. Albania, India, the Philippines, and Turkey are planning new or expanded ferrochromium production facilities.

Albania.—Fondmetall, a Gothenburg-based metals and steel trading company in Sweden, reportedly has signed a contract to be the sole agent to sell Albanian ferrochromium worldwide. Albanian ferrochromium production, which started in 1979, is about 28,000 tons per year. Albania's current 5-year plan calls for a substantial increase in both chromite and ferrochromium production.

China.—China is reported to have two chromite mines, one each in the Xinjiang Autonomous Region, north of Urumqi, and in Jilin Province, east of Changchun. Chromium deposits are reported in the Provinces of Xizang, Yunnan, Hunan, Jiangsu, Zhejiang, and Liaoning. The major consumers of Chinese chromite ore are Japan and Southeast Asian countries. China exported 2,800 short tons of high-carbon ferrochromium to the United States in 1981. These are the first recorded shipments of chromium materials received in the United States from China.

Greece.—Greece is continuing development of a ferrochromium industry. The development project is being carried out by the Government-owned Hellenic Industrial and Mining Investment Co., S.A. (HIMIC), and represents a vertical upgrading of Greek chromite reserves at an estimated cost of $65 million. The project includes: (a) chromite mine development near Kozanis in the Macedonia Province, (b) concentrator construction near the mine sites, and (c) high-carbon ferrochromium plant construction at Tsigeli near Almyros in Thessalia Province. The concentrator will have a capacity of about 60,000 tons per year and cost about $3.4 million, while the ferrochromium plant will have a capacity of about 30,000 tons per year and cost about $53.4 million. This project is part of a larger Greek Government plan to create a basic metallurgical industry. Hellenic Ferroalloys, S.A., was established by HIMIC to carry out the project. Greece contracted with Outokumpu Oy of Finland to construct the ferrochromium plant, noting the energy efficiency of the Finnish process. Ground breaking for the ferrochromium plant was held in March. Upon completion of this project in 1983, Greece will be the only European Community ferrochromium producer to use its own raw materials.

India.—Ferro Alloys Corp., Ltd. (FACOR), a private company, started construction of a 50,000-ton-per-year ferrochromium plant near the chromite mines in Orissa. FACOR is purchasing a 45-megavolt-ampere (MVA) ferrochromium furnace from Japan's Tanabe Kakoki Ltd. and is converting a 16-MVA furnace to ferrochromium production. India's state-owned Orissa Mining Corp. Ltd. (OMC) is planning a 50,000-ton-per-year ferrochromium plant at Baminipal in Keonjhar district in Orissa State. OMC has contracted with Outokumpu Oy for its Kemi-Tornio technology and with Vöest-Alpine of Austria for equipment. Outokumpu's process is for low-grade chromite, upgraded and pelletized before smelting. OMC's charge chrome plant has received local cabinet approval for construction at Baminipal. Indian Metals and Ferro Alloys Ltd. has proposed the construction of a third 50,000-ton-per-year ferrochromium plant, which is still under consideration by the Indian Government.

Japan.—About 50% of Japan's ferrochromium consumption is imported, principally from the Republic of South Africa (80%). Japan's high-carbon ferrochromium industry, composed of seven manufacturers, has had an oversupply in recent years. Steel production, which consumes 80% of Japan's domestic high-carbon ferrochromium, was lower in 1981 than in 1980. Japan purchased ferrochromium from alternate sources on a spot basis, reportedly to curb South African attempts to raise prices.

Norway.—Elkem AS completed the purchase of Union Carbide's ferrochromium plants in the United States. The purchase included several other domestic and foreign ferroalloy plants owned by Union Carbide.

Pakistan.—The possibility of developing chromite mines at Muslimbagh in the Zhob Valley region of Baluchistan Province in conjunction with a ferrochromium smelter is being studied by the Baluchistan Development Authority. Reportedly some 9,500 tons of chromite have been extracted for testing.

Papua New Guinea.—A joint venture formed by Nord Resources Corp. (via its subsidiary Nord Australex), Mount Isa Mines Ltd., and Highlands Energy Corp. is investigating the extent, quality, and mining potential of a cobalt-bearing nickel laterite deposit overlain by chromite mineralization at the Ramu River concession southwest of Madang. Nord Resources revealed that 100 million tons of 5% to 10% free Cr_2O_3 has been outlined. A feasibility study is being conducted for Nord by the Bechtel Group of San Francisco. It was reported that Nord is considering divesting itself of its oil and gas operations to devote its resources to the development of its Papua New Guinea deposits.

Philippines.—AMAX Inc. (United States) and Kawasaki Steel Corp. (Japan) along with Philchrome Mining Corp., started production at a new refractory chromite mine in the Narra area of Palawan Island. At full production, mine output will be 20,000 tons per year of chromite.

Trident Mining and Industrial Corp. completed expansion of its Palawan Island operations. Capacity has been increased to 750 tons per day from 200 tons per day. Owing to weak demand, Trident closed one of its two concentrating plants on Palawan Island.

Ferrochrome Philippines, a joint venture between Herdis Group Inc. and Vöest-Alpine, has secured sufficient credit to build a ferrochromium plant in Cagayan de Oro. Acoje Mining, another subsidiary of Herdis/Vöest-Alpine, would supply the plant's requirements for metallurgical-grade chromite concentrates. Upon completion in 1982, this 50,000-ton-per-year charge chrome plant will make the Philippines' first ferrochromium product.

Consolidated Mines Inc. (CMI), the owner of Masinloc refractory chromite mines, and Benguet Corp., the mine operator, have renewed their operating contract that was due to expire in early 1981. The new agreement will run for 25 years and allow CMI to take 25% of the production, with the remainder going to Benquet. Plans are to increase production capacity from about 340,000 to 400,000 tons per year of concentrates.

South Africa, Republic of.—The Council for Mineral Technology (Mintek) is proceeding with the formation of a Chromium Centre. One of the main aims of the Centre will be the stimulation of research and development work on new uses for chromium. Mintek met with the South African industry in August to discuss the proposed Centre. The representatives unanimously agreed to recommend to their companies that they actively support the Chromium Centre.

Southern Cross Steel Co. (Pty.) Ltd. started producing a new steel, a 12% chromium corrosion-resistant steel designated 3CR12, which is expected to be competitive with carbon steels treated with special protective coatings. If the company's production projection of from 3,000 tons per year in 1981 to more than 1 million tons per year by mid-1990 is accurate, this would by itself double the worldwide consumption of chromium.

In 1981, the Republic of South Africa supplied the United States with about 40% of its chromite imports and 62% of its ferrochromium imports.

Turkey.—Etibank, the Government-owned mining concern, converts part of Turkey's chromite production into high- and low-carbon ferrochromium at its smelters in Elazig and Antalaya, respectively. High-carbon ferrochromium capacity is 50,000 tons per year and low-carbon ferrochromium, 100,000 tons per year. Expansion of the high-carbon ferrochromium capacity at Elazig to 250,000 tons per year, at a cost of $44 million, is to be engineered by Elkem, utilizing Outokumpu Oy process technology. The new unit is expected to go into production in 1985.

Zimbabwe.—Zimbabwe Mining and Smelting (owned by Union Carbide) is increasing its ferrochromium production capacity with the addition of two new furnaces. The first of these has been brought into production for high-carbon ferrochromium; the second will be brought into production in 1982 for low-carbon ferrochromium and ferrochromium-silicon. The ferrochromium plant is located at Que Que between Union Carbide's mines at Mtorashanga and Selukwe, which are at opposite ends of the Great Dyke. The two new 18-megawatt furnaces each add 83,000 tons per year to production capacity, increasing capacity by 55% to over 230,000 tons per year at a cost of $35 million. Zimbabwe Mining and Smelting is expecting to increase its chromite mining capacity at Mtorashanga and Selukwe by 40% to 500,000 tons per year. The Que Que plant could supply 12% of the Western World's high-carbon ferrochromium production.

Plans by Rhodall, Ltd. (owned by Anglo American Corp.), to expand its high-carbon ferrochromium production have been shelved owing to poor market prospects. Rhodall's smelter is at Gwelo, and it has three chromite mines on the Great Dyke. Current smelter capacities are 52,000 tons per year of high-carbon ferrochromium, 32,000 tons per year of low-carbon ferrochromium, and 25,000 tons per year of ferrochromium-silicon.

Zimbabwe requested the U.S. Government for inclusion of its low-carbon ferrochromium and ferrochromium-silicon in its scheme of Generalized System of Preferences. Inclusion would grant duty-free status to those products. Currently, low-carbon ferrochromium and ferrochromium-silicon are imported into the United States at 4% and 10% ad valorem duties, respectively. International Minerals and Chemicals Corp., the sole U.S. distributor of Zimbabwean low-carbon ferrochromium, supported Zimbabwe's request. By yearend, the request was under consideration by DOC.

The Zimbabwean Government is creating the Mineral Marketing Corp., which will transfer the mining industries marketing function from foreign-owned multinationals to state control. A mining development corporation is to be formed to promote Government investment in mining operations and exploration.

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

(Thousand short tons)

Country[2]	1977	1978	1979	1980[p]	1981[e]
Albania[e 3]	970	1,090	1,120	1,190	1,260
Brazil	342	297	375	316	450
Colombia[e]	(4)	(4)	(4)	--	--
Cuba	22	32	31	33	32
Cyprus	16	17	17	18	18
Egypt	1	1	(5)	--	--
Finland[6]	r443	r449	479	376	455
Greece[7]	46	41	49	47	47
India	389	293	341	352	370
Iran[e]	257	218	150	90	33
Japan	20	10	13	15	12
Madagascar	182	152	141	198	175
New Caledonia	9	9	14	2	3
Pakistan	9	12	3	3	3
Philippines	593	r595	613	547	490
South Africa, Republic of	3,372	3,466	3,634	3,763	3,160
Sudan	r21	r22	34	31	30
Thailand	1	(5)	(5)	--	--
Turkey[e 8]	560	r413	500	440	440
U.S.S.R.[e]	r2,400	r2,550	2,550	2,700	2,650
Vietnam[e]	14	14	15	17	17
Yugoslavia	2	2	(5)	(5)	(5)
Zimbabwe	r746	527	597	608	580
Total	r10,415	r10,210	10,676	10,746	10,225

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through June 9, 1982.
[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.
[3]Figures represent crude ore output, not marketable production.
[4]Revised to zero.
[5]Less than 1/2 unit.
[6]Production of marketable product (direct-shipping lump ore, plus concentrates and foundry sand).
[7]Exports of direct-shipping ore plus production of concentrates.
[8]Estimated production of marketable product (direct-shipping ore plus concentrates) based on reported production of run-of-mine ore, which was as follows in thousand short tons: 1977—1,049; 1978—720 (estimated); 1979—750 (estimated); 1980—600 (estimated); 1981—600 (estimated).

TECHNOLOGY

The BOM is conducting research on extracting chromium from low-grade ores, on extending the lifetime of chromium-containing chemicals, and on developing substitutes for commonly used chromium-containing metals.

Ore samples have been collected by BOM from central, southern, and southeastern Alaska and from Montana, including chromites and chromium-containing alluvial deposits. Sample analyses indicate several samples have Cr:Fe ratios in excess of 2:1 and beneficiation is possible. For one sample, concentration yielded about 45% Cr_2O_3 with a Cr:Fe ratio of 1.3:1 at about 20% recovery. More complex, but currently practiced, beneficiation techniques yielded better results. Bench-scale studies to extract chromium from domestic chromite or leached laterite residues by a low-temperature roast-leach method are being conducted. Chromium extraction of 92% has been achieved in the laboratory.[2]

Leather tanning requires a chromium-containing solution. BOM started research on the tanning process to determine how chromium consumption can be economically minimized. It appears that the greatest potential for reducing chromium consumption in leather tanning lies in recovering chromium from leather scraps.

Earlier studies by BOM found that 73,000 tons per year of chromium is lost to the domestic industry through waste and scrap materials. BOM has developed two processes to recover chromium from superalloy scrap. Both of these processes have now been tested and verified in the laboratory.[3] One process uses a pyrometallurgical oxidation-reduction approach to selectively oxidize chromium in a superalloy molten bath, resulting in a chromium-rich slag. This slag can then be used in the same way chromite is now used. Chromium recoveries of 99% have been achieved for some superalloys in the laboratory. The other process sulfurizes a molten bath of superalloy to form a matte. The solid matte contains chromium (and other metal) sulfides. The metallic sulfides are then separated by conventional techniques. Chromium recoveries of 93% have been achieved for some superalloys in the laboratory.

A patented plasma smelting process is being commercialized by British and U.S. companies in the Republic of South Africa. Tetronics Research and Development of Faringdon, Oxfordshire, in the United Kingdom, has operated a 1.4-megawatt plasma furnace. Middleburg Steel and Alloys of the Republic of South Africa has contracted Foster Wheeler Corp. of Livingston, N.J., to design, engineer, and construct the first commercial plasma ferrochromium furnace of 10.8 megawatts at its Krugersdorp, Republic of South Africa, plant. Advantages of the plasma furnace are reduced capital cost, the use of coal instead of coke in the process, and a 25% reduction in overall operating costs.

A new application may have been found for chromium. Chrome aggregate is being tested for highway use. The aggregate is made from slag material resulting from the processing of chromite ore into ferrochromium alloy for steelmaking. A preliminary study conducted by the Tennessee Highway Department indicated that the slag produces a high-quality aggregate which retains skid resistance. The chrome aggregate does not polish. Warren Brothers, a subsidiary of Ashland Oil Co., is testing the materials provided by Chromasco, Ltd.,'s Memphis, Tenn., ferrochromium plant. Chromasco has a large stockpile of aggregate accumulated from years of ferrochromium production.

Pieles Raras S.A., a Mexican company, has perfected a fishskin tanning process in which chromium-containing compounds are the main tanning agents. Pieles Raras is tanning 12,000 skins per month and has increased its tanning capacity by a factor of 10. The skins are soft and durable when tanned and are used in making expensive leather products.

A commonly used chromium-containing chemical is an etching solution. Etching solutions are used in anodizing aluminum, etching circuit boards, and plating chrome. A BOM-developed process and equipment to regenerate chromic acid were tested in a commercial circuit board etching process. The BOM-developed hardware is connected to the etching bath and continuously regenerates the chromic acid without interrupting the production process. BOM's patented regenerator extended the life of the chromic acid from 1 day to over 6 months and eliminated the need to add chromium to the bath. The system is becoming commercially available.[4]

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[1]Physical scientist, Division of Ferrous Metals.

[2]Smith, G. E., J. L. Huiatt, and M. B. Shirts. Amine Flotation of Chromite Ores From the Stillwater Complex, Mont. BuMines RI 8502, 1981, 12 pp.

[3]De Barbadillo, J. J., J. K. Pargeter, and H. V. Makar. Process for Recovering Chromium and Other Metals From Superalloy Scrap. BuMines RI 8570, 1981, 73 pp.

Kusic, C. L., K. Parameswaran, D. J. Kinneberg, and H. V. Makar. Pyrometallurgical Recovery of Chromium and Other Metals From Superalloy Scrap. BuMines RI 8571, 1981, 73 pp.

[4]Soboroff, D. M., J. D. Troyer, and A. A. Cochran. Regeneration and Recycling of Waste Chromic Acid-Sulfuric Acid Etchants. BuMines RI 8377, 1979, 13 pp.

Clays

By Sarkis G. Ampian[1]

Clays in 1 or more of 6 classification categories (kaolin, ball clay, fire clay, bentonite, fuller's earth, or common clay and shale) were produced in 44 States and Puerto Rico during 1981. Clay production was not reported in Alaska, Delaware, Hawaii, the District of Columbia, Rhode Island, Vermont, or Wisconsin. The States leading in output were Georgia, 8.0 million tons; Texas, 4.2 million tons; Wyoming, 3.9 million tons; California, 2.3 million tons; and Ohio, 2.2 million tons, followed in order by North Carolina and South Carolina. Georgia also led in total value of clay output with $554 million; Wyoming was second with $101 million. Compared with 1980 figures, clay production increased in 10 States and value increased in 20 States. Total quantity of clays sold or used by domestic producers in 1981 was 9% lower than that of 1980; total value rose 10% to an alltime high. Increases in value per ton were reported for all clays in 1981 owing to increased labor, fuel, and material costs. The energy crisis, or more specifically, the unpredictable shortages and costs of fuels, continued to cause considerable concern among clay producers and clay product manufacturers. Industrywide efforts were made both to economize and to obtain standby fuels. The cost of environmental protection equipment, environmental restrictions, and rising capital costs also continued to adversely affect production during 1981.

Production of the specialty clays, ball clay, fire clay, and kaolin, all decreased, except for bentonite and fuller's earth, which showed increased production. A downturn in construction that lowered demand for building materials (brick, lightweight aggregate, vitrified clay pipe, clay floor and wall tile, etc.) was responsible for the decline in production of common clay and shale. Production of bentonite increased 18% and that of fuller's earth increased 8%, while the following decreased: Common clays, 15%; fire clay, 8%; ball clay, 5%; and kaolin, 3%. The decreases were largely due to the overall downturn in the economy that lowered demand across the board.

Kaolin in 1981 accounted for only 17% of the total clay production but for 58% of the value.

Table 1.—Salient clays and clay products statistics in the United States[1]

(Thousand short tons and thousand dollars)

	1977	1978	1979	1980	1981
Domestic clays sold or used by producers:					
Quantity	53,196	56,822	54,689	48,790	44,379
Value	$579,170	$717,274	$846,089	$898,947	$988,845
Exports[2]:					
Quantity	2,561	2,665	3,205	3,214	3,151
Value	$160,790	$194,914	$243,722	$263,147	$292,914
Imports for consumption[2]:					
Quantity	36	25	51	34	33
Value	$1,917	$2,082	$3,972	$6,688	$7,895
Clay refractories shipments:[2] Value	$465,442	$497,567	$580,257	$557,386	$609,949
Clay construction products shipments: Value	$993,508	$1,158,278	$1,179,058	$1,061,507	$971,824

[1]Excludes Puerto Rico.
[2]U.S. Department of Commerce.

Table 2.—Clays sold or used by producers in the United States in 1981, by State[1]

(Short tons)

State	Ball clay	Bentonite	Common clay and shale	Fire clay	Fuller's earth	Kaolin	Total	Total value
Alabama	--	W	1,402,897	257,879	--	249,395	[2]1,910,171	[2]$25,406,161
Arizona	--	33,240	114,924	--	--	--	148,164	1,105,236
Arkansas	--	--	738,235	--	--	141,683	879,918	9,332,946
California	W	75,286	2,183,227	W	--	32,312	2,308,778	19,118,482
Colorado	--	41,100	210,038	24,742	--	--	275,880	1,734,234
Connecticut	--	--	72,854	--	--	--	72,854	390,668
Florida	--	--	180,964	--	518,031	32,071	731,066	[3]35,318,515
Georgia	--	--	1,209,399	--	584,103	6,235,867	8,029,369	553,726,128
Idaho	--	W	W	W	--	W	26,344	288,377
Illinois	--	--	300,192	21,553	W	--	[4]321,745	[4]1,540,081
Indiana	--	--	690,593	--	--	--	690,593	1,601,914
Iowa	--	--	476,249	--	--	--	476,249	2,374,802
Kansas	--	27,000	887,714	--	--	--	914,714	4,756,060
Kentucky	W	--	484,157	5,815	--	--	[5]489,972	[5]2,394,327
Louisiana	--	W	379,921	--	--	--	[2]379,921	[2]6,337,687
Maine	--	--	56,650	--	--	--	56,650	166,460
Maryland	W	--	596,811	--	--	--	[5]596,811	[5]1,984,202
Massachusetts	--	--	258,853	--	--	--	258,853	1,322,424
Michigan	--	--	1,609,562	--	--	--	1,609,562	5,862,484
Minnesota	--	--	83,778	--	--	--	83,778	1,077,154
Mississippi	W	285,446	649,145	--	W	--	1,217,705	23,309,359
Missouri	--	--	973,710	668,839	--	104,488	1,747,037	18,413,648
Montana	--	586,991	13,095	546	--	--	600,632	23,110,541
Nebraska	--	--	135,965	--	--	--	135,965	409,278
Nevada	--	14,127	W	--	W	--	72,947	2,947,865
New Hampshire	--	--	W	--	--	--	W	W
New Jersey	--	--	51,786	10,644	--	--	62,430	562,898
New Mexico	--	--	63,720	W	--	--	[6]63,720	[6]118,811
New York	W	--	597,276	--	--	--	[5]597,276	[5]2,310,037
North Carolina	--	--	2,110,380	--	--	W	[3]2,110,380	[3]6,838,420
North Dakota	--	--	W	--	--	--	W	W
Ohio	--	--	1,853,302	360,031	--	3,592	2,216,925	10,411,492
Oklahoma	--	--	838,339	--	--	--	838,339	2,063,568
Oregon	--	--	176,359	--	--	--	176,359	299,642
Pennsylvania	--	--	1,020,275	226,109	--	W	[3]1,246,384	[3]7,497,144
Puerto Rico	--	--	200,049	--	--	--	200,049	473,932
South Carolina	--	--	907,432	--	W	724,724	[4]1,632,156	[4]28,600,339
South Dakota	--	W	116,250	--	--	--	[2]116,250	[2]209,050
Tennessee	559,468	W	403,330	--	W	--	1,047,115	23,134,060
Texas	W	116,096	3,901,802	41,941	W	W	4,172,364	29,134,663
Utah	--	7,845	247,271	W	W	--	289,614	2,295,997
Virginia	--	--	501,829	--	--	--	501,829	2,015,834
Washington	--	--	262,652	W	--	--	[6]262,652	[6]1,524,212
West Virginia	--	--	219,693	W	--	--	[6]219,693	[6]502,231
Wyoming	--	3,584,287	270,909	--	--	--	3,855,196	100,926,186
Undistributed	[7]285,692	[7]175,740	[7]91,899	[7]309,024	[7]553,720	[7]136,349	[8]934,853	[8]26,371,300
Total	845,160	4,947,158	27,543,486	1,927,123	1,655,854	7,660,481	44,579,262	989,318,829

W Withheld to avoid disclosing company proprietary data; included with "Undistributed."
[1]Includes Puerto Rico.
[2]Excludes bentonite.
[3]Excludes kaolin.
[4]Excludes fuller's earth.
[5]Excludes ball clay.
[6]Excludes fire clay.
[7]Total of States indicated by symbol W.
[8]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 1981, by State

State	Ball clay	Bentonite	Common clay	Fire clay	Fuller's earth	Kaolin	Total
Alabama	--	1	25	7	--	14	47
Arizona	--	4	5	--	--	--	9
Arkansas	--	--	18	--	--	3	21
California	1	6	55	--	--	10	72
Colorado	--	4	29	8	--	--	41
Connecticut	--	--	3	--	--	--	3
Florida	--	--	4	--	9	2	15
Georgia	--	--	16	--	12	65	93
Idaho	--	1	2	1	--	1	5
Illinois	--	--	13	1	3	--	17
Indiana	--	--	21	--	--	--	21
Iowa	--	--	16	--	--	--	16
Kansas	--	1	21	--	--	--	22
Kentucky	6	--	10	13	--	--	29
Louisiana	--	1	9	--	--	--	10

Table 3.—Number of mines from which producers sold or used clays in the United States in 1981, by State —Continued

State	Ball clay	Bentonite	Common clay	Fire clay	Fuller's earth	Kaolin	Total
Maine	--	--	5	--	--	--	5
Maryland	1	--	9	--	--	--	10
Massachusetts	--	--	3	--	--	--	3
Michigan	--	--	9	--	--	--	9
Minnesota	--	--	2	--	--	--	2
Mississippi	1	4	19	--	2	--	26
Missouri	--	--	16	77	--	16	109
Montana	--	13	10	1	--	--	24
Nebraska	--	--	5	--	--	--	5
Nevada	--	6	1	--	1	--	8
New Hampshire	--	--	1	--	--	--	1
New Jersey	--	--	2	2	--	--	4
New Mexico	--	--	4	2	--	--	6
New York	1	--	10	--	--	--	11
North Carolina	--	--	57	--	--	2	59
North Dakota	--	--	4	--	--	--	4
Ohio	--	--	62	19	--	1	82
Oklahoma	--	--	17	--	--	--	17
Oregon	--	--	10	--	--	--	10
Pennsylvania	--	--	42	32	--	1	75
South Carolina	--	--	34	--	1	17	52
South Dakota	--	1	2	--	--	--	3
Tennessee	22	--	14	--	1	--	37
Texas	3	8	84	1	3	1	100
Utah	--	3	8	5	1	--	17
Virginia	--	--	15	--	--	--	15
Washington	--	--	7	3	--	--	10
West Virginia	--	--	3	1	--	--	4
Wyoming	--	121	4	--	--	--	125
Total	35	174	706	173	33	133	1,254

DOMESTIC PRODUCTION, PRICES, AND FOREIGN TRADE, BY TYPE OF CLAY

KAOLIN

Domestic production of kaolin in 1981 decreased 3%, and the value increased 10%. The average unit value for all grades of kaolin in 1981 was $75.44 per ton, $8.54 higher than in 1980. Kaolin was produced at mines in 12 States. Two States, Georgia (81%) and South Carolina (9%), accounted for 90% of total U.S. production in 1981. Alabama ranked third; Arkansas, fourth; and Missouri, fifth. Output in 1981 increased in Missouri and Florida, but declined in Alabama, Arkansas, California, Georgia, Idaho, Nevada, North Carolina, Pennsylvania, South Carolina, and Texas.

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.

All Georgia waterwashed kaolin producers again either announced planned increases in production or were increasing production during 1981. The J. M. Huber Corp. was completing a major expansion at its Wilkinson County mining operations, with a new pipeline and dragline project that was estimated to cost $14 million. The company also announced plans to build a new calcining facility costing between $5 and $10 million for 1983 startup. In another Huber activity, the company completed its new facility for delaminating kaolin clays at its Edisto, S.C., complex.

Installation of, and/or plans for, spray dryers and high-intensity magnetic separator units (HIMS) continued in the Macon-Sandersville, Ga., kaolin belt. Georgia Kaolin Co. took delivery of a dryer at its Dry Branch complex, and Freeport Kaolin Co. ordered another for installation at Gordon. Engelhard Minerals and Chemical Corp. ordered another spray dryer, reportedly the largest in the United States, for phasing-in at its McIntyre facility. Engelhard, also at McIntyre, installed a 120-inch magnetic separator, and Nord Kaolin Co. received a smaller unit at its Jeffersonville plant. These two separators represent a new series of reduced-power consumption magnets. To date, every major Georgia waterwashed kaolin producer has at least one HIMS on-stream. HIMS and spray dryers are the most important pieces of capital equipment to be incorporated into the modern-day waterwashed kaolin flowsheets. The magnetic separator impacts favorably on the reserve picture, while the spray dryers economically produce dust-free and free-flowing kaolin aggregates.

A majority of the waterwashed kaolin producers began supplying a new whole-fraction filler directly from degritted, crude, fine-particle clays. This lower cost filler slurry essentially replaced coarse-fraction filler obtained by classifying crude Georgia kaolins. The coarse-fraction became feed for producing premium coating clays by the delamination process.

Among acquisitions, Allied Corp. purchased the West Coast Refractories and Minerals Div. of Interpace Corp. for its Eltra subsidiary. Eltra was already in this business through its North American Refractories Div. The acquisition was to increase and diversify North American's raw material base and expand its marketing capabilities in the West Coast. The Interpace unit had been a leading manufacturer of aluminosilicate refractory brick in the Western United States and operated kaolin, fire clay, and pyrophyllite mines in the West. It had mines and/or plants in Ione, Victorville, Pittsburg, and Indian Hill, Calif., and Renton, Wash. In another acquisition, Ottawa Silica Co. acquired the assets and business of the Kosse, Tex., industrial sand- and kaolin-producing facilities of Dresser Industries, Inc. The new company was to be known as Texas Industrial Minerals Co., a wholly owned subsidiary of Ottawa Silica, Ottawa, Ill. The Kosse operation produced a high-grade silica sand used by the glass container industry in its area. The facility also produced pulverized sand and calcined and uncalcined kaolin.

Exports of kaolin, as reported by the U.S. Department of Commerce, increased from 1.39 million tons valued at $134 million in 1980 to 1.41 million tons valued at $156 million in 1981. The tonnage of kaolin exported in 1981 increased slightly, while the value rose 17% over that shipped in 1980. The increased unit value of exported kaolin was attributed to both the greater percentage of higher quality paper-coating grades shipped and higher prices.

Kaolin, including calcined, was exported to 73 countries. The major recipients were Japan, 31%; Canada, 15%; the Netherlands, 13%; Italy, 11%; the Federal Republic of Germany, 5%; and the remaining countries, 25%. Of those countries listed in 1981, exports to 16 countries increased, and those to 10 countries decreased. Kaolin producers reported the end uses for their exports as follows: Paper coating, 48%; refractories, 21%; paper filling, 7%; rubber, 3%; paint, 2%; and others, including ceramics, chemical manufacturing, medical, pharmaceutical and cosmetics, pesticides and related products, sanitary ware, graphite, anodes, ink, and plastics, 19%.

Kaolin imports in 1981 decreased from 15,800 tons valued at $1.87 million in 1979 to 13,600 tons valued at $1.51 million. The United Kingdom supplied 79%; Canada, 21%; and three other countries supplied small quantities.

Kaolin prices quoted in the trade journals in 1981, except for the calcined and delaminated grade, remained unchanged from 1980. Chemical Marketing Reporter, December 29, 1981, quoted prices as follows:

Waterwashed, fully calcined, bags, carload lots, f.o.b. Georgia, per ton	$218.00
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, airfloated, 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	1980		1981	
	Short tons	Value	Short tons	Value
Alabama	413,170	$19,017,072	249,395	$12,896,587
Arkansas	213,358	12,847,072	141,683	7,983,553
California	52,001	1,706,901	32,312	1,353,600
Florida	30,777	W	32,071	W
Georgia	6,311,407	463,700,320	6,235,867	519,496,664
Missouri	77,113	1,450,516	104,488	2,220,370
South Carolina	657,752	20,835,482	724,724	25,928,842
Other[1]	123,415	7,541,246	139,941	8,013,986
Total	7,878,993	527,098,609	7,660,481	577,893,602

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes Idaho, Nevada (1980), North Carolina, Ohio, Pennsylvania, Texas, and data indicated by symbol W.

Table 5.—Kaolin sold or used by producers in the United States, by kind

Kind	1980		1981	
	Short tons	Value	Short tons	Value
Airfloat	1,558,386	$59,966,953	1,311,093	$56,426,719
Calcined[1]	1,656,351	144,921,268	1,494,801	147,637,273
Delaminated	438,310	40,600,948	470,998	43,603,922
Unprocessed	700,394	8,232,709	759,795	11,262,648
Waterwashed	3,525,552	273,376,731	3,623,794	318,963,040
Total	7,878,993	527,098,609	7,660,481	577,893,602

[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 kind and State

State	High temperature		Low temperature	
	Short tons	Value	Short tons	Value
1980				
Georgia	707,446	$58,791,366	277,019	$50,257,125
Other[1]	671,886	35,872,777	--	--
Total	1,379,332	94,664,143	277,019	50,257,125
1981				
Georgia	672,648	60,198,079	403,121	63,863,012
Other[1]	419,032	23,576,182	--	--
Total	1,091,680	83,774,261	403,121	63,863,012

[1]Includes Alabama, Arkansas, California, Idaho, Pennsylvania, and Texas.

Table 7.—Georgia kaolin sold or used by producers, by kind

Kind	1980		1981	
	Short tons	Value	Short tons	Value
Airfloat	1,067,084	$38,748,311	753,930	$29,574,295
Calcined[1]	984,465	109,048,491	1,075,769	124,061,091
Delaminated	438,310	40,600,948	470,998	43,603,922
Unprocessed	295,996	1,925,839	313,841	3,435,670
Waterwashed	3,525,552	273,376,731	3,621,329	318,821,686
Total	6,311,407	463,700,320	6,235,867	519,496,664

[1]Includes both low-temperature filler and high-temperature refractory grades.

Table 8.—Georgia kaolin sold or used by producers, by kind and use

(Short tons)

Use	1980				1981			
	Air-float	Unprocessed[1]	Water-washed[2]	Total	Air-float	Unprocessed[1]	Water-washed[2]	Total
Domestic:								
Adhesives	40,663	--	16,835	57,498	5,685	--	41,906	47,591
Alum (aluminum sulfate) and other chemicals	9,511	219,520	9,252	238,283	58,769	229,717	260	288,746
Animal feed	10,220	--	--	10,220	3,131	--	209	3,340
Asphalt tile and linoleum	5,744	6,000	--	11,744	--	4,955	--	4,955
Catalysts (oil-refining)	--	--	67,082	67,082	--	--	99,093	99,093
China and dinnerware; crockery and earthenware	25,827	2,096	8,547	36,470	7,915	2,490	8,444	18,849
Electrical porcelain	22,741	--	--	22,741	11,923	--	--	11,923
Face brick	289	32,083	--	32,372	--	27,524	--	27,524
Fiberglass and mineral wool	69,611	--	56	69,667	14,698	--	12,690	27,388
Firebrick, block, shapes	352	2,658	--	3,010	464	11,121	--	11,585
Floor and wall tile, ceramic	W	--	W	W	W	--	--	W
Flue linings and high-alumina brick	40,176	4,492	--	44,668	64,291	2,934	--	67,225
Foundry sand	671	--	510	1,181	571	--	235	806
Glazes, glass, enamels, hobby ceramics	W	--	--	W	W	--	--	W
Grogs and crudes, refractory	W	444,748	--	444,748	W	445,789	--	445,789
Ink	W	--	--	W	W	--	W	11,805
Kiln furniture, mortar, cement	W	W	--	33,132	W	W	--	22,422
Medical, pharmaceutical, cosmetic	W	--	W	1,990	W	--	W	980
Paint	33,262	--	103,426	136,688	9,239	--	66,886	76,125
Paper coating	65,887	--	2,217,027	2,282,914	--	--	2,405,505	2,405,505
Paper filling	448,736	--	734,193	1,182,929	421,275	--	758,503	1,179,778
Plastics	5,277	--	42,557	47,834	7,472	--	44,889	52,361
Pottery	14,203	6,607	--	20,810	5,821	5,500	--	11,321
Roofing granules	17,361	--	--	17,361	9,747	--	--	9,747
Roofing and structural tile	434	--	--	434	106	--	--	106
Rubber	66,849	--	10,657	77,506	32,620	--	42,545	75,165
Sanitary ware	111,054	--	69	111,123	36,794	--	52	36,846
Miscellaneous, airfloat:								
Animal oil (1980), fertilizers, gypsum products oil and grease absorbents (1980), pesticides and related products, textiles (1980), waterproofing and sealing, other, unknown	40,280	--	--	40,280	39,625	--	--	39,625

See footnotes at end of table.

Miscellaneous, unprocessed:								
Drain tile, flower pots, gypsum products, other (1981)	--	6,263	--	6,263	--	19,441	--	19,441
Miscellaneous, waterwashed:								
Gypsum products, pesticides and related products, waterproofing and sealing, other, unknown	--	--	42,569	42,569	--	--	73,800	73,800
Undistributed	24,934	18,935	890	[3]9,637	9,035	17,646	11,360	[3]2,834
Total	1,054,082	743,402	3,253,670	5,051,154	739,181	767,117	3,566,377	5,072,675
Exports:								
Paint	--	--	25,494	25,494	87	--	31,310	31,397
Paper coating	--	--	691,446	691,446	--	--	604,296	604,296
Paper filling	30	--	72,399	72,429	--	--	77,992	77,992
Plastics	--	--	21,997	21,997	--	--	23,895	23,895
Refractories	--	260,040	--	260,040	--	219,372	--	219,372
Rubber	78	--	498	576	55	--	364	419
Undistributed	12,894	--	175,377	188,271	14,607	--	191,214	205,821
Total	13,002	260,040	987,211	1,260,253	14,749	219,372	929,071	1,163,192
Grand total	1,067,084	1,003,442	4,240,881	6,311,407	753,930	986,489	4,495,448	6,235,867

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

[1]Includes high-temperature calcined.

[2]Includes low-temperature calcined and delaminated.

[3]Incomplete total; difference included in totals for specific uses.

Table 9.—South Carolina kaolin sold or used by producers, by kind

Kind	1980 Short tons	1980 Value	1981 Short tons	1981 Value
Airfloat	457,231	$19,231,850	514,070	$24,309,941
Unprocessed	200,521	1,603,632	210,654	1,618,901
Total	657,752	20,835,482	724,724	25,928,842

Table 10.—South Carolina kaolin sold or used by producers, by kind and use

(Short tons)

Kind and use	1980	1981
Airfloat:		
Adhesives	13,802	17,766
Animal feed and pet waste absorbent	1,444	--
Ceramics[1]	23,395	117,941
Fertilizers	20,383	15,444
Fiberglass	105,709	98,427
Paint	1,146	841
Paper coating and filling	4,292	3,292
Pesticides and related products	15,135	17,075
Plastics	11,499	13,966
Rubber	191,059	122,625
Other refractories[2]	7,213	5,202
Other uses[3]	7,268	50,744
Exports[4]	56,612	50,747
Total	458,957	514,070
Unprocessed: Face brick; firebrick, block and shapes; miscellaneous	198,795	210,654
Grand total	657,752	724,724

[1]Includes floor and wall tile; glazes, glass, and enamels (1980); pottery; roofing granules; and sanitary ware.
[2]Includes refractory grogs and crudes; refractory mortar and cement.
[3]Includes common brick, crockery and other earthenware (1980), ink (1980), roofing tile (1981), structural tile (1980), and miscellaneous.
[4]Includes ceramics, paper filling, pesticides and related products, rubber, and miscellaneous.

Table 11.—Kaolin sold or used by producers in the United States, by kind and use

(Short tons)

Use	1980 Airfloat	1980 Unprocessed [1]	1980 Water-washed [2]	1980 Total	1981 Airfloat	1981 Unprocessed [1]	1981 Water-washed [2]	1981 Total
Domestic:								
Adhesives	54,465	4,376	16,835	75,676	23,451	6,161	41,900	71,512
Alum (aluminum sulfate) and other chemicals	9,633	332,616	9,252	351,501	77,701	373,388	260	451,349
Animal feed	11,664	5,110	--	16,774	3,131	8,690	209	12,030
Brick, common and face	1,378	256,576	--	257,954	1,061	269,092	--	270,153
Catalysts (oil and gas-refining)	--	--	67,082	67,082	29,511	--	99,093	128,604
Cement, portland	--	W	W	18,947	--	10,105	--	10,105
China and dinnerware	23,829	3,679	8,547	36,055	12,191	4,923	8,444	25,558
Crockery and other earthenware	7,922	618	--	8,540	W	W	--	1,417
Electrical porcelain	31,964	2,373	--	34,337	20,103	3,650	--	23,753
Fertilizers [3]	29,660	11,935	--	41,595	15,807	13,750	2	29,559
Fiberglass; mineral wool and other insulation	176,688	8,176	56	184,920	113,858	9,105	12,690	135,653
Firebrick, block, shapes	2,366	199,589	--	201,955	2,388	128,904	--	131,292
Floor and wall tile, ceramic	20,153	3,050	--	23,203	12,435	5,425	--	17,860
Flue linings and high-alumina brick	41,099	4,492	--	45,591	65,253	2,934	--	68,187
Foundry sand	1,138	--	510	1,648	571	--	235	806
Glazes, glass, enamels	60	3,737	--	3,797	715	4,168	--	4,883
Grogs and crudes, refractory	4,300	805,561	--	809,861	4,674	631,053	--	635,727
Gypsum products	2,732	7,613	463	10,808	2,828	9,763	73	12,664
Ink	W	--	--	W	W	--	W	11,805
Kiln furniture	2,056	--	--	2,056	2,582	2,500	--	5,082
Linoleum and asphalt tile	5,744	6,000	--	11,744	--	4,955	--	4,955
Medical, pharmaceutical, cosmetic	W	--	W	1,990	W	--	W	986
Mortar and cement, refractory	17,395	22,815	--	40,210	4,994	20,746	--	25,740
Paint	34,408	26,566	103,426	164,400	10,080	--	66,886	76,966
Paper coating	251,328	--	2,255,278	2,506,606	--	--	2,405,505	2,405,505
Paper filling	229,358	--	734,193	963,551	426,567	--	758,503	1,185,070
Pesticides and related products	15,235	32,273	1,326	48,834	40,372	39,009	1,280	80,661

See footnotes at end of table.

Table 11.—Kaolin sold or used by producers in the United States, by kind and use —Continued

(Short tons)

Use	1980				1981			
	Airfloat	Unprocessed [1]	Water-washed [2]	Total	Airfloat	Unprocessed [1]	Water-washed [2]	Total
Domestic —Continued								
Plastics	16,776	--	42,557	59,333	21,438	--	44,889	66,327
Pottery	19,001	9,246	--	28,247	10,149	9,400	--	19,549
Roofing granules	19,152	399	--	19,551	9,944	460	--	10,404
Roofing tile and structural tile	--	467	--	467	606	1,000	--	1,606
Rubber	257,908	8,549	10,657	277,114	155,245	9,866	42,545	207,656
Sanitary ware	128,080	4,088	69	132,237	150,979	4,553	52	155,584
Waterproofing and sealing	612	--	82	694	9,212	--	159	9,371
Miscellaneous	73,581	21,062	890	[4]74,596	16,147	20,828	86,117	[4]108,884
Total	1,489,680	1,780,966	3,251,223	6,521,869	1,243,993	1,594,428	3,568,842	6,407,263
Exports:								
Ceramics	2,480	--	2,447	4,927	3,071	--	1,851	4,922
Foundry sand; grogs, crudes, other refractories	308	298,760	--	299,068	321	257,047	--	257,368
Paint	--	--	25,494	25,494	87	--	31,310	31,397
Paper coating	--	--	691,446	691,446	--	--	604,296	604,296
Paper filling	5,620	--	72,399	78,019	4,225	--	77,992	82,217
Plastics	--	--	21,997	21,997	--	--	23,895	23,895
Rubber	44,554	--	498	45,052	43,058	--	364	43,422
Other	15,744	--	175,377	191,121	16,338	--	189,363	205,701
Total	68,706	298,760	989,658	1,357,124	67,100	257,047	929,071	1,253,218
Grand total	1,558,386	2,079,726	4,240,881	7,878,993	1,311,093	1,851,475	4,497,913	7,660,481

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.

BALL CLAY

Reported production of domestically mined ball clay in 1981 decreased 5%, while value increased 4%. Tennessee provided 66% of the Nation's output, followed in order by Kentucky, Mississippi, Texas, Maryland, New York,[2] and California. Production in Kentucky and Mississippi increased over that reported in 1980; production in all remaining States decreased.

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, new plants, and acquisitions and/or mergers slowed during 1981. By yearend, Kentucky-Tennessee Clay Co. had expanded its laboratory facilities in Kentucky and Tennessee and began operation of a new quality control laboratory at its Gleason, Tenn., operation. In addition, the company's customer service laboratory, presently located in Alliance, Ohio, was scheduled to be merged with the Mayfield, Ky., laboratory.

The average unit value for ball clay reported by domestic producers rose in 1981 to $32.95 per ton, an increase of $2.92 per ton. Chemical Marketing Reporter, December 29, 1981, listed ball clay prices unchanged from 1980, as follows:

Domestic, airfloated, bags, carload lots, Tennessee, per ton	$18.00-$22.00
Domestic, crushed, moisture-repellent, bulk, carload lots, Tennessee, per ton	8.00- 11.25
Imported, airfloated, bags, carload lots, Atlantic ports, per ton	70.00
Imported, lump, bulk, Great Lakes, per ton	40.50

Ball clay exports in 1981 amounted to 212,000 short tons valued at $6.6 million, compared with 211,000 tons worth $6.4 million in 1980. Unit value increased $0.87 per ton. Shipments were made to 29 countries. The major recipients were Mexico, 58%, and Canada, 35%.

Ball clay imports, largely from Canada and the United Kingdom, decreased from 9,400 tons valued at $1.06 million in 1980 to 7,300 tons valued at $856,000 in 1981.

Table 12.—Ball clay sold or used by producers in the United States, by kind and State

State	Airfloat		Unprocessed		Total	
	Short tons	Value	Short tons	Value	Short tons	Value
1980						
Tennessee	374,144	$12,419,212	231,440	$5,112,716	605,584	$17,531,928
Other	[1]208,396	[1]7,701,968	[2]79,644	[2]1,610,230	288,040	9,312,198
Total	582,540	20,121,180	311,084	6,722,946	893,624	26,844,126
1981						
Tennessee	317,156	11,751,863	242,312	6,212,308	559,468	17,964,171
Other	[1]231,225	[1]8,704,208	[2]54,467	[2]1,175,908	285,692	9,880,116
Total	548,381	20,456,071	296,779	7,388,216	845,160	27,844,287

[1]Includes Kentucky, Maryland, Mississippi, and Texas.
[2]Includes Arizona (1980), California, Kentucky, Maryland (1981), Mississippi, New York, and Texas.

Table 13.—Ball clay sold or used by producers in the United States, by kind and use

(Short tons)

Use	1980			1981		
	Air-float	Un-processed	Total	Air-float	Un-processed	Total
Adhesives	1,614	--	1,614	3,577	--	3,577
Animal feed	W	--	W	W	--	W
Brick, face	--	W	W	--	W	W
China and dinnerware	37,308	--	37,308	13,838	23,427	37,265
Crockery and other earthenware	13,525	--	13,525	976	8,259	9,235
Drilling mud	W	--	W	W	--	W
Electrical porcelain	28,159	--	28,159	12,614	11,150	23,764
Fiberglass and catalysts (oil-refining)	48,860	--	48,860	W	--	W
Firebrick, block, shapes	--	15,255	15,255	524	6,171	6,695
Glazes, glass, enamels	W	W	2,808	W	W	2,567

See footnotes at end of table.

Table 13.—Ball clay sold or used by producers in the United States, by kind and use —Continued

(Short tons)

Use	1980 Air-float	1980 Un-processed	1980 Total	1981 Air-float	1981 Un-processed	1981 Total
Grogs and crudes, high-alumina; mortar and cement refractories	79,989	19,630	99,619	87,846	9,813	97,659
Kiln furniture	W	W	2,505	W	W	2,540
Paper coating and filling	13,874	--	13,874	15,533	--	15,533
Pesticides and related products	898	--	898	W	W	763
Pottery	129,631	92,150	221,781	192,092	26,933	219,025
Rubber	W	--	W	--	W	W
Sanitary ware	64,265	20,171	84,436	68,698	12,130	80,828
Tile:						
Floor and wall	53,299	37,289	90,588	69,467	12,649	82,116
Other	--	--	--	--	W	W
Miscellaneous	38,837	68,944	[1]102,468	52,090	104,979	[1]151,199
Exports	72,281	57,645	129,926	31,126	81,268	112,394
Total	582,540	311,084	893,624	548,381	296,779	845,160

W Withheld to avoid disclosing company proprietary data; included with "Miscellaneous."
[1]Incomplete total; difference included in totals for specific uses.

FIRE CLAY

Fire clay sold or used by domestic producers in 1981 was reported at 1,927,123 tons valued at $31.2 million. Fire clay is defined as detrital material, either plastic or rock-like, containing low percentages of iron oxide, lime, magnesia, and alkalies to enable the material to withstand temperatures of 1,500° C or higher. Fire clay 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.

Fire clay production was reported in 1981 from mines in 16 States. The first five States—Missouri, Ohio, West Virginia, Alabama, and Pennsylvania—in order of volume, accounted for 92% of the total domestic output.

Exports of fire clay decreased from 308,000 tons worth $17.9 million in 1980 to 290,000 tons valued at $19.3 million in 1981. Fire clay exports decreased 6% in tonnage and increased 7% in value. The price of exported fire clay increased by $8.31 to $66.59 per ton, indicating a larger percentage of higher quality material shipped.

Fire clay was exported to 37 countries in 1981, with Mexico and the Federal Republic of Germany receiving 25% each, while Canada and Japan received 17% and 14%, respectively. No imports of fire clay were reported during 1981.

There were no price quotations in domestic journals for fire clay, but per-ton value reported by producers ranged from $4.77 to $22.40. The reported average unit value for fire clay produced in the United States decreased 6% from $17.19 per ton in 1980 to $16.18 in 1981.

Table 14.—Fire clay sold or used by producers in the United States, by State[1]

State	1980 Short tons	1980 Value	1981 Short tons	1981 Value
Alabama	223,146	$4,379,015	257,879	$5,777,179
Colorado	24,128	179,599	24,742	204,771
Illinois	19,758	204,298	21,553	245,920
Indiana	256	2,825	--	--
Kentucky	55,457	475,568	5,815	67,037
Missouri	699,512	12,807,753	668,839	13,396,750
Montana	535	2,670	546	2,730
New Jersey	11,239	222,880	10,644	233,539
Ohio	410,312	5,023,064	360,031	4,641,786
Pennsylvania	309,014	7,268,546	226,109	3,582,448
Texas	56,731	743,454	41,941	258,954
Other[2]	285,273	4,712,462	309,024	2,766,098
Total	2,095,361	36,022,134	1,927,123	31,177,212

[1]Refractory uses only.
[2]Includes California, Idaho, New Mexico, Utah, Washington, and West Virginia.

BENTONITE

Bentonite production in 1981 increased 18% in tonnage and 30% in value over that of 1980. A general increase was noted in domestic consumption, particularly in drilling mud with smaller increases in foundry sand and pelletizing iron ore. A decrease was noted in bentonite exports.

Bentonite was produced in 15 States in 1981. Increased bentonite production was reported for Alabama, California, Colorado, Mississippi, Nevada, South Dakota, Tennessee, Texas, and Wyoming. Production decreased in Arizona, Idaho, Kansas, Montana, and Utah.

The high-swelling or sodium bentonites have been produced chiefly in Wyoming, Montana, and California. The calcium or low-swelling bentonites have been produced in the other States.

During 1981, all of the major western and southern bentonite producers either announced planned expansions or had expansions underway. With successful conversion to coal from oil and gas firing in dryers, the industry was continuing to explore the practicality of augmenting coal with wood chips as a fuel. Kaiser Aluminum and Chemical Corp. acquired the catalyst and clay products operations of Filtrol Corp., a wholly owned subsidiary of Ashland Oil, Inc., for $92 million. Filtrol's catalysts, acid-activating plants, and bentonite mines in the United States and Canada were to become part of Kaiser's Industrial Chemicals Div.

On December 29, 1980, Chemical Marketing Reporter quoted bentonite prices as unchanged. Domestic material, 200 mesh, bags, carload lots, f.o.b. mines, was priced from $28 to $30 per ton; imported Italian, white, high-gel material, bags, 5-ton lots, ex-warehouse was not listed. The average unit value reported by domestic producers for bentonite sold or used in 1981 was $30.17, an increase of $2.63 from the $27.54 average of 1980. Per-ton values reported in the various producing States ranged from $10.00 to $86.87, but the average value reported by the larger producers was near the Montana average figure of $39.32.

Bentonite exports in 1981 decreased from 898,000 tons in 1980 to 862,000 tons; value increased from $62.2 million in 1980 to $64.5 million in 1981. The unit value of exported bentonite increased from $69.27 per ton in 1980 to $74.87 per ton in 1981. This increase in unit value was attributed to a larger percentage of the higher cost drilling muds and foundry sand grades shipped. Domestic bentonite producers were facing increased competition in foreign markets. Bentonite from the Greek Island of Milos was being blended with the U.S. clay for pelletizing Canadian taconite ores on a large scale.

Bentonite was exported to 84 countries in 1981. The major recipients were Canada, 36%; Japan and the Netherlands, 10% each; Singapore, 9%; Saudi Arabia, 8%; and others, 27%. Domestic bentonite producers reported that the end uses of their exports were drilling mud, 58%; foundry sand, 35%; iron ore pelletizing, 6%; and other, 1%.

Bentonite imports in 1981, 98% chemically activated material, totaled 10,024 tons valued at $4.8 million, compared with 5,300 tons valued at $2.7 million in 1980. The chemically activated bentonite was imported from six countries, with Canada supplying 51%; the Federal Republic of Germany, 34%; Mexico, 10%; and the United Kingdom, Japan, and Switzerland, the remaining 5%.

Table 15.—Bentonite sold or used by producers in the United States, by kind and State

State	Nonswelling		Swelling		Total	
	Short tons	Value	Short tons	Value	Short tons	Value
1980						
Arizona	35,155	$715,682	--	--	35,155	$715,682
California	44,935	2,594,650	19,431	$787,262	64,366	3,381,912
Colorado	1,510	18,000	35,450	567,200	36,960	585,200
Kansas	--	--	30,000	368,700	30,000	368,700
Mississippi	274,998	6,233,997	--	--	274,998	6,233,997
Montana	--	--	606,130	22,142,532	606,130	22,142,532
Nevada	--	--	11,201	498,813	11,201	498,813
Texas	108,602	7,058,484	50	2,500	108,652	7,060,984
Utah	--	--	8,504	71,708	8,504	71,708
Wyoming	--	--	2,877,040	70,682,075	2,877,040	70,682,075
Other	[1]116,413	[1]2,763,433	[2]15,200	[2]729,960	131,613	3,493,393
Total	581,613	19,384,246	3,603,006	95,850,750	4,184,619	115,234,996

See footnotes at end of table.

Table 15.—Bentonite sold or used by producers in the United States, by kind and State —Continued

State	Nonswelling		Swelling		Total	
	Short tons	Value	Short tons	Value	Short tons	Value
1981						
Arizona	33,220	$655,126	20	$1,200	33,240	$656,326
California	53,073	3,433,167	22,213	1,036,324	75,286	4,469,491
Colorado	2,000	28,000	39,100	391,000	41,100	419,000
Kansas	--	--	27,000	331,830	27,000	331,830
Mississippi	285,446	7,060,084	--	--	285,446	7,060,084
Montana	--	--	586,991	23,077,808	586,991	23,077,808
Nevada	--	--	14,127	706,717	14,127	706,717
Texas	116,046	8,262,576	50	2,500	116,096	8,265,076
Utah	--	--	7,845	89,062	7,845	89,062
Wyoming	--	--	3,584,287	99,745,102	3,584,287	99,745,102
Other	[1]147,648	[1]3,334,000	[2]28,092	[2]1,118,111	175,740	4,452,111
Total	637,433	22,772,953	4,309,725	126,499,654	4,947,158	149,272,607

[1]Includes Alabama, Idaho, and Louisiana (1981).
[2]Includes Idaho, South Dakota, and Tennessee.

Table 16.—Bentonite sold or used by producers in the United States, by kind and use

(Short tons)

Use	1980			1981		
	Non-swelling	Swelling	Total	Non-swelling	Swelling	Total
Domestic:						
Adhesives	W	W	3,696	W	W	382
Animal feed	64,057	106,379	170,436	57,855	99,258	157,113
Brick, face	W	--	W	--	W	W
Catalysts (oil refining)	8,722	--	8,722	7,749	5	7,754
Cement, portland	--	W	W	--	W	W
Drilling mud	59,061	1,374,150	1,433,211	60,554	2,004,088	2,064,642
Fertilizers	--	4,658	4,658	--	4,054	4,054
Filtering, clarifying, decolorizing:						
Animal oils and mineral oils and greases	99,930	2,787	102,717	102,702	2,610	105,312
Vegetable oils	9,242	--	9,242	55,662	--	55,662
Foundry sand	228,550	403,530	632,080	270,289	521,430	791,719
Glazes, glass, enamels	--	W	W	--	W	W
Medical, pharmaceutical, cosmetic	--	2,451	2,451	--	2,818	2,818
Paint	--	14,111	14,111	--	14,412	14,412
Pelletizing (iron ore)	849	861,538	862,387	--	884,976	884,976
Pesticides and related products	3,251	2,694	5,945	506	2,872	3,378
Pet waste absorbent	W	--	W	W	--	W
Waterproofing and sealing	2,160	89,494	91,654	1,897	88,882	90,779
Miscellaneous	86,043	126,941	[1]209,288	63,944	71,168	[1]134,730
Total	561,865	2,988,733	3,550,598	621,158	3,696,573	4,317,731
Exports:						
Drilling mud	1,782	331,302	333,084	--	364,342	364,342
Foundry sand	12,646	222,681	235,327	13,956	203,928	217,884
Pelletizing (iron ore)	--	--	--	--	37,771	37,771
Other	5,320	60,290	65,610	2,319	7,111	9,430
Total	19,748	614,273	634,021	16,275	613,152	629,427
Grand total	581,613	3,603,006	4,184,619	637,433	4,309,725	4,947,158

W Withheld to avoid disclosing company proprietary data; included with "Miscellaneous."
[1]Incomplete total; difference included with total for each specific use.

FULLER'S EARTH

Production of fuller's earth in 1981 increased 8% in quantity and 17% in value. The average unit value increased $4.31 in 1981 to $56.28 per ton.

Fuller's earth production was reported from operations in nine States. The two top producing States, Georgia (35%) and Florida (31%), accounted for 66% of domestic production. All States except Georgia and Illinois showed slight gains in production. Missouri reported no production for 1981.

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, Fla., 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.

In 1981, expansions were either underway or completed by the Pennsylvania Glass Sand Corp. in its gelling clay and granules units at its Quincy, Fla., mining and processing complex; Molthan, Inc., a subsidiary of Gurley Oil Co., Memphis, Tenn., at its Paris, Tenn., operation outside of Memphis; and by Mid-Florida Mining Co., Inc., at its Lowell, Fla., mill by the new owner, Florida Crushed Stone, Inc. SCA, Inc., acquired the idle Bennett Minerals works at Pinewood, S.C. Mid-Florida Mining was processing material from the newly acquired SCA operation in Florida. Bennett Minerals' new mine and processing facilities at Walkerton, Va., 23 miles northeast of Richmond, came onstream with the industries first wood-fired kiln.

Attapulgite, a fuller's earth-type clay, finds wide application in both the absorbent and thickening areas. Mineral thickeners are used in such diverse markets as paints, joint compound cement, polishes, and plastics. The thixotropic properties of attapulgite clays provide the important thickening and viscosity controls necessary for suspending solids.

Prices for fuller's earth were not publicly quoted in 1981, but the value per ton for attapulgite reported by producers ranged from $45.00 to $61.25; montmorillonite prices ranged from $35.09 to $54.29.

In 1981, fuller's earth was exported to 42 countries; exports decreased from 115,000 tons in 1980 to 111,000 tons in 1981. The unit value of exported fuller's earth increased by $14.00 to $94.23 per ton. The major recipients were Canada, 47%; the Netherlands, 23%; the United Kingdom, 10%; and other countries, 20%.

Imports of fuller's earth in 1981 were 216 tons valued at $55,000, all from the United Kingdom.

Table 17.—Fuller's earth sold or used by producers in the United States, by kind and State

State	Attapulgite		Montmorillonite		Total	
	Short tons	Value	Short tons	Value	Short tons	Value
1980						
Florida	417,358	$23,849,643	--	--	417,358	$23,849,643
Georgia	425,084	23,081,875	223,718	$9,585,352	648,802	32,667,227
Other	[1]83,552	[1]2,375,494	[2]384,091	[2]20,831,653	467,643	23,207,147
Total	925,994	49,307,012	607,809	30,417,005	1,533,803	79,724,017
1981						
Florida	518,031	34,955,895	--	--	518,031	34,955,895
Georgia	346,995	19,035,619	237,108	11,137,782	584,103	30,173,401
Other	[1]51,283	[1]3,108,462	[2]502,437	[2]24,945,910	553,720	28,054,372
Total	916,309	57,099,976	739,545	36,083,692	1,655,854	93,183,668

[1]Includes Nevada and Texas.
[2]Includes Illinois, Mississippi, Nevada, South Carolina, Tennessee, and Utah.

Table 18.—Fuller's earth sold or used by producers in the United States, by kind and use

(Short tons)

Use	1980 Atta-pulgite	1980 Montmoril-lonite	1980 Total	1981 Atta-pulgite	1981 Montmoril-lonite	1981 Total
Domestic:						
Adhesives	969	--	969	1,226	--	1,226
Animal feed	290	20	310	5,969	--	5,969
Drilling mud	158,203	1,453	159,656	191,287	2,027	193,314
Fertilizers	61,185	24,532	85,717	55,442	22,841	78,283
Filtering, clarifying, decolorizing mineral oils and greases	22,318	--	22,318	20,647	--	20,647
Medical, pharmaceutical, cosmetic	82	--	82	74	--	74
Oil and grease absorbents	235,667	158,796	394,463	196,465	246,821	443,286
Paint	3,732	--	3,732	5,347	--	5,347
Paper filling	2,503	--	2,503	4,472	--	4,472
Pesticides and related products	108,243	72,351	180,594	117,549	66,669	184,218
Pet waste absorbent	169,308	253,875	423,183	116,657	304,080	420,737
Rubber	362	--	362	252	--	252
Miscellaneous	24,651	54,994	79,645	70,220	36,378	106,598
Total	787,513	566,021	1,353,534	785,607	678,816	1,464,423
Exports:						
Drilling mud	6	--	6	363	--	363
Oil and grease absorbents	53,805	24,732	78,537	37,330	33,112	70,442
Pet waste absorbent	70,770	10,741	81,511	85,666	27,283	112,949
Miscellaneous	13,900	6,315	20,215	7,343	334	7,677
Total	138,481	41,788	180,269	130,702	60,729	191,431
Grand total	925,994	607,809	1,533,803	916,309	739,545	1,655,854

COMMON CLAY

Domestic production of common clay and shale in 1981 totaled 27.5 million tons valued at $109.9 million. Common clay and shale represented 62% of the quantity and 11% of the value of the total clays in 1981. Domestic clays and shales are for the most part used by the producer in fabricating or manufacturing products. Less than 10% of the total clay and shale output was sold. The average unit value for all common clay and shale produced in the United States and Puerto Rico in 1981 was $3.99 per short ton, $0.46 more than in 1980. The range in unit value reported for the bulk of the output was from $1.83 to $16.88 per ton.

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 consolidated sedimentary rock composed chiefly of clay minerals that has been both laminated and indurated while buried under other sediments. These materials 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 1981. Acme Brick Co., a subsidiary of Justin Industries, dedicated its third brick manufacturing plant in Malvern, Ark. This new Quachita plant represents an investment of $6 million and will be eventually capable of producing in excess of 40 million bricks per year. A contract was awarded to Basic Machinery Co., Inc., to design and construct a raw material grinding plant at the Martinsburg, W. Va., facility of the Continental Clay Product Co. The new grinding plant completes the firm's initial modernization program and opens the way for further enlargements of its brickmaking facilities. Particulars of the Western Hemisphere's largest brick kiln installed at the Interstate Brick and Ceramic Tile Co.'s plant in West Jordan, Utah, were released. The kiln, built solely to fire a new 16-inch loadbearing brick, is 509 feet long and has a theoretical capacity of 80 million brick equivalent per year. Total cost of the new complex was more than $12 million.

A major expansion of Sun Valle Tile Kiln, Inc.'s, main plant at Corona, Calif., was announced. The expansion of the roof tile operation featured an additional fuel-efficient kiln that was to increase capacity by 40% and enable Sun Valle to diversify its product line in the future.

Boral, Ltd., of Australia, purchased the Merry Co.'s brickmaking facilities in Augusta and Macon, Ga., Baltimore, Md., and Anniston, Ala. Merry, after acquisition by Boral, either bought or assumed control of Frame Brick Co., Anniston, Ala.; Baltimore Brick Co., Baltimore, Md.; and Burns Brick Co., Macon, Ga. The combined production capacities of these three facilities exceeded 600 million bricks per year.

Output of the energy-intensive common clay and shale industry was hindered again by high fuel costs and labor shortages; also, lower construction rates depressed demand in 1981. Industry attention in the Northwest and Southeast focused on coal, sawdust, and woodchip firing as a possible escape from the high cost and intermittent shortages of oil and gas.

Export data on common clay and shale are not collected by the U.S. Department of Commerce. Most countries have local deposits of clays and/or shales that are adequate for manufacturing structural clay products, cement clinker, and lightweight aggregates, and thus have no need to import such materials.

Table 19.—Common clay and shale sold or used by producers in the United States, by State[1]

State	1980		1981	
	Short tons	Value	Short tons	Value
Alabama	1,385,485	$6,435,401	1,402,897	$6,732,395
Arizona	115,377	434,967	114,924	448,910
Arkansas	936,609	1,555,393	738,235	1,349,393
California	2,422,097	12,580,201	2,183,227	13,208,448
Colorado	275,354	1,458,479	210,038	1,110,463
Connecticut	92,188	481,692	72,854	390,668
Florida	165,683	314,128	180,964	362,620
Georgia	1,322,574	4,187,253	1,209,399	4,156,061
Illinois	439,463	1,714,575	300,192	1,294,161
Indiana	931,765	1,926,675	690,593	1,601,914
Iowa	753,879	2,555,129	476,249	2,374,802
Kansas	855,780	1,956,105	887,714	4,424,230
Kentucky	692,303	3,216,353	484,157	2,327,290
Louisiana	379,838	5,841,314	379,921	6,337,687
Maine	77,924	173,803	56,650	166,460
Maryland	733,152	2,267,089	596,811	1,984,202
Massachusetts	210,457	870,273	258,853	1,322,424
Michigan	1,981,957	7,211,572	1,609,562	5,862,484
Minnesota	93,660	1,206,310	83,778	1,077,154
Mississippi	1,054,446	3,291,888	649,145	2,028,457
Missouri	1,040,718	2,539,693	973,710	2,796,528
Montana	19,062	55,016	13,095	30,003
Nebraska	153,781	456,295	135,965	409,278
New Jersey	52,215	301,803	51,786	329,359
New Mexico	59,866	113,910	63,720	118,811
New York	596,182	2,479,416	597,276	2,310,037
North Carolina	2,851,749	7,307,603	2,110,380	6,838,420
Ohio	2,303,746	6,473,395	1,853,302	5,752,626
Oklahoma	971,625	2,249,374	838,339	2,063,568
Oregon	171,690	321,214	176,359	299,642
Pennsylvania	1,340,577	4,843,644	1,020,275	3,914,696
Puerto Rico	290,866	677,050	200,049	473,932
South Carolina	1,552,821	4,333,397	907,432	2,671,497
South Dakota	168,664	283,080	116,250	209,050
Tennessee	499,809	1,171,215	403,330	939,808
Texas	3,475,351	13,265,270	3,901,802	15,359,280
Utah	348,544	1,229,612	247,271	1,048,196
Virginia	761,632	3,172,455	501,829	2,015,834
Washington	301,100	1,571,409	262,652	1,524,212
West Virginia	290,955	642,183	219,693	502,231
Wyoming	203,644	829,823	270,909	1,181,084
Other[2]	120,249	704,789	91,899	598,836
Total	32,494,837	114,700,246	27,543,486	109,947,151

[1]Includes Puerto Rico.
[2]Includes Idaho, Nevada, New Hampshire, North Dakota, and Wisconsin (1980).

CONSUMPTION AND USES

The manufacture of heavy clay products (building brick, sewer pipe, and drain, roofing, structural, terra cotta, and other tile), portland cement clinker, and lightweight aggregate accounted for 29%, 20%, and 11%, respectively, of total domestic consumption for 1981. In summary, 60% of all clay produced in 1981 was consumed in the manufacture of these clay- and shale-based construction materials. The utilization of clays in 1981 for portland cement and lightweight aggregates remained unchanged and decreased 3% for heavy clay products over the 1980 value.

Heavy Clay Products.—The value reported for shipments of heavy clay products for 1981 decreased 8% to $972 million from the 1980 value of $1,062 million. Thousand-unit counts for building or common face brick decreased 20% in 1981 from that shipped in 1980, shipments of glazed and unglazed ceramic tile and glazed brick decreased 24%, and clay floor and wall tile decreased 11%. The tonnage of unglazed structural tile decreased 10%, and vitrified clay sewer pipe and fittings shipped during the year decreased 29%. The value of these shipments decreased 14% for building brick and clay and increased 10% for floor and wall tile. The value decreased 33% for clay sewer pipe and increased 14% for the structural tiles.

Lightweight Aggregates.—Consumption of clay and shale in the making of lightweight aggregate decreased 9% in 1981 to 4.89 million tons. This was attributed to a downturn in construction rates, but uses in the newer markets, such as running tracks, golf courses, potting plants, and a host of other horticultural applications, continued growing.

The tonnage of raw material mentioned in tables 20 and 23 for lightweight aggregate production refers only to clay and shale and does not include the quantity of slate and blast furnace slag similarly used. In 1981, 238,000 tons of slate was expanded for lightweight aggregate, a 53% decrease from the 1980 figure of 503,000 tons. The amount of slag used for lightweight concrete aggregate and in block manufacture increased more than 100% from 369,000 tons in 1980 to 800,000 tons in 1981.

Refractories.—All types of clay were used in manufacturing refractories. Fire clay, kaolin, and bentonite accounted for 45%, 22%, and 20%, respectively, of the total clays used for this purpose. Bentonite was used primarily as a bonding agent in proprietary foundry formulations. Minor tonnages of ball clay, fuller's earth, and common clay and shale (the remaining 13%) were also used, primarily as bonding agents.

The tonnage used for refractories in 1981 increased slightly and constituted 9% of the total clays produced. This reversed a downward trend noted in 1979-80. The previous increases, as in 1981, were caused primarily by the continued expansion in refractory aggregate production and an upsurge in the manufacturing of more conventional brick-type refractories. Refractory aggregates are used mostly in plastic, gunning, ramming, and castable mixes.

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 a large number of products, such as paper, rubber, paint, and adhesives. Fuller's earth was used primarily in pesticides and fertilizers. Clays in pesticides and fertilizers have been used either as carriers, diluents, or prilling agents. Bentonites were used mainly in animal feed.

In 1981, 10% of clay produced was used in filler applications. Of all clay used for these purposes, kaolin accounted for 89%, fuller's earth, 6%, and bentonite, 4%. Ball clay, common clay and shale, and fire clay accounted for the remaining 1%. The total amount of kaolin consumed as fillers did not change significantly. In the individual kaolin categories, an increase of 17% occurred for gypsum products, while paper coating and rubber decreased 4% and 25%, respectively. Decreases occurred also for adhesives (6%) and fertilizers (29%), while plastics increased 12%. The total quantity of fuller's earth used in insecticides and fungicides increased 2%.

Absorbent Uses.—Absorbent uses for clays accounted for 979,000 tons, or 2% of the total 1981 clay production. Demand for absorbents in 1981 increased 6% over that reported for 1980. Fuller's earth was the principal clay used in absorbent applications; 88% of the entire output was consumed for this purpose. Bentonite was used to a lesser degree. Demand for clays in pet waste absorbent, representing 50% of the 1981 absorbent demand, decreased 2% from that reported for 1980. Demand for use in floor absorbents, chiefly to absorb hazardous oily substances, represented the remaining 50% of absorbent demand and increased 15% from the 1980 figure.

Drilling Mud.—Demand for clays in rotary-drilling muds increased 42% in 1981, from 1.59 million tons in 1980 to 2.26 million tons. The Natural Gas Policy Act of 1978 continued to spur exploratory gas well drilling. To a lesser degree, oil well drilling was stimulated by both the oil price increases and the Presidential Executive Order No. 12287, January 28, 1981, which not only advanced the price deregulation of crude oil, originally scheduled for September 1981, but also freed gasoline and propane from price regulations. Drilling muds consumed 5% of the entire 1981 clay production. Swelling-type bentonite is the principal clay used in drilling mud mixes, although fuller's earth and nonswelling bentonite are also used to a limited extent. Bentonite and fuller's earth accounted for nearly 100% of the total amount of clay used for this purpose. Small amounts of ball clay and kaolin were used in specialized formulations.

Floor and Wall Tile.—Common clay and shale, ball clay, fire clay, and kaolin, in order of demand, were used in manufacturing floor, wall, and quarry tile. This end-use category accounted for less than 1% of the total clay production in 1981. Demand in 1981 decreased 27% to 349,000 tons.

Pelletizing Iron Ore.—Bentonite is used as a binder in forming hard iron ore pellets. Demand increased slightly in 1981 to 885,000 tons. This increase in the use of bentonite for iron ore pelletizing, reflecting a slight upturn in taconite pellet production because of increasing steel demand, was tempered by inroads made by cheaper foreign bentonites into a traditional U.S. clay market. Of the total bentonite produced in 1981, about 9% of the swelling variety was consumed for this purpose. U.S. deposits continued to be the major world source for swelling bentonites.

Ceramics.—The total demand for clays in the manufacture of pottery, sanitary waste, china and dinnerware, and related products (excluding clay flower pots) accounted for 3% of the total 1981 clay output. This demand, principally ball and kaolin clays, increased from approximately 842,000 tons in 1980 to approximately 1,132,000 tons in 1981.

Table 20.—Clays sold or used by producers in the United States in 1981, including Puerto Rico, by type and use

(Short tons)

Use	Ball clay	Bentonite	Common clay and shale	Fire clay (refractory only)	Fuller's earth	Kaolin	Undistributed[1]	Total[2]
Adhesives	3,577	382	--	--	1,226	71,512	--	76,697
Alum (aluminum sulfate) and other chemicals	73,298	2,044	--	--	W	451,349	W	526,691
Animal feed	W	157,113	--	W	5,969	12,030	1,577	176,689
Building brick:								
Common	W	W	1,969,789	W	--	33,432	26,678	2,029,899
Face	W	W	10,227,307	W	--	236,721	32,562	10,496,590
Catalysts (oil-refining)	W	7,754	--	--	W	128,604	31,811	168,169
Cement, portland	--	W	8,744,549	W	--	10,105	2,838	8,757,492
China and dinnerware	37,265	--	--	--	--	25,558	--	62,823
Crockery and other earthenware	9,235	--	W	--	--	1,417	W	10,652
Drilling mud	W	2,064,642	--	--	193,314	W	2,642	2,260,598
Electrical porcelain	23,764	--	W	--	--	23,753	W	47,517
Fertilizers	--	4,054	--	--	78,283	29,559	--	111,896
Fiberglass, mineral wool, other insulation	--	6,154	--	--	--	135,653	--	141,807
Filtering, clarifying, decolorizing:								
Animal oil	--	89,900	--	--	--	--	--	89,900
Mineral oils and greases	--	15,412	--	--	20,647	--	--	36,059
Vegetable oils	--	55,662	--	--	--	--	--	55,662
Firebrick, block, shapes	6,695	W	64,209	1,252,948	--	131,292	W	1,455,144
Flower pots	--	--	32,680	600	--	1,245	--	34,525
Flue linings and high-aluminum (minimum 50% Al_2O_3) refractories	9,429	--	36,192	153,116	--	68,187	--	266,924
Foundry sand	--	791,719	W	36,239	--	806	W	828,764
Glazes, glass, enamels	2,567	W	--	--	--	4,883	W	7,450
Grogs and crudes, refractory	1,133	--	W	160,754	--	635,727	W	797,614
Gypsum products	--	--	--	--	W	12,664	W	12,664
Ink	--	--	--	--	--	11,805	--	11,805
Kiln furniture	2,540	--	--	--	--	5,082	--	7,622
Lightweight aggregate:								
Concrete block	--	--	2,983,586	--	--	--	--	2,983,586
Structural concrete	--	--	1,550,074	--	--	--	--	1,550,074
Highway surfacing	--	--	230,856	--	--	--	--	230,856
Other	--	--	129,246	--	--	--	--	129,246
Linoleum and asphalt tile	3,927	--	--	--	--	4,955	--	8,882
Medical, pharmaceutical, cosmetic	--	2,818	--	--	74	986	--	3,878

Mortar and cement, refractory	87,097	W	209,260	206,263	51,811	25,740	W	580,171
Oil and grease absorbents	--	W	--	--	443,286	W	47,103	490,389
Paint	W	14,412	W	--	5,347	76,966	5,451	102,176
Paper coating	878	W	--	--	--	2,405,505	W	2,406,383
Paper filling	14,655	W	--	--	4,472	1,185,070	W	1,204,197
Pelletizing (iron ore)	--	884,976	--	--	--	--	--	884,976
Pesticides and related products	763	3,378	W	--	184,218	80,661	W	269,020
Pet waste absorbent	--	W	W	--	420,737	--	68,068	488,805
Plastics	--	W	W	--	W	66,327	10,139	76,466
Plug, tap, wad	--	--	--	2,989	--	--	--	2,989
Pottery	219,025	--	150,271	12,450	--	19,549	--	401,295
Roofing granules	W	--	--	--	W	10,404	39,080	49,484
Rubber	W	W	--	--	252	207,656	2,014	209,922
Sanitary ware	80,828	--	--	--	--	155,584	--	236,412
Sewer pipe, vitrified	--	--	603,577	W	--	--	W	603,577
Tamping dummies	--	--	4,400	--	--	--	--	4,400
Tile:								
Drain	--	--	115,308	--	--	W	W	115,308
Floor and wall	82,116	--	77,424	600	--	17,860	--	178,000
Quarry	--	--	152,422	W	--	--	W	152,422
Roofing	--	--	34,826	--	--	1,606	--	36,432
Structural	--	--	42,112	--	--	--	--	42,112
Terra cotta	--	--	1,605	--	--	--	--	1,605
Waterproofing and sealing	--	90,779	20	--	--	9,371	--	100,170
Miscellaneous[3]	10,049	70,135	40,395	20,055	8,665	66,471	--	215,770
Exports	112,394	629,427	26,535	21,839	191,431	1,253,218	--	2,234,844
Total	781,235	4,890,761	27,426,643	1,867,853	1,609,732	7,619,313	269,963	44,465,500
Total undistributed	63,925	56,397	116,843	59,270	46,122	41,168	113,762	113,762
Grand total	845,160	4,947,158	27,543,486	1,927,123	1,655,854	7,660,481	--	44,579,262

W Withheld to avoid disclosing company proprietary data; included with "undistributed."
[1]Publishable total of clays indicated by symbol W; unpublishable data included with "Total undistributed."
[2]Data may show incomplete total; difference included with "Total undistributed."
[3]Includes asphalt emulsion, graphite anodes, and unknown uses.

Table 21.—Shipments of principal structural clay products in the United States

Product	1977	1978	1979	1980	1981
Unglazed common and face brick:					
Quantity ________ million standard brick	8,060	8,957	8,020	6,513	5,202
Value ________ million	$607	$765	$749	$625	$540
Unglazed structural tile:					
Quantity ________ thousand short tons	50	76	69	102	92
Value ________ million	$3	$4	$4	$7	$8
Vitrified clay and sewer pipe fittings:					
Quantity ________ thousand short tons	1,140	924	847	654	463
Value ________ million	$140	$126	$120	$109	$73
Unglazed, salt-glazed, ceramic-glazed structural facing tile, including glazed brick:					
Quantity ________ million equivalent	63	58	56	46	35
Value ________ million	$11	$11	$11	$11	$10
Clay floor and wall tile, including quarry tile:					
Quantity ________ million square feet	291	299	314	323	288
Value ________ million	$233	$253	$295	$310	$341
Total value ________ do	$994	[1]$1,158	$1,179	$1,062	$972

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

Source: Bureau of Census Report Form M32-D(81), Current Industrial Reports—Clay Construction Products.

Table 22.—Common clay and shale used in building brick production in the United States, by State

State	1980		1981	
	Short tons	Value	Short tons	Value
Alabama	717,422	$2,308,673	641,145	$2,135,878
Arizona and New Mexico	137,014	313,567	139,985	342,327
Arkansas	517,645	948,613	422,690	848,809
California	511,265	1,661,139	445,498	1,594,921
Colorado	254,542	1,364,979	201,584	1,062,536
Connecticut, Florida, New Jersey (1981)	143,762	773,345	125,998	715,313
Georgia	1,165,412	3,754,359	1,056,185	3,790,366
Idaho and Utah	85,396	475,020	56,520	391,447
Illinois	199,986	930,364	144,200	749,296
Indiana and Iowa	416,725	1,110,001	367,652	936,988
Kansas	189,954	394,413	156,166	346,385
Kentucky	186,048	784,326	182,071	809,379
Louisiana	125,838	253,314	137,921	311,887
Maine, Massachusetts, New Hampshire	163,516	803,712	129,231	737,801
Maryland and West Virginia	389,866	1,352,104	315,328	1,170,087
Michigan, Minnesota, Wisconsin (1980)	192,715	1,839,204	96,590	812,290
Mississippi	669,278	2,393,262	460,241	1,572,078
Missouri	146,700	457,146	87,579	325,494
Nebraska and North Dakota	175,373	477,325	148,077	418,971
New York	168,410	456,833	137,466	182,455
North Carolina	2,346,506	6,030,305	1,801,488	5,953,531
Ohio	1,036,304	2,584,711	865,976	2,482,645
Oklahoma	347,268	846,740	288,400	766,472
Oregon	33,300	62,496	29,485	40,291
Pennsylvania	1,109,867	3,800,961	838,867	3,032,334
South Carolina	753,116	2,223,396	605,265	1,849,449
Tennessee	279,073	544,007	217,222	439,964
Texas	1,588,407	5,556,020	1,485,188	5,532,686
Virginia	634,552	1,419,242	442,299	1,110,668
Washington	159,058	681,169	146,125	602,603
Wyoming	39,602	248,745	24,654	238,479
Total	14,883,920	46,849,491	12,197,096	41,303,830

Table 23.—Clay and shale used in lightweight aggregate production in the United States, by State and use

State	Short tons					Total value
	Concrete block	Structural concrete	Highway surfacing	Other	Total	
1980						
Alabama and Arkansas	610,569	122,118	21,558	--	754,245	$3,342,777
California	270,568	311,861	--	66,965	649,394	6,357,224
Florida, Indiana, Iowa	377,492	26,800	10,349	--	414,641	1,217,314
Kansas, Kentucky, Louisiana	495,601	174,531	65,333	5,666	741,131	7,273,748
Maryland, Massachusetts, Minnesota	444,305	46,570	--	7,900	498,775	2,220,016
Mississippi, North Carolina, North Dakota	333,428	141,242	173,753	--	648,423	1,554,774
Montana and New York	168,600	134,750	--	1,500	304,850	1,750,451
Ohio, Oklahoma, Pennsylvania	293,858	75,957	100	--	369,915	858,507
South Dakota, Utah, Virginia	270,045	115,390	--	3,580	389,015	2,538,381
Texas	290,428	207,841	75,014	93,957	667,240	2,292,780
Total	3,554,894	1,357,060	346,107	179,568	5,437,629	29,405,972
1981						
Alabama and Arkansas	579,261	105,158	25,695	--	710,114	3,191,196
California	238,791	317,661	--	60,438	616,890	5,833,408
Florida, Indiana, Iowa	227,841	49,324	--	5,222	282,387	1,084,707
Kansas, Kentucky, Louisiana	499,906	147,090	62,570	12,736	722,302	9,867,171
Massachusetts, Minnesota, Missouri	191,437	85,083	7,500	7,004	291,024	2,587,258
Mississippi and New York	291,334	171,189	12,275	1,500	476,298	2,263,173
Montana, North Carolina, North Dakota	118,366	72,844	--	1,240	192,450	538,032
Ohio, Oklahoma, Pennsylvania	278,342	70,979	100	--	349,421	838,114
South Dakota, Utah, Virginia	188,797	84,868	--	8,860	282,525	1,631,353
Texas	369,511	445,878	122,716	32,246	970,351	3,078,803
Total	2,983,586	1,550,074	230,856	129,246	4,893,762	30,913,215

Table 24.—Shipments of refractories in the United States, by product

Product	Unit of quantity	1980 Quantity	1980 Value (thousands)	1981 Quantity	1981 Value (thousands)
CLAY REFRACTORIES					
Superduty fire clay brick and shapes	1,000 9-inch equivalent.	51,188	$49,388	48,727	$51,608
Other fire clay, including semisilica, brick and shapes, glasshouse pots, tank blocks, feeder parts, upper structure parts used only for glass tanks.	do	129,646	78,003	110,309	73,910
High-alumina (50% to 60% Al_2O_3) brick and shapes made of calcined diaspore or bauxite.[1]	do	73,210	135,317	76,779	150,115
Insulating firebrick and shapes	do	46,399	35,789	46,373	40,398
Ladle brick	do	162,034	47,168	149,582	49,407
Sleeves, nozzles, runner brick, tuyeres	do	39,312	29,682	42,311	35,480
Hot-top refractories	Short tons	11,261	1,855	6,067	1,022
Kiln furniture, radiant heater elements, potter's supplies, other miscellaneous-shaped refractory items.	do	16,823	23,740	22,350	22,761
Refractory bonding mortars	do	63,661	19,836	65,113	23,569
Plastic refractories and ramming mixes, containing up to 87.5% Al_2O_3.[2]	do	157,500	35,160	170,444	39,442
Castable refractories	do	142,266	34,064	139,643	36,103
Gunning mixes	do	82,297	14,251	96,973	20,648
Other clay refractory materials sold in lump or ground form.[3 4]	do	433,833	53,133	420,028	65,486
Total clay refractories		XX	557,386	XX	609,949
NONCLAY REFRACTORIES					
Silica brick and shapes	1,000 9-inch equivalent.	NA	NA	NA	NA
Magnesite and magnesite-chrome brick and shapes	do	67,285	218,364	71,444	273,164
Chrome and chrome-magnesite brick and shapes	do	9,193	34,507	8,558	35,590
Shaped refractories containing natural graphite	Short tons	23,179	34,509	24,995	42,000
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.	17,285	109,237	13,461	83,454
Other mullite, kyanite, sillimanite, or andalusite brick and shapes.	do	3,524	17,106	3,025	15,748
Other extra-high (over 60%) alumina brick and fused bauxite, fused alumina, dense-sintered alumina shapes.[6]	do	2,103	39,972	8,426	44,506
Silicon carbide brick, shapes, kiln furniture	do	1,728	12,102	1,158	32,382
Refractory bonding mortar	Short tons	27,265	15,038	30,849	16,693
Hydraulic-setting nonclay refractory castables	do	44,676	25,887	35,752	24,494
Plastic refractories and ramming mixes	do	215,061	93,725	224,031	108,005
Gunning mixes	do	362,769	97,437	365,863	89,812
Dead-burned magnesia or magnesite[3 7]	do	515,949	130,045	426,954	118,905
Other nonclay refractory material sold in lump or ground form.[3]	do	567,611	57,454	557,113	58,717
Total nonclay refractories		XX	885,383	XX	943,470
Grand total refractories		XX	1,442,769	XX	1,553,419

NA Not available. 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]Including 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.

Table 25.—U.S. exports of clays in 1981, by country and type

(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	--	--	1	329	(2)	11	(2)	58	11	1,700	1	688	14	2,787
Australia	(2)	5	38	1,960	14	996	1	95	17	2.095	3	1,412	73	6,563
Belgium-Luxembourg	--	--	(2)	64	3	281	6	797	7	938	1	232	17	2,312
Brazil	2	12	15	2,168	(2)	2	(2)	52	6	1,283	2	303	23	3,820
Canada	75	1,872	310	16,782	50	2,919	52	3,995	213	17,420	57	5,552	757	48,540
Chile	(2)	15	7	1,175	--	--	(2)	60	2	395	1	195	10	1,840
Colombia	(2)	4	7	745	1	58	(2)	1	6	852	1	160	15	1,820
Ecuador	2	133	2	240	(2)	4	(2)	6	2	298	1	170	7	851
Finland	--	--	7	155	--	--	--	--	2	200	(2)	4	9	359
France	(2)	50	1	223	(2)	7	5	757	23	6,402	2	378	31	7,817
Germany, Federal Republic of	(2)	6	3	409	73	5,277	(2)	31	70	6,432	16	1,513	162	13,668
Guatemala	(2)	15	5	694	(2)	1	1	107	3	368	2	210	11	1,394
Hong Kong	--	--	1	266	--	--	--	--	1	160	1	172	3	598
Indonesia	(2)	13	15	773	(2)	55	--	--	2	343	--	--	18	1,184
Italy	--	--	1	145	(2)	33	(2)	118	155	17,621	1	234	157	18,151
Japan	5	463	85	8,032	42	3,428	(2)	17	438	47,036	65	9,057	635	68,034
Korea, Republic of	(2)	10	2	893	2	548	(2)	5	26	6,161	1	273	31	7,890
Mexico	122	3,427	9	1,218	73	2,959	1	41	83	6,840	48	6,111	336	20,595
Netherlands	--	--	85	4,410	(2)	60	26	1,978	182	17,792	18	1,150	311	25,390
New Zealand	(2)	7	(2)	101	--	--	1	115	4	399	(2)	57	6	679
Peru	(2)	11	2	272	(2)	47	--	--	3	376	2	335	7	1,041
Philippines	2	170	5	966	(2)	20	--	--	4	604	3	630	14	2,390
Saudi Arabia	--	--	72	4,533	--	--	2	385	(2)	56	(2)	162	74	5,136
Singapore	--	--	80	5,182	--	--	(2)	191	(2)	82	(2)	124	81	5,579
South Africa, Republic of	(2)	8	1	180	--	--	(2)	30	26	3,584	1	243	28	4,045
Spain	--	--	6	508	(2)	49	--	--	5	761	(2)	172	12	1,490
Sweden	(2)	5	(2)	19	5	537	(2)	2	26	3,129	7	890	38	4,582
Switzerland	--	--	--	--	(2)	2	(2)	10	16	1,991	1	117	17	2,120
Taiwan	1	95	7	1,051	5	252	--	--	31	3,721	4	421	48	5,540
Thailand	--	--	2	333	--	--	--	--	4	351	(2)	36	6	720

See footnotes at end of table.

Table 25.—U.S. exports of clays in 1981, by country and type —Continued

(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
Trinidad	--	--	5	408	--	--	(2)	8	(2)	14	(2)	18	5	448
United Arab Emirates	--	--	2	847	--	--	(2)	31	--	--	--	--	2	878
United Kingdom	(2)	1	27	2,401	15	1,338	11	1,053	6	1,357	7	1,358	66	7,508
Venezuela	1	94	31	2,930	1	93	(2)	70	26	2,809	8	1,247	67	7,243
Other	3	161	30	4,125	4	333	3	447	12	2,429	8	2,407	60	9,902
Total[1]	212	6,576	862	64,537	290	19,311	111	10,460	1,412	155,999	264	36,031	3,151	292,914

[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 1981, by kind

Kind	Quantity (short tons)	Value (thousands)
China clay or kaolin, whether or not beneficiated:		
Brazil	3	$5
Canada	2,835	170
Germany, Federal Republic of	21	4
Norway	18	3
United Kingdom	10,742	1,329
Total	13,619	1,511
Fuller's earth, not beneficiated: United Kingdom	216	55
Bentonite:		
Canada	53	41
Germany, Federal Republic of	13	9
United Kingdom	13	5
Total	79	55
Common blue and other ball clay, not beneficiated:		
Canada	26	4
United Kingdom	5,257	453
Total	5,283	457
Common blue and other ball clay, wholly or partly beneficiated:		
France	20	6
Mexico	2	1
United Kingdom	1,994	392
Total	2,016	399
Other clay, not beneficiated:		
Canada	36	7
China	2	3
Denmark	8	3
Germany, Federal Republic of	25	10
Mexico	139	7
United Kingdom	12	2
Total	222	32
Clay, n.e.c., wholly or partly beneficiated:		
Belgium	19	5
Canada	278	47
Denmark	1	1
Germany, Federal Republic of	199	80
Japan	13	29
Mexico	21	3
United Kingdom	1,403	457
Total	1,934	622
Artificially activated clay:		
Canada	5,100	1,068
Germany, Federal Republic of	3,370	2,482
Japan	6	8
Mexico	1,007	451
Switzerland	1	6
United Kingdom	461	749
Total	9,945	4,764
Grand total	33,314	7,895

Source: U.S. Department of Commerce.

WORLD REVIEW

Australia.—Comalco, Ltd., was conducting a feasibility study into producing paper-coating-grade kaolin from its Weipa bauxite operation in Queensland. The extent and quality of the kaolin deposit, believed to underlie the bauxite ore, had not been revealed by Comalco. The company planned to penetrate the Japanese, western Canadian, and United States markets that were largely supplied by U.S. kaolins. In a fuller's earth activity, Mallina Holdings Ltd. was planning an attapulgite fines pelletizing plant at its Geraldton minerals processing facility on the west coast.

Benin.—A series of test pits indicated the presence of a kaolin deposit of at least 60,000 tons in a 10-acre-square area with a trend covering more than 100 acres. The test pits, underwritten by the United Nations, were to be followed by a drilling program in 1982. The ceramic-quality clay uncovered was targeted for local consumption.

Brazil.—The china clay plant under construction by English China Clays Ltd. (ECC) to supply the South American paper industry was scheduled to come onstream during 1982.

Canada.—Noranda Mines Ltd. announced that it acquired a 34.5% interest in Avonlea Mineral Industries of Regina, Saskatchewan, for an undisclosed purchase price. Avonlea, the sole domestic sodium bentonite producer, mined and processed its ore 14 miles southwest of Wilcox. Annual production of the Avonlea facility was about 60,000 tons per year. A multimillion dollar turnkey contract for a complete brick plant was awarded by I-XL Industries Ltd., Medicine Hat, Alberta, to Ferro Corp.'s Temtek-Allied Div., Crystal Lake, Ill. Construction of the new plant, sited in Edmonton, Alberta, was underway. The totally automated new facility was to include provisions for future expansion from the initial production of 40 million bricks annually.

China.—Discovery of a large sodium bentonite deposit of unknown quality in the southwestern Province of Sichurn was announced.

Guyana.—The Government announced plans for a detailed feasibility study to determine whether the extensive kaolin beds underlying its bauxite deposits can be economically mined. The study, with technical assistance provided by the Inter-American Development Bank and local support by the Bauxite Industry Development Co., was to focus on the Topira bauxite near Ituni, the center of its bauxite mining belt.

Netherlands.—A one-third interest in a major catalyst manufacturer, Katalistiks International BV, was acquired by ECC. Katalistiks had announced earlier plans to construct a plant in the United States. The catalysts, essentially built up on kaolin substrates, are used in fractionating crude oil.

Pakistan.—The Punjab Mineral Development Corp. announced a planned feasibility study for developing a fuller's earth plant (calcium or nonswelling bentonites) based on clay discovered in the Dera Ghazi Khan district of Punjab.

Portugal.—In a joint venture with an unnamed Portuguese company, ECC began constructing a new kaolin calcining plant.

Saudi Arabia.—A contract in excess of $7 million was awarded to Pullman Swindell, Div. of Pullman Inc., by Saudi Red Bricks Co., Jeddah, for two tunnel kilns, two dryers, and related plant equipment. The new contract was to double the existing capacity of the plant to 1,000 tons per day and was scheduled for completion by early 1982.

South Africa, Republic of.—A new air mill and air separator was ordered for grinding and classifying bentonites by Cullinan Minerals Ltd. for its new facility. The output of the new mill was rated at 5 to 6 tons per day, with a product size of 96% passing 100 mesh.

Spain.—ECC announced two kaolin joint ventures with Spanish companies. The first was with Caobar SL to investigate the deposits in the Poveda area of Guadalajara Province. The development plans for the new company, Compania Espanola De Caolines, were not announced. The other venture, with an unannounced company, was to begin with construction of a new kaolin calcining plant.

Sweden.—Hoeganaes AB, a producer of ceramic-grade kaolin at Axeltrop, had found a large deposit of high-quality, paper-coating-grade kaolin under its existing residual deposit. A pilot plant was developing a process for recovering a paper-grade clay for domestic use. A plant capable of producing more than 100,000 tons per year was scheduled for startup in 1984. Sweden continued to import paper-grade clays largely from England.

United Kingdom.—Laporte Industries Ltd. opened its new $11 million activated fuller's earth (calcium bentonite) plant at Widnes. The new unit, replacing older units at Redhill, Surrey, and Bath, became the only one of its kind in the country. The annual capacity of the plant was rated at 35,000 tons per year. The product was to be used largely for filtering, decolorizing, and clarifying animal and vegetable oils and one-half was destined for export.

In brickmaking activities, improvements at the Ravenhead No. 2 plant in Lancashire enabling production of 800,000 bricks per week were completed. Further planned improvements, announced by Steetley Brick Ltd. in 1979, included an eventual parallel second tunnel kiln. London Brick Co. closed its 40-million-brick-per-year Redgmont works in Bedforshire at midyear. The decision was prompted by the continuing decline of home building in the United Kingdom.

Yugoslavia.—Reserves of a newly discovered bentonite deposit near Sipovo in Bosnia-Hercegovina were established at 500,000 tons with the likelihood of containing upward of 1 million tons. Construction of a plant capable of producing 25,000 tons per year was scheduled pending completion of tests at the INA Petrochemija enterprise at Kutina. A prospecting effort was targeted for the Kosovo region for a variety of minerals and deposits, including kaolin and bentonite.

Zambia.—A new ceramics plant, based mainly on local clays and other raw materials for producing tableware, sanitary ware, wall and floor tiles, and other ceramic products, was to be built in Kitwe.

Table 27.—Kaolin: World production, by continent and country[1]

(Thousand short tons)

Continent and country[2]	1977	1978	1979	1980[p]	1981[e]
North America:					
Costa Rica	1	1	1	1	1
Mexico	196	198	85	158	165
United States[3]	6,489	6,973	7,761	7,879	7,660
South America:					
Argentina	82	51	146	101	[4]114
Brazil (beneficiated)	286	[r]325	385	452	485
Chile	61	53	65	66	65
Colombia	[r]871	863	903	867	[4]893
Ecuador	[r]5,055	[r]3,929	4,400	4,409	4,400
Paraguay	[e]24	39	44	55	60
Peru	[r]3	4	5	6	7
Venezuela	11	25	24	[e]24	[4]72
Europe:					
Austria (marketable)	82	[r]85	87	92	95
Belgium[e]	130	130	130	130	130
Bulgaria	214	219	223	229	230
Czechoslovakia	639	[r]451	565	571	570
Denmark[e]	25	25	22	22	22
France	[r]324	[r]292	347	[e]353	340
Germany, Federal Republic of (marketable)	551	574	613	[e]660	550
Greece	[r]67	53	36	47	50
Hungary	79	75	70	57	55
Italy:					
Crude	90	76	74	74	80
Kaolinitic earth	[r]21	[r]3	28	30	35
Poland	100	73	54	55	55
Portugal	80	[r]81	[e]60	55	55
Romania[e]	100	100	100	100	100
Spain (marketable)[5]	[r]73	64	80	51	55
U.S.S.R.[e]	2,500	2,600	2,800	2,800	2,800
United Kingdom	4,782	4,629	4,899	4,370	4,200
Yugoslavia	122	198	196	[e]200	210
Africa:					
Algeria	13	19	[e]20	20	21
Angola[e]	1	--	--	--	--
Burundi[e]	3	3	2	2	2
Egypt	54	61	51	45	45
Ethiopia (including Eritrea)	[e]45	35	33	61	60
Kenya	1	2	[e]2	2	2
Madagascar	2	3	2	3	3
Mozambique	--	--	(6)	(6)	(6)
Nigeria	[e]1	[e]1	1	1	1
South Africa, Republic of	98	135	164	[4]119	--
Tanzania[e]	1	NA	NA	NA	NA
Asia:					
Bangladesh[7]	5	[r]6	8	11	11
Hong Kong	3	[r]28	3	1	[4]9
India:					
Salable crude	385	335	398	385	450
Processed	106	126	121	107	110
Indonesia	42	41	65	83	90
Iran	123	[e]198	176	165	110
Israel	6	7	25	10	11
Japan	249	250	240	252	235
Korea, Republic of	[r]393	[r]404	413	302	250
Malaysia	35	34	36	51	50
Pakistan	1	15	17	30	45
Sri Lanka	6	6	6	7	8
Taiwan	32	73	94	88	[4]100
Thailand	27	37	47	22	20
Turkey	65	48	[e]65	55	55

See footnotes at end of table.

Table 27.—Kaolin: World production, by continent and country[1] —Continued

(Thousand short tons)

Continent and country[2]	1977	1978	1979	1980[p]	1981[e]
Oceania:					
Australia	98	[r]98	160	154	160
New Zealand	104	37	28	51	50
Total	[r]24,957	[r]24,191	26,380	25,941	25,452

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available.
[1]Table includes data available through July 7, 1982.
[2]In addition to the countries listed, China, the German Democratic Republic, Lebanon, Vietnam, and Zimbabwe 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]Kaolin sold or used by producers.
[4]Reported figure.
[5]Excludes unwashed kaolin.
[6]Less than 1/2 unit.
[7]Data for year ending June 30 of that stated.

Table 28.—Bentonite: World production, by continent and country[1]

(Short tons)

Continent and country[2]	1977	1978	1979	1980[p]	1981[e]
North America:					
Guatemala	--	2,858	[e]2,900	[e]2,900	2,750
Mexico	65,223	154,682	187,225	194,037	198,000
United States	3,746,487	4,468,000	4,422,075	4,184,619	4,947,000
South America:					
Argentina	126,585	117,900	173,484	144,826	174,275
Brazil	119,485	184,763	234,244	273,322	275,600
Colombia	(3)	(3)	(3)	--	--
Peru	[r]34,392	[r]20,729	--	--	[4]33,620
Europe:					
France	8,888	[e]8,800	[e]9,900	11,000	9,920
Greece	[r]592,020	[r]450,546	545,837	553,225	553,360
Hungary	88,188	90,622	79,904	85,633	85,500
Italy	[r]308,647	[r]259,042	310,851	356,046	[4]305,340
Poland[e]	55,000	55,000	55,000	55,000	55,000
Romania[e]	70,000	72,000	72,000	72,000	72,000
Spain	[r]126,325	119,400	133,025	107,701	121,250
Africa:					
Algeria (bentonitic clay)	26,896	39,313	[e]40,000	40,000	41,900
Egypt	4,201	3,801	[e]3,900	5,732	5,732
Morocco	5,299	5,291	1,118	3,620	3,700
Mozambique	3,025	3,307	1,825	1,650	1,650
South Africa, Republic of	41,029	38,051	51,141	54,910	[4]48,911
Tanzania	39	22	88	55	55
Asia:					
Burma	1,075	1,518	1,594	1,485	1,320
Cyprus[5]	14,550	9,370	7,351	9,758	8,800
Iran[e]	25,800	44,100	22,000	22,000	11,000
Israel (metabentonite)	8,818	7,663	6,930	20,195	16,535
Japan[e]	440,000	440,000	440,000	440,000	440,000
Pakistan	1,200	999	1,588	1,658	1,130
Philippines	2,512	1,730	3,443	5,570	5,500
Turkey	4,803	9,127	[e]15,400	11,000	11,000
Oceania:					
Australia[6]	6,176	[r]5,132	7,303	7,716	8,300
New Zealand (processed)	2,866	10,803	5,461	3,307	3,900
Total	[r]5,929,529	[r]6,624,569	6,835,587	6,668,965	7,443,048

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through July 7, 1982.
[2]In addition to the countries listed, Austria, Canada, China, the Federal Republic of Germany, and the U.S.S.R. are believed to produce bentonite, but output is not reported and available information is inadequate to make reliable estimates of output levels.
[3]Revised to zero.
[4]Reported figure.
[5]Includes bleaching earths.
[6]Includes bentonitic clay.

Table 29.—Fuller's earth: World production, by country[1]

(Short tons)

Country[2]	1977	1978	1979	1980[p]	1981[e]
Algeria	4,814	5,343	[e]5,500	5,512	5,600
Argentina	4,551	3,838	6,002	5,205	5,700
Australia	55	[e]50	55	55	55
Italy	6,993	[e]4,382	1,190	4,740	6,000
Mexico	67,648	[r]44,770	53,815	56,615	57,320
Morocco (smectite)	23,176	8,819	14,976	19,213	19,840
Pakistan	19,842	19,842	44,457	26,966	22,490
Senegal (attapulgite)	3,753	7,639	14,330	4,385	4,300
South Africa, Republic of	--	284	1,013	794	480
Spain (attapulgite)	[e]39,476	43,244	68,809	52,933	NA
United Kingdom	245,815	240,304	242,508	231,485	220,460
United States	1,428,326	[r]1,529,617	1,568,247	1,533,802	[3]1,655,854
Total	[r]1,844,449	[r]1,908,132	2,020,902	1,941,705	1,998,099

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

[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 7, 1982.

[2]In addition to the market-economy countries listed, France, Iran, Japan, and Turkey have reportedly produced fuller's earth in the past and may continue to do so, but output is not reported and available information is inadequate to make reliable estimates of output levels.

[3]Reported figure.

TECHNOLOGY

The Federal Bureau of Mines published the results of clay-related research conducted at its Research Centers in Tuscaloosa (Ala.), Salt Lake City (Utah), Albany (Oreg.), and Reno (Nev.). The Tuscaloosa study developed a dewatering technique for Florida phosphatic clay wastes using moving screens.[3] The report of the work, done in cooperation with 10 Florida phosphate companies, describes a novel way to compress the contained solids using a moving screen that, by distorting the gel structure of the phosphatic clay system, causes release of the water. This technique was expected to be invaluable in reclaiming water lost with clays and for reclaiming mined land. The Salt Lake City Center reported on a bench-scale method for extracting more than 80% of the lithium from lithium-containing montmorillonite clays by chlorinating with HCl.[4] The addition of calcium carbonate to the clay was found to improve the lithium recovery. The best conditions for selective chlorination of the lithium, in these calcium- and magnesium-bearing clays, were 2:1 clay-carbonate, 750° C, and 20 weight-percent HCl. The experimental results and trends were explained thermodynamically. The Albany Center detailed the successful production of titanium castings with sodium bentonite-bonded rammed olivine and zircon molds.[5] These bentonite-bonded sands produced titanium casting not only superior to either of the conventional organic- or waterglass-bonded sands but also without the traditional fuming and mold instability. The Reno Center investigated sulfurous acid leaching to extract alumina from kaolin clays.[6] The process consists of leaching the calcined kaolin with a 30 weight-percent SO_2 solution at 60° C and 160 psig for 17 hours, filtering the leach slurry, precipitating monobasic aluminum sulfite from the filtrate at 110° C and 60 psig and decomposing the sulfite in the spent liquor at 150° C and 55 psig to produce crude alumina that is purified using a modified Bayer process. Recoveries of nearly 70% of the contained alumina were accomplished.

A small pilot plant involving a new blast furnace technique using coke as a reductant and substituting alumina-rich clay for bauxite as a feed was to be built.[7] In the process, clay containing 30% alumina is reduced by coke in the blast furnace at a temperature of 2,000° C to an aluminum-silicon alloy. This new process was reported to consume less energy than aluminum reduction by conventional electrolytic smelting.

An in-depth review of major industrial minerals, including bentonites, expanded shales, fire clays, kaolins, and other refractory and ceramic clays currently mined in Japan, was published.[8] The review covered the geology, mineralogy, output, production flowsheets, and consumption of clays by the refractory, ceramic, glass, and paper industries. A special feature of the article included a section on the Japanese nomenclature for clays, and the chemical and physical properties of indigenous bentonitic and kaolinitic clays. Similar reviews, including sections on companies and their marketing strategies, were devoted to Bulgaria,[9] Scandinavia (Sweden, Norway, and Denmark),[10] Belgium,[11] the Netherlands,[12] Luxembourg,[13] Austria,[14] Tanzania,[15] and Czechoslovakia.[16]

An article examined broadly the chemistry, mineralogy, geology, and mining flowsheets of four main producers of the Westerwald clays of the Federal Republic of Germany.[17] The Westerwald region has Western Europe's largest production of plastic clays for use mainly in the heavy clayware section of the ceramics industry. A feasibility study was outlined for a plant to activate bentonites found in the Paris Basin with soda ash to supply the French foundry industry.[18] The study contains engineering flowsheets and data on direct operating costs.

A comprehensive bentonite market survey by the Indian Bureau of Mines detailed the terminology, uses and specifications, and processing methods for foundry, drilling muds, iron ore pelletizing, bleaching, earth, and civil engineering uses for bentonite.[19] The report presented current and future world and internal demand for bentonites and related this to bentonite reserves in more than 13 districts in 3 Indian States.

The geology, physical properties, and uses or potential uses of clay in the Midwest States were described.[20] Included were fire clays and plastic clays in Ohio, Kentucky, Indiana, Illinois, and Missouri; flint clays in Kentucky and Missouri; ball clays in Kentucky and Tennessee; absorbent clays (fuller's earth) in Missouri, southern Illinois, and Tennessee; unique kaolin clays in Minnesota, Missouri, and Illinois; halloysite in southern Indiana; and alluvial clays and shales for structural clay products from every State.

The unique adobe brick industry in New Mexico was discussed.[21] The report details the history, terminology, and general characteristics, geology, mineralogy, physical properties, and techniques for adobe clays and their production in New Mexico.

Three well-known methods of preparing clay fractions, two aqueous settling and a vacuum method, both for quantitative X-ray diffraction analysis, were tested and evaluated.[22] The vacuum method was preferred because the layering effect, due to differing settling rates of the finely divided clay fraction, precluded kaolinite identification.

Several whiteware production processes that show promise of industry-changing advancement were surveyed.[23] The survey compared typical present-day processes with those likely to be used in the future, as well as a brief discussion of the effects of environmental factors. The dewatering of ceramic slips by spray-drying, powder-pressing instead of plastic forming, pressure casting of slips, and glazing applications by spraying techniques were a few of the new processes mentioned.

A nondestructive ultrasonic testing method was developed for detecting internal cracks and other structural defects and/or variations in fire clay refractories.[24] The method was particularly useful as a control test for checking fire clay shapes both during production and under field conditions before actual construction of coke oven batteries. In another fire clay work, the mechanism of corrosion of fire clay crowns of continuous lead glass tanks were investigated under both industrial and laboratory conditions by chemical, microscopic, microprobe, and X-ray fluorescence and diffractometric techniques.[25] The corrosion, which caused refractory degradation, glass contamination, and "stone" inclusion, was initiated by reaction of potassium vapors, from the glass melt, with the highly reactive glassy phase components of the firebrick. The study was expected to prove valuable in fabricating more corrosion-resistant glass tank crowns.

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[1]Physical scientist, Division of Industrial Minerals.

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Cobalt

By Scott F. Sibley and William S. Kirk[1]

Domestic consumption of cobalt deteriorated significantly in 1981, reflecting general recessionary economic conditions. Reported consumption declined to 11.7 million pounds, about 24% less than that of 1980. Similarly, calculated apparent consumption dropped from 17.1 to 12.5 million pounds. Nearly all end-use areas showed declines in consumption. Notable exceptions were consumption of cobalt for full alloy steel and pigments, both of which are relatively small end uses. Consumption of cobalt in driers increased slightly. Ongoing substitution in most end uses also contributed to the general decline.

The producer price was lowered several times during the year and ended at $17.26 per pound in response to the relatively low free market price, which reached a low point of $9.50 per pound late in the year. In January, the spot price was $22.00 per pound. The very soft market conditions caused a buildup of producer inventories worldwide. Production was cut back slightly in Zaire by mining ores with a lower cobalt-to-copper ratio. The percentage of imports originating in Zaire dropped dramatically from 46% in 1980 to 33% in 1981.

Mining companies investigating a resumption of domestic production scaled back their staffs at sites in Missouri (Madison Mine) and Idaho (Blackbird Mine) and postponed plans to build new facilities.

The U.S. General Services Administration (GSA) awarded a contract to Société Zairoise de Commercialization des Minerais (SOZACOM), the Zairian marketing agency for cobalt, for the purchase of 5.2 million pounds of cobalt at $15 per pound for the national stockpile. Partial deliveries were made by yearend. Also, an international organization was established to promote the use of cobalt and to provide technical information.

Table 1.—Salient cobalt statistics

(Thousand pounds of contained cobalt unless otherwise specified)

	1977	1978	1979	1980	1981
United States:					
Consumption	16,577	19,994	17,402	15,321	11,680
Imports for consumption	17,548	19,029	19,998	16,302	15,594
Stocks, Dec. 31: Consumer	3,738	4,387	3,390	2,540	1,411
Price: Metal, per pound	$5.20-$6.40	$6.40-$20.00	$20.00-$25.00	$25.00	$17.26-$25.00
World: Production, mine[1]	r51,698	r59,542	r65,586	p67,476	e68,898

eEstimated. pPreliminary. rRevised.
[1]Based on estimated recovered cobalt.

Legislation and Government Programs.—The Government stockpile goal of 85.415 million pounds of cobalt was lowered slightly to 85.4 million pounds by the Federal Emergency Management Agency (FEMA) in 1980. Despite a contract to purchase 5.2 million pounds of cobalt from Zaire, announced by GSA, the stockpile inventory of cobalt remained at 40.8 million pounds throughout the year. Partial deliveries on the contract were made late in the year, but because of delays in analyzing and certifying incoming shipments as meeting the specifications for grade A or B electrolytic cobalt, the material had not been recorded as inventory. The entire purchase was to be made directly from SOZACOM at a cost of $78 million. The contract price, at $15 per pound of cobalt, was appreciably below the prevailing producer price quote of $20 per pound. In late June, the U.S. free market price for cobalt ranged from $16.50 to $17.00 per pound. The Zairian offer was 1 of 17 that had been received by GSA. Owing to the favorable price offered, GSA decided to exercise its option to buy an additional 4 million pounds over the 1.2-million-pound commitment that had been stipulated in the original purchase tender.

In late March, GSA amended the chemical specifications for stockpile purchases of cobalt originally announced on March 13. The amended specifications, as published by the U.S. Department of Commerce (DOC) with approval of FEMA, allowed for the purchase of a slightly lower quality grade B cobalt. The original specifications, which defined grade A cobalt, restricted purchases to material at least 99.9% pure. Specifications for grade B material allowed for a lower minimum cobalt content of 99.6% and set higher maxima contents for several trace impurities. The purpose of allowing the lower quality cobalt was to increase the number of potential suppliers. Both grades of cobalt were to be in the form of broken cathodes and meet specified packaging, labeling, and sampling requirements. Any grade A cobalt supplies would be suitable for producing extra fine powder for cemented carbide drill bits and cutting tool inserts.

The National Oceanic and Atmospheric Administration of DOC issued regulations September 15 to implement the Deep Seabed Hard Mineral Resources Act of 1980. The regulations cover procedures mining companies must follow to obtain seabed exploration licenses. The license applications were to be processed over a 15-month period, but no mining permits would be issued for several years. Under the act, commercial mining could not begin before January 1, 1988.

DOMESTIC PRODUCTION

There was no domestic mine production of cobalt in 1981. According to the annual report of AMAX, Inc., 893,000 pounds of cobalt was recovered from imported matte at the firm's Port Nickel refinery in Braithwaite, La. AMAX also submitted a proposal to FEMA, whereby the Government would guarantee the purchase of cobalt from AMAX for the National Defense Stockpile. According to company officials, a purchase guarantee would allow the firm to expand the cobalt capacity of the Port Nickel refinery and modify it so that higher cobalt, meeting stringent stockpile specifications, could be produced. The firm would also strive to develop the capability of recovering byproduct cobalt from ores mined in the Missouri lead-zinc district.

Since 1979, Anschutz Mining Co. had conducted a program of exploration, metallurgical testing, economic evaluation and rehabilitation to determine the feasibility of reopening the Madison Mine near Fredericktown, Mo. About $21 million had been spent on development, and the total capital and associated costs for the project were estimated at $115 million. Annual output of cobalt would be 2 million pounds, with copper, lead, and nickel as major byproducts. The mine was projected to have a 10-year life. Former production of copper, nickel, and cobalt at the site ended in 1961 under other management. Late in 1981, Anschutz cut back on their staff and curtailed plans for production because of depressed market conditions and unfavorable prospects for financial assistance from the Government.

Similarly, Noranda Mining Co., which had conducted extensive development work at the Blackbird Mine in central Idaho, decided to delay development plans and halved its work force of approximately 120 personnel at the site. Early in the year, Noranda had taken an option on land near Blackfoot, Idaho, in order to evaluate the property as a site for a plant to process cobalt concentrates to be produced from the Blackbird Mine. At the Blackfoot plantsite, located about 150 miles southeast of the proposed mine, cobalt metal would be recovered through leaching, solvent extraction, and electrowinning.

CONSUMPTION AND USES

Reported domestic consumption of cobalt decreased approximately 24% from that of 1980. The decline in consumption was largely the result of general recessionary economic conditions. Despite price declines during the year, the relatively high price encouraged continuation of conservation and substitution efforts. Only driers, of the major end-use areas, experienced an increase in cobalt usage. The largest declines occurred in tool steel (47%), other alloys (41%), and superalloys (33%).

Apparent industrial demand, calculated from net imports, secondary production, and change in industry and Government stocks, decreased to 12.5 million pounds, about 27% less than that of 1980. Industrial demand declined for the third consecutive year.

Of the forms of cobalt used by domestic consumers, 64% was as metal, 21% as salts and driers, 8% as purchased scrap, 5% as oxide, and 2% in other forms. Scrap consumption decreased for the first time since 1976. Consumer stocks of cobalt were held at a relatively low level throughout the year owing to high interest rates and greater availability than in 1979 and 1980.

Table 2.—Cobalt products[1] produced and shipped by refiners and processors in the United States

(Thousand pounds)

	1980				1981			
	Production		Shipments		Production		Shipments	
	Gross weight	Cobalt content	Gross weight	Cobalt content	Gross weight	Cobalt content	Gross weight	Cobalt content
Metal	1,000	1,000	NA	NA	893	893	NA	NA
Hydrate (hydroxide)	NA	220	NA	392	NA	416	NA	413
Salts[2] (inorganic compounds)	NA	1,092	NA	1,062	NA	958	NA	891
Driers (organic compounds)	NA	962	NA	1,021	NA	1,035	NA	1,117
Total	1,000	3,274	NA	2,475	893	3,302	NA	2,421

NA Not available.
[1]Figures on oxide withheld to avoid disclosing company proprietary data.
[2]Various salts combined to avoid disclosing company proprietary data.

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

(Thousand pounds of contained cobalt)

End use	Quantity 1980	Quantity 1981
Steel:		
Stainless and heat-resisting	47	35
Full-alloy	116	141
High-strength, low-alloy	W	W
Tool	321	170
Superalloys	6,285	4,195
Alloys (excludes alloy steels and superalloys):		
Cutting and wear-resistant materials[1]	1,344	1,076
Welding materials (structural and hard-facing)	620	488
Magnetic alloys	2,267	1,687
Nonferrous alloys	150	131
Other alloys	210	123
Mill products made from metal powder	W	W
Chemical and ceramic uses:		
Pigments	282	329
Catalysts	1,656	1,279
Ground coat frit	482	441
Glass decolorizer	40	40
Drier in paints or related usage	1,331	1,378
Feed or nutritive additive	75	58
Miscellaneous and unspecified	95	109
Total	15,321	11,680

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	1977	1978	1979	1980	1981
Metal	11,547	12,823	12,006	10,825	7,450
Oxide	426	467	704	441	557
Purchased scrap	507	1,036	1,170	1,183	972
Salts and driers	3,778	5,399	[1]3,254	[1]2,475	[1]2,421
Other	319	269	268	397	280
Total	16,577	19,994	17,402	15,321	11,680

[1]Chemical compounds (organic and inorganic) other than oxide.

PRICES

The listed producer price of cobalt declined on three occasions in 1981 in response to a weak market. The $25 per pound price, which had been in effect since February 1, 1979, was lowered to $20 per pound effective March 2. Zaire's state-owned marketing organization, SOZACOM, took the lead in lowering the price. Other major producers followed suit. The price cut was forced by the minimal demand conditions, a buildup of producer inventories, and an effort by producers to counteract price discounting and substitution. The price was further adjusted downward on August 3 to $17.66 per pound. The change was attributed to a strengthening of the U.S. dollar with respect to the Belgian franc. Zambia adjusted its price to $17.50 at that time. Another downward shift occurred September 1, when the price was lowered to $17.26 per pound. The producer price remained at that level through yearend. Although spot prices for cobalt began the year above $20 per pound, there was a progressive erosion in dealer prices throughout the year, reaching as low as $9.50 per pound during the fall. Because Zaire did not respond quickly to this dealer market and the discounting that was prevalent, its U.S. market share declined significantly during the year.

FOREIGN TRADE

Exports of unwrought cobalt metal and waste and scrap totaled 2.2 million pounds, gross weight, with an estimated 834,000 pounds cobalt content and a value of $16.5 million. These exports were shipped to 41 countries, with Belgium-Luxembourg, the Federal Republic of Germany, Japan, the Netherlands, France, and Norway receiving the largest quantities. Exports of wrought cobalt metal totaled 632,000 pounds, gross weight, with a value of $12.3 million. Of the 38 countries to which wrought cobalt was shipped, Ireland, Norway, Switzerland, France, Mexico, and Canada were the major recipients.

Total imports of cobalt in 1981 were 15.6 million pounds (contained weight), a decrease of 4.3% compared with those of 1980. The major sources of cobalt imports were Zaire, Canada, Norway, Japan, Zambia, Finland, Belgium-Luxembourg, and Botswana. Material originating in southern Africa, that is imports from Zaire, Zambia, Belgium-Luxembourg (Zairian origin), and Botswana, represented 47% of total cobalt imports during the year, compared with 62% for that area in 1980.

Table 5.—U.S. imports for consumption of cobalt, by country

(Thousand pounds and thousand dollars)

Country	Metal[1]				Oxide				Other forms[2]				Total content[3]	
	1980		1981		1980		1981		1980		1981			
	Gross weight	Value	Gross weight	Value	Gross weight	Value	Gross weight	Value	Cobalt content	Value	Cobalt content	Value	1980	1981
Australia	2	18	(4)	9	9	119	31	381	105	[5]1,575	60	[5]713	114	83
Belgium-Luxembourg	940	27,598	818	17,199	282	5,391	115	1,628	110	2,420	36	629	1,259	939
Botswana	--	--	--	--	--	--	--	--	397	[5]5,955	633	[5]7,495	397	633
Canada	1,045	24,743	1,712	26,703	107	1,879	143	1,971	4	48	28	332	1,128	1,846
Finland	1,090	27,718	1,206	24,099	--	--	--	--	--	--	--	--	1,090	1,206
France	419	9,271	367	5,112	--	--	--	--	(4)	14	(4)	1	419	367
Germany, Federal Republic of	140	2,453	175	2,765	1	28	1	16	1	57	38	972	141	213
Japan	1,243	27,221	1,624	30,729	12	205	--	--	17	185	(4)	(4)	1,269	1,624
Netherlands	113	1,842	59	654	--	--	--	--	(4)	7	5	49	113	64
New Caledonia	--	--	--	--	--	--	--	--	141	[5]2,115	87	[5]1,030	141	87
Norway	1,165	29,299	1,631	28,796	--	--	--	--	--	--	--	--	1,165	1,631
South Africa, Republic of	78	1,872	15	240	--	--	--	--	224	[5]3,214	449	[5]4,966	302	464
United Kingdom	206	4,020	488	6,528	(4)	1	150	1,362	1	55	(4)	9	207	599
Zaire	6,238	147,279	4,176	66,726	--	--	--	--	--	--	--	--	6,238	4,176
Zambia	2,225	54,311	1,513	27,138	--	--	--	--	3	9	--	--	2,228	1,513
Other	88	938	121	2,123	3	8	4	18	1	23	25	423	91	149
Total[6]	14,992	358,583	13,906	238,820	414	7,630	444	5,375	1,004	15,677	1,361	16,619	16,302	15,594

[1]Includes unwrought metal and waste and scrap.
[2]Contained cobalt in nickel-copper and nickel matte from Australia, Botswana, New Caledonia, and the Republic of South Africa. Salts and compounds were imported from the remaining countries.
[3]Estimated contained cobalt.
[4]Less than 1/2 unit.
[5]Based on weighted average cobalt metal price of $25.00 per pound for 1980 and $19.73 per pound for 1981, multiplied by 0.6 (estimated factor for matte) for imports from Australia, Botswana, New Caledonia, and the Republic of South Africa.
[6]Data may not add to totals shown because of independent rounding.

Table 6.—U.S. imports for consumption of cobalt, by class

(Thousand pounds and thousand dollars)

Class	1979	1980	1981
Metal:[1]			
Gross weight	18,887	14,992	13,906
Cobalt content[e]	18,887	14,992	13,906
Value	$462,250	$358,583	$238,820
Oxide:			
Gross weight	505	414	444
Cobalt content[e]	373	306	329
Value	$9,429	$7,630	$5,375
Salts and compounds:			
Gross weight	370	655	1,249
Cobalt content[e]	111	197	375
Value	$2,192	$3,572	$4,969
Other forms:[2]	627	807	984
Value	$9,249	$12,105	$11,650
Total content	19,998	16,302	15,594

[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, 1982	Most favored nation (MFN) Jan. 1, 1987	Non-MFN Jan. 1, 1982
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	5.6% ad valorem	4.2% ad valorem	30% ad valorem.

WORLD REVIEW

International.—An official of SOZACOM announced in November that the cobalt producers had decided to establish a Cobalt Development Institute. The announcement was made during the inaugural session of a Brussels, Belgium, conference on "Cobalt—Metallurgy and Uses." Refiners, distributors, and consumers of cobalt were also invited to join the Institute, which was to be operative beginning January 1, 1982. Its purpose was to assist those companies and individuals needing technical information. The Institute would also undertake various promotional activities to support and develop the use of cobalt and its alloys. The provisional location of the Cobalt Development Institute was 3 Rue Ravenstein, 1000 Brussels, Belgium. A general meeting of the founding member countries was scheduled for March 4, 1982, when the organization was to be officially launched. Member companies included La Générale des Carrières et des Mines (GÉCAMINES) of Zaire; Nchanga Consolidated Copper Mines Ltd. and Roan Consolidated Mines Ltd., both of Zambia; Outokumpu Oy of Finland; Sumitomo Metals Mining Co., Ltd., and Nippon Mining Co., Ltd., both of Japan; Metaux S.A. of France; and Compagnie de Tifnout Tiranimine of Morocco. Inco, Ltd., and Falconbridge Nickel Mines, Ltd., both of Canada, also requested to join the organization at yearend.

The 10th session of the Third United Nations Conference on the Law of the Sea was concluded in Geneva in August. No final treaty was developed, partly because the U.S. position with respect to the treaty was under review.

Australia.—Work was underway at the Greenvale nickel laterite mine, jointly owned by Metals Exploration Pty. and Freeport Queensland Nickel Pty., Ltd., to convert the power source for the boilers and dryers from oil to coal. By yearend, the dryers were expected to be converted, and work on the boilers was expected to be completed by mid-1982.

A possible cobalt find was reported early in the year. Known as the Gunsight prospect, grades assayed 0.26% cobalt in one drillhole, with one pocket up to 0.86% cobalt. Drilling was expected to take about 1 year to complete. The prospect was owned by North Flinders Mines, Ltd., and Marathon Petroleum of Australia, Ltd.

Botswana.—Sinking of the third shaft at the Botswana RST Ltd. Pikwe copper-nickel-cobalt mine was completed early in the year to a depth of 3,163 feet. The shaft was equipped with 10 full stations spaced 197 feet apart. Total ore production at the Selebi-Pikwe complex normally totals about 220,000 short tons of ore per month, about 70% of which comes from the Pikwe Mine. According to an interim report of Botswana RST Ltd., AMAX Nickel Inc. made a request to BCL Ltd., which operates the Selebi-Pikwe Mines, to reduce contracted matte sales to AMAX by about 25% to about 33,000 tons annually. By yearend, no decision had been made on the request.

Burundi.—The Government of Burundi received a $4 million line of credit from the International Development Association of the World Bank to explore for nickel-cobalt resources. Additional holes were to be drilled in the Musongati area to determine the nickel content. United Nations exploration in 1973-74 and 1976-77 indicated resources of 80 million tons of dry ore grading 1.6% nickel and 0.1% cobalt. Studies were also to be carried out on the quality and availability of local peat to determine its suitability for use as a fuel should a processing facility be built there. A search was to be made for sulfide minerals. Aside from the question of power supply, the difficulty of transport in and out of the remote, land-locked country was a major consideration.

Canada.—Construction of the electrolytic cobalt plant of Inco, Ltd., at Port Colborne, Ontario, continued, with completion expected by early 1983. Capacity of the plant was to be about 2 million pounds of cobalt per year. In addition, Inco announced late in the year the development of a new open pit mine at Thompson to replace its existing open pit mine there. About $72 million was to be spent on the first phase of mine development, with new production targeted for 1984. A strike at Thompson began September 16 and lasted until yearend.

Indonesia.—No new developments took place on the P.T. Pacific Nikkel Indonesia (PTPNI) project on Gag Island because of an inability to obtain financing. The nickel-cobalt laterite deposit was estimated to contain 160 million tons of ore grading about 1.64% nickel and 0.12% cobalt. Extensive engineering and financial studies have been made on the project, and plans call for the annual production of 57,500 tons of nickel and 550 tons of cobalt during the initial 10-year period. Equity in PTPNI is held by United States Steel Corp., Amoco Minerals, Inc., and IJmuiden Hoogovens, BV, of the Netherlands. The Indonesian Government has an option of 20% participation.

Morocco.—A United States-Moroccan Mining Colloquium was held in Rabat, March 9-11. One of the topics of discussion was the Bou Azzer cobalt mining district. The meeting provided an opportunity for exchange of information on investment potential and conditions under which investment is possible in Morocco. Also discussed were recent technological breakthroughs, especially in fields of pollution control, energy efficiency, and usage of scarce water resources in the beneficiation process. About 39 representatives of U.S. private sector mining concerns attended.

Norway.—A fire at Falconbridge Nikkelverk's nickel-cobalt refinery on October 28 had virtually no effect on cobalt production. The fire occurred in the matte leach plant.

Philippines.—Marinduque Mining and Industrial Corp. planned to build a 1,200-ton-per-year, $20 million cobalt refinery by late 1983. At yearend, Marinduque was attempting to renegotiate a 10-year smelting contract with Sumitomo Mining Co. that still had about 7 years remaining before expiration.

South Africa, Republic of.—Matthey Rustenburg Refiners, Ltd. (MRR), opened a 21,000-ton-per-year nickel refinery on October 13. At capacity, about 12,000 tons per year of copper and 2,800 tons per year of cobalt sulfate could also be produced. Previously, a large portion of the MRR production was shipped in matte form to the Port Nickel, La., facility of AMAX, Inc., for refining. The nickel feedstock for the new plant is a byproduct of the MRR platinum mining. Sherritt Gordon Mines, Ltd., of Canada, provided technical services.

Western Platinum Mines, Ltd., which mined for platinum-group metals from the Merensky Reef, produced copper, nickel, and cobalt in matte form for shipment to the Kristiansand, Norway, refinery of Falconbridge Mines, Ltd.

Uganda.—The Government of Uganda negotiated a $394,000 loan at midyear from the European Investment Bank for a feasibility study for reopening the Kilembe copper-cobalt mine in western Uganda. The study would include possible rehabilitation of the copper smelter at Jinja and construction of a cobalt plant. About 28 million pounds of cobalt is estimated to be contained in copper tailings, with an average grade of 1.4% cobalt, at Kisese, near Kilembe. Falconbridge Nickel Mines had held discussions with Uganda regarding possible processing of the tailings, but Falconbridge decided early in the year that the operation was not feasible at prevailing prices.

United Kingdom.—Construction of a new nickel-cobalt facility in North Wales was begun in September. High-purity nickel and cobalt and their salts were to be recovered from superalloy grindings. The refinery was to be operated by Chapman Metallurgical, Ltd., and be in production by mid-1982. Superalloy scrap would be processed to nickel and cobalt suitable for reuse in the aerospace industry. Capacity of the plant, expected to be reached by 1983, would be about 1,000 tons per year of nickel plus cobalt.

Zaire.—The state-controlled mining company GÉCAMINES reduced cobalt output in the second half of 1981 in response to very weak demand. Total production for the year was 14,330 tons of cobalt, a decline of 12% from that of 1980.

Work continued on the Inga-Shaba power transmission line. Construction was expected to be completed in 1983. The expansion program of the smelter and refinery complex at Kolwezi remained uncompleted, however, as available capital was diverted to other requirements. Zaire had a debt of $6 billion to service. Maintenance and repair of existing facilities remained major problems. Additional power requirements for this expansion were to be met by the Inga-Shaba powerline. The Tenke-Fungurume project, which was halted in 1975-76, depended on completion of the Inga-Shaba powerline. The Société Minière de Tenke-Fungurume consortium, led by the French Government agency Compagnie Générale de Matières Nucleaires (26.5%), considered reviving the project on a smaller scale than originally planned (from 6,500 to 2,200 tons per year of cobalt). Other participants included Anglo American, Ltd., and Charter Consolidated, Ltd., (28%); Mitsui (14%); and the French Bureau de Recherches Géologiques et Minières (85%).

Zambia.—Zambia's two major copper and cobalt producers, Roan Consolidated Mines, Ltd., and Nchanga Consolidated Copper Mines Ltd. (NCCM) were to be merged into one new company to be called Zambian Consolidated Copper Mines Ltd., according to an announcement by company officials. The company would still be controlled by the Zambian Government. In 1981, total production of both companies was 3,640 tons. Wildcat strikes affected operations in Zambia in January and July. Both were relatively brief.

About 10,000 expatriate workers at the two divisions of NCCM went on strike July 7 to protest a company decision to stop emergency supplies of cornmeal to the workers. The strike was not supported by the mineworkers' union. This strike ended July 14. Several days later, the Zambian workers struck, seeking pay equal to that of expatriate workers, whom they outnumber 8 to 1. This strike was also relatively brief.

Construction of a roast-leach-electrowinning cobalt plant at Rokana by NCCM proceeded as planned and was expected to be completed early in 1982. Modification and rehabilitation of the Rokana concentrator significantly improved cobalt recovery. More cobalt concentrate was produced than could be processed. The processed material was stockpiled pending completion of the new Rokana refining plant. Cobalt ore was expected to be mined in the future from Rokana, Konkola, and both the underground and open pit sections of the Chingola Mine. At Chambishi, a vacuum refining furnace was being installed. Cobalt from this furnace was expected to be suitable for use in superalloy production.

Table 8.—Cobalt: World production, by country[1]

(Short tons)

Country	Mine output, metal content[2]				Metal[3]			
	1978	1979	1980[p]	1981[e]	1978	1979	1980[p]	1981[e]
Australia[e] [4]	[r]1,490	1,650	1,760	1,760	--	--	--	--
Botswana	288	324	249	275	--	--	--	--
Canada[5]	1,360	1,808	1,767	2,500	572	524	518	700
Cuba[e]	[r]1,610	1,360	1,790	1,970	--	--	--	--
Finland	[r]1,336	1,174	1,141	[6]1,140	1,016	1,281	1,269	[6]1,355
France	--	--	--	--	998	850	1,139	1,100
Germany, Federal Republic of	--	--	--	--	386	424	440	440
Japan	--	--	--	--	2,055	2,924	3,160	[6]2,669
Morocco	1,250	1,059	924	829	--	--	--	--
New Caledonia[e] [7]	170	230	200	155	--	--	--	--
Norway	--	--	--	--	575	1,051	1,405	1,592
Philippines	1,313	1,510	1,467	1,200	--	--	--	--
U.S.S.R.[e]	2,150	2,200	2,370	2,480	[r]3,910	3,970	4,020	4,130
United Kingdom[e] [8]	--	--	--	--	720	375	800	800
United States	--	--	--	--	322	464	500	[6]447
Zaire	[e]14,660	[e]16,530	17,090	17,090	14,468	15,543	16,200	14,330
Zambia	[r]4,124	4,718	4,850	4,960	2,274	3,501	3,649	3,640
Zimbabwe	[e]20	[e]230	[e]130	90	19	225	127	75
Total	[r]29,771	32,793	33,738	34,449	[r]27,315	31,132	33,227	31,278

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

[1]Table includes data available through June 10, 1982.

[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 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 Cuba. Belgium has imported small quantities of partly processed materials containing cobalt but available information is inadequate for reliable estimates of cobalt recovery from these materials.

[4]Data series on mine output represents an estimate of actual recovery. Australia does not report any production of metallic cobalt, but produces intermediate metallurgical products (cobalt oxide and nickel-cobalt sulfide) with cobalt content as follows, in short tons: 1977—916 (revised); 1978—1,286; 1979—1,745; 1980—not available; and 1981—not available.

[5]Actual output is not reported. Data for mine output are total cobalt content of all products derived from ores of Canadian origin, including cobalt oxide shipped to the United Kingdom for further processing, and nickel-copper-cobalt matte shipped to Norway for further processing. Data presented for metal output represent the output within Canada of metallic cobalt from ores of both Canadian and non-Canadian origin.

[6]Reported figure.

[7]Series reflect estimated actual recovery from ores and intermediate metallurgical products exported from New Caledonia to Japan, France, and the United States. The estimated content of total ores mined is as follows, in short tons: 1977—3,447 (revised); 1978—1,982 (revised); 1979—2,446 (revised); 1980—2,468 (revised); and 1981—2,200.

[8]Estimated recovery of elemental cobalt in refined cobalt oxides and salts from intermediate metallurgical products originating in Canada.

TECHNOLOGY

Bureau of Mines researchers continued testing a process for recovery of nickel, copper, and cobalt from Duluth Gabbro resources in northern Minnesota. The work was conducted at the Twin Cities Research Center, Twin Cities, Minn. Also, a report on the extraction of metals from Pacific seabed nodules was published.[2] In addition, differential flotation and matte separation techniques to separate the nickel and copper content of their respective fractions were evaluated. The Albany Research Center in Albany, Oreg., continued development of a method to recover nickel, cobalt, and copper from laterites containing less than 1.2% nickel and 0.25% cobalt. Pilot plant testing of the process was carried out by UOP, Inc., in Tucson, Ariz., and a final report was expected in early 1982. Other research in Albany included solvent extraction technology for cobalt separation and substitution of cobalt in cemented carbides. The Rolla (Missouri) Research Center continued its investigations into methods of recovering nickel, cobalt, and copper from mattes and drosses generated during the smelting of lead ore concentrates. Beneficiation procedures for recovering cobalt and nickel from commercial lead, zinc, and copper concentrates by modifying milling procedures, now practiced in the Missouri Lead Belt, were also developed. Other cobalt-related research at Rolla included carbonyl recovery of critical metals and minerals and the creation of intermetallic compounds from superalloy scrap to recover critical metals. In addition, contract studies on recovery of nickel, cobalt, chromium, and other metals from superalloy scrap were completed under the guidance of researchers at the Avondale Research Center, Avondale, Md.[3]

At the Salt Lake City Research Center in Utah, research was conducted to determine the best methods for recovery of cobalt from concentrates that would be produced from the Blackbird district of Idaho. Other work at the Salt Lake City Center included thermodynamics and kinetics of cobalt reactions, separation and recovery of cobalt from hydrometallurgy solutions by ion exchange, and critical-metals recovery from grinding wastes.

Teledyne Vasco, Inc., of Latrobe, Pa., began marketing a new high-strength nickel maraging steel developed by Inco Research and Development Center, Inc. The new cobalt-free alloy contained less molybdenum than the conventional 250-grade maraging steel. Cobalt was replaced with titanium, but constituted a lower percentage of the alloy composition. Nickel content was about 18%. Maraging steel is used for working various metals and for high-strength components such as gun recoil springs, trunnion pins in aircraft, and drive shafts.[4]

DOC conducted workshops in February and June in partial compliance with the Materials and Minerals Policy, Research and Development Act of 1980, Public Law 96-479. A report was issued containing contributions by industry at the workshop, which dealt with critical-materials needs in the aerospace industry. Cobalt and other critical metals were extensively discussed.[5]

Research and development of substitutes for cobalt continued. New alloys were introduced in hard-facing, magnetic materials, and superalloys. These alloy substitutes would reduce but not eliminate, in most cases, quantities of cobalt consumed.[6]

Ion implantation, in which the ion of one element, such as cobalt, is implanted on the surface of another, was studied as a possible means of conserving cobalt.[7] Other techniques that contributed to cobalt conservation included rapid solidification rate, single-crystal growth, directional solidification, and hot isostatic pressing.

The use of ceramics and composite materials as possible substitutes for superalloys also received some attention. In particular, silicon carbide and silicon nitride, because of their strength, light weight, and low cost, were considered. Development projects for use of ceramics in automobile, truck, and aircraft gas turbine engines received Government funding. In aircraft engines, the problem of brittleness was a major obstacle to ceramics' use. It was for this reason that many experts on ceramics in this application felt its use was unlikely prior to 1990.[8] With the drive both to reduce consumption of strategic and critical materials and increase operating temperatures of gas turbines, thereby increasing fuel efficiency, it is possible that this substitute will be used sooner than generally predicted.

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[1]Physical scientist, Division of Ferrous Metals.

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[3]DeBarbadillo, J. J., J. K. Pargeter, and H. V. Makar. Process for Recovering Chromium and Other Metals From Superalloy Scrap. BuMines RI 8570, 1981, 73 pp.

[4]American Metal Market. New Nickel Maraging Steel Marketed by Teledyne Vasco. V. 89, No. 207, Oct. 26, 1981, p. 35.

[5]U.S. Department of Commerce. Proceedings, U.S. Dept. of Commerce Public Workshop On Critical Materials Needs in the Aerospace Industry. NBSIR 81-2305, Feb. 9-10, 1981, 650 pp.

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Columbium and Tantalum

By Thomas S. Jones[1] and Larry D. Cunningham[1]

A relatively insignificant quantity of columbium- and tantalum-bearing concentrates was produced domestically, and the United States continued to be dependent on imports. New developments, such as a new pyrochlore concentration plant in Brazil and upgraded milling operations in Canada and Australia, favored greater availability of both columbium and tantalum in the future. To help ensure future availability of tantalum to the United States, a contract for purchase of tantalum materials for the National Defense Stockpile was signed by the General Services Administration (GSA), the first such acquisition contract in over 20 years.

Consumption of columbium as ferrocolumbium and nickel columbium was down slightly from that of the previous year. Gains made in the steelmaking industry, where consumption for the first time exceeded 5 million pounds, were more than offset by significant declines in superalloys. Demand for tantalum materials dropped; shipments of tantalum as powder and anodes and as mill products experienced large declines. Processor consumption of tantalum in raw materials was down by about one-third.

Tantalum prices receded from their 1980 peaks, those for tantalite concentrates dropping the most. Prices for the higher purity forms of columbium also continued the decline begun in 1980.

Foreign trade declined. Imports for consumption of mineral concentrates decreased by over one-half for columbium and by over one-fifth for tantalum. Exports of tantalum metal were less than one-half as great as those of 1980.

Table 1.—Salient columbium statistics

(Thousand pounds of columbium content unless otherwise specified)

	1977	1978	1979	1980	1981
United States:					
Mine production of columbium-tantalum concentrates	--	--	--	(1)	(1)
Releases from Government excesses	--	[2]1	--	--	--
Consumption of raw materials	2,427	2,673	2,402	3,122	1,983
Production of primary products:					
Columbium metal	W	W	W	W	W
Ferrocolumbium	1,455	1,566	969	2,028	1,145
Consumption of primary products: Ferrocolumbium and nickel columbium	4,389	5,694	6,337	6,503	6,244
Exports: Columbium metal, compounds, and alloys (gross weight)	75	[e]95	[e]100	[e]120	[e]150
Imports for consumption:					
Mineral concentrate	1,551	1,982	1,690	2,320	1,050
Columbium metal and columbium-bearing alloys	2	(3)	[e]4	73	(3)
Ferrocolumbium[e]	2,676	4,159	5,515	5,918	6,068
Tin slags[4]	880	[5]436	[5]1,133	[5]1,417	NA
World: Production of columbium-tantalum concentrates	[r]19,406	[r]21,311	31,718	[p]33,165	[e]34,779

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available. W Withheld to avoid disclosing company proprietary data.

[1]A small unreported quantity was produced.

[2]Net change in inventory report.

[3]Less than 1/2 unit.

[4]Receipts reported by consumers; includes synthetic concentrates and other miscellaneous materials.

[5]After deduction of reshipments.

Table 2.—Salient tantalum statistics

(Thousand pounds of tantalum content unless otherwise specified)

	1977	1978	1979	1980	1981
United States:					
Mine production of columbium-tantalum concentrates	--	--	--	(1)	(1)
Releases from Government excesses	r 2 4	2 1	--	--	--
Consumption of raw materials	1,448	1,571	1,740	1,863	1,269
Production of primary metal	678	974	NA	NA	NA
Consumption of primary products: Tantalum metal	732	978	NA	NA	NA
Exports:					
Tantalum ore and concentrate (gross weight)	118	64	3 329	3 468	3 99
Tantalum metal, compounds, and alloys (gross weight)	470	686	426	524	205
Tantalum and tantalum alloy powder (gross weight)	234	211	296	251	97
Imports for consumption:					
Mineral concentrate	657	596	630	860	650
Tantalum metal and tantalum-bearing alloys	126	137	144	140	4 32
Tin slags[5]	1,275	6 676	6 1,140	6 1,327	NA
World: Production of columbium-tantalum concentrates	901	r 766	1,088	p 1,268	e 1,037

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available.
[1]A small unreported quantity was produced.
[2]Net change in inventory report.
[3]Includes reexports.
[4]Exclusive of waste and scrap.
[5]Receipts reported by consumers; includes synthetic concentrates and other miscellaneous materials.
[6]After deduction of reshipments.

Table 3.—Columbium and tantalum materials in Government inventories as of December 31, 1981

(Thousand pounds of columbium or tantalum content)

Material	Stockpile goals	National Defense Stockpile inventory: Stockpile grade	National Defense Stockpile inventory: Nonstockpile grade	Total
Columbium:				
Concentrates	5,600	911	869	1 1,780
Carbide powder	100	21	--	21
Ferrocolumbium	--	598	333	1 931
Metal	--	45	--	1 45
Total	(2)	1,575	1,202	2,777
Tantalum:				
Minerals	8,400	1,399	1,152	3 2,551
Carbide powder	--	29	--	3 29
Metal	--	201	(4)	3 201
Total	(2)	1,629	1,152	2,781

[1]All surplus ferrocolumbium and columbium metal were used to offset columbium concentrates shortfall. Total offset = 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 = 271,000 pounds.
[4]100 pounds.

Legislation and Government Programs.—U.S. Government inventories of columbium and tantalum materials did not change during 1981. There were neither acquisitions nor any sales of stockpile excesses. However, in March, the President directed the Federal Emergency Management Agency to begin a program of purchasing strategic and critical materials for the National Defense Stockpile, the first such program in over 20 years. Tantalum and columbium were identified as priority materials to be considered for acquisition, and a contract for purchase of tantalum materials was entered into by GSA in December.

This contract called for purchase of tantalum minerals containing 36,630 pounds of Ta_2O_5 (30,000 pounds of Ta) at a price of $1,349,690 ($36.85 per pound of Ta_2O_5, f.o.b. the Hammond, Ind., storage depot). The seller, Norore Corp. of New York City, agreed to make delivery by mid-1982. This followed a solicitation in September for tantalum minerals, Grade 1 material, containing up to 61,050 pounds of Ta_2O_5 (50,000 pounds of Ta). Grade 1 material as defined by a new National Stockpile Purchase Specification P-113a for Tantalum Source Materials, issued in August by the Department of Commerce, requires a minimum Ta_2O_5 content of 25%, a minimum combined Ta_2O_5 plus Cb_2O_5 content of 55%, SnO_2 and TiO_2 contents not exceeding 6% of each, and a maximum Sb content of 0.01%. Necessity for the low antimony limit was questioned by some in the tantalum industry.

DOMESTIC PRODUCTION

In 1981, as in 1980, small quantities of columbium- and tantalum-bearing concentrates were produced in South Dakota; production was from mine operations as well as from existing mine stockpiles. Exploration drilling and sampling for new columbium and/or tantalum deposits continued, primarily in the West.

Domestic production of ferrocolumbium, expressed as contained columbium, was down by over two-fifths. Value of ferrocolumbium produced dropped to an estimated $13 million. The regular grade was favored significantly over the high-purity grade of ferrocolumbium in the production mix.

Tantalum content of raw materials consumed by processors in the production of tantalum compounds and metals was reported to be less than 1.3 million pounds, a significant drop from the 1980 figure. Consumption of purchased metal scrap by processors experienced a slight decline to 95,000 pounds. Recycling of tantalum as carbide scrap increased, but quantities were unmeasured.

Metallurg, Inc., relocated its Refractory Metals, Inc., operation from Houston, Tex., to Newfield, N.J., site of Metallurg's Shieldalloy Corp. facility. Both Metallurg manufacturing operations were consolidated under the Shieldalloy Corp.

Construction of a new hot-rolling mill was started by the Engineered Products Group of Cabot Corp., at Kokomo, Ind. This was to be gradually brought into full operation in 1982. The mill was to be initially devoted to processing superalloys and eventually will process refractory metals such as columbium and tantalum.

Table 4.—Major domestic columbium and tantalum processing and producing companies in 1981

Company	Plant location	Products[1]						
		Metal[2]		Carbide		Oxide and/or salts		FeCb and/or NiCb
		Cb	Ta	Cb	Ta	Cb	Ta	
Cabot Corp.:								
KBI Div	Boyertown, Pa	X	X	--	--	X	X	--
Do	Revere, Pa	--	--	--	--	--	--	X
Kennametal, Inc	Latrobe, Pa	--	X	X	X	--	X	--
Mallinckrodt, Inc	St. Louis, Mo	--	--	--	--	X	X	--
Metallurg, Inc.: Shieldalloy Corp	Newfield, N.J	--	X	X	X	--	--	X
NRC Inc.[3]	Newton, Mass	--	X	--	--	--	--	--
The Pesses Co	Newton Falls, Ohio	--	--	--	--	--	--	X
H. K. Porter Co., Inc.:								
Fansteel, Inc	Muskogee, Okla	X	X	X	X	X	X	--
Do	North Chicago, Ill	--	X	--	--	--	--	--
Reading Alloys, Inc	Robesonia, Pa	--	--	--	--	--	--	X
Teledyne Inc.: Teledyne Wah Chang Albany Div.	Albany, Oreg	X	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 was 6.2 million pounds, a 4% decrease from that of 1980 and a reversal of the upward trend of recent years. The steelmaking industry consumed over 5.3 million pounds of columbium, up by 16%. In addition to an overall increase of 7% in steel production, columbium demand in steelmaking was augmented by increased usage per ton of steel produced. The strongest columbium consumption increase was in carbon steel, higher by 50% and totaling more than 2 million pounds for the first time. Consumption for high-strength, low-alloy (HSLA) steel, which included a small quantity of columbium for full-alloy steel reported separately in previous years, experienced a modest 8% increase. Demand for columbium in stainless and heat-resisting steel declined again, by 28%.

Continued use of columbium in HSLA steel for pipelines was attributed chiefly to the strengthening that it imparts, which results from columbium's grain refining effect. This effect has contributed to development of modern X70 grade linepipe, which has become an important application for columbium.[2] Along with such metallurgical factors as field weldability, cost and availability of the various ferroalloying elements were also noted to require consideration in choosing composition of pipeline steels. Interplay of the various selection factors was outlined for the Alaska Highway Pipeline Project, for which the leading alloying alternates for the X70 grade steels needed to meet specifications were Cb-Mo and Cb-V combinations.[3] The need for lighter and more fuel-efficient vehicles sustained the demand for columbium microalloyed steels for automotive applications. Development of a Cb-P alloy steel was proving attractive for car body components.[4]

In 1981, demand for columbium in superalloys dropped significantly, by 52%; for the first year since 1977, consumption in this use was less than 1 million pounds. That portion used in the form of nickel columbium declined more than 50% to somewhat less than 350,000 pounds. This decreased use of columbium in superalloys was attributed partly to a decline in engine-building programs for the commercial segment of the aircraft market. Among new or potential applications for Inconel 718, containing 5% columbium, were its use in fasteners for graphite-epoxy composite structures in future aircraft, in magnets for the Tokamak fusion reactor under construction at Princeton, N.J., and as pipe-coupling material in deep sour-gas wells.[5]

The Tantalum Producers Association reported a 35% decrease in overall shipments of tantalum, reflecting a sizable decline in tantalum consumption. Major segments of the tantalum market showing declines were powder and anodes at 39% and mill products at 38%. This was the first year since 1975 that tantalum material shipments totaled less than 1 million pounds.

Tantalum capacitor factory sales were 7% lower as reported by the Electronic Industries Association; high tantalum powder prices and continued development of miniature aluminum and ceramic devices shared in the weakening of the tantalum capacitor market. Sprague Electric Co. announced construction of a plant in San Antonio, Tex., for expansion of its solid tantalum capacitor manufacturing capability, with operations to start in late 1982. However, tantalum capacitor production in Scottsdale, Ariz., by the Siemens Corp. was being phased out.

Table 5.—Reported shipments of columbium and tantalum materials

(Pounds of metal content)

Material	1980	1981	Change, percent
Columbium products:			
Compounds, including alloys	1,066,550	632,160	-41
Metal, including worked products	344,700	260,500	-24
Other	18,500	20,500	+11
Total	1,429,750	913,160	-36
Tantalum products:			
Oxides and salts	48,700	50,700	+4
Alloy additive	8,100	--	--
Carbide	125,730	137,160	+9
Powder and anodes	852,900	520,200	-39
Ingot (unworked consolidated metal)	23,000	7,100	-69
Mill products	318,800	196,700	-38
Scrap	130,900	72,700	-44
Other	1,700	--	--
Total	1,509,830	984,560	-35

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]

	1980	1981
END USE		
Steel:		
Carbon	1,552,338	2,322,045
Stainless and heat-resisting	824,904	596,022
Full alloy	r(2)	(2)
High-strength, low-alloy	r2,206,264	2,387,206
Electric	(3)	(3)
Tool	(3)	(3)
Unspecified	6,901	2,176
Total	4,590,407	5,307,449
Superalloys	1,885,935	900,665
Alloys (excluding alloy steels and superalloys)	21,599	29,465
Miscellaneous and unspecified	5,142	6,358
Total consumption	6,503,083	6,243,937
STOCKS		
December 31:		
Consumer	W	W
Producer[4]	W	W
Total stocks	1,964,000	1,868,000

rRevised. W Withheld to avoid disclosing company proprietary data.
[1]Includes columbium and tantalum in ferrotantalum-columbium, if any.
[2]Small; included with high-strength, low-alloy steel.
[3]Withheld to avoid disclosing company proprietary data; included with "Steel: Unspecified."
[4]Ferrocolumbium only.

Contrary to overall trends for tantalum products, shipments of tantalum for cemented carbides experienced a moderate 9% increase over those in 1980. Based on the high-melting-point properties needed in hotter running, more-fuel-efficient turbine engines, consumption in superalloys appeared to have potential as a fast-growing end use for tantalum. Consumption in capacitor and carbide cutting tools seemed likely to continue as large uses for tantalum.

Data on aggregate stocks of columbium and tantalum raw materials reported by processors for 1981 were incomplete at the time this chapter was prepared. Aggregate stocks of columbium and tantalum raw materials reported by processors for yearend 1980 contained 4,812,000 pounds of columbium and 3,261,000 pounds of tantalum, both up from those of yearend 1979.

PRICES

Prices were stable for pyrochlore concentrates and columbium products based on them. A price for Brazilian concentrates was no longer available because they were not being exported. The price of pyrochlore concentrates produced in Canada by Niobec Inc. was quoted throughout 1981 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. The spot price of regular-grade ferrocolumbium containing 63% to 68% columbium was also unchanged at $6.22 to $6.35 per pound of contained columbium, f.o.b. shipping point.

Prices continued to decline for high-purity ferrocolumbium, nickel columbium, columbium metal, columbite concentrates, and columbium oxide. The price of high-purity ferrocolumbium was reduced three times, dropping overall by about one-fifth from $30.15 to $30.90 per pound of contained columbium as of January 1 to $24.80 in the fourth quarter. Contributing to this decrease were price slides for columbite concentrates, quoted at $9 to $11 in January and $8 to $10 in December per pound of combined pentoxides, c.i.f. U.S. ports, and for both domestic and foreign columbium oxide, reported to be selling by midyear for less than $8 per pound of oxide.

Tantalum price trends were all downward. The most pronounced decrease was for tantalite concentrates. In the spot market, where trading volume was reportedly light, the tantalite price fell by about two-thirds, ending at $35 to $40, after starting at $103 to $108 per pound of combined tantalum and columbium pentoxides, 60% basis, c.i.f. U.S. ports. Contract prices also declined by about one-sixth for Canadian (Tantalum Mining Corp. of Canada Ltd.) tantalite, which went from $102.50 to $85 per pound of contained pentoxide. For about one-half of 1981, a contract price was in effect for tantalite from Australia (Greenbushes Tin N.L.), a producer price of $101 per pound of contained tantalum pentoxide having been initiated in May. Market conditions were such that this was lowered to $88 in July and then withdrawn altogether late in the year. Published price quotations for tantalum mill products and powder decreased by about one-fifth, so that prices were about $200 per pound at yearend.

FOREIGN TRADE

Net trade was at a deficit for both columbium and tantalum, with the value of imports of raw materials and such intermediates as ferrocolumbium substantially exceeding the value of net exports of upgraded forms of columbium and tantalum. Volume and value of trade in both columbium and tantalum were down appreciably for nearly all items.

In 1981, exports and reexports of tantalum ores and concentrates declined approximately 80% to 99,000 pounds at a value of $1.7 million. As in 1980, the Federal Republic of Germany was the principal recipient. Exports of ferrocolumbium and nickel columbium, mostly ferrocolumbium, were reported by the Office of Export Administration to have exceeded 90,000 pounds in 1981 and to have all gone to the Federal Republic of Germany.

Table 7.—U.S. foreign trade in columbium and tantalum metal and alloys, by class

(Thousand pounds, gross weight, and thousand dollars)

Class	1980 Quantity	1980 Value	1981 Quantity	1981 Value	Principal destinations and sources, 1981
EXPORTS[1]					
Tantalum:					
Powder	251	39,880	97	19,999	Japan 28, $5,978; France 28, $5,804; Federal Republic of Germany 19, $3,900; United Kingdom 12, $2,298.
Unwrought, and waste and scrap	399	31,539	164	12,454	Federal Republic of Germany 83, $5,390; Belgium-Luxembourg 35, $2,820.
Wrought	125	20,896	41	6,341	United Kingdom 10, $1,870; Japan 11, $1,839; Federal Republic of Germany 7, $1,352.
Total	XX	92,315	XX	38,794	Federal Republic of Germany, $10,600; Japan, $9,100; France, $7,400; United Kingdom, $5,000.[2]
IMPORTS FOR CONSUMPTION					
Columbium:					
Ferrocolumbium[e]	9,104	28,224	9,335	32,570	All from Brazil.
Unwrought metal, and waste and scrap	4	16	1	18	Taiwan [2]1, $10; United Kingdom [2]1, $7.
Unwrought alloys	115	2,561	--	--	
Wrought	(3)	(3)	--	--	
Tantalum:					
Waste and scrap	118	3,924	116	5,954	Mexico 54, $2,880; Japan 12, $745; France 26, $695.
Unwrought metal	68	12,387	31	4,166	Federal Republic of Germany 13, $2,495; Belgium-Luxembourg 17, $1,643.
Unwrought alloys	36	4,703	(3)	40	All from Canada.
Wrought	1	173	(3)	94	Netherlands (3), $61; Austria (3), $13.
Total	XX	51,988	XX	42,842	Brazil, $32,600; Mexico, $2,900; Federal Republic of Germany, $2,700.[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	1980		1981	
	Gross weight	Value	Gross weight	Value
Brazil	1,565	4,127	91	597
Canada	1,446	3,504	926	2,141
China	430	3,053	--	--
Malaysia	91	1,043	78	608
Nigeria	996	8,357	752	6,340
Thailand	64	198	34	417
Uganda	4	7	--	--
Total[1]	4,595	20,289	1,882	10,102

[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	1980		1981	
	Gross weight	Value	Gross weight	Value
Australia	390	18,133	268	9,688
Brazil	580	19,074	540	15,348
Burundi	5	193	--	--
Canada	505	15,011	628	20,146
Cayman Islands[1]	--	--	2	70
China	94	2,843	20	744
Germany, Federal Republic of[1]	302	8,388	4	176
Malaysia	106	1,273	--	--
Mozambique	9	492	--	--
Netherlands[1]	119	3,433	--	--
Rwanda	131	2,875	62	1,204
Singapore[1]	--	--	7	196
South Africa, Republic of	13	497	4	189
Spain	36	1,299	92	2,215
Thailand	81	2,204	157	2,446
Uganda	2	29	--	--
United Kingdom[1]	18	121	--	--
Zaire	112	2,601	127	3,500
Zimbabwe	7	362	42	1,805
Total[2]	2,510	78,829	1,952	57,726

[1]Presumably country of transshipment rather than original source.
[2]Data may not add to totals shown because of independent rounding.

Imports for consumption from Brazil in 1981 included over 9 million pounds of ferrocolumbium, up only slightly from those of 1980. Imports for consumption of columbium oxides from Brazil declined 73% to less than 159,000 pounds at a value of $1.3 million owing to lower demand. Estimated data for both ferrocolumbium and columbium oxide were based on entries in nonspecific classes.

Imports for consumption of columbium-mineral concentrates declined nearly 60%, to the lowest level since 1975. Imports from Brazil were much less than in 1980 because pyrochlore concentrates were no longer being exported as of 1981. The total value of imports for consumption dropped 50%. Imports were estimated to contain 750,000 pounds of columbium and 70,000 pounds of tantalum and to have an average grade of approximately 57% Cb_2O_5 and 5% Ta_2O_5.

Imports for consumption of tantalum-mineral concentrates were down 22%, and average unit value was 6% lower. Imports were estimated to contain 580,000 pounds of tantalum and 300,000 pounds of columbium; average contents of Ta_2O_5 and Cb_2O_5 were 37% and 21%, respectively. Canada was the leading source, providing approximately one-third of both quantity and value.

Data on receipts of raw materials other than mineral concentrates were incomplete.

Imports for consumption of columbium-tantalum synthetic concentrates totaled 3.7 million pounds in 1981 with a value of $76.9 million; these figures are not included elsewhere in this chapter. Approximately 9,000 pounds of potassium tantalum fluoride were imported from China in 1981 at a value of $629,000.

WORLD REVIEW

World production of columbium and tantalum minerals is detailed in table 10; the table does not include tantalum (or columbium) recovered from contemporary or old tin slags or in struverite. Tantalum contained in tin slags produced in 1977, 1978, 1979, and 1980 was, in thousand pounds, 822, 790, 987, and 1,133, respectively, according to data of the Tantalum Producers International Study Center (TIC). No data were available for the U.S.S.R. for either minerals or slag. Exclusive of the U.S.S.R., the TIC data were believed to represent more than 90% of the recoverable tantalum contained in tin slags produced in 1977-80.

Shipments of old tin slags from Thailand rose significantly from 916 short tons in 1979 to 10,387 tons in 1980. Estimated Ta_2O_5 content of these slags was about 5%. Whereas the bulk of old slag shipments in years immediately prior to 1980 had been reported as going to Singapore and Malaysia, about two-fifths of 1980 shipments went each to the Federal Republic of Germany and the Netherlands, with most of the remaining one-fifth going to the United States. Data were not available as to further disposition of any of these shipments.

Australia.—Tin-tantalite mine operations at Greenbushes Tin N.L. were augmented by tailings retreatment at a plant commissioned in March 1981 and by production of a tantalum "glass" (slag) during tin smelting. Operating statistics for fiscal years ending June 30 follow, for 1981 and 1980, respectively: Production of tantalite concentrates, 163 versus 118 tons; Ta_2O_5 content of concentrates produced (nominal 40% Ta_2O_5), 131,000 versus 94,000 pounds; and ore processed, 1.52 (including 0.1 in tailings) versus 1.5 million cubic meters. Additionally produced in fiscal 1981 were 73 tons of tin slags (nominal 20% Ta_2O_5) containing 29,000 pounds of Ta_2O_5. Total Ta_2O_5 output was thus raised to 160,000 pounds, an increase of about 70% compared with output in fiscal 1980. Approximately 10,000 pounds of tantalum oxide and 5,000 pounds of columbium oxide were separated in Greenbushes' pilot solvent extraction plant in fiscal 1981, through processing of a portion of Greenbushes' raw material production.

Greenbushes continued exploration and development work on its underground pegmatite deposit. Resources at this site were placed at 13 million pounds of tantalum, corresponding to a cutoff grade of 0.5% tin equivalent and a Ta_2O_5 grade of 0.06%. Diamond drilling also outlined a sizable lithium resource in a spodumene zone adjacent to tin-tantalum mineralization. Planning and financial negotiations were conducted aimed at establishing a new mine, processing plant, and refinery based on the underground pegmatite. A mine capacity of about 1 million tons of ore having a Ta_2O_5 grade of 0.06% was projected as of 1985. The proposed refinery was incorporated as a Greenbushes subsidiary, Tantalum Refinery Co. Pty. Ltd., and was to be at Kwinana. Conditions in the tantalum market caused planning to be scaled back, however, to a staged development to begin at over 250,000 tons of ore per year. Operations at the existing mine were cut back late in 1981.

Brazil.—Companhia Brasileira de Metalurgia e Mineração (CBMM) brought a new pyrochlore concentration plant onstream late in the year. This plant was rated at 55 million pounds Cb_2O_5 per year, in terms of output of pyrochlore concentrates (nominal 60% Cb_2O_5) from a mine ore feed of over 1.2 million tons (3,500 tons per day). CBMM suspended columbium oxide production for most of the year because of insufficient demand. However, the company moved further into manufacture of columbium in upgraded forms. Products added included grades of columbium oxide pure enough for optical and electronic applications, high-purity ferrocolumbium, and nickel columbium.

Brazil's production and exports of ferrocolumbium both declined for the first time since 1977 to 16,100 tons for production and to 16,000 tons for exports. The decreases, compared with the 1980 quantities, were one-sixth for production but negligible for exports.

Canada.—As reported by Teck Corp., Ltd., for fiscal years ending September 30, production of columbium oxide at the Niobec Inc. mine at St. Honoré, Quebec, increased to 5,960,776 pounds in 1981 from 5,440,159 pounds in 1980. Ore milled (762,838 tons in 1981 versus 657,074 in 1980) also increased, as the mill operated at 95% of its enlarged capacity of 2,300 tons per day. Recovery improved (67% versus 66%) in spite of a fall in Cb_2O_5 grade of ore (0.58% versus 0.63%). Ore reserves were stated as 30% greater, content basis, as of the end of the fiscal year (13,000,000 tons at 0.67% Cb_2O_5 versus 10,347,000 tons at 0.65% Cb_2O_5).

Total production of Ta_2O_5 in concentrates at the Bernic Lake, Manitoba, operation of Tantalum Mining Corp. of Canada Ltd. (Tanco) declined slightly to 297,000 pounds. Mill recovery was raised to around 70% in the latter part of the year by making changes to mill circuitry and operations and by lowering throughput to 800 from 1,000 tons per day. The quantity of tailings reprocessed was up significantly at a recovery of around 50%. In 1981, 152,000 tons of ore at a Ta_2O_5 grade of 0.122% was milled and 55,000 tons of tailings was reprocessed, whereas in 1980 the corresponding statistics were 162,000 tons of ore milled at a Ta_2O_5 grade of 0.136% and 35,000 tons of tailings reprocessed. Mine reserves (stated as proven, probable, and possible) at yearend were reported to have decreased only slightly, from 2.8 to 2.7 million pounds of contained tantalum. Tantalum contained in stored tailings declined to 790,000 pounds.

Exploration and test work at other Canadian properties with potential for columbium and/or tantalum included that by Société Québécoise d'Exploration Minière (SOQUEM) at the Crevier alkaline complex in the Lake St. John area, north of Quebec. A columbium-tantalum-uranium-phosphorus-bearing dike, mineralized with uranpyrochlore and pyrochlore, was found to average 0.2% Cb_2O_5 and 0.02% Ta_2O_5. About the same Cb_2O_5 content was encountered by Nuinsco Resources (formerly New Insco Mines) during additional drilling of the Prairie Lake carbonatite complex near Marathon in northwest Ontario. Columbium was associated with uranium in this uranium-columbium-phosphorus-bearing complex also. Test work at the tantalum-columbium-rare earths property of Highwood Resources Ltd. in the Northwest Territories indicated further beneficiation studies were needed. Fine-grained tantalocolumbite crystals in the deposit were resistant to separation by conventional gravity and magnetic methods.

China.—Tantalum production was estimated by industry sources as 50,000 to 100,000 pounds overall. Tantalum was reportedly mined at Yichun in Jiangxi Province, near Guangzhou in Guangdong Province, and near Urumqi in Xinjiang, all from ores with 0.02% or less Ta_2O_5. Additional tantalum was obtained as a byproduct at Limu, Guangxi Province, where slag from a small tin smelter was chemically processed to produce both tantalum and columbium as oxides.

Nigeria.—Columbite production fell significantly with a combined output of 401 tons in 1981 versus 610 tons in 1980 being reported by the group of Amalgamated Tin Mines of Nigeria Ltd. (ATMN), Bisichi-Jantar (Nigeria) Ltd., Gold and Base Metal Mines of Nigeria, Ltd., and Vectis Tin Mines Ltd. Over 60% of production was by Bisichi-Jantar, with practically all the rest coming from ATMN. ATMN operated at a loss, partly because increases in the minimum wage raised mining costs.

Thailand.—Tantalum's growing contribution to Thailand's mineral economy became increasingly evident, as shown by the prior year's export statistics. In 1980, tantalum-bearing tin slags were second only to tin in value of exports of metals and minerals. The proposal by Thailand Tantalum Industry Corp., Ltd. (TTIC), to set up a plant to upgrade tin slags into intermediate forms of tantalum and columbium, thereby retaining the added value of such processing for Thailand, was still being implemented. The patterns of ore movement and smelting of tin concentrates were altered somewhat when Thai Pioneer Enterprise Co., Ltd. (TPE), started a tin smelter during the first of the year. TPE's output was slow in building toward capacity, partly because its new electric furnace north of Bangkok was competing for concentrates with the much larger, established smelter of Thailand Smelting and Refining Co., Ltd. (Thaisarco), at Phuket.

Zaire.—The Government approved formation of a new consortium, Société Minière de Kivu (SOMIKIVU), to mine and process the pyrochlore ore deposit at Lueshe, Kivu Province, into concentrates. Metallurg, headquartered in New York City, was to have a majority interest in SOMIKIVU, other participants being Société Minière et Industrielle de Kivu (SOMINKI), a producer of tin, tantalite, and other minerals, and the Government. Pending final Government approvals, a pilot treatment plant was to be built in 1982. Initial output of a subsequent production facility which might be built was expected to be several million pounds of columbium oxide per year contained in nominal 60% Cb_2O_5 concentrates.

The Government was encouraging revival of tin mining, which could also enhance production of such accessory commodities as tantalum. Efforts to increase production were underway at several small tin operations, some of which were new, as well as at the two major established producers, SOMINKI and Société Zairetain, S.Z.A.R.L.

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]				
	1977	1978	1979	1980[p]	1981[e]	1977	1978	1979	1980[p]	1981[e]	1977	1978	1979	1980[p]	1981[e]
Argentina:															
Columbite	1	(5)	4	3	3	[6]1	(5 6)	3	2	2	(5 6)	(5 6)	(5 6)	(5)	(5)
Tantalite	(5)	(7)	--	--	--	(5)	(6 7)	--	--	--	(5 6)	(5 6)	(5 6)	(5 6)	(5)
Australia: Columbite-tantalite	346	306	379	351	543	69	61	76	70	98	114	101	125	116	190
Brazil:															
Columbite-tantalite	303	448	825	1,182	1,100	56	83	153	213	231	95	141	260	378	297
Pyrochlore	34,421	[r]39,463	63,733	67,682	70,550	[6]14,436	[r 6]16,574	[6]26,729	28,426	29,631	--	--	--	--	--
Burundi: Columbite-tantalite	[r e]9	--	--	5	4	2	--	--	--	--	2	--	--	--	--
Canada:															
Pyrochlore[e]	9,220	9,087	9,229	8,563	10,018	[6]3,866	[6]3,811	3,876	3,596	4,208	--	--	--	--	--
Tantalite	595	624	783	770	[6]747	17	17	21	21	22	[6]265	[6]278	345	339	224
Malaysia: Columbite-tantalite	99	51	88	73	51	39	13	22	18	8	15	4	7	8	--
Mozambique:															
Columbite[e]	5	5	5	NA	NA	1	1	1	NA	NA	2	2	2	NA	NA
Microlite	88	88	[e]70	NA	NA	4	4	3	NA	NA	48	48	40	NA	NA
Tantalite[e]	80	80	70	NA	NA	13	13	10	NA	NA	33	30	25	NA	NA
Nigeria:															
Columbite	1,898	1,468	1,250	1,221	803	773	646	550	537	353	175	88	75	73	48
Tantalite	2	2	2	2	2	(5)	(5)	(5)	(5)	(5)	2	1	1	1	1
Portugal: Tantalite	7	18	8	9	7	2	4	2	2	2	2	4	2	2	2
Rwanda: Columbite-tantalite	142	107	104	132	125	44	33	35	42	38	30	19	20	24	28
Thailand:															
Columbite	73	141	842	470	440	16	32	191	108	66	13	23	138	179	88
Tantalite	90	--	55	315	300	18	--	18	63	60	24	--	14	82	78
Uganda: Columbite-tantalite[e]	5	5	5	--	--	1	1	1	--	--	1	1	1	--	--
United States: Columbite-tantalite	--	--	--	(8)	(8)	--	--	--	(8)	(8)	--	--	--	(8)	(8)
Zaire: Columbite-tantalite	183	40	71	203	165	41	11	20	57	45	56	9	15	43	46
Zimbabwe: Columbite-tantalite[e]	[r]65	[r]70	65	90	100	[r]7	[r]7	7	10	15	24	[r]17	18	23	35
Total	[r]47,632	[r]52,003	77,588	81,071	84,958	[r]19,406	[r]21,311	31,718	33,165	34,779	901	[r]766	1,088	1,268	1,037

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available.
[1]Excludes columbium and tantalum-bearing tin ores and slags. Table includes data available through June 6, 1982.
[2]In addition to the countries listed, China, Spain, 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 U.S. Bureau of Mines estimates.
[5]Less than 1/2 unit.
[6]Reported in official country sources.
[7]Revised to zero.
[8]A small unreported quantity was produced.

TECHNOLOGY

The possibility of economically coproducing phosphorus during processing of Canadian pyrochlore ore was investigated. Pilot plant tests showed a flotation circuit devised to treat reject carbonate concentrate was capable of producing an apatite concentrate analyzing 34% P_2O_5.[6]

Columbium and its compounds were the subject of a comprehensive review that covered various chemical and metallurgical aspects, including extractive metallurgy.[7] In another review, a number of processes were described for producing columbium and columbium compounds from the kinds of concentrates, both natural and synthetic, that are basically used as tantalum source materials. Specialized processing methods and products were discussed, especially those involving a chloride.[8] Specialized processing was found to be required also in preparing the purest columbium metal for materials characterization. According to the current state of the art, transforming commercially pure metal into the highest purity columbium was achievable by applying a sequential combination of fused salt electrolytic refining (to remove tantalum and tungsten), electron-beam float zone melting (to remove volatile metallic impurities), and ultra-high-vacuum annealing (to remove interstitial impurities).[9]

Contemporary commercial processes for producing tantalum metal and the chief tantalum compounds were described in a review of tantalum's extractive and process metallurgy.[10] Interest in tantalum recovery from tin slags has led to development of a procedure for X-ray fluorescence analysis of such slags for tantalum and columbium. This procedure, based on fusion of a slag sample in a sodium-lithium borate flux, was to be applicable to slags with up to 15% each of Ta_2O_5 and Cb_2O_5.[11]

Columbium additions have been found to improve elevated-temperature performance of ferritic stainless steels, such as are used in vehicle catalytic converters, in both a steel with 18% chromium and another with 12% chromium.[12]

Among advances in electronic applications of columbium and tantalum was development of an improved method of fabricating filamentary columbium-bearing superconductors. Making a starting billet from a "jelly roll" of expanded columbium metal or alloy laminated with an appropriate second metal was claimed to reduce the number of extrusions required and to give a stronger product at higher yield.[13] Comparative laboratory testing of aluminum electrolytic capacitors, developed recently to compete with solid tantalum capacitors, indicated tantalum capacitors were preferable when stability and/or long-term reliability was important.[14]

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Copper

By W. C. Butterman[1]

World consumption of refined copper in 1981 rose 9% to 9.44 million tons.[2] The United States was the leading world producer of mined copper, followed by Chile, the U.S.S.R., Canada, Zambia, Zaire, Peru, Poland, and 50 other countries. Copper prices declined in 1981 as demand slackened. The U.S. producers' price for delivered wirebar averaged $0.89 per pound in January and dropped to $0.80 by December; it averaged $0.85 for the year compared with $1.02 in 1980.

Table 1.—Salient copper statistics

	1977	1978	1979	1980	1981
United States:					
Ore produced ---- thousand metric tons--	235,844	239,247	r277,532	r221,597	277,682
Average yield of copper -----percent--	0.52	0.51	r0.47	r0.48	0.51
Primary (new) copper produced—					
From domestic ores, as reported by—					
Mines ---------- metric tons--	1,364,374	1,357,586	1,443,556	r1,181,116	1,538,160
Value ---------- thousands--	$2,009,297	$1,990,323	r$2,960,675	r$2,666,931	$2,886,440
Smelters ---------- metric tons--	1,265,008	1,269,981	1,313,224	994,479	1,294,962
Percent of world total -------	16	16	16	13	16
Refineries -------- metric tons--	1,280,035	1,327,373	1,411,518	1,121,897	1,430,210
From foreign ores, matte, etc., as reported by refineries ------------do----	77,281	121,684	103,858	88,957	113,807
Total new refined, domestic and foreign ----------do----	1,357,316	1,449,057	1,515,376	1,210,854	1,544,017
Secondary copper recovered from old scrap only ----------------do----	409,928	501,650	604,301	613,458	598,122
Exports: Refined --------------do----	46,745	91,923	73,677	14,489	24,397
Imports for consumption:[1]					
Unmanufactured -----------do----	396,484	531,678	281,584	547,006	429,601
Refined ----------------do----	350,957	402,673	203,855	426,948	330,625
Stocks, Dec. 31: Producers:					
Refined (primary producers) ---do----	212,000	153,000	64,000	49,000	151,000
Blister and materials in solution -do----	314,000	263,000	275,000	272,000	277,000
Total ----------------do----	526,000	416,000	339,000	321,000	428,000
Consumption:					
Refined copper ------------do----	1,982,162	2,189,301	2,158,442	1,862,096	2,025,169
Apparent consumption, primary copper ---------------do----	r1,622,000	r1,819,000	r1,735,000	r1,638,000	1,748,000
Apparent consumption, primary and old copper (old scrap only) ------do----	r2,032,000	r2,321,000	r2,339,000	r2,251,000	2,346,000
Price: Weighted average, cents per pound ---	66.77	66.51	93.33	102.42	85.12
World:					
Production:					
Mine ------- thousand metric tons--	r7,738	r7,618	r7,674	pr7,656	e8,171
Smelter ----------------do----	r8,137	r8,018	r8,046	pr7,939	e8,325
Price: London, average cents per pound ----	59.44	61.88	90.07	99.25	[2]79.35

eEstimated. pPreliminary. rRevised.
[1]Series revised to show imports for consumption rather than general imports.
[2]Based on January-November monthly averages. (See table 32.)

Legislation and Government Programs.—The second of eight annual staged reductions in tariffs negotiated during the Tokyo Round of multilateral trade negotiations went into effect January 1, 1981, and affected 37 classes of unwrought copper, copper scrap, and brass mill products.

DOMESTIC PRODUCTION

Primary Copper.—Domestic mine production rebounded in 1981 from the low 1980 total, which reflected a protracted labor strike. Production at primary smelters from ores, including a small amount of foreign ores, and refinery production derived from ores, also including some foreign ores, both increased in 1981.

Mine Production.—Copper was mined in 14 States in 1981. Arizona accounted for 68% of domestic production, and Arizona, Utah, New Mexico, and Montana together produced 95% of the total.

Surface mines yielded 84% of U.S. primary copper, and underground mines, 16%. Twenty of the top 25 producing mines were surface mines; these, and 3 of the underground mines, were exploiting porphyry deposits. Eighty-three percent of the copper was extracted from ores that had been concentrated by flotation, and another 16% was recovered by leaching of ores and tailings. The remainder came from small amounts of direct-smelting ores and other base metal ores. The average yield of copper ores, except those leached in dumps or in place, was 11 pounds of copper per ton of ore or 0.51%.

The value of byproduct gold and silver, while still important to a number of copper mines, declined in 1981 as prices for these metals dropped sharply. Revenues from gold and silver averaged $1.18 per ton of domestic ore (excluding leached ore) or $0.11 per pound of copper. Revenues from molybdenum, important at some mines, also suffered in 1981, as the molybdenum price averaged nearly one-third lower than that of 1980.

Anaconda Copper Co. suspended production at its Carr Fork Mine in Utah in November but hoped to reopen the mine in about 1 year under improved market conditions and after further development work and reevaluation of the mining method. The mine had been operating at only 40% of capacity before the shutdown. The work schedule at the Berkeley pit in Butte, Mont., was cut to 6 days per week at the end of March to allow the mill to keep pace with mine output; the milling rate had slowed because of harder-than-usual ore. The company commissioned a feasibility study to determine if the Weed concentrator should be enlarged. In June, as part of a 25% reduction in its Butte labor force, Anaconda stopped development work at the Kelley Mine; the work was begun in late 1979 to test the feasibility of block-caving operations. The mine was to be maintained, and the company expected to reevaluate its status when the copper market improved.

ASARCO Incorporated began limited production in the third quarter of 1981 at its new silver-copper mine near Troy, Mont. The mine was expected to yield, when fully operational, about 18,000 tons of copper and 4.2 million ounces of silver per year. Asarco also completed the reinvestment program at its Mission Mine, in Arizona, having modified the molybdenum plant, installed new large-volume ore flotation cells, and replaced the truck fleet with more fuel-efficient, 170-ton trucks. In December, the company closed the Silver Bell Mine, in Arizona, indefinitely, pending improvement in the copper market.

In March, the Chino Mines Div. of Kennecott Minerals Co. became Chino Mines Co., owned two-thirds by Kennecott Minerals and one-third by Mitsubishi Corp. of Japan. The modernization program begun the year before by Kennecott Minerals proceeded in 1981, and at yearend the new concentrator was 7 months from completion. The 3-year program called for the expansion of output by 70%, to 100,000 tons of copper per year.

Cities Service Co., in May, expressed interest in selling its copper-producing properties to obtain capital for investment in petroleum production. The new solvent-extraction electrowinning plant at the Pinto Valley Mine began production of copper from dump leaching in July; its capacity was rated at more than 5,000 tons of copper per year.

Cyprus Mines Corp. continued the expansion of mine and mill facilities at the Bagdad Mine, in Arizona, designed to increase production 30% to 77,000 tons of copper per year by 1982.

Duval Corp. closed its Esperanza, Mineral Park, and Sierrita Mines in mid-December as a consequence of low copper prices, for a period expected to last 3 months.

Inspiration Consolidated Copper Co. announced a 10-year, $150 million program to modernize and increase production at its mill and processing facilities in Arizona.

Kennecott Corp. became a wholly owned subsidiary of Standard Oil Co. of Ohio (Sohio) in June. The Federal Trade Commission, after considering antitrust implications, agreed in principle to the acquisition after British Petroleum Co., the majority stockholder in Sohio, agreed to sell its 6.8% share of AMAX Inc., a competitor of Kennecott Corp. in the nonferrous metals industry. It was reported later in the year that Kennecott Corp. was planning a major renovation of facilities at the Bingham Canyon Mine in Utah that would involve new ore-crushing facilities, transportation of ore by conveyor belts in place of rail haulage, and a new concentrator to replace the three existing concentrators. The company was also reported to be studying a possible renovation and expansion at its Ray Mine in Arizona.

Citing unsatisfactory copper prices, Phelps Dodge Corp. closed its Metcalf Mine at the beginning of the year and moved personnel and equipment to the lower cost Morenci Mine. Production at Morenci was cut 8% in March by shortening the workweek. The company began engineering detail work on a 40-ton-per-day solvent-extraction electrowinning plant at its Tyrone Mine in New Mexico.

At yearend, Quintana Minerals Corp. was ready to start up its new open pit mine at Copper Flat, near Hillsboro, N. Mex., rated at 15,000 tons of ore per day.

Low metal prices, and the consequent need to contain costs, led some companies to halt development work on ore bodies. Magma Copper Co. near yearend scheduled the shutdown of development work on the Kalamazoo deposit adjacent to the San Manuel Mine. AMAX scaled down work on the Minnamax Copper-Nickel Project, near Babbit, Minn., in March, and then halted work in August, closing the test shaft. In September, Asarco suspended development of the deposit adjacent to the Sacaton Pit, near Casa Grande, Ariz.

Exxon Minerals Co. in February suspended plans for a test mine at its Pinos Altos, N. Mex., property. Toward yearend, the company was negotiating the sale of the property. Exxon Minerals continued exploring its large zinc-copper property near Crandon, Wis. Noranda Mining Inc. scaled down metallurgical development work at the Blackbird cobalt-copper mine near Salmon, Idaho. Phelps Dodge slowed development work at its Safford Project in Arizona.

Smelter Production.—Fifteen primary smelters, operating in eight States, produced 1.32 million tons of copper from ores and another 0.06 million tons from secondary material. Forty-three secondary smelters, mainly in the Midwestern and Eastern States, produced 0.49 million tons from scrap.

Asarco announced plans to bring its Hayden, Ariz., smelter into compliance with State and Federal clean air regulations by April 1, 1984; until that date it would operate under an agreement signed with the Environmental Protection Agency (EPA). The present reverberatory furnaces were to be replaced with an Inco Flash Furnace. In recent years air pollution regulations had forced a reduction of throughput at Hayden, as at other smelters equipped with reverberatory furnaces; it was expected that the new technology would increase effective capacity by 35%, returning the smelter to design capacity. Asarco's Tacoma, Wash., smelter continued to operate in 1981 under a variance granted by the Puget Sound Air Pollution Control Agency.

The Hurley, N. Mex., smelter of Chino Mines Co. was granted a Nonferrous Smelter Order by the EPA, which would allow it until January 1, 1983, to achieve compliance with the sulfur dioxide emission limits in the State Implementation Plan. The company was reported to be considering a $100 million modernization of the smelter, involving the replacement of reverberatory furnaces by an Inco Flash Furnace.

Inspiration Consolidated in 1981 worked on a $15 million improvement program at its Miami, Ariz., smelter which would allow closer control of the smelter and acid plant.

The Utah Air Conservation Committee in April approved new sulfur dioxide regulations governing Kennecott Minerals' smelter at Magna.

Phelps Dodge signed an agreement with the EPA in March to bring its Morenci, Ariz., smelter into compliance with emission standards by January 1, 1985, and its Ajo, Ariz., smelter into compliance by December 31, 1985. The company planned to achieve compliance by converting its reverberatory furnaces to oxygen-sprinkle operation using technology marketed by Dravo

Corp. It was reported that the company considered it impractical to bring its Douglas, Ariz., smelter into compliance, and the smelter would probably be closed by the end of 1987 at the latest, barring changes in emissions regulations.

Refinery Production.—Twelve refineries and 10 electrowinning plants produced 2.04 million tons of refined copper, of which 76% was derived from ores and 24% from scrap. Copper Range Co. began construction of a new 55,000-ton-per-year electrolytic refinery at White Pine, Mich., scheduled for completion in late 1982.

Copper Sulfate.—Copper sulfate was produced from electrolytic refinery solutions, blister copper, and secondary metal by seven companies. Production increased 15% in 1981.

Table 2.—Copper sulfate producers in 1981

Company	Plant location
Anaconda Copper Co	Great Falls, Mont.
Chevron Chemical Co	Richmond, Calif.
Cities Service Co	Copperhill, Tenn.
CP Chemicals Inc	Sewaren, N.J.
Madison Industries Inc	Old Bridge, N.J.
Phelps Dodge Corp	Laurel Hill, N.Y., and El Paso, Tex.
Van Waters & Rogers Inc	Wallace, Idaho, and Midvale, Utah.

Byproduct Sulfuric Acid.—Sulfuric acid was produced at 13 copper smelters from the sulfur dioxide contained in offgases. Production, which had been depressed in 1980 because of the prolonged labor strike, rebounded in 1981 to 2.86 million tons.

CONSUMPTION AND USES

Consumption of refined copper increased in 1981. The refinery shapes used most frequently were cathodes and wirebars. About 53% of all copper fabricated went to electrical uses, 20% to building construction, 13% to industrial machinery, 8% to transportation, and 6% to other uses.

The Bureau of the Mint announced plans to replace the traditional copper penny with a new zinc-copper penny consisting of a core of 99.2% zinc and 0.8% copper, plated with solid copper, giving an overall content of 97.6% zinc and 2.4% copper. Copper consumption by the Bureau of the Mint in recent years amounted to less than 2% of annual domestic copper consumption.

The use of copper in solar energy heating systems was expected to grow rapidly in the next several years, but in 1981, consumption for this use was less than 0.5% of total copper consumption.

The replacement of copper in telecommunications trunk lines by fiber optic cables was expected to grow in the decade of the 1980's but not to affect the copper market significantly for several years. The impact of nonmetallic conductors, the so-called synmetals, was estimated to be even more remote, but of eventual importance to the copper market.[3]

STOCKS, PRICES, AND FOREIGN TRADE

Stocks of refined copper increased by nearly one-third in 1981. Stocks at primary smelting and refining plants tripled, and stocks at wire rod mills and brass mills rose sharply, but stocks at Commodity Exchange, Inc. (COMEX), increased only slightly.

The copper price continued through 1981 the long decline that had begun in March 1980. The average was $0.85 per pound, down $0.17 from the 1980 average.

The United States was a net importer of copper in 1981, but imports of unwrought copper declined, and net import reliance, calculated as a percent of apparent consumption, was only 1%. Refined copper comprised most of the imports and came principally from Chile, Canada, Peru, and Zambia.

WORLD REVIEW

After the lengthy labor strike in the United States in 1980, world mine production recovered in 1981. The United States was again the leading producer, followed by Chile, the U.S.S.R., Canada, Zambia, Zaire, Peru, Poland, and 50 other countries. As estimated from data published by the World Bureau of Metal Statistics, world consumption of refined copper remained at 9.3 million tons. Stocks of refined copper in the market economy countries increased 5% to 1.1 million tons, of which 0.3 million tons was in warehouses of COMEX (New York) and of the London Metal Exchange.[4]

Copper produced by member countries of the Council of Copper Exporting Countries in 1981, amounted to 3.07 million tons or 38% of the world total.

A brief review of copper in the leading producing countries follows; more detail can be found in individual country chapters in Volume III of the 1981 Minerals Yearbook.

Canada.—Copper was produced at about three dozen mines at which it was the principal product and at about one dozen mines at which it was an important coproduct. Copper was produced in the 2 Territories and in 7 of the 10 Provinces; British Columbia was the leading producer with 43% of the national total, followed by Ontario with 32%, Quebec with 12%, and Manitoba with 8%. The remaining 5% was produced in the Yukon, New Brunswick, Newfoundland, Saskatchewan, and the Northwest Territories.

Details on the operation of individual mines and on exploration and development activities were published in the Canadian Minerals Yearbook.

Chile.—The Government-owned Corporacíon del Cobre de Chile (CODELCO-Chile) produced more than 85% of the Chilean copper from its four large mines, Chuquicamata, El Teniente, El Salvador, and Andina. Production at El Teniente was affected by a labor strike lasting nearly 2 months. Low copper prices reportedly forced the closure of a great many small and medium copper mines in 1981 with a loss of at least 50,000 tons of copper production. However, exploration and development continued at several important copper deposits in 1981, with several large foreign petroleum and mining companies exploring or investing in Chilean copper properties.

Peru.—Mine production declined as a result of a 7-week strike in the third quarter of 1981 at Southern Peru Copper Corp. (SPCC) operations and two earlier 1-week strikes at SPCC's Toquepala Mine. Ten mines produced about 94% of Peruvian copper in 1981; SPCC's Cuajone and Toquepala Mines together accounted for 70%; and the Cerro Verde Mine of Empresa Minera del Perú (Minero Perú) yielded about 10%. The Cobriza Mine of Empresa Minera del Centro del Perú (Centromin) produced about 8%, and six other mines produced another 6%.

Peru sought to promote the development of its mining industry, which produces nearly half its export earnings, by extensive changes in taxation and reinvestment laws, making private-sector mines more competitive with the Government mining corporations and encouraging the flow of foreign funds needed to develop the country's several large copper porphyry deposits.

Plans to expand the Toquepala Mine from its present capacity of 110,000 tons of copper per year to 145,000 tons per year were delayed when a feasibility study completed in 1981 showed the planned expansion to be uneconomical. Alternative plans were being considered.

Loans covering most of the capital needed to develop the Tintaya deposit in southern Peru were obtained from Canada's Export Development Corp. and a group of Canadian banks.

Poland.—Political unrest and the adoption of a shorter workweek for miners resulted in a 9% drop in Polish copper production in 1981. About 90% of mine output came from the Lubin, Polkowice, and Rudna Mines in southwestern Poland. The remainder was accounted for by the Sieroszowice Mine, currently being developed, and the Konrad Mine.

Zaire.—Copper was produced by the Government-owned La Générale des Carrières et des Mines du Zaire, which produced copper from 10 mines and accounted for nearly two-thirds of the country's export earnings, and by a joint Government-private Japanese company, Société de Développement Industriel et Minière du Zaire.

Zambia.—Copper was produced by the two Government-controlled companies, Nchanga Consolidated Copper Mines Ltd. (NCCM) and Roan Consolidated Mines Ltd. (RCM), each of which operated five mines. NCCM accounted for two-thirds of Zambian copper and RCM for one-third. A merger of the two companies was proposed in 1981, and by yearend, merger terms had been agreed upon and had received Government approval. It was expected that the Zambian Government would hold 60.3% ownership in the merged corporation, which would, through copper exports, account for about 95% of Zambia's export earnings.

TECHNOLOGY

Research and development on the many facets of copper technology continued in 1981; the following is a selection of reported topics: (1) The use of an impact breaker in the San Manuel Mine of Magma Copper Co.;[5] (2) energy consumption in copper production, and energy balances in refining and electrowinning;[6] (3) improvements in nitric-sulfuric acid leaching;[7] (4) the economics of beneficiating copper oxide ores before leaching;[8] (5) cupric chloride leaching of chalcopyrite;[9] (6) a broad-based scheme of temper designations for copper and copper alloys;[10] (7) pickling copper with hydrogen peroxide-sulfuric acid mixtures;[11] (8) electroplating of solderable coatings on copper;[12] and (9) potential substitutes for copper in electrical uses.[13]

The Bureau of Mines published a number of reports dealing with research on various aspects of copper technology[14] and in 1981 was conducting or funding research in the following areas: (1) Evaluation of improved conveyor belt systems for surface mines; (2) roasting technology for copper and zinc concentrates; (3) the use of lasers and microprocessors for controlling the operation of mining equipment; (4) byproduct recovery from leaching low-grade copper ores; and (4) recovery of metals and minerals from copper smelter slags and flue dusts.

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[1]Physical scientist, Division of Nonferrous Metals.
[2]In this chapter, ton means metric ton.
[3]Business Week. The Electric Promise of Synmetals. Apr. 14, 1980, pp. 40E-40F.
[4]World Metal Statistics. V. 35, No. 4, April 1982, 115 pp.
[5]Seaney, H. W. Impact Breakers Improve Productivity. Min. Cong. J., v. 67, No. 4, April 1981, pp. 19-20, 52.
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[12]Rothschild, B. F. Electroplating of Solderable Coatings. Metal Progress, v. 119, No. 7, June 1981, pp. 25-29.
[13]Work cited in footnote 3.
[14]Anable, W. E., J. I. Paige, and D. L. Paulson. Copper Recovery From Primary Smelter Dusts. BuMines RI 8554, 1981, 19 pp.
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Table 3.—Copper produced from domestic ores in the United States

(Thousand metric tons)

Year	Mine	Smelter	Refinery
1977	1,364	1,265	1,280
1978	1,358	1,270	1,327
1979	1,444	1,313	1,412
1980	r1,181	994	1,122
1981	1,538	1,295	1,430

rRevised.

Table 4.—Copper ore and recoverable copper produced in the United States

(Percent)

Year	Open pit		Underground	
	Ore	Copper[1]	Ore	Copper[2]
1977	90	83	10	17
1978	90	85	10	15
1979	r89	84	r11	16
1980	r91	r86	r9	r14
1981	89	84	11	16

rRevised.
[1]Includes copper from dump leaching.
[2]Includes copper from in-place leaching.

Table 5.—Mine production of recoverable copper in the United States, by month

(Metric tons)

Month	1980r	1981
January	125,100	123,244
February	117,596	117,620
March	130,599	127,559
April	128,395	127,251
May	129,853	130,953
June	120,737	127,188
July	49,718	123,726
August	34,287	136,221
September	48,518	134,731
October	76,400	140,771
November	102,520	134,944
December	117,393	113,952
Total	1,181,116	1,538,160

rRevised.

Table 6.—Mine production of recoverable copper in the United States, by State

(Metric tons)

State	1977	1978	1979	1980	1981
Arizona	838,037	891,404	946,002	r770,118	1,040,813
California	200	W	W	W	W
Colorado	1,720	1,191	362	461	W
Idaho	3,676	3,888	3,618	3,103	4,245
Maine	1,213	--	W	--	--
Michigan	38,442	W	W	W	W
Missouri	10,648	10,819	13,021	13,576	8,411
Montana	78,202	67,326	69,854	37,749	62,485
Nevada	60,837	20,453	W	W	W
New Mexico	149,412	127,828	164,281	149,394	154,114
Oregon	5	W	2	--	W
Tennessee	5,613	11,289	W	W	W
Utah	176,111	186,330	193,082	157,775	211,276
Other[1]	259	37,057	53,335	48,941	56,815
Total[2]	1,364,374	1,357,586	1,443,556	r1,181,116	1,538,160

rRevised. W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes South Carolina (1981), Washington (1978, 1979, and 1981), and data indicated by symbol W.
[2]Data may not add to totals shown because of independent rounding.

Table 7.—Twenty-five leading copper-producing mines in the United States in 1981, in order of output

Rank	Mine	County and State	Operator	Source of copper
1	Bingham Canyon	Salt Lake, Utah	Kennecott Minerals Co	Copper ore and copper precipitates.
2	Morenci	Greenlee, Ariz	Phelps Dodge Corp	Do.
3	San Manuel	Pinal, Ariz	Magma Copper Co	Copper ore.
4	Ray	do	Kennecott Minerals Co	Copper ore and copper precipitates.
5	Twin Buttes	Pima, Ariz	Anamax Mining Co	Copper ore.
6	Pinto Valley	Gila, Ariz	Cities Service Co	Copper ore and copper precipitates.
7	Sierrita	Pima, Ariz	Duval Corp	Copper ore.
8	Tyrone	Grant, N. Mex	Phelps Dodge Corp	Copper ore and copper precipitates.
9	Bagdad	Yavapai, Ariz	Cyprus Bagdad Copper Co	Copper ore.
10	Chino	Grant, N. Mex	Chino Mines Co	Copper ore and copper precipitates.
11	Berkeley	Silver Bow, Mont	Anaconda Copper Co	Do.
12	Inspiration	Gila, Ariz	Inspiration Consolidated Copper Co	Do.
13	White Pine	Ontonagon, Mich	Copper Range Co	Copper ore.
14	Eisenhower	Pima, Ariz	Eisenhower Mining Co	Do.
15	Magma	Pinal, Ariz	Magma Copper Co	Do.
16	Pima	Pima, Ariz	Cyprus Pima Mining Co	Do.
17	New Cornelia	do	Phelps Dodge Corp	Do.
18	Mission	do	ASARCO Incorporated	Do.
19	Silver Bell	do	do	Copper ore and copper précipitates.
20	Sacaton	Pinal, Ariz	do	Copper ore.
21	Esperanza	Pima, Ariz	Duval Corp	Copper ore and copper precipitates.
22	Continental	Grant, N. Mex	Sharon Steel Corp	Copper ore.
23	Mineral Park	Mohave, Ariz	Duval Corp	Copper ore and copper precipitates.
24	Carr Fork	Tooele, Utah	Anaconda Copper Co	Copper ore.
25	Lakeshore	Pinal, Ariz	Noranda Lakeshore Mines Inc	Do.

Table 8.—Mine production of recoverable copper in the United States, by method of treatment

Method of treatment	Ore treated (thousand metric tons)	Recoverable copper		Remarks
		Metric tons	Percent yield	
1980				
Copper ore:				
By concentration	r207,287	r963,506	0.46	
By smelting	111	420	.38	
By leaching[r]	14,199	97,179	.68	
Total or average	r221,597	r1,061,105	.48	
Tailings, dump, in-place material by leaching	--	r102,263	--	
Miscellaneous from cleanup, tailings, noncopper ores	--	r17,748	--	
Total	XX	r1,181,116	XX	
1981				
Copper ore:				
By concentration	263,069	1,275,999	.49	See table 10.
By smelting	158	223	.14	See table 11.
By leaching	14,455	131,400	.91	See table 12.
Total or average	277,682	1,407,622	.51	
Tailings, dump, in-place material by leaching	--	113,991	--	See table 12.
Miscellaneous from cleanup, tailings, noncopper ores	--	16,547	--	
Total	XX	1,538,160	XX	

[r]Revised. XX Not applicable.

Table 9.—Copper ore shipped directly to smelters or concentrated in the United States in 1981, by State, with copper, gold, and silver content in terms of recoverable metal

State	Ore shipped or concentrated (thousand metric tons)	Recoverable metal content: Copper, Metric tons	Copper, Percent	Gold (troy ounces)	Silver (troy ounces)	Value of gold and silver per metric ton of ore
Arizona	184,476	850,180	0.46	95,496	7,565,368	$0.67
Montana	13,730	52,136	.38	14,403	2,029,438	2.04
New Mexico	22,615	133,425	.59	W	W	W
Utah	36,678	189,049	.52	W	W	W
Other[1]	5,728	51,432	.90	242,906	4,458,032	2.44
Total or average	263,227	1,276,222	.48	352,805	14,052,838	1.18

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes Idaho, Michigan, Nevada, New Mexico, Oregon, Tennessee, Utah, and copper-zinc ore.

Table 10.—Copper ore concentrated[1] in the United States in 1981, by State, with content in terms of recoverable copper

State	Ore concentrated (thousand metric tons)	Recoverable copper content: Metric tons	Percent
Arizona	184,366	849,971	0.46
Montana	13,730	52,136	.38
New Mexico	22,567	133,411	.59
Utah	36,678	189,049	.52
Other[2]	5,728	51,432	.90
Total or average	263,069	1,275,999	.49

[1]Includes the following methods of concentration: Dual process (leaching followed by concentration), LPF (leach-precipitation-flotation), and froth flotation.
[2]Includes copper-zinc ore.

Table 11.—Copper ore shipped directly to smelters[1] in the United States in 1981, by State, with content in terms of recoverable copper

State	Ore shipped to smelters: Metric tons	Recoverable copper content: Metric tons	Percent
Arizona	109,716	209	0.19
New Mexico	48,255	14	.03
Total or average	157,971	223	.14

[1]Primarily smelter fluxing material.

Table 12.—Copper precipitates (leached from dump and in-place material or tailings) shipped directly to smelters and copper ore leached (heap, vat, or tank) in the United States in 1981, by State, with content in terms of recoverable copper

State	Precipitates shipped (metric tons)	Recoverable copper content (metric tons)	Ore leached (metric tons)	Recoverable copper content (metric tons)	Percent
Arizona	108,095	68,284	12,192,193	122,286	1.00
Montana	11,093	7,415	--	--	--
Nevada and New Mexico[1]	22,857	16,669	2,262,519	9,114	.40
Utah	28,559	21,623	--	--	--
Total or average	170,604	113,991	[2]14,454,712	131,400	.91

[1]Combined to avoid disclosing company proprietary data.
[2]Includes 9,595,367 metric tons of ore leached for electrowinning.

Table 13.—Copper ore smelted and concentrated and average yield in copper, gold, and silver in the United States

Year	Smelting ore: Thousand metric tons	Smelting ore: Yield in copper (percent)	Concentrating ore: Thousand metric tons[1 2]	Concentrating ore: Yield in copper (percent)	Total: Thousand metric tons[1]	Total: Yield in copper (percent)	Total: Yield per metric ton in gold (ounce)	Total: Yield per metric ton in silver (ounce)	Total: Value per metric ton in gold and silver
1977	272	0.31	217,861	0.51	r218,133	0.52	0.0016	0.061	$0.52
1978	258	.22	224,893	.50	r225,151	.51	.0016	.056	.62
1979	199	.30	248,722	.49	r248,921	r.47	.0016	.057	1.12
1980	111	.38	r207,287	.46	r207,398	.47	.0013	r.053	r1.90
1981	158	.14	263,069	.49	263,227	.51	.0013	.053	1.18

rRevised.
[1]Includes some ore classed as copper-zinc and minor amount of tailings.
[2]Excludes tank or vat and heap leaching. (See tables 8 and 12.)

Table 14.—Copper produced by primary smelters in the United States

(Metric tons)

Year	Domestic	Foreign	Secondary	Total
1977	1,265,008	36,962	44,846	1,346,816
1978	1,269,981	18,397	54,216	1,342,594
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

Table 15.—Primary and secondary copper produced by primary refineries and electrowinning plants in the United States

(Metric tons)

	1977	1978	1979	1980	1981
PRIMARY					
From domestic ores, etc.:[1]					
Electrolytic	1,052,505	1,124,585	1,207,626	r924,190	1,206,404
Electrowon	126,512	98,416	98,801	r113,238	149,245
Fire-refined	101,018	104,372	105,091	84,469	74,561
Total	1,280,035	1,327,373	1,411,518	1,121,897	1,430,210
From foreign ores, etc.:[1]					
Electrolytic[2]	77,281	121,684	103,858	88,957	113,807
Electrowon	W	W	W	W	W
Fire-refined	W	W	W	W	--
Total refinery production of primary copper	1,357,316	1,449,057	1,515,376	1,210,854	1,544,017
SECONDARY					
Electrolytic[2]	240,552	293,437	298,344	315,062	303,338
Electrowon	W	W	W	W	W
Fire-refined	W	W	W	W	W
Total secondary	240,552	293,437	298,344	315,062	303,338
Grand total	1,597,868	1,742,494	1,813,720	1,525,916	1,847,355

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, as accurate separation is not possible at this stage of processing.
[2]Includes electrowon and fire-refined quantities indicated by symbol W.

Table 16.—Copper cast in forms at primary refineries in the United States

	1980		1981	
	Thousand metric tons	Percent	Thousand metric tons	Percent
Billets	100	7	108	6
Cakes	65	4	84	5
Cathodes	827	54	1,128	61
Ingots and ingot bars	62	4	62	3
Wirebars	432	28	424	23
Other forms	40	3	41	2
Total	1,526	100	1,847	100

Table 17.—Production, shipments, and stocks of copper sulfate in the United States

(Metric tons)

Year	Production		Shipments[1]	Stocks, Dec. 31
	Quantity	Copper content		
1977	27,306	7,199	28,084	6,985
1978	31,881	8,551	31,208	7,658
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

[1]Includes consumption by producing companies.

Table 18.—Byproduct sulfuric acid[1] (100% basis) produced in the United States

(Metric tons)

Year	Copper plants[2]	Lead plants	Zinc plants[3]	Total
1977	2,138,567	127,898	669,304	2,935,769
1978	2,484,111	202,935	686,275	3,373,321
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

[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 in order to conceal company proprietary data.

Table 19.—Secondary copper produced in the United States

(Metric tons unless otherwise specified)

	1977	1978	1979	1980	1981
Copper recovered as unalloyed copper	364,721	437,120	516,271	534,556	514,518
Copper recovered in alloys[1]	720,704	810,115	1,036,254	902,871	903,594
Total secondary copper[1]	1,085,425	1,247,235	1,552,525	1,437,427	1,418,112
Source:					
New scrap	675,497	745,585	948,224	823,969	819,990
Old scrap	409,928	501,650	604,301	613,458	598,122
Percentage equivalent of domestic mine output	80	92	108	[r]122	92

[r]Revised.
[1]Includes copper in chemicals, as follows: 1977—3,283; 1978—2,911; 1979—3,004; 1980—2,869; and 1981—3,219.

Table 20.—Copper recovered from scrap processed in the United States, by kind of scrap and form of recovery

(Metric tons)

	1980	1981
KIND OF SCRAP		
New scrap:		
Copper-base	803,527	797,513
Aluminum-base	20,247	22,281
Nickel-base	173	162
Zinc-base	22	34
Total	823,969	819,990
Old scrap:		
Copper-base	598,591	582,814
Aluminum-base	14,610	15,043
Nickel-base	127	123
Tin-base	5	--
Zinc-base	125	142
Total	613,458	598,122
Grand total	1,437,427	1,418,112
FORM OF RECOVERY		
As unalloyed copper:		
At primary plants	315,062	314,053
At other plants	219,494	200,465
Total	534,556	514,518
In brass and bronze	850,188	850,546
In alloy iron and steel	2,317	1,876
In aluminum alloys	47,306	47,728
In other alloys	191	217
In chemical compounds	2,869	3,227
Total	902,871	903,594
Grand total	1,437,427	1,418,112

Table 21.—Copper recovered as refined copper and in alloys and other forms from copper-base scrap processed in the United States

(Metric tons)

Recovered by—	From new scrap		From old scrap		Total	
	1980	1981	1980	1981	1980	1981
Secondary smelters	239,675	220,407	301,327	273,693	541,002	494,100
Primary copper producers	87,281	75,049	227,781	239,004	315,062	314,053
Brass mills	453,017	475,883	29,868	31,503	482,885	507,386
Foundries and manufacturers	21,467	23,809	38,833	37,760	60,300	61,569
Chemical plants	2,087	2,365	782	854	2,869	3,219
Total	803,527	797,513	598,591	582,814	1,402,118	1,380,327

Table 22.—Production of secondary copper and copper-alloy products in the United States, by item produced from scrap

(Metric tons)

Item produced from scrap	1980	1981
UNALLOYED COPPER PRODUCTS		
Refined copper by primary producers	315,062	314,053
Refined copper by secondary smelters	200,021	179,499
Copper powder	13,203	13,594
Copper castings	6,270	7,372
Total	534,556	514,518
ALLOYED COPPER PRODUCTS		
Brass and bronze ingots:		
Tin bronzes	21,145	22,064
Leaded red brass and semired brass	120,869	123,286
High-leaded tin bronze	19,884	19,416
Yellow brass	11,892	9,860
Manganese bronze	8,105	9,436
Aluminum bronze	8,337	9,486
Nickel silver	2,707	2,909
Silicon bronze and brass	3,769	4,009
Copper-base hardeners and master alloys	15,430	16,737
Total	212,138	217,203
Brass-mill products	598,672	623,940
Brass and bronze castings	38,858	39,929
Brass powder	877	1,102
Copper in chemical products	2,869	3,227
Grand total	1,387,970	1,399,919

Table 23.—Composition of secondary copper-alloy production in the United States

(Metric tons)

	Copper	Tin	Lead	Zinc	Nickel	Aluminum	Total
Brass and bronze production:[1]							
1980	194,113	2,949	6,366	8,250	404	56	212,138
1981	193,291	4,280	8,124	11,094	370	44	217,203
Secondary metal content of brass-mill products:							
1980	482,885	366	3,003	110,734	1,661	23	598,672
1981	507,386	302	2,848	110,983	2,392	29	623,940
Secondary metal content of brass and bronze castings:							
1980	31,272	1,174	2,382	3,848	105	77	38,858
1981	32,487	1,244	2,335	3,640	139	84	39,929

[1]About 96% from scrap and 4% from other than scrap in 1980, and about 95% from scrap and 5% from other than scrap in 1981.

Table 24.—Stocks and consumption of purchased copper scrap in the United States in 1981, 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	2,051	38,964	4,793	34,296	39,089	1,926
No. 2 wire, mixed heavy and light copper	11,639	245,918	123,427	113,039	236,466	21,091
Composition or red brass	3,653	55,579	10,657	44,499	55,156	4,076
Railroad-car boxes	254	1,750	--	1,768	1,768	236
Yellow brass	3,445	42,503	7,586	34,339	41,925	4,023
Cartridge cases and brass	90	209	--	255	255	44
Auto radiators (unsweated)	3,749	59,717	--	61,243	61,243	2,223
Bronze	1,678	17,133	2,836	14,266	17,102	1,709
Nickel silver and cupronickel	544	2,763	315	2,308	2,623	684
Low brass	528	2,772	893	1,958	2,851	449
Aluminum bronze	162	245	218	70	288	119

Table 24.—Stocks and consumption of purchased copper scrap in the United States in 1981, by class of consumer and type of scrap —Continued

(Metric tons, gross weight)

Class of consumer and type of scrap	Stocks, Jan. 1	Receipts	Consumption			Stocks, Dec. 31
			New scrap	Old scrap	Total	
SECONDARY SMELTERS —Continued						
Low-grade scrap and residues	10,675	202,000	155,568	44,156	199,724	12,951
Total	38,468	669,553	306,293	352,197	658,490	49,531
PRIMARY PRODUCERS						
No. 1 wire and heavy copper	4,220	91,884	24,408	69,018	93,426	2,678
No. 2 wire, mixed heavy and light copper	3,821	166,417	36,671	125,432	162,103	8,135
Refinery brass	22,226 (Refinery brass and Low-grade scrap and residues)	3,317	68	2,978	3,046	31,167 (Refinery brass and Low-grade scrap and residues)
Low-grade scrap and residues		206,880	48,492	149,718	198,210	
Total	30,267	468,498	109,639	347,146	456,785	41,980
BRASS MILLS[1]						
No. 1 wire and heavy copper	12,318	183,583	153,346	30,237	183,583	11,614
No. 2 wire, mixed heavy and light copper	2,135	60,304	58,753	1,551	60,304	2,531
Yellow brass	19,864	241,163	241,163	--	241,163	17,788
Cartridge cases and brass	10,346	67,693	67,624	69	67,693	8,841
Bronze	775	3,903	3,903	--	3,903	543
Nickel silver and cupronickel	3,756	19,746	19,746	--	19,746	3,020
Low brass	3,724	57,305	57,305	--	57,305	2,142
Aluminum bronze	6	182	182	--	182	4
Total[1]	52,924	633,879	602,022	31,857	633,879	46,483
FOUNDRIES, CHEMICAL PLANTS, AND OTHER MANUFACTURERS						
No. 1 wire and heavy copper	3,042	29,523	14,122	16,075	30,197	2,368
No. 2 wire, mixed heavy and light copper	693	7,402	3,566	3,735	7,301	794
Composition or red brass	680	14,431	2,636	11,770	14,406	705
Railroad-car boxes	851	6,069	--	5,840	5,840	1,080
Yellow brass	349	11,661	6,395	4,673	11,068	942
Auto radiators (unsweated)	456	5,271	1,528	2,287	3,815	1,912
Bronze	869	695	396	307	703	861
Nickel silver and cupronickel	14	385	16	371	387	12
Low brass	51	1,449	1,140	320	1,460	40
Aluminum bronze	72	1,287	830	405	1,235	124
Low-grade scrap and residues	--	1	--	1	1	--
Total	7,077	78,174	[2]30,629	[2]45,784	76,413	8,838
GRAND TOTAL						
No. 1 wire and heavy copper	21,631	343,954	196,669	149,626	346,295	18,586
No. 2 wire, mixed heavy and light copper	18,288	480,041	222,417	243,757	466,174	32,551
Composition or red brass	4,333	70,010	13,293	56,269	69,562	4,781
Railroad-car boxes	1,105	7,819	--	7,608	7,608	1,316
Yellow brass	23,658	295,327	255,144	39,012	294,156	22,753
Cartridge cases and brass	10,436	67,902	67,624	324	67,948	8,885
Auto radiators (unsweated)	4,205	64,988	1,528	63,530	65,058	4,135
Bronze	3,322	21,731	7,135	14,573	21,708	3,113
Nickel silver and cupronickel	4,314	22,894	20,077	2,679	22,756	3,716
Low brass	4,303	61,526	59,338	2,278	61,616	2,631
Aluminum bronze	240	1,714	1,230	475	1,705	247
Low-grade scrap and residues[3]	32,901	412,198	204,128	196,853	400,981	44,118
Total	128,736	1,850,104	1,048,583	776,984	1,825,567	146,832

[1]Brass-mill stocks include home scrap; purchased scrap consumption is assumed equal to receipts, so lines in brass-mill and grand total sections do not balance.
[2]Of the totals shown, chemical plants reported the following: Unalloyed copper scrap, 2,486 tons new and 889 tons old.
[3]Includes refinery brass.

Table 25.—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
1980:						
Copper scrap	448,450	608,205	--	74,302	719,948	1,850,905
Refined copper[1]	--	511,627	1,308,922	36,580	4,967	1,862,096
Brass ingot	--	6,087	--	[2]207,631	--	213,718
Slab zinc	--	90,413	--	2,311	6,102	98,826
Miscellaneous	--	--	--	180	[r]4,450	[r]4,630
1981:						
Copper scrap	456,785	633,879	--	76,413	658,490	1,825,567
Refined copper[1]	--	536,210	1,449,583	33,931	5,445	2,025,169
Brass ingot	--	17,824	--	[2]199,460	--	217,284
Slab zinc	--	104,330	--	2,948	5,708	112,986
Miscellaneous	--	--	--	180	5,915	6,095

[r]Revised.
[1]Detailed information on consumption of refined copper will be found in table 29.
[2]Shipments to foundries by smelters and changes in stocks at foundries.

Table 26.—Foundry consumption of brass ingot in the United States, by type

(Metric tons)

Type	1977	1978	1979	1980	1981
Tin bronzes	34,649	35,951	35,242	30,327	28,885
Leaded red brass and semired brass	97,095	106,053	107,596	95,138	94,142
Yellow brass	23,841	21,368	21,138	17,780	19,659
Manganese bronze	5,296	7,430	7,724	6,287	6,270
Hardeners and master alloys	3,484	4,398	5,913	5,446	4,411
Nickel silver	2,096	2,330	2,315	2,579	2,030
Aluminum bronze	6,122	7,071	7,267	6,727	6,853
Total	172,583	184,601	187,195	164,284	162,250

Table 27.—Foundries and miscellaneous manufacturers consumption of brass ingot and refined copper and copper scrap in the United States in 1981, 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 ingot	Refined copper consumed	Copper scrap consumed
New England:										
Connecticut	466	1,405	620	33			216	3,347	187	449
Maine, New Hampshire, Rhode Island, Vermont	267	1,860	141	304	537	340	100	2,833	657	80
Massachusetts	277	1,669	249	210				2,514		
Total	1,010	4,934	1,010	547	537	340	316	8,694	844	529
Middle Atlantic:										
New Jersey	704	831	254	98			191	2,134		
New York	697	7,088	992	149	648	538	98	9,072	3,347	5,275
Pennsylvania	6,997	5,954	1,177	551			1,500	17,261	4,077	5,311
Total	8,398	13,873	2,423	798	648	538	1,789	28,467	7,424	10,586
East North Central:										
Illinois		8,759	2,863	558			1,270	14,521	349	
Indiana	4,575	7,573	768	250	1,293	92	54	13,204	414	9,552
Michigan		3,501	476	939			413	5,659	6,071	2,956
Ohio		8,207	2,929	965			429	19,444		10,138
Wisconsin	8,321	6,050	1,793	186	880	244	111	10,671	6,369	4,153
Total	12,896	34,090	8,829	2,898	2,173	336	2,277	63,499	13,203	26,799
West North Central:										
Iowa, Kansas, Minnesota	161	2,327	898	606	58	6	146	4,176	2,025	12,459
Missouri, Nebraska, South Dakota	79	1,433	1,021	228			76	2,863		
Total	240	3,760	1,919	834	58	6	222	7,039	2,025	12,459

South Atlantic:										
Delaware, District of Columbia, Florida, Georgia, Maryland	332	404	478	65	2	640	43	1,539	2,253	7,830
North Carolina, South Carolina, Virginia, West Virginia	142	8,941		59			342	9,909		
Total	474	9,345	478	124	2	640	385	11,448	2,253	7,830
East South Central:										
Alabama, Kentucky, Mississippi, Tennessee	1,673	11,272	1,975	278			1,520	15,474		5,149
West South Central:										
Arkansas, Louisiana, Oklahoma, Texas	2,105	7,776	1,032	143	104	154		12,556	7,007	1,512
Mountain:										
Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah	301	468	276	37			14	1,098		351
Pacific:										
California	1,680	8,524	1,717	611	889	16	330	12,606	777	7,011
Oregon and Washington	108	100						1,369		811
Total	1,788	8,624	1,717	611	889	16	330	13,975	777	7,822
Grand total	28,885	94,142	19,659	6,270	4,411	2,030	6,853	162,250	33,533	73,037

Table 28.—Primary refined copper supply and withdrawals on domestic account in the United States

(Metric tons)

	1977	1978	1979	1980	1981
Production from domestic and foreign ores, etc	1,357,316	1,449,057	1,515,376	1,210,854	1,544,017
Imports for consumption[1]	r350,957	r402,673	r203,855	r426,948	330,625
Stocks, Jan. 1[1]	172,000	212,000	153,000	64,000	49,000
Total available supply	r1,880,273	r2,063,730	r1,872,231	r1,701,802	1,923,642
Copper exports[1]	46,745	91,923	73,677	14,489	24,397
Stocks, Dec. 31[1]	212,000	153,000	64,000	49,000	151,000
Total	258,745	244,923	137,677	63,489	175,397
Apparent withdrawals on domestic account	r1,622,000	r1,819,000	r1,735,000	r1,638,000	1,748,000

rRevised.
[1]May include some copper refined from scrap.

Table 29.—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
1980:							
Wire rod mills	714,050	560,904	W	W	--	33,968	1,308,922
Brass mills	233,695	22,107	54,076	84,251	117,370	128	511,627
Chemical plants	--	--	--	--	--	333	333
Secondary smelters	1,333	--	2,654	--	--	980	4,967
Foundries	2,510	W	6,795	--	W	1,601	10,906
Miscellaneous[1]	8,585	W	4,076	W	W	12,680	25,341
Total	960,173	583,011	67,601	84,251	117,370	49,690	1,862,096
1981:							
Wire rod mills	950,402	467,654	W	W	--	31,527	1,449,583
Brass mills	236,681	21,546	54,127	121,844	101,862	150	536,210
Chemical plants	--	--	--	--	--	398	398
Secondary smelters	1,356	--	3,515	--	--	574	5,445
Foundries	3,247	W	5,802	--	W	2,290	11,339
Miscellaneous[1]	7,176	W	3,243	W	W	11,775	22,194
Total	1,198,862	489,200	66,687	121,844	101,862	46,714	2,025,169

W Withheld to avoid disclosing company proprietary data; included with "Miscellaneous."
[1]Includes iron and steel plants, primary smelters producing alloys other than copper, consumers of copper powder and copper shot, and other manufacturers.

Table 30.—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
1977	314,000	212,000	106,000	31,000	6,000	167,000
1978	263,000	153,000	63,000	28,000	7,000	163,000
1979	275,000	64,000	44,000	25,000	9,000	90,000
1980	272,000	49,000	50,000	22,000	10,000	163,000
1981	277,000	151,000	109,000	26,000	9,000	170,000

[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 31.—Dealers' monthly average buying price for copper scrap and consumers' alloy-ingot prices at New York in 1980,[1] by grade

(Cents per pound)

Grade	Jan.	Feb.	Mar.	Apr.	May	June
No. 2 heavy copper scrap	74.91	82.35	70.30	60.18	57.60	56.50
No. 1 composition scrap (red brass)	67.11	70.00	67.30	64.45	62.88	60.93
No. 115 brass ingot (85-5-5-5)	98.82	120.70	115.92	109.50	103.14	100.00

Grade	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average
No. 2 heavy copper scrap	65.36	64.88	64.21	65.37	66.09	58.36	65.51
No. 1 composition scrap (red brass)	66.34	63.74	62.83	63.37	64.91	60.93	64.57
No. 115 brass ingot (85-5-5-5)	101.19	103.50	103.50	103.89	108.00	105.21	106.11

[1]Data not available for 1981.

Source: Metal Statistics, 1981.

Table 32.—Average monthly prices for electrolytic copper in the United States and on the London Metal Exchange

(Cents per pound)

Month	1980				1981			
	Domestic delivered		London spot[1]		Domestic delivered		London spot[1]	
	Cathode	Wirebar	Cathode	Wirebar	Cathode	Wirebar	Cathode	Wirebar
January	118.07	119.39	114.00	117.89	87.59	88.57	88.05	84.73
February	132.85	133.81	126.71	132.29	85.06	86.07	81.25	81.67
March	105.05	106.04	100.45	104.55	86.19	87.38	81.94	82.44
April	93.62	94.85	90.96	93.91	87.11	88.03	81.90	82.58
May	92.16	93.48	90.79	92.82	84.90	85.80	78.38	79.00
June	91.66	92.71	88.26	90.96	84.43	85.23	76.53	77.09
July	102.24	103.56	95.80	98.68	83.49	84.41	75.85	76.26
August	99.72	100.71	91.09	94.39	86.71	87.39	80.90	81.04
September	97.99	98.86	90.30	93.41	83.95	84.72	77.45	77.55
October	98.45	99.47	89.70	92.75	81.48	82.31	75.29	75.56
November	95.81	96.98	89.00	91.16	80.26	81.22	74.55	74.88
December	88.10	89.13	83.21	85.17	79.31	80.29	74.70	(2)
Average	101.31	102.42	96.09	99.25	84.21	85.12	78.98	[3]79.35

[1]Based on average monthly rates of exchange.
[2]Wirebar contract replaced by high-grade contract.
[3]Based on January-November monthly averages.

Source: Metals Week.

Table 33.—Average weighted prices of copper delivered

(Cents per pound)

Year	Domestic copper	Foreign copper
1977	66.8	59.3
1978	66.5	61.9
1979	93.3	90.0
1980	102.4	99.2
1981	85.1	79.0

Source: Metals Week.

Table 34.—U.S. exports of copper, by country

Country	Ore and concentrates (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)
1980	106,825	$203,375	6,881	$15,474	14,489	$31,099	61,225	$93,059	3,802	$7,296
1981:										
Africa	--	--	--	--	--	--	184	109	--	--
Belgium-Luxembourg	18	20	1,162	3,243	25	46	776	2,031	98	157
Brazil	--	--	--	--	843	1,853	126	203	18	28
Canada	5,472	3,743	647	1,398	6,438	8,209	9,344	10,592	5,263	9,886
Finland	2,514	5,517	--	--	--	--	34	62	--	--
France	--	--	1	2	1,373	3,041	201	293	2	3
Germany, Federal Republic of	162	368	81	223	1,107	2,212	1,298	1,763	995	1,663
Greece	--	--	--	--	--	--	--	--	865	1,400
India	--	--	277	388	--	--	4,257	5,539	23	45
Israel	--	--	--	--	23	54	--	--	--	--
Italy	--	--	--	--	654	1,218	--	--	1	1
Japan	116,764	160,482	184	805	3,857	7,447	7,086	11,278	1,716	2,629
Korea, Republic of	--	--	--	--	296	558	15,862	22,557	23	30
Mexico	46	45	2,062	484	7,211	13,447	5,303	8,375	33	61
Netherlands	--	--	46	56	49	98	107	90	2	3
Oceania	--	--	--	--	6	12	19	33	8	28
Saudi Arabia	--	--	2	2	3	10	--	--	74	207
Spain	--	--	398	215	869	1,684	2,090	2,340	1	2
Sweden	--	--	--	--	145	289	105	74	--	--
Taiwan	8,430	11,862	--	--	51	115	2,038	2,798	46	140
U.S.S.R.	17,376	24,975	--	--	--	--	--	--	--	--
United Kingdom	--	--	1,424	958	1,337	2,838	697	1,081	33	52
Venezuela	--	--	--	--	--	--	1	2	2	3
Other	--	--	--	--	110	222	550	886	24	57
Total	150,782	207,012	6,284	7,774	24,397	43,353	50,078	70,106	9,227	16,395

	Pipes and tubing		Plates and sheets		Wire and cable, bare		Wire and cable, insulated		Other copper manufactures[2]	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
1980	17,652	$58,284	1,843	$6,708	6,295	$27,868	65,098	$317,008	41,071	$94,760
1981:										
Africa	134	572	11	44	373	1,268	7,890	30,142	517	1,099
Belgium-Luxembourg	5	24	6	113	54	410	180	5,110	1	14
Brazil	(3)	1	3	88	637	1,674	224	1,501	1	9
Canada	2,196	6,401	775	2,722	672	3,383	17,847	66,137	3,604	7,723
El Salvador	--	--	(3)	2	13	94	21	129	584	972
Finland	7	16	--	--	1	13	28	594	--	--
France	73	186	1	9	35	280	475	9,846	90	168
Germany, Federal Republic of	119	387	35	192	13	110	808	12,796	562	992
Greece	11	61	--	--	(3)	3	9	135	35	125
India	2	3	--	--	38	119	1,321	3,526	287	749
Israel	672	1,898	1	4	45	547	1,022	7,974	3	10
Italy	264	779	2	7	9	119	221	3,859	3,082	5,658
Japan	2	15	59	228	24	125	607	10,279	500	977
Korea, Republic of	12	40	2	34	19	55	492	4,618	--	--
Mexico	1,705	5,462	1,231	2,659	2,422	12,915	20,884	72,988	2,394	4,629
Netherlands	242	789	20	102	23	236	191	2,944	901	2,625
Oceania	72	185	5	20	31	239	690	6,586	34	177
Saudi Arabia	1,132	3,281	53	198	1,170	3,556	13,947	64,809	29	75
Singapore	13	79	7	10	67	490	918	7,610	2	6
Spain	1,230	2,975	1	2	1	43	89	1,075	4	19
Sweden	85	260	--	--	1	10	116	2,338	388	687
Taiwan	33	280	7	26	2	380	3,083	14,897	22	78
U.S.S.R.	--	--	--	--	1	10	1	5	--	--
United Arab Emirates	128	370	--	--	68	11	201	1,981	(3)	4
United Kingdom	1,279	3,614	16	67	68	619	1,751	19,505	20	28
Venezuela	359	1,449	28	131	324	982	932	5,007	4,720	9,331
Other	1,164	3,911	70	387	911	4,303	8,974	46,129	671	1,309
Total	10,939	33,038	2,333	7,045	7,022	31,994	82,922	402,520	18,451	37,464

[1]Includes matte.
[2]Excludes copper wire cloth.
[3]Less than 1/2 unit.

Table 35.—U.S. exports of copper scrap, by country

Country	Unalloyed copper scrap				Copper-alloy scrap			
	1980		1981		1980		1981	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Argentina	18	$19	--	--	55	$74	--	--
Belgium-Luxembourg	5,591	7,808	776	$2,031	14,497	23,496	5,061	$16,354
Brazil	1,166	2,084	126	203	2,010	2,937	405	539
Canada	8,705	12,957	9,344	10,592	12,002	13,766	10,302	11,354
Finland	--	--	34	62	1,609	2,861	1,150	2,138
France	184	277	201	293	250	567	180	279
German Democratic Republic	57	97	--	--	18	23	--	--
Germany, Federal Republic of	9,883	15,315	1,298	1,763	22,300	30,799	12,123	7,216
Hong Kong	167	319	89	113	1,492	1,628	291	356
India	4,304	5,399	4,257	5,539	7,083	8,374	11,951	13,565
Italy	2,588	3,093	--	--	4,845	4,957	154	174
Japan	6,435	10,416	7,086	11,278	17,753	26,428	22,631	29,639
Korea, Republic of	2,916	5,114	15,862	22,557	7,446	11,062	5,793	8,411
Mexico	6,912	11,876	5,303	8,375	3,355	3,636	3,697	4,671
Netherlands	2,196	3,491	107	90	1,444	2,322	238	296
Spain	5,472	7,777	2,090	2,340	18,742	22,567	4,842	5,572
Sweden	216	389	105	74	560	965	643	3,135
Switzerland	18	32	--	--	163	263	74	293
Taiwan	3,062	4,168	2,038	2,798	10,843	13,714	14,185	14,423
Thailand	18	35	71	121	164	222	--	--
Turkey	81	130	379	633	752	1,176	513	605
United Kingdom	903	1,708	697	1,081	2,102	3,676	1,402	2,746
Other	332	557	215	163	284	465	514	783
Total[1]	61,225	93,059	50,078	70,106	129,767	175,981	96,149	122,549

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

Table 36.—U.S. imports for consumption of unmanufactured copper (copper content), by country[1]

Country	Ore and concentrates: Quantity (metric tons)	Ore and concentrates: Value (thousands)	Matte: Quantity (metric tons)	Matte: Value (thousands)	Blister: Quantity (metric tons)	Blister: Value (thousands)	Refined: Quantity (metric tons)	Refined: Value (thousands)	Scrap: Quantity (metric tons)	Scrap: Value (thousands)	Total: Quantity (metric tons)	Total: Value (thousands)
1980	52,360	$72,636	392	$719	44,537	$86,284	426,948	$935,262	22,769	$40,865	547,006	$1,135,766
1981:												
Argentina	--	--	--	--	--	--	1,000	1,607	82	92	1,082	1,699
Australia	981	1,026	--	--	524	1,166	--	--	--	--	1,505	2,192
Belgium-Luxembourg	--	--	--	--	22	63	1,935	3,464	--	--	1,957	3,527
Canada	3,445	4,918	871	896	25	50	84,864	156,383	19,274	29,897	108,479	192,144
Chile	611	854	382	625	11,700	25,887	125,042	216,287	81	98	137,816	243,751
Dominican Republic	--	--	--	--	--	--	--	--	573	858	573	858
Japan	--	--	--	--	493	1,105	6,407	10,962	17	40	6,917	12,107
Mexico	10,897	13,719	362	778	3,387	8,227	4,368	8,990	4,809	6,303	23,823	38,017
Panama	--	--	--	--	--	--	--	--	973	1,269	973	1,269
Peru	2,740	3,618	1,103	933	13,938	31,507	34,189	60,032	--	--	51,970	96,090
Philippines	20,404	32,393	--	--	--	--	--	--	--	--	20,404	32,393
United Kingdom	--	--	--	--	--	--	583	1,141	29	58	612	1,199
Yugoslavia	--	--	--	--	--	--	2,447	3,787	--	--	2,447	3,787
Zaire	--	--	--	--	--	--	24,688	37,443	--	--	24,688	37,443
Zambia	--	--	--	--	--	--	44,082	80,124	--	--	44,082	80,124
Other	54	20	--	--	35	78	1,020	1,865	1,164	2,090	2,273	4,053
Total	39,132	56,548	2,718	3,232	30,124	68,083	330,625	582,085	27,002	40,705	429,601	750,653

[1]Table revised to show imports for consumption rather than general imports.

Table 37.—Copper: World mine production, by continent and country[1]

(Thousand metric tons)

Continent and country	1977	1978	1979	1980[p]	1981[e]
North and Central America:					
Canada[2]	759.4	659.4	636.4	716.4	[3]718.1
Cuba	2.6	2.8	2.8	3.3	3.6
Guatemala	2.5	2.1	1.8	.8	.5
Honduras	.5	.6	1.4	.3	.3
Mexico	89.7	87.2	107.1	175.4	[3]230.5
Nicaragua[4]	.3	[e].1	--	--	--
United States[2]	1,364.4	1,357.6	1,443.6	1,181.1	1,538.2
South America:					
Argentina	.2	.3	.1	.2	.2
Bolivia	3.2	2.9	1.8	1.9	[3]2.6
Brazil	(5)	(5)	5.3	1.4	18.0
Chile	1,056.2	1,035.5	1,060.6	1,067.7	1,080.0
Colombia	[r](5)	[r].1	.1	.1	[3].1
Ecuador	1.0	.8	1.2	1.2	1.2
Peru	[r]338.1	366.4	390.7	366.8	[3]327.6
Europe:					
Albania[e]	10.0	11.5	14.0	15.3	15.5
Bulgaria	57.0	58.0	58.0	58.0	58.0
Czechoslovakia[e]	5.4	4.7	6.2	6.2	6.3
Finland	46.7	46.9	41.1	36.9	38.2
France	[r].1	.6	.4	.5	.5
German Democratic Republic[e]	17.0	16.0	15.0	15.0	16.0
Germany, Federal Republic of[2,6]	1.2	.8	.9	1.3	1.3
Greece	3.5	1.5	(5)	(5)	(5)
Hungary	1.0	.5	.1	--	--
Ireland[4]	4.9	4.8	4.9	4.2	3.5
Italy[6]	.7	.5	.5	.6	.8
Norway[6]	29.1	[r]29.1	28.9	28.0	28.2
Poland[2]	289.3	321.0	325.0	346.1	315.2
Portugal[6]	[r]3.2	[r]3.6	3.6	5.2	5.0
Romania[2]	27.0	27.0	29.0	28.0	27.0
Spain[6,7]	[r]36.0	[r]33.9	25.6	42.5	51.4
Sweden	44.8	47.6	45.8	42.8	[3]42.8
U.S.S.R.[e,2,6]	830.0	865.0	885.0	900.0	950.0
United Kingdom	.4	.1	.1	(5)	.1
Yugoslavia[4]	116.2	123.3	111.4	[e]134.0	130.0
Africa:					
Algeria	.3	.2	.2	.2	.2
Botswana[8]	11.8	14.6	14.6	15.6	16.5
Congo (Brazzaville)[4]	[r]1.0	.8	1.0	1.3	1.3
Mauritania	7.6	1.8	--	--	--
Morocco[4]	4.8	4.7	7.0	7.2	6.7
Mozambique[e]	--	.1	.2	.2	.2
Namibia	49.2	37.7	41.9	39.2	[3]46.1
South Africa, Republic of	208.3	[r]205.7	190.6	200.7	208.7
Uganda	4.0	(5)	--	--	--
Zaire	481.6	423.8	400.0	459.4	497.0
Zambia	656.0	643.0	588.3	595.8	588.0
Zimbabwe	34.8	33.8	29.7	27.0	21.7
Asia:					
Burma[8]	(5)	.1	.1	.1	.1
China	195.0	200.0	200.0	200.0	200.0
Cyprus[6]	6.8	5.8	1.2	--	--
India	31.2	26.0	26.5	22.0	27.0
Indonesia	[r]57.1	[r]59.0	60.2	58.0	60.0
Iran[e]	13.5	20.0	5.3	3.6	3.6
Israel	--	--	--	.8	--
Japan[4]	81.4	72.0	59.1	52.5	51.5
Korea, North[e,2]	15.0	15.0	15.0	15.0	15.0
Korea, Republic of	1.7	.7	.5	.4	[3]1.1
Malaysia	[r]23.7	[r]24.9	24.0	27.0	[3]30.0
Mongolia	--	4.0	21.7	44.0	71.8
Nepal	(5)	(5)	--	--	(5)
Philippines	272.8	[r]263.6	298.3	304.5	289.3
Taiwan	2.0	.8	.8	1.2	1.0
Turkey	33.4	[r]27.3	31.4	20.8	35.0

See footnotes at end of table.

Table 37.—Copper: World mine production, by continent and country[1] —Continued

(Thousand metric tons)

Continent and country	1977	1978	1979	1980[p]	1981[e]
Oceania:					
Australia	221.6	[r]222.1	237.6	231.8	[3]223.2
Papua New Guinea	182.3	[r]198.6	170.8	146.8	[3]165.4
Total	[r]7,738.5	[r]7,618.3	7,674.4	7,656.3	8,171.1

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Data presented represent copper content (recoverable, where indicated) of ore mined wherever possible. If such data are not available, the figures presented are the nonduplicative total copper content of ores, concentrates, matte, metal, and/or other copper-bearing products measured at the least stage of processing for which data are available. Table includes data available through June 23, 1982.
[2]Recoverable.
[3]Reported figure.
[4]Copper content of concentrates produced.
[5]Less than 1/2 unit.
[6]Includes copper content of cupriferous pyrites.
[7]Excludes an unreported quantity of copper in iron pyrites which may or may not be recovered.
[8]Copper content of matte produced.
[9]Revised to zero.

Table 38.—Copper: World smelter production,[1] by continent, country, and metal origin

(Thousand metric tons)

Continent, country, and metal origin	1977	1978	1979	1980[p]	1981[e]
North America:					
Canada:					
Primary	481.6	[e]410.3	[e]374.5	[e]473.7	457.0
Secondary	18.7	[e]15.0	[e]10.0	[e]19.0	18.0
Total	500.3	425.3	384.5	492.7	[2]475.0
Mexico, primary	87.5	87.0	83.9	85.7	61.3
United States:					
Primary	1,302.0	1,288.4	1,335.6	1,008.4	1,316.8
Secondary	44.8	54.2	60.2	44.9	60.9
Total	1,346.8	1,342.6	1,395.8	1,053.3	1,377.7
South America:					
Argentina, primary[e]	.1	.1	.1	.1	.1
Chile, primary	888.4	927.4	946.9	953.1	[2]953.9
Peru, primary	[r]307.4	318.9	371.4	321.0	253.4
Europe:					
Albania, primary[e]	9.0	9.5	9.7	9.9	10.0
Austria, secondary	12.1	12.1	13.2	11.0	10.0
Belgium:					
Primary[e]	13.0	9.0	1.5	.7	.5
Secondary[e]	48.6	46.9	47.8	49.3	47.5
Total[e]	61.6	55.9	49.3	50.0	48.0
Bulgaria:					
Primary[e]	57.0	61.0	61.0	61.0	61.0
Secondary[e]	3.0	3.0	3.0	3.0	3.0
Total[e]	60.0	64.0	64.0	64.0	64.0
Czechoslovakia:					
Primary[e]	7.4	6.7	8.2	7.6	7.4
Secondary[e]	2.6	3.3	1.8	2.4	2.4
Total[e]	10.0	10.0	10.0	10.0	9.8
Finland:					
Primary	61.5	53.7	55.3	[e]49.2	49.0
Secondary	10.6	10.0	9.9	[e]10.0	10.0
Total	72.1	63.7	65.2	59.2	59.0
France, secondary	5.3	[r]3.2	5.0	7.3	7.0
German Democratic Republic, primary	18.0	17.0	19.0	18.0	18.0

See footnotes at end of table.

Table 38.—Copper: World smelter production,[1] by continent, country, and metal origin —Continued

(Thousand metric tons)

Continent, country, and metal origin	1977	1978	1979	1980[p]	1981[e]
Europe—Continued					
Germany, Federal Republic of:					
Primary	189.6	165.8	158.2	153.9	155.0
Secondary	58.4	55.7	92.5	103.9	105.0
Total	248.0	221.5	250.7	257.8	260.0
Hungary, secondary	.8	.3	.1	.1	.1
Norway, primary	26.6	20.1	27.3	33.7	[2]32.0
Poland, primary and secondary	311.0	337.0	341.0	363.5	[2]330.8
Portugal:					
Primary	3.3	2.8	5.1	6.1	4.4
Secondary	.1	.2	.4	.5	.4
Total	3.4	3.0	5.5	6.6	4.8
Romania:					
Primary	41.4	38.9	41.1	40.7	40.5
Secondary	4.0	4.0	4.0	4.0	4.0
Total	45.4	42.9	45.1	44.7	44.5
Spain:					
Primary	99.5	95.5	90.3	[e]85.1	128.1
Secondary	18.0	17.0	18.0	[e]18.0	20.0
Total	117.5	112.5	108.3	103.1	[2]148.1
Sweden:					
Primary	46.7	53.2	51.7	45.7	[2]60.6
Secondary	15.0	13.8	12.9	10.7	[2]13.2
Total	61.7	67.0	64.6	56.4	[2]73.8
U.S.S.R.:					
Primary	850.0	865.0	885.0	900.0	950.0
Secondary	85.0	90.0	95.0	95.0	95.0
Total	935.0	955.0	980.0	995.0	1,045.0
Yugoslavia:					
Primary	97.4	107.5	108.7	114.0	110.0
Secondary	68.4	87.7	71.3	72.0	71.0
Total	165.8	195.2	180.0	186.0	181.0
Africa:					
Namibia, primary	53.4	45.9	42.7	40.0	39.7
South Africa, Republic of, primary	188.4	[r]191.4	178.0	180.8	[2]199.4
Uganda, primary	8.3	--	--	--	--
Zaire, primary	[r]459.1	[r]400.1	382.4	447.8	462.0
Zambia, primary	[r]658.5	[r]653.9	582.1	609.9	567.0
Zimbabwe, primary	[r]32.5	[r]32.2	28.5	26.1	21.0
Asia:					
China, primary and secondary[e]	195.0	200.0	200.0	200.0	200.0
India, primary	23.5	[r]19.5	21.4	28.5	[2]25.7
Iran, primary	7.0	6.0	.7	.8	.8
Japan:					
Primary	848.4	854.5	853.7	889.5	937.0
Secondary	103.9	56.0	67.7	40.3	43.1
Total	952.3	910.5	921.4	929.8	[2]980.1
Korea, North:					
Primary[e]	15.0	15.0	15.0	15.0	15.0
Secondary[e]	5.0	5.0	3.0	3.0	3.0
Total[e]	20.0	20.0	18.0	18.0	18.0
Korea, Republic of:					
Primary[e]	[r]20.8	[r]30.9	33.2	50.1	87.0
Secondary	[r]16.0	[r]15.0	15.0	14.0	14.0
Total	36.8	45.9	48.2	64.1	[2]101.0
Taiwan, primary	[r]5.0	[r]7.5	10.0	13.0	50.0

See footnotes at end of table.

Table 38.—Copper: World smelter production,[1] by continent, country, and metal origin —Continued

(Thousand metric tons)

Continent, country, and metal origin	1977	1978	1979	1980[p]	1981[e]
Asia —Continued					
Turkey:					
Primary[e]	30.9	25.6	21.6	15.3	26.7
Secondary[e]	.6	.6	.6	.6	.6
Total[e]	31.5	26.2	22.2	15.9	[2]27.3
Oceania:					
Australia:					
Primary	167.7	164.4	163.2	174.9	160.4
Secondary	4.1	2.8	6.2	7.1	5.0
Total	171.8	167.2	169.4	182.0	165.4
Grand total	[r]8,136.9	[r]8,017.5	8,045.6	7,938.9	8,324.7
Of which:					
Primary	[r]7,105.9	[r]6,984.7	6,967.0	6,859.3	7,260.7
Secondary	[r]525.0	[r]495.8	537.6	516.1	533.2
Undifferentiated	506.0	537.0	541.0	563.5	530.8

[e]Estimated. [p]Preliminary. [r]Revised.
[1]This table has been revised in general format to include total production of copper metal at the unrefined stage, whether produced by thermal, electrolytic, or electrowinning methods, and whether derived from ore, concentrates, 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. In instances where copper is recovered in a single step from raw material to refined product, the amount recovered has been included. Table includes data available through June 23, 1982.
[2]Reported figure.

Table 39.—Copper: World refinery production,[1] by continent, country, and metal origin

(Thousand metric tons)

Continent, country, and metal origin	1977	1978	1979	1980[p]	1981[e]
North America:					
Canada:					
Primary[e]	479.8	420.3	377.3	475.2	445.6
Secondary[e]	29.0	26.0	20.0	30.0	28.0
Total[e]	508.8	446.3	397.3	505.2	[2]473.6
Mexico:					
Primary[e]	67.1	70.0	76.8	80.6	63.0
Secondary[e]	6.0	5.0	5.0	5.0	5.0
Total[e]	73.1	75.0	81.8	85.6	[2]68.0
United States:					
Primary	1,357.3	1,449.1	1,515.4	1,210.9	1,544.0
Secondary	349.6	420.1	498.4	515.1	493.6
Total	1,706.9	1,869.2	2,013.8	1,726.0	2,037.6
South America:					
Brazil, secondary	45.9	45.0	53.1	63.0	[2]45.0
Chile, primary	676.0	749.1	779.5	810.7	[2]775.6
Peru, primary	[r]187.2	182.8	230.8	226.3	[2]209.1
Europe:					
Albania, primary[e]	7.0	7.0	7.5	7.7	9.0
Austria:					
Primary[e]	9.7	15.5	8.0	9.0	9.0
Secondary[e]	22.0	16.0	24.8	34.3	30.1
Total[e]	31.7	31.5	32.8	43.3	39.1
Belgium:					
Primary[e]	408.7	332.6	318.8	321.7	265.0
Secondary[e]	56.0	56.0	50.0	52.0	45.0
Total[e]	464.7	388.6	368.8	373.7	310.0
Bulgaria, primary and secondary[e]	58.0	62.0	62.0	62.0	62.0

See footnotes at end of table.

Table 39.—Copper: World refinery production,[1] by continent, country, and metal origin —Continued

(Thousand metric tons)

Continent, country, and metal origin	1977	1978	1979	1980[p]	1981[e]
Europe—Continued					
Czechoslovakia, primary and secondary	23.1	23.8	24.6	25.6	26.0
Finland:					
Primary[e]	32.8	32.7	33.0	30.5	25.8
Secondary[e]	10.0	10.0	10.0	10.0	8.0
Total[e]	42.8	42.7	43.0	40.5	[2]33.8
France:					
Primary	22.3	20.7	22.0	23.0	23.0
Secondary	[r]22.7	20.6	23.3	23.3	23.0
Total	[r]45.0	41.3	45.3	46.3	[2]46.0
German Democratic Republic, primary and secondary[e]	51.0	49.0	51.0	51.0	51.0
Germany, Federal Republic of:					
Primary	340.7	318.6	303.1	302.5	[2]304.0
Secondary	99.5	84.9	79.4	61.3	[2]83.3
Total	440.2	[r]403.5	382.5	363.8	[2]387.3
Hungary, primary and secondary	12.1	13.1	12.0	12.0	12.0
Italy:					
Primary[e]	4.0	3.5	2.6	2.0	1.0
Secondary[e]	16.0	14.0	13.0	10.2	22.7
Total[e]	20.0	17.5	15.6	12.2	23.7
Norway:					
Primary	21.2	15.7	[e]21.0	[e]25.8	21.1
Secondary	1.3	5.6	[e]6.0	[e]6.0	5.0
Total	22.5	21.3	27.0	31.8	[2]26.1
Poland, primary and secondary	306.6	332.2	335.8	357.3	[2]327.2
Portugal, primary	3.4	3.0	3.4	4.6	4.8
Romania, primary and secondary	40.0	40.5	42.0	42.0	42.0
Spain:					
Primary[e]	130.0	117.0	119.4	127.7	122.4
Secondary[e]	29.0	30.0	25.0	30.0	30.0
Total[e]	159.0	147.0	144.4	157.7	[2]152.4
Sweden:					
Primary	47.7	53.2	49.7	[e]46.7	51.9
Secondary	14.0	11.2	12.0	[e]9.0	10.0
Total	61.7	64.4	61.7	55.7	[2]61.9
U.S.S.R.:					
Primary[e]	790.0	810.0	830.0	845.0	890.0
Secondary[e]	160.0	170.0	170.0	170.0	170.0
Total[e]	950.0	980.0	1,000.0	1,015.0	1,060.0
United Kingdom:					
Primary	44.4	46.2	48.5	68.3	[2]59.8
Secondary	77.8	79.4	73.2	93.0	[2]76.4
Total	122.2	125.6	121.7	161.3	[2]136.2
Yugoslavia:					
Primary	93.0	103.9	99.2	[e]100.0	100.0
Secondary	50.5	46.9	38.3	[e]31.3	32.6
Total	143.5	150.8	137.5	131.3	[2]132.6
Africa:					
South Africa, Republic of, primary[3]	145.9	149.1	150.8	140.9	144.1
Zaire, primary	[r]140.7	[r]146.4	136.5	179.6	165.0
Zambia, primary	648.0	627.7	561.9	607.6	[2]573.1
Zimbabwe, primary	[r]3.0	[r]3.0	3.0	3.1	8.0

See footnotes at end of table.

Table 39.—Copper: World refinery production,[1] by continent, country, and metal origin —Continued

(Thousand metric tons)

Continent, country, and metal origin	1977	1978	1979	1980[p]	1981[e]
Asia:					
China, primary and secondary[e]	260.0	270.0	280.0	280.0	280.0
India, primary[3]	[r]21.1	17.6	14.7	17.0	[2]14.6
Iran, primary[e]	7.0	6.0	3.0	.8	.8
Japan:					
Primary	[r]848.6	854.5	853.7	889.5	[2]930.0
Secondary	[r]85.1	104.6	130.0	124.8	[2]120.2
Total	933.7	959.1	983.7	1,014.3	[2]1,050.2
Korea, North, primary and secondary[e]	25.0	25.0	22.0	22.0	22.0
Korea, Republic of:					
Primary[e]	[r]20.8	[r]30.9	46.3	54.6	87.0
Secondary[e]	[r]22.1	[r]21.5	16.8	18.3	21.0
Total	[r]42.9	[r]52.4	63.1	72.9	[2]108.0
Taiwan:					
Primary[e]	[r]4.7	7.4	8.3	11.5	45.2
Secondary[e]	[r]7.0	7.0	7.0	8.0	8.0
Total[e]	[r]11.7	[r]14.4	15.3	19.5	53.2
Turkey, primary	25.3	30.1	22.2	18.8	22.6
Oceania:					
Australia:					
Primary	152.0	152.6	138.4	144.8	[2]164.2
Secondary	[r]31.1	[r]26.3	33.6	38.1	[r]26.6
Total	[r]183.1	178.9	172.0	182.9	[2]190.8
Grand total	[r]8,649.8	[r]8,791.9	8,903.1	8,971.0	9,184.4
Of which:					
Primary	[r]6,739.4	[r]6,776.2	6,784.8	6,786.4	7,078.7
Secondary	[r]1,134.6	[r]1,200.1	1,288.9	1,332.7	1,283.5
Undifferentiated	775.8	815.6	829.4	851.9	822.2

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

[1]This table has been revised in general format to include total production of refined copper, whether produced by thermal, electrolytic, or electrowinning methods, and whether derived from primary unrefined copper or from scrap. To the extent possible, primary and secondary output of each country is shown separately. In some cases, total refinery production is officially reported, but the distribution between primary and secondary has been estimated. Table includes data available through June 23, 1982.

[2]Reported figure.

[3]Although only primary production is reported, an unknown but small additional output of secondary refined copper may have been produced.

Diatomite

By A. C. Meisinger[1]

Domestic production of processed diatomite was 687,000 tons in 1981, almost the same as in 1980; however, value of sales established a new record high of $113 million, a 12% increase over that of the previous year. Production came from four Western States with California operations accounting for more than half of the 1981 output. Manville Products Corp. (formerly Johns-Manville Sales Corp.), with operations at Lompoc, Calif., continued to be the leading domestic producer.

U.S. diatomite exports declined, for the first time since 1975, to 162,000 tons, compared with 173,000 tons in 1980. Imports of diatomite increased by 31% in 1981 to 385 tons.

Apparent domestic consumption increased slightly (2%) in 1981 to 525,000 tons.

DOMESTIC PRODUCTION

U.S. output of diatomite in 1981 was 687,000 tons valued at $113 million. Sales declined in quantity by 2,000 tons from that of 1980, but total value of sales increased 12% in 1981 to a new record high. Producers attributed the increase in value primarily to higher fuel costs.

Domestic production in 1981 was in 9 plants processing from 11 mining operations in 4 Western States: California, Nevada, Oregon, and Washington. Diatomite operations in California continued to account for more than half of the total annual U.S. production of diatomite.

The 1981 producers were the same as in 1980. Principal producers were Manville Products, with operations at Lompoc, Calif.; Grefco, Inc. (Dicalite Div.), at Lompoc, Calif., and Mina (Basalt), Nev.; Eagle-Picher Industries, Inc. (Minerals Div.), at Sparks and Lovelock, Nev.; and Witco Chemical Corp. (Inorganic Specialties Div.) at Quincy, Wash. Other producers were Excel-Mineral Co., Taft, Calif.; Cyprus Diatomite Co., Fernley, Nev.; and Oil-Dri Production Co., Christmas Valley, Oreg.

American Exploration and Management Co. reported relinquishment of their diatomite property in Rio Arriba County, N. Mex.,to new ownership. Details of the transaction were not reported.

Table 1.—Diatomite sold or used by producers in the United States

(Thousand short tons and thousand dollars)

	1977	1978	1979	1980	1981
Domestic production (sales)	648	651	717	689	687
Total value of sales	$63,870	$72,429	$90,323	$100,610	$113,010

CONSUMPTION AND USES

Apparent domestic consumption of diatomite in 1981 (sales, plus imports, minus exports) totaled 525,000 tons, a slight increase (2%) over that of 1980. Demand for diatomite as a filtration medium declined 2% from that of 1980, but continued to account for most (64%) of the total sales in 1981. Diatomite used as filler increased from 21% in 1980 to 23% of total sales; however, insulation use declined from 3% in 1980 to 2%. Other uses of diatomite in 1981 were absorbents, abrasives, fertilizer coatings, and lightweight aggregates, which together accounted for 11% of the total quantity sold or used by domestic producers.

Table 2.—Diatomite sold or used,[1] by principal use

(Percent of U.S. production)

Use	1977	1978	1979	1980	1981
Filtration	59	63	65	66	64
Fillers	W	23	21	21	23
Insulation	5	3	3	3	2
Other	36	11	11	10	11

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1] Includes exports.

PRICES

The weighted average value reported by producers for processed diatomite sold or used in 1981 was $164.50 per ton, a 13% increase compared with the 1980 average value of $146.02 per ton, and a 31% increase compared with the 1979 average value. The average annual value per ton for each of the principal end uses of diatomite (table 3) in 1981 increased substantially over those of 1980.

Table 3.—Average annual value per ton[1] of diatomite, by use

Use	1979	1980	1981
Abrasives	$174.09	W	W
Fillers	118.22	$132.56	$153.14
Filtration	136.52	158.88	179.01
Insulation	94.67	103.47	125.02
Miscellaneous[2]	87.81	101.79	110.19
Weighted average	125.91	146.02	164.50

W Withheld to avoid disclosing company proprietary data; included with "Miscellaneous."
[1]Based on unrounded data.
[2]Includes absorbents, abrasives (1980-81), admixtures and silicates (1979), catalysts (1979-80), fertilizer coatings, lightweight aggregates (1980-81), and pozzolan additive (1979).

FOREIGN TRADE

In 1981, domestic producers exported 162,000 tons of processed diatomite, a decrease of 6% from the quantity exported in 1980, and the first such decrease since 1975. Average value per ton of exports continued to increase and was $203.29 compared with $186.35 in 1980. The quantity of diatomite exported in 1981 represented 24% of U.S. production compared with 25% the previous year. Diatomite was exported to 87 countries compared with 80 countries in 1980, and the following 4 countries received 51% of the total: Canada, 32,900 tons; Japan, 22,100 tons; Australia, 14,000 tons; and the Federal Republic of Germany, 13,400 tons.

Imports of diatomite increased from 295 tons in 1980 to 385 tons, with 78% coming from Mexico compared with 91% in 1980. Value of imports from Mexico (U.S. Customs declared average value at U.S. ports of entry) in 1981 was $71,428, compared with $83,545 in 1980.

Table 4.—U.S. exports of diatomite

(Thousand short tons and thousand dollars)

Year	Quantity	Value[1]
1978	153	21,463
1979	170	26,496
1980	173	32,238
1981	162	32,933

[1]U.S. Customs.

WORLD REVIEW

World production of diatomite in 1981 was an estimated 1,638,000 tons, a slight decrease from the 1980 production of 1,645,000 tons. The United States maintained its leadership with 687,000 tons produced, or 42% of total world output in 1981. The U.S.S.R. and France were the next two largest producing countries with 250,000 tons and 243,000 tons, respectively (table 5).

Denmark.—During the year, Skarrehage Molervaerk A/S (Skamol) was reported to have acquired the Molisol Produkt moler brick operations.[2] Before the acquisition, Molisol Produkt was the second largest producer of moler bricks. Moler, an impure diatomaceous earth containing 20% to 25% clay, is used extensively in Denmark to produce insulation bricks.

Tanzania.—Two possible sources of high-grade diatomite were reported to occur in Tanzania.[3] One deposit area was found in the lower reaches of the Kagera River, near Bukoba and the other at Makutapora, north of Dodoma. Many lower grade diatomite occurrences have also been reported, particularly within the Rift Valley area of the country.

[1]Industry economist, Division of Industrial Minerals.
[2]Watson, I. The Industrial Minerals of Scandinavia-Denmark. Ind. Miner. (London), No. 171, December 1981, pp. 47, 51.
[3]Jones, G. K. The Industrial Minerals of Tanzania. Ind. Miner. (London), No. 166, July 1981, p. 39.

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

(Thousand short tons)

Country	1977	1978	1979	1980[p]	1981[e]
North America:					
Canada	1	2	2	[e]2	2
United States	648	651	717	689	[2]687
Latin America:					
Argentina	14	8	8	7	7
Brazil (marketable)	[r]11	13	18	19	19
Chile	1	6	1	1	1
Colombia	1	1	1	1	1
Costa Rica	1	1	1	1	1
Mexico	26	[r]45	49	[e]25	25
Peru	[r]9	[r]5	(3)	--	--
Europe:					
Austria	(4)	1	--	--	--
Denmark:					
Diatomite[e]	28	28	28	28	28
Moler[e 5]	175	175	140	140	140
France	227	[e]220	[e]220	[e]240	243
Germany, Federal Republic of	55	52	48	58	57
Iceland	[6]23	22	23	20	20
Italy[e]	[r]35	[r]35	35	35	31
Portugal	4	3	3	3	3
Romania[e]	45	45	45	45	45
Spain	31	24	30	30	26
U.S.S.R.[e]	235	240	250	250	250
United Kingdom[e]	2	2	2	2	2
Africa:					
Algeria	5	4	5	5	5
Egypt	(4)	(4)	(4)	--	--
Kenya	3	2	2	2	2
South Africa, Republic of	1	1	1	1	1
Asia:					
Korea, Republic of	25	21	26	28	28
Thailand	(4)	1	4	2	2
Turkey	10	10	[e]10	[e]10	11
Oceania:					
Australia	1	3	4	(4)	(4)
New Zealand	1	[e]1	[e]1	[e]1	1
Total	[r]1,618	[r]1,622	1,674	1,645	1,638

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through Apr. 14, 1982.
[2]Reported figure.
[3]Revised to zero.
[4]Less than 1/2 unit.
[5]Estimated diatomite content of moler produced.
[6]Exports.

Feldspar, Nepheline Syenite, and Aplite

By Michael J. Potter[1]

Total U.S. feldspar output in 1981 (including soda, potash, and mixed varieties) decreased by 6% to 665,000 tons. Feldspar was mined in six States, with North Carolina in the lead, followed by Connecticut and Georgia. The other producing States were California, Oklahoma, and South Dakota. Shipments went to at least 31 States and to foreign destinations, primarily Canada and Mexico. Aplite of glassmaking quality was produced only in Virginia; output figures are not released, but the tonnage produced was approximately 5% less than in 1980. Imports of crude and ground nepheline syenite in 1981 totaled 506,000 short tons, about the same as in 1980.

The 1981 end-use distribution of feldspar in the United States indicated that 57% went into glassmaking and 40% into pottery. The remaining 3% was used in other applications such as enamels, sanitary ware, and fillers.

In Washington, Feldslite Corp. of America obtained permits to mine and process, in Chelan County, a deposit containing, principally, feldspar, quartz, and mica.

The Glass Packaging Institute launched a campaign to counteract inroads made by plastic bottles.[2] Most of the gain in plastic containers has been in food and beverage bottles (especially soft drinks).[3]

Legislation and Government Programs.—According to provisions of the Tax Reform Act of 1969, which continued in force throughout 1981, the depletion rate allowed on feldspar production (both domestic and foreign operations) was 14%.

Table 1.—Salient feldspar and nepheline syenite statistics

	1977	1978	1979	1980	1981
United States:					
Feldspar:					
Produced[1] ____ short tons	734,000	735,000	740,000	710,000	665,000
Value ____ thousands	$17,190	$18,200	$21,500	$23,200	$21,000
Exports ____ short tons	6,200	10,330	12,300	13,000	14,025
Value ____ thousands	$394	$853	$1,025	$896	$1,110
Imports for consumption ____ short tons	242	39	266	404	206
Value ____ thousands	$8	$3	$31	$133	$61
Nepheline syenite:					
Imports for consumption ____ short tons	502,600	548,000	536,000	504,000	506,100
Value ____ thousands	$9,135	$10,446	$10,846	$11,264	$11,529
Consumption, apparent[2] (feldspar plus nepheline syenite) ____ thousand short tons	1,231	1,273	1,264	1,201	1,157
World production (feldspar) ____ do	[r]3,240	[r]3,402	[r]3,512	[p]3,480	[e]3,444

[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. Hand-cobbed or hand-sorted feldspar is usually obtained from pegmatites (coarse-grained, igneous dike rock) and is relatively high in K_2O compared with Na_2O. Feldspar flotation concentrates can be 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 processed mixture obtained from flotation.

Feldspar was mined in six States in 1981, led by North Carolina and followed in descending order by Connecticut, Georgia, California, Oklahoma, and South Dakota. The combined output of the top four States was about 95% of the U.S. total.

Most of the feldspar used in glassmaking is ground no finer than 20 to 40 mesh, and substantial tonnages of feldspathic sands (feldspar-quartz mixtures) enter into glass furnace feeds with no further reduction in particle size. Feldspar for ceramic and filler applications is usually pulverized to minus 200 mesh or finer. In 1981, 10 U.S. companies operating 11 plants produced feldspar in 6 States for shipment to at least 31 States and to foreign countries, primarily Canada and Mexico. North Carolina had five plants, California had two, and Connecticut, Georgia, South Carolina, and South Dakota each had one.

In Washington, Feldslite obtained permits to mine the deposit on Wenatchee Ridge on national forest land and to build a processing plant near Nason Creek, both in Chelan County. Production at the plant could occur in late 1982, initially at about 120,000 tons per year of rock. Feldspar, quartz, and mica are the major components, and iron content is low at approximately 0.25% Fe_2O_3. Reserves were reported to be very large.[4]

The data for potash feldspar in tables 1-6 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, in order to publish potash feldspar data and to maintain proprietary company data, the potash feldspar included in tables 1-6 has a K_2O content of 8% or higher.

Table 2.—Feldspar produced in the United States[1]

(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
1977	23	309	568	12,600	142	4,280	734	17,190
1978	26	400	568	13,240	140	4,550	735	18,200
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

[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

In 1981, there continued to be no significant consumption of run-of-mine feldspar. The majority of users acquired their supplies already ground and sized by the 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.

In 1981, 57% of total feldspar consumed in the United States was used in glassmaking (including container glass, flat glass, and fiberglass), and 40% was used in pottery. The remaining 3% was used in other applications, including enamels, sanitary ware, rubber products, and electrical insulators.

Recent trends indicate that U.S. manufacturers will ship 7.3 billion pounds of glass fibers in 1995. Reinforced plastics would be the primary growth outlet. Other promising areas are passenger car tires (glass belted) and electrical and electronic applications.[5]

In recent years, porcelain enamel has been the preferred finish for most household appliances and fixtures. Another potential area of growth is on the exteriors of residential buildings, with both steel and aluminum siding.[6]

Table 3.—Feldspar sold or used by producers in the United States, by use[1]

(Thousand short tons and thousand dollars)

Use	1980		1981	
	Quantity	Value	Quantity	Value
Hand-cobbed:				
Pottery	W	W	13	935
Other	15	995	1	45
Total	15	995	[2]13	980
Flotation concentrate:				
Glass	298	7,870	251	7,310
Pottery	W	W	236	10,610
Other	266	10,990	19	1,160
Total	564	18,860	[2]505	19,080
Feldspar-silica mixture:[3]				
Glass	106	4,790	118	4,900
Pottery	W	W	15	935
Other	25	1,620	3	310
Total	131	6,410	136	6,145
Total:				
Glass[4]	404	12,660	369	12,210
Pottery	276	11,390	264	12,480
Other[5]	30	2,220	22	1,510
Total	710	[2]26,300	655	26,200

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes potash feldspar (8% K_2O or higher).
[2]Data do not add to totals shown because of independent rounding.
[3]Feldspar content.
[4]Includes container glass, flat glass, and fiberglass.
[5]Includes enamel, sanitary ware, filler, electrical insulators, etc., and unknown; totals for "Quantity" and "Value" may not correspond to the sums of the subtotals of the three "Other" categories above.

Table 4.—Destination of shipments of feldspar sold or used by producers in the United States, by State[1]

(Short tons)

State	1977	1978	1979	1980	1981
Alabama	(2)	35,500	13,900	21,100	19,600
Arkansas	5,500	5,200	W	W	W
California	(2)	(2)	(2)	(3)	(4)
Connecticut	(2)	23,800	21,600	18,400	17,800
Florida	(2)	20,000	23,600	32,800	25,700
Georgia	(2)	35,800	69,000	64,700	68,300
Illinois	37,000	47,600	43,700	36,600	31,100
Indiana	30,800	32,600	25,300	26,700	22,700
Kentucky	10,100	10,200	13,100	12,800	11,700
Louisiana	16,200	19,200	16,900	14,600	13,900
Maryland	5,000	6,500	7,600	5,100	4,300
Massachusetts	18,400	W	W	11,100	8,800
Michigan	800	2,500	4,000	2,700	W

See footnotes at end of table.

Table 4.—Destination of shipments of feldspar sold or used by producers in the United States, by State[1] —Continued

(Short tons)

State	1977	1978	1979	1980	1981
Mississippi	20,800	22,000	17,600	15,600	13,000
Missouri	7,600	4,200	7,600	4,900	4,300
New Jersey	45,100	50,400	59,600	64,600	63,400
New York	20,600	21,400	22,000	23,100	19,400
Ohio	63,300	59,200	64,400	56,400	52,800
Oklahoma	34,300	33,600	31,700	31,000	34,700
Pennsylvania	53,700	55,400	52,900	46,200	42,900
South Carolina	NA	W	17,700	15,600	16,400
Tennessee	21,700	19,700	19,400	18,300	16,100
Texas	39,400	38,800	40,400	35,000	39,400
West Virginia	37,000	38,200	59,800	55,400	36,100
Other[5]	267,200	153,200	112,200	97,300	92,600
Total	[6]735,000	735,000	744,000	710,000	655,000

NA Not available. W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes potash feldspar (8% K_2O or higher).
[2]Data are incomplete; included with "Other."
[3]Data are incomplete; Bureau of Mines estimate is 40,000 tons or more; included with "Other."
[4]Data are incomplete; Bureau of Mines estimate is 35,000 tons or more; included with "Other."
[5]Includes North Carolina, Rhode Island, Wisconsin, other States, and foreign destinations.
[6]Data do not add to total shown because of independent rounding.

Table 5.—Potash feldspar sold or used by producers in the United States, by use[1]

Use	1980		1981	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Pottery	69,500	$4,050	66,850	$4,538
Other[2]	15,500	700	13,550	620
Total	85,000	4,750	80,400	5,158

[1]K_2O content of 8% or higher.
[2]Includes glass, enamel, sanitary ware, etc.

Table 6.—Destination of shipments of potash feldspar sold or used by producers in the United States, by State[1]

(Short tons)

State	1977	1978	1979	1980	1981
Illinois, Indiana, Wisconsin	W	14,900	15,500	13,400	11,300
Maryland, New York, West Virginia	27,300	27,500	29,500	28,200	24,800
Massachusetts	1,100	W	1,400	W	W
Ohio	12,100	12,100	12,000	10,700	9,800
Pennsylvania	11,100	12,000	9,000	8,200	9,100
Texas	600	400	W	400	200
Other States	34,600	18,300	18,600	18,150	17,480
Mexico	W	1,500	2,900	1,600	2,800
Canada	3,800	4,600	5,200	4,300	4,900
Other destinations	100	--	--	50	20
Total	90,700	91,300	94,100	85,000	80,400

W Withheld to avoid disclosing company proprietary data; included with "Other States."
[1]K_2O content of 8% or higher.

PRICES

Engineering and Mining Journal, December 1981, listed the following prices for feldspar, per short ton, f.o.b. mine or mill, carload lots, bulk, depending on grade:

	1980	1981
North Carolina:		
20 mesh, flotation	$25.50	$27.50
40 mesh, flotation	41.00	46.00
200 mesh, flotation	38.25	$41.25-65.00
Georgia:		
40 mesh, granular	41.00	46.00
200 mesh	58.00	64.00
Connecticut:		
20 mesh, granular	30.25	34.50
200 mesh	41.75	46.75

Feldspar prices were quoted by Industrial Minerals (London), December 1981, as follows (converted from pounds sterling per metric ton to dollars per short ton, using an exchange rate of £1.00=US$2.00):

Ceramic grade, powder, 200 mesh, bagged, ex-store, United Kingdom	$136-$145
Sand, 2 to 3 millimeters, ceramic and/or glass grade, c.i.f. main European port	73- 82

FOREIGN TRADE

U.S. exports in 1981 classified as feldspar, leucite, and nepheline syenite (but presumably mostly feldspar) amounted to 14,025 tons valued at $1,110,000. This was 8% higher in tonnage than in 1980. Chief recipients of the exported material were Canada, 48%; Mexico, 32%; and Venezuela, 7%. The remaining 13% was shared among 11 other countries.

In addition to feldspar and nepheline syenite, U.S. imports in 1981 were 1,489 tons of "Other mineral fluxes, crushed" with a value of $310,986 and 23,538 tons of "Other crude natural mineral fluxes" with a value of $873,867.

The tariff schedule in force throughout 1981 for most favored nations provided for a 3.3% ad valorem duty on ground feldspar; imports of unground feldspar were admitted duty free.

Table 7.—U.S. imports for consumption of feldspar

(Short tons)

Country	1980		1981	
	Quantity	Value	Quantity	Value
Crude:				
Canada	232	$111,693	93	$42,597
Japan	--	--	15	1,138
Ground, crushed, or pulverized:				
Germany, Federal Republic of	1	796	2	484
Japan	--	--	1	326
Norway	103	10,401	--	--
Peru	--	--	(1)	1,230
Sweden	68	9,837	85	11,970
United Kingdom	--	--	10	3,630
Total	404	132,727	206	61,375

[1]Less than 1/2 unit.

WORLD REVIEW

A comprehensive journal article discussed the use of flux materials in the ceramics and glass industries, with special emphasis on the United Kingdom. Also discussed were other end uses such as fillers and extenders, and consumption of feldspathics in the United States. Production, major producing companies, and feldspar exports for 1978-79 were given for Norway, Sweden, the Federal Republic of Germany, France, Italy, the United Kingdom, Spain, Portugal, and the United States.[7]

Belgium-Luxembourg.—Feldspar imports in 1978 were about 71,000 tons. Principal countries of origin and the share supplied were France, 43%; Norway, 33%; and the Netherlands, 13%. In 1979, imports were 74,000 tons. Principal countries of origin and the percentages supplied were Norway, 46%; and France, 42%. In 1980, feldspar imports were from France, 45%; and Norway, 41%.[8]

Bulgaria.—A journal article discussed specifications of feldspar produced from pegmatites and from quartz-feldspar sands that are feebly cemented by clay minerals.[9]

Czechoslovakia.—Feldspar deposits were discussed in a journal article. All of the mined deposits occur in the Bohemian Massif, with microcline pegmatites being the most abundant. In addition to pegmatites, leucocratic granitoids are also a source of feldspar. Among the secondary feldspar deposits is the feldspar gravel deposit at Halámky. After grinding and high-intensity electromagnetic separation, this material has an Fe_2O_3 content of 0.15% and is suitable for manufacture of chinaware and electrical porcelain.[10]

Japan.—A discussion of feldspathic deposits was given in a journal article. The country's needs are mostly supplied by domestic production, and over 90% come from aplitic rocks and altered granite.[11]

Spain.—Aislamic Silicatos Ibericos SL, a prominent producer of feldspar in the Provinces of Burgos, Madrid, and Cordoba, also has extensive mineral lease holdings throughout Spain. The company's El Cabril Mine in Cordoba has a large deposit of high-quality pegmatite. Estimated reserves are 16 million tons, and total reserves may be as high as 50 million tons. A large stockpile of pegmatite material was built up, and plans were to install a flotation plant to recover feldspar, quartz, and mica. Total output of these products would be 200,000 tons per year, with a large portion destined for export markets.[12]

Another company, Llansa S.A., in Gerona produced sodium-potassium and sodium feldspar, with a total output in 1980 of approximately 44,000 tons. The company was investigating the possibility of upgrading the quality of its feldspar products by the installation of a flotation plant.[13]

Table 8.—Feldspar: World production, by country[1]

(Thousand short tons)

Country[2]	1977	1978	1979	1980[p]	1981[e]
North America:					
Guatemala	14	17	12	24	20
Mexico	126	[r]121	122	[e]140	140
United States	734	735	740	710	[3]665
South America:					
Argentina	47	46	37	36	40
Brazil[4]	106	114	156	136	140
Chile	3	1	([5])	2	2
Colombia	[r]30	29	32	28	30
Peru	[r]2	[r]3	2	17	20
Uruguay	2	3	3	3	3
Venezuela	29	77	98	7	8
Europe:					
Austria	4	3	8	12	10
Finland	79	[r]78	75	82	80
France	[r]226	[r]233	215	[e]220	220
Germany, Federal Republic of	434	425	411	420	420
Italy	[r]236	277	325	379	370
Norway[6]	78	66	97	[e]77	80
Poland[e]	44	44	44	44	44
Portugal	17	[r]24	37	45	50
Romania[e]	66	66	66	66	66
Spain[7]	103	128	128	114	120
Sweden	[r]57	[r]60	[e]55	55	60
U.S.S.R.[e]	320	330	340	340	350
United Kingdom (china stone)[e]	55	55	55	55	55
Yugoslavia	62	53	62	62	55

See footnotes at end of table.

Table 8.—Feldspar: World production, by country[1] —Continued

(Thousand short tons)

Country[2]	1977	1978	1979	1980[p]	1981[e]
Africa:					
Egypt	3	4	4	4	4
Kenya	2	1	[e]1	(5)	(5)
Madagascar	(5)	(5)	(5)	(5)	(5)
Mozambique[e]	1	1	--	--	--
Nigeria[e]	6	6	6	6	6
South Africa, Republic of	56	58	52	57	60
Zambia	1	(5)	(5)	(5)	(5)
Asia:					
Burma	2	2	2	2	2
Hong Kong	4	3	1	[8]18	4
India	60	57	55	65	70
Japan[9]	[r]46	46	42	33	30
Korea, Republic of	54	76	75	79	70
Pakistan	4	[r]15	17	12	13
Philippines	18	[r]20	19	18	20
Sri Lanka	4	3	4	4	4
Thailand	[r]20	36	29	26	30
Turkey	83	83	[e]80	79	80
Oceania: Australia	2	[r]3	5	3	3
Total	[r]3,240	[r]3,402	3,512	3,480	3,444

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through Apr. 14, 1982.
[2]In addition to the countries listed, China, Czechoslovakia, Romania, 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]Reported figure.
[4]Series revised to exclude production of leucite and sodalite; data presented now 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: 1976—94; 1977—110; 1978—109; 1979—408; and 1980—[e]410.
[5]Less than 1/2 unit.
[6]Described in source as lump feldspar; does not include nepheline syenite as follows in thousand short tons: 1976—239; 1977—231; 1978—256; 1979—not available; 1980—not available.
[7]Includes pegmatite.
[8]Includes feldspar sand, a byproduct from kaolin washing, not reported (and presumably not produced) in prior years; of the total, approximately one-fifth is feldspar and four-fifths is feldspar sand.
[9]In addition, the following quantities of aplite were produced in thousand short tons: 1976—395; 1977—435; 1978—416; 1979—435; and 1980—[e]420.

TECHNOLOGY

The Federal Bureau of Mines has experimented on a laboratory scale with the separation of mineral mixtures based on their dielectric properties. A continuous device called the "rotating drum dielectric separator" consists primarily of a high-voltage drum electrode and a screen electrode immersed in a liquid. Finely divided mineral particles, 65- to 400-mesh, are fed to the top of the drum and are separated into low-dielectric particles and high-dielectric particles. Twenty-eight mineral mixtures were tested, with quartz or quartz combined with feldspar as the gangue minerals. Minerals such as rutile, zircon, monazite, celestite, and ilmenite responded favorably to separation from quartz and, to a lesser degree, from quartz-feldspar mixture.[14]

A journal article discussed the response of feldspar flotation in a nonfluoride reagent system. A diamine collector (Duomeen TDO) was used in the presence of sulfuric acid. Several process variables were studied, such as flotation feed size, conditioning pH, conditioning pulp density, etc. A number of conclusions were given at the end of the article.[15]

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. mined nepheline syenite from the deposit at Blue Mountain, Ontario. Canadian production in 1980 totaled approximately 650,000 tons valued at $15.9 million.

A journal article discussed nepheline syenite, including Canadian exports in 1979-80, processing, and the market.[16] Another article described the Nephton, Ontario, complex of Indusmin, the world's largest plant, including mining, processing, product specifications, etc.[17]

Other than Canada, only two countries were known to be producing significant quantities of nepheline syenite, Norway with 267,000 tons in 1979[18] and the U.S.S.R. where, although production figures were not released, the mineral was known to serve the customary applications of the glass and ceramics industries and was a major source of cell-feed alumina for electrolytic aluminum plants.

In Brazil, trial production of glass-quality nepheline syenite was begun at Mineraçao Canaan's 13,000-ton-per-year pilot plant. The Canaan Mine is located 18 miles north of Rio de Janeiro. Initial results from the operation were reported to be successful, and plans were being drawn up for the development of a fully commercial operation. The first stage of the plan called for construction of a 40,000-ton-per-year plant to come onstream in late 1981. Beneficiation, although not finalized, would consist of grinding and magnetic separation. Main emphasis would be on supplying material to the domestic market, with some trial lots to be shipped for evaluation by overseas consumers.[19]

In another journal article, a general discussion of nepheline syenite was given.[20]

The price range quoted for imported nepheline syenite in Ceramic Industry magazine, January 1982, was from $20 to $145 per ton, depending upon grade, purity, grind, packaging, transportation, quantity sold, and other factors. Industrial Minerals (London), December 1981, quoted price ranges as follows (converted from Canadian dollars and pounds sterling per metric ton to dollars per short ton):

Canadian:	
Glass grade, 30 mesh, bulk, car lots-truck lots, per short ton.	$19-$22
Ceramic grade, 200 mesh, bagged, 10-ton lots, per short ton.	37- 41
Norwegian:	
Glass grade, 32 mesh (Tyler), bulk, per short ton, c.i.f. main European port.	69
Ceramic grade, 325 mesh (Tyler), bagged, per short ton, c.i.f. main European port.	105

The April 5, 1982, issue of the American Paint & Coatings Journal quoted paint-grade nepheline syenite in 50-pound bags, car or truck lots, f.o.b. Ontario, at $74 to $160 per ton.

Table 9.—U.S. imports for consumption of nepheline syenite

Year	Crude		Ground	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1979	2,260	$28	533,700	$10,818
1980	6,760	71	497,580	11,193
1981	2,780	25	503,320	11,504

APLITE

Aplite is another rock of granitic texture containing quartz mixed with varying proportions of soda or lime-soda feldspar. Aplite is usually not suitable for use in ceramics, but if sufficiently low in iron, finds acceptance in the manufacture of glass, especially container glass. Japan, with an annual production of 400,000 to 500,000 tons, is the world's foremost producer of aplite.

Aplite of glassmaking quality was produced in the United States in 1981 from only one open pit operation. 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, drying, and high-intensity magnetic separation to eliminate iron-bearing minerals.

Domestic output in 1981 was approximately 5% lower in tonnage than in the previous year. Specific annual data on aplite production, sales, and value are not released for publication. Aplite traditionally commands a somewhat lower price than feldspar. Industrial Minerals (London), December 1981, gave a value of about $22 per ton for glass-grade, bulk, 100% plus 200 mesh, f.o.b. Montpelier, Va.

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[1]Physical scientist, Division of Industrial Minerals.

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[17]Vitunski, S. Indusmin Nepheline Syenite Plant World's Largest. The Northern Miner, v. 67, No. 24, Aug. 20, 1981, pp. B13-B14, B17.

[18]Page 45 of work cited in footnote 7.

[19]Page 37 of work cited in footnote 7.

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Ferroalloys

By Raymond E. Brown[1]

The domestic and world ferroalloy industries were plagued by lower production in 1981 because of continued weak demand for their products. The iron and steel industry, the major consumer of ferroalloys, had lower production in 1981 than in 1980 in most industrialized countries. The shift of ferroalloy production from industrialized countries to countries that have both developing ferroalloy industries and indigenous ores, or low-cost electrical power, continued to be the trend.

Legislation and Government Programs.—The revised National Defense Stockpile goals set for ferroalloys in 1980 by the Federal Emergency Management Agency and the inventories held at yearend were unchanged in 1981.

Table 1.—Government inventory of ferroalloys, December 31, 1981

(Thousand short tons)

Alloy	Stockpile grade	Nonstockpile 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

Table 2.—Ferroalloys produced and shipped from furnaces in the United States[1]

	1980				1981			
	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]	189,472	80	194,347	$99,626	192,690	76	188,255	$104,072
Silicomanganese	188,317	66	161,568	70,329	173,263	66	172,542	81,849
Ferrosilicon[3]	686,377	61	681,420	442,567	680,484	60	635,201	397,482
Chromium alloys:								
Ferrochromium	184,408	63	185,480	125,101	164,933	60	148,425	100,961
Other alloys[4]	54,207	50	51,987	54,831	62,319	46	58,852	65,818
Total	238,615	60	237,467	179,932	227,252	56	207,277	166,779
Ferrocolumbium	1,558	65	1,266	34,491	887	64	807	12,608
Ferrophosphorus	116,482	24	85,371	13,060	80,547	22	52,817	9,382
Other[5]	[r]126,224	XX	[r]124,675	[r]289,896	137,649	XX	127,680	270,295
Grand total	[r]1,547,045	XX	[r]1,486,114	[r]1,129,901	1,492,772	XX	1,384,579	1,042,467

[r]Revised. 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 silicon metal and 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.

DOMESTIC PRODUCTION

Total domestic ferroalloy production in 1981 was 1.5 million tons, slightly down from the low levels of 1980. This is the lowest production figure recorded over the past 20 years. Weak demand and especially strong competition from imports were major factors that contributed to the decline in production. During the peak years, 1965 through 1970, the U.S. ferroalloy industry controlled approximately 90% of the domestic market, and total production ranged from 2.6 to 2.8 million tons. Since that time, domestic production has declined, particularly for manganese and chromium ferroalloys, and in 1981 the domestic producers' market share dropped to 49%. A similar trend appears to be surfacing for ferrosilicon and silicon metal, for which the United States has domestic ores.

Because of weak demand for their products and intensified import pressure, many producers were forced to either cut back production or shut down their furnaces, at least temporarily. For example, Macalloy Inc. halted ferrochromium production in November at its Charleston, S.C., facility, which has two furnaces with a combined capacity of 80 megawatts; SKW Alloys, Inc., temporarily shut down its 40-megawatt ferrosilicon furnace in October at its Calvert City, Ky., plant. In December, Autlan Manganese Corp. shut down its only furnace at Mobile, Ala., and laid off all its employees. The furnace was rated at 27 megawatts and could produce either ferromanganese or silicomanganese. In December, the Foote Mineral Co. decreased production of silvery pig iron at its plant in Keokuk, Iowa, and ferrosilicon at its Graham, W. Va., plant.

Union Carbide Corp. permanently closed and put up for sale its Portland, Oreg., plant because of outdated equipment and rising power costs. The plant had two ferromanganese furnaces with a combined rating of 12 megawatts and one silicomanganese furnace rated at 8 megawatts. The Hanna Mining Co., the only domestic integrated mine-to-metal producer of nickel, appeared unable to sustain operations at its ferronickel plant in Riddle, Oreg., owing to power rate increases proposed by the Bonneville Power Administration, which could triple the cost of power for the energy-intensive ferronickel process. In general, the overall ferroalloy industry operated at only about 50% of its rated capacity.

On July 1, Union Carbide Corp. completed its sale of five ferroalloy plants, which included three in the United States and two in Norway, to Norwegian groups headed by Elkem AS. Also, Elkem AS has an option to acquire two of Union Carbide's ferroalloy plants in Quebec, Canada, before 1988. Elkem Metals Co., a subsidiary of Elkem AS, will coordinate the operation of the three U.S. plants, located in Alloy, W. Va., and in Ashtabula and Marietta, Ohio, from its home office in Pittsburgh, Pa. The products produced at the three U.S. plants include ferroalloys of chromium, manganese, and silicon, and their respective metals. Union Carbide retained its plant at Niagara Falls, N.Y., and continued to produce ferrovanadium and ferrotungsten. Consolidated Gold Fields Ltd., an international and diversified precious and nonferrous metals mining firm based in London, attempted to buy a controlling interest in Newmont Mining Corp., the parent of Foote Mineral Co. After 6 months of negotiations between the two companies, an agreement was reached that would limit Gold Fields' interest to 26% of Newmont's stock through the end of 1984. In another proposed merger, the Fesil Group, representing four Norwegian ferroalloy producers, signed a letter of intent in June to acquire Ohio Ferro-Alloys Corp.'s three plants in Philo and Powhatan Point, Ohio, and Montgomery, Ala., which produce ferrosilicon and silicon metal. Toward yearend, the Fesil Group withdrew its offer to purchase the plants and cited unfavorable economics in ferroalloys as the reason.

The Ferroalloys Association reported that its member companies consumed 7.5 billion kilowatt-hours of electricity in 1981, down from 8.0 billion in 1980.

Table 3.—Producers of ferroalloys in the United States in 1981

Producer	Plant location	Products[1]	Type of furnace
FERROALLOYS (EXCEPT FERROPHOSPHORUS)			
Alabama Alloy Co., Inc	Bessemer, AL	FeSi	Electric.
Aluminum Co. of America, Northwest Alloys, Inc	Addy, WA	Si, FeSi	Do.
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	FeSi, Si	Do.
Elkem AS, Elkem Metals Co	Alloy, WV; Ashtabula, OH; Marietta, OH	FeCr, FeMn, FeSi, Si, SiMn, other.[2]	Do.
Engelhard Minerals & Chemicals Corp., Minerals and Chemicals Div	Strasburg, VA	FeV	Metallothermic.
Foote Mineral Co., Ferroalloys Div	Cambridge, OH; Graham, WV; Keokuk, IA	FeSi, FeV, silvery pig iron, other.[2]	Electric.
Hanna Mining Co., The:			
Hanna Nickel Smelting Co	Riddle, OR	FeNi, FeSi	Do.
Silicon Div	Wenatchee, WA	Si, FeSi	Do.
Interlake, Inc., Globe Metallurgical Div	Beverly, OH; Selma, AL	FeCr, Si, FeSi, SiMn.	Do.
International Minerals & Chemical Corp., Industry Group, TAC Alloys Div.	Bridgeport, AL	FeSi	Do.
	Kimball, TN	do	Do.
Macalloy Inc	Charleston, SC	FeCr, FeCrSi	Do.
Metallurg, Inc., Shieldalloy Corp	Newfield, NJ	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	Newton Falls, OH; Solon, OH; Pulaski, PA; Fort Worth, TX	FeAl, FeB, FeCb, FeMo, FeNi, FeTi, FeW, other.[2]	Electric and metallothermic.
Reactive Metals and Alloys Corp	West Pittsburg, PA	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	Do.
Teledyne, Inc., Teledyne Wah Chang, Albany Div	Albany, OR	FeCb	Metallothermic.
Union Carbide Corp., Metals Div	Alloy, WV; Ashtabula, OH; Marietta, OH; Niagara Falls, NY; Portland, OR	FeB, FeCr, FeMn, FeSi, FeV, FeW, Si, SiMn, 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	do	Do.
	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]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; Si, silicon metal; SiMn, silicomanganese.
[2]Includes specialty silicon alloys, zirconium alloys, and miscellaneous ferroalloys.

Table 4.—Consumption of ferroalloys as additives in the United States in 1981, by end use[1]

(Short tons of alloys)

End use	FeMn	SiMn	FeSi	FeTi	FeP	FeB
Steel:						
Carbon	627,601	95,034	[2]115,157	603	12,017	1,194
Stainless and heat-resisting	15,075	4,707	[2]46,847	1,420	(3)	21
Other alloy	167,935	41,846	[2]67,112	870	1,895	432
Tool	586	66	[2]2,373	(3)	--	--
Unspecified	879	1,019	46,300	19	3	--
Total	812,076	142,672	277,789	2,912	13,915	1,647
Cast irons	16,698	9,450	225,119	62	4,035	W
Superalloys	421	W	256	W	--	31
Alloys (excluding alloy steels and superalloys)	13,517	2,725	66,024	161	84	88
Miscellaneous and unspecified	2,098	894	77,979	70	2,011	24
Total consumption	844,810	155,741	647,167	3,205	20,045	1,790
Percent of 1980	104	100	99	105	118	122

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 including other phosphorus materials; FeB, ferroboron including other boron materials.

[2]Part included with "Unspecified."

[3]Included with "Unspecified."

Table 5.—Consumption of ferroalloys as alloying elements in the United States in 1981, by end use[1]

(Short tons of contained elements)

End use	FeCr	FeMo	FeW	FeV	FeCb	FeNi
Steel:						
Carbon	4,992	64	--	1,278	1,161	--
Stainless and heat-resisting	172,823	398	25	35	298	21,179
Other alloy	54,214	1,408	33	3,955	[2]1,194	3,381
Tool	2,711	200	130	584	(3)	(3)
Unspecified	(4)	(4)	--	--	1	--
Total[5]	234,740	2,070	188	5,852	2,654	24,560
Cast irons	6,423	1,128	W	42	--	300
Superalloys	6,931	118	W	20	450	739
Alloys (excluding alloy steels and superalloys)	3,551	275	5	[5]11	15	681
Miscellaneous and unspecified	1,703	50	16	15	3	10
Total consumption	253,348	3,641	209	5,940	3,122	26,290
Percent of 1980	100	92	85	111	96	88

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 including melting base self-reducing tungsten; FeV, ferrovanadium including other vanadium-carbon-iron ferroalloys; FeCb, ferrocolumbium including nickel columbium; FeNi, ferronickel.

[2]Part included with "Unspecified."

[3]Included with "Other alloy."

[4]Included with "Miscellaneous and unspecified."

[5]With minor exceptions as denoted by footnote 4.

CONSUMPTION AND USES

Total ferroalloy consumption in 1981 was little changed from the low levels of 1980. Consumption increased during the first half of the year, but declined in the second half as the economy entered a downturn. Combined consumption for the bulk ferroalloys of manganese, chromium, and silicon for the production of steel increased 4%. For the second consecutive year, reported ferrosilicon consumption for cast irons was lower than that for total steel because of reduced demand by the automotive industry for iron castings. The consumption patterns for ferroalloys closely paralleled the overall production patterns for iron and steel.

Consumption was down for ferronickel, ferromolybdenum, and ferrotungsten by a greater percentage than that for other ferroalloys. This can be attributed primarily to decreased production of tool steels, molybdenum-bearing stainless steels, and superalloys for the depressed commercial aircraft industry. A significant increase in the production of molybdenum-bearing drill pipe for the oil and gas industry was not enough to offset the reduction in consumption of ferromolybdenum for other uses. Demand for ferroalloys of vanadium, boron, and phosphorus to make alloy and carbon steels was up in 1981, and accounts for the relatively higher consumption percentage for each of these ferroalloys.

Table 6.—Stocks of ferroalloys held by producers and consumers in the United States at yearend

(Short tons)

	Producer		Consumer		Total	
	1980 (gross weight)	1981 (gross weight)	1980 (gross weight)	1981 (gross weight)	1980 (gross weight)	1981 (gross weight)
Manganese ferroalloys[1]	72,654	95,909	175,303	172,023	247,957	267,932
Silicon alloys[2]	120,795	167,026	43,015	43,587	163,810	210,613
Ferrochromium[3]	43,920	60,002	60,203	56,068	104,123	116,070
Ferroboron[4]	W	W	305	317	305	317
Ferrophosphorus[5]	104,852	133,296	2,631	2,887	107,483	136,183
Ferrotitanium	W	W	659	655	659	655
Total	342,221	456,233	282,116	275,537	624,337	731,770
	1980 (contained element)	1981 (contained element)	1980 (contained element)	1981 (contained element)	1980 (contained element)	1981 (contained element)
Ferrocolumbium[6]	W	W	W	W	982	934
Ferromolybdenum[7]	1,249	1,010	754	457	2,003	1,467
Ferronickel	W	W	r2,046	2,257	r2,046	2,257
Ferrotungsten[8]	W	W	54	48	54	48
Ferrovanadium[9]	r746	1,683	770	548	r1,516	2,231
Total	r1,995	2,693	r3,624	3,310	r6,601	6,937

rRevised. W Withheld to avoid disclosing company proprietary data.
[1]Includes ferromanganese, silicomanganese, and manganese metal.
[2]Includes ferrosilicon, miscellaneous silicon alloys, and silicon metal.
[3]Includes other chromium alloys and chromium metal.
[4]Consumer totals include other boron materials.
[5]Consumer totals include other phosphorus materials.
[6]Consumer totals include nickel columbium.
[7]Consumer totals include calcium molybdate.
[8]Consumer totals include melting base self-reducing tungsten.
[9]Includes other vanadium-iron-carbon ferroalloys.

PRICES

Price increases for most ferroalloys produced domestically were limited by weak demand and strong competition from foreign imports, despite rising production costs. Listed producer prices for ferromanganese, most low-carbon ferrochromium grades, ferrochromium-silicon, and regular-grade ferrocolumbium did not change during the year, but high-carbon ferrochromium prices advanced 7% in July. Ferrosilicon, magnesium ferrosilicon, and silicon metal prices were raised in both January and October, culminating in a total increase of between 13% and 17% for each alloy or metal specification. The price of silicomanganese advanced from $0.245 to $0.265 per pound of alloy in June, the first increase since May 1979. In spite of weak demand, ferrovanadium producers increased prices 10% in January to $8.50 per pound of vanadium. Depressed prices for ferromolybdenum, ferronickel, and high-purity ferrocolumbium reflected weak demand and oversupply conditions. For ferromolybdenum, this is a reversal of the sharp escalation of prices that resulted from the shortage of molybdenum in both 1978 and 1979. Posted prices for imported ferroalloys were generally 9% to 27% lower than those of domestically produced ferroalloys.

Alloy	End of year price[1] 1980	1981
Charge chromium (66% to 70%)	$0.485	$0.52
Low-carbon ferrochromium, 0.02% maximum carbon (Simplex)	.95	1.00
Standard 78% ferromanganese, per long ton of alloy	490.00	490.00
Ferromolybdenum, lump	11.52	9.40
Ferronickel	3.40	3.16
Ferrosilicon, 50%	.42	.4925
Ferrosilicon, 75%	.4625	.5325

[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 rose sharply from $493 million in 1980 to $702 million in 1981. This deficit, the largest ever recorded, has climbed steadily from $7 million in 1970. In contrast, deficits ranged from $4 million to $54 million during the 1960 decade.

The quantity of ferroalloy exports on a gross weight basis decreased 51% to 0.06 million tons in 1981, about the same low level that it was 20 years ago. Exports over the past 2 decades have remained relatively constant, fluctuating between 0.03 and 0.2 millions tons. The value and quantity of exports in 1981 were 7% and 4% those of imports, respectively.

Total imports of ferroalloys and ferroalloy metals increased 32% to 1.5 million tons, a record high quantity. The most marked change occurred in ferrosilicon imports, which more than doubled. Ferroalloy imports were equal to two-thirds of reported domestic consumption. Although demand for ferroalloys was greater in the United States than in most other steelmaking countries, domestic producers found it difficult to compete with the low-priced foreign imports.

Ferroalloys and ferroalloy metals imported into the United States in 1981 had the following breakdown by region: Africa 43%, Europe 30%, and the Western Hemisphere 21%. The Republic of South Africa and Zimbabwe collectively supplied 76% of the chromium ferroalloy imports, down from 90% in 1980. Yugoslavia and Brazil picked up a larger share of the U.S. market and together shipped 16% of the chromium ferroalloys. Major sources for imported manganese ferroalloys were the Republic of South Africa with 37% and France with 24%. The Western Hemisphere furnished 20% of the manganese ferroalloy imports with Canada, Brazil, and Mexico as the leading suppliers. Leading suppliers of ferrosilicon were Brazil (29%), Norway (20%), Venezuela (15%), and Canada (13%).

On March 11, the U.S. Court of International Trade ruled that preferential railroad rates for exported cargos in the Republic of South Africa constituted a bounty or grant. This ended a 4-year court battle between domestic and South African high-carbon ferrochromium producers. The Court placed a provisional 4% countervailing duty on South African high-carbon ferrochromium imports. The duty was lifted in June when the Republic of South Africa instituted a uniform rail rate system. In May, the International Trade Commission (ITC) was petitioned by domestic high-carbon ferrochromium producers to extend for 3 years the floor price and penalty duty on imported high-carbon ferrochromium, which would expire November 15. The additional charge was 4 cents per pound of contained chromium on all high-carbon ferrochromium entering the United States below a floor price of 38 cents per pound of contained chromium. After considering the recommendations of the ITC, the President extended the import trade relief for 1 year. On August 18, in response to a petition submitted by The Ferroalloys Association, the Office of Industrial Mobilization, U.S. Department of Commerce, launched an investigation under the authority of section 232 of the Trade Expansion Act of 1962 as to whether imports of chromium, manganese, and silicon ferroalloys constituted a threat to national security.

Table 7.—U.S. exports of ferroalloys

Alloy	1979		1980		1981	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Ferrocerium and alloys	42	$273	17	$196	11	$117
Ferrochromium	14,762	14,558	31,705	22,233	14,098	10,361
Ferromanganese	25,344	19,252	11,686	7,657	14,925	12,477
Silicomanganese	5,243	2,627	6,489	3,468	3,941	2,172
Ferromolybdenum	840	10,029	880	17,104	228	2,984
Ferrophosphorus	37,292	3,678	44,692	6,778	7,463	2,031
Ferrosilicon	22,357	14,740	27,488	18,572	15,768	12,136
Ferrovanadium	879	7,881	802	6,995	434	4,397
Ferroalloys, n.e.c	6,441	12,616	4,710	10,130	6,358	8,439
Total[1]	113,200	85,655	128,470	93,133	63,226	55,114

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

Table 8.—U.S. imports for consumption of ferroalloys and ferroalloy metals

Alloy	1980			1981		
	Gross weight (short tons)	Content (short tons)	Value (thousands)	Gross weight (short tons)	Content (short tons)	Value (thousands)
Manganese alloys:						
Ferromanganese containing less than 1% carbon	3,957	3,483	$3,455	3,207	2,788	$3,065
Ferromanganese containing over 1% and less than 4% carbon	38,409	31,121	23,747	31,904	25,749	18,496
Ferromanganese containing 4% or more carbon	563,336	438,795	184,163	636,067	493,289	205,057
Ferrosilicon-manganese (Mn content)	74,975	49,158	29,291	129,005	84,900	49,754
Spiegeleisen	2,850	(1)	177	103	(1)	67
Total manganese alloys	(2)683,528	522,557	240,833	800,286	606,726	276,439
Ferrosilicon:						
8%-30% silicon	1,187	184	126	2,783	393	177
30%-60% silicon, over 2% magnesium	5,523	2,706	5,293	4,360	2,011	3,671
30%-60% silicon, n.e.c	14,108	6,971	7,621	14,242	7,451	9,522
60%-80% silicon, over 3% calcium	8,373	6,020	6,217	16,217	11,089	11,343
60%-80% silicon, n.e.c	41,729	30,993	23,271	116,778	87,963	54,918
80%-90% silicon	97	80	55	1,153	980	568
Over 90% silicon	135	124	56	115	111	118
Total ferrosilicon	71,152	47,078	42,639	155,648	109,998	80,317
Chromium alloys:						
Ferrochromium containing 3% or more carbon	275,227	158,806	128,162	387,637	219,961	173,529
Ferrochromium containing less than 3% carbon	21,993	15,293	25,328	40,602	27,453	40,082
Ferrosilicon-chromium	5,082	1,967	2,313	11,435	4,402	5,224
Total chromium alloys	302,302	176,066	155,803	439,674	251,816	218,835
Ferronickel	51,742	16,667	104,156	69,853	20,247	119,321
Other ferroalloys:						
Ferrocerium and other cerium alloys	72	(1)	902	92	(1)	1,249
Ferromolybdenum	23	15	243	587	459	6,353
Ferrophosphorus	4	(1)	10	61	(1)	28
Ferrotitanium and ferrosilicon titanium	623	(1)	1,679	615	(1)	1,582
Ferrotungsten and ferrosilicon tungsten	272	223	4,039	198	162	3,020
Ferrovanadium	327	263	3,477	1,236	984	13,288
Ferrozirconium	981	(1)	1,222	877	(1)	1,223
Ferroalloys, n.e.c.(3)	4,826	(1)	30,942	5,816	(1)	34,392
Total other ferroalloys	7,128	XX	(2)42,513	9,482	XX	61,135
Total ferroalloys	(2)1,115,854	XX	585,944	1,474,943	XX	756,047
Metals:						
Manganese	7,915	(1)	8,032	8,343	(1)	8,419
Silicon (96%-99% silicon)	15,887	(1)	15,607	17,776	(1)	18,485
Silicon (99%-99.7% silicon)	5,370	5,322	5,760	11,026	10,926	12,188
Chromium	4,075	(1)	28,367	3,539	(1)	24,626
Total ferroalloy metals	33,247	XX	57,766	40,684	XX	63,718
Grand total	1,149,101	XX	(2)643,711	1,515,627	XX	819,765

XX Not applicable.
[1]Not recorded.
[2]Data do not add to total shown because of independent rounding.
[3]Principally ferrocolumbium.

WORLD REVIEW

World ferroalloy production and consumption was again lower than that of the preceding year because of reduced steel production. Ferroalloy production increased in only a few countries, including India and Zimbabwe, which have active ferroalloy industries and domestic ore supplies. However, production in major producing countries such as the United States, France, Japan, and the Republic of South Africa was lower. Although world production was lower, new capacity was being added. Construction of the new capacity near the ore supply, not the consumption site, continued to be the trend.

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]	1977	1978	1979	1980[p]	1981[e]
Albania: Electric furnace, ferrochromium[e]	--	--	NA	16	28
Argentina: Electric furnace:					
Ferromanganese	[r]40	28	41	[r e]39	38
Silicomanganese	7	11	18	[r e]17	15
Ferrosilicon	17	11	17	[r e]15	14
Other	1	1	3	[r e]2	2
Total	[r]65	51	79	73	69
Australia: Electric furnace:[5]					
Ferromanganese	78	105	95	95	94
Silicomanganese	26	--	22	21	21
Ferrosilicon	21	21	21	21	20
Total	125	126	138	137	135
Austria: Electric furnace, undistributed	8	8	10	9	9
Belgium: Electric furnace, ferromanganese[6]	61	96	99	94	99
Brazil: Electric furnace:					
Ferromanganese	142	130	147	155	[7]141
Silicomanganese	83	117	141	148	[7]135
Ferrosilicon	66	80	83	120	[7]136
Silicon metal	5	6	6	14	[7]15
Ferrochromium	73	69	93	103	[7]129
Ferrochromium-silicon	5	5	8	9	[7]11
Ferronickel	12	12	13	12	[7]12
Other	23	32	42	47	[7]42
Total	409	451	533	608	[7]621
Bulgaria: Electric furnace:					
Ferromanganese[e 8]	33	31	31	31	31
Ferrosilicon[e]	21	19	18	18	18
Other[e]	1	1	1	1	1
Total	55	51	50	[e]50	50
Canada: Electric furnace:					
Ferromanganese[e 8]	66	77	[r]45	[r]95	120
Ferrosilicon	126	143	105	153	[7]121
Silicon metal	25	31	29	43	[7]31
Other[e 9]	13	25	[r]13	[r]28	38
Total	[e]230	[e]276	192	319	[7]310
Chile: Electric furnace:					
Ferromanganese	5	6	6	[e]6	6
Silicomanganese	([10])	([10])	([10])	[e]([10])	([10])
Ferrosilicon	3	2	6	[r e]6	5
Other	1	([10])	1	[e]1	1
Total	9	8	13	[r e]13	12
China:[e]					
Furnace type unspecified:					
Ferromanganese[8]	255	340	375	375	370
Ferrosilicon	120	165	180	[r]185	180
Silicon metal	5	9	10	15	15
Ferrochromium[11]	80	100	100	100	100
Other[9]	40	46	55	55	55
Total	500	660	720	[r]730	720
Colombia: Electric furnace, ferrosilicon[12]	[r]1	[r]1	1	1	1
Czechoslovakia: Electric furnace					
Ferromanganese[e 8]	110	110	110	[r]110	108
Ferrosilicon[e]	39	39	36	[r]35	34
Silicon metal[e]	5	6	6	6	6
Ferrochromium[e]	33	33	31	30	30
Other[e 9]	11	13	10	[r]10	9
Total[13]	198	201	193	191	187

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]	1977	1978	1979	1980[p]	1981[e]
Dominican Republic: Electric furnace, ferronickel	[r]73	41	73	47	[7]55
Egypt: Electric furnace, ferrosilicon	5	[e]5	--	--	--
Finland: Electric furnace, ferrochromium	37	49	54	58	58
France:					
Blast furnace:					
Spiegeleisen	10	7	10	11	7
Ferromanganese	395	430	485	518	337
Electric furnace:					
Silicomanganese[14]	23	21	14	23	[7]10
Ferrosilicon	266	219	300	271	[7]221
Silicon metal	47	46	61	66	66
Ferrochromium[11]	112	102	105	95	[7]13
Other[15]	139	143	157	137	[7]126
Total	[r]992	968	1,132	1,121	[7]780
German Democratic Republic:					
Blast furnace, spiegeleisen	--	4	--	--	--
Electric furnace:					
Ferromanganese[e 8]	98	88	88	86	86
Ferrosilicon[e]	22	34	33	32	32
Silicon metal[e]	3	4	4	4	4
Ferrochromium[e]	26	28	23	22	22
Other[e 9]	21	23	22	21	21
Total[13]	170	181	170	165	165
Germany, Federal Republic of:					
Blast furnace:					
Ferromanganese	193	231	257	220	[7]236
Ferrosilicon	96	86	87	71	[7]55
Electric furnace:					
Ferromanganese[e 8]	55	17	33	28	21
Ferrosilicon[e]	55	33	55	55	46
Ferrochromium[e]	61	55	66	66	55
Other[e 9]	60	48	56	55	47
Total	520	470	554	495	460
Greece: Electric furnace, ferronickel	39	61	60	56	56
Hungary: Electric furnace:					
Ferromanganese[8]	3	3	5	3	3
Ferrosilicon	8	8	9	11	12
Silicon metal[e]	2	2	2	2	2
Total[13]	13	13	16	16	17
Iceland: Electric furnace, ferrosilicon	--	--	17	28	[7]28
India: Electric furnace:					
Ferromanganese	213	243	208	179	[7]230
Silicomanganese	[r]11	3	6	5	[7]10
Ferrosilicon	49	58	56	47	[7]66
Silicon metal	1	[r]3	3	3	3
Ferrochromium	20	24	24	18	[7]34
Ferrochromium-silicon	5	4	4	4	[7]5
Other	[r]1	[r]1	1	1	1
Total	[r]300	336	302	257	349
Indonesia: Electric furnace, ferronickel	24	22	20	20	20
Italy:					
Blast furnace:					
Spiegeleisen	7	3	3	6	[7]1
Ferromanganese	64	68	74	67	[7]65
Electric furnace:					
Ferromanganese	19	31	24	24	24
Silicomanganese	44	47	60	50	[7]60
Ferrosilicon	84	75	89	79	[7]61
Silicon metal	18	16	[e]17	[e]17	17
Ferrochromium	44	41	47	45	[7]11
Ferrochromium-silicon	--	([10])	--	--	--
Other[16]	9	8	12	16	[7]17
Total[16]	289	289	326	304	256

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]	1977	1978	1979	1980[p]	1981[e]
Japan: Electric furnace:					
Ferromanganese	581	502	665	627	[7]626
Silicomanganese	368	334	330	342	[7]312
Ferrosilicon	321	298	352	335	[7]259
Silicon metal	41	16	17	17	[7]13
Ferrochromium	440	302	403	444	[7]337
Ferrochromium-silicon	13	10	14	23	[7]12
Ferronickel	247	219	335	305	[7]269
Other	23	22	24	26	[7]16
Total	2,034	1,703	2,140	2,119	[7]1,844
Korea, North: Furnace type unspecified:					
Ferromanganese[e] [8]	62	72	72	77	77
Ferrosilicon[e]	25	33	33	33	33
Other[e] [9]	13	15	15	22	22
Total[e]	100	120	120	132	132
Korea, Republic of: Electric furnace:					
Ferromanganese	[e] [17]40	[e] [17]52	[17]58	60	[7]71
Ferrosilicon	[17]30	[17]34	[17]42	33	[7]39
Other[17] [18]	[e]1	[e]1	23	27	[7]31
Total	71	87	123	120	[7]141
Mexico: Electric furnace:					
Ferromanganese	110	118	136	138	138
Silicomanganese	30	37	34	34	33
Ferrosilicon	25	27	27	30	28
Ferrochromium	3	5	5	--	--
Other	([10])	1	1	2	2
Total	168	188	203	204	201
New Caledonia: Electric furnace, ferronickel	[r] [e]132	[r] [e]86	136	146	125
Norway: Electric furnace:					
Ferromanganese	269	301	372	326	[7]247
Silicomanganese	140	147	203	185	[7]218
Ferrosilicon	246	293	372	353	[7]302
Silicon metal[e]	56	70	77	94	[7]100
Ferrochromium	25	17	13	12	[7]13
Ferrochromium-silicon	([10])	1	1	([10])	[7]1
Other	34	33	33	22	[7]13
Total[13]	770	862	1,071	992	[7]894
Peru: Electric furnace:					
Ferromanganese	--	[e]1	[e]1	[e]1	1
Ferrosilicon	([10])	[e]1	[e]1	[e]1	1
Total	([10])	[e]2	[e]2	[e]2	2
Philippines: Electric furnace, ferrosilicon[e] [19]	17	15	20	[e]22	22
Poland:					
Blast furnace:					
Spiegeleisen	12	8	9	11	8
Ferromanganese	136	131	143	134	131
Electric furnace:					
Ferromanganese[e] [8]	55	55	[r]57	[r]57	56
Ferrosilicon[e]	61	58	[r]63	[r]61	61
Silicon metal[e]	12	12	12	11	11
Ferrochromium[e]	55	55	[r]57	[r]57	56
Other[e] [9]	21	18	[r]17	[r]14	14
Total[13]	352	337	358	345	337
Portugal: Electric furnace:					
Ferromanganese[e] [20]	61	86	83	82	81
Silicomanganese[e] [20]	5	17	17	19	20
Ferrosilicon[e]	26	33	28	28	26
Silicon metal[e]	15	22	35	36	35
Other[e]	([10])	([10])	([10])	([10])	([10])
Total[13]	[r] [e]107	158	163	165	162

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]	1977	1978	1979	1980[p]	1981[e]
South Africa, Republic of: Furnace type unspecified:					
Ferromanganese[e]	[r]342	[r]364	[r]617	[r]551	496
Silicomanganese[e]	[r]24	[r]24	[r]50	[r]66	55
Ferrosilicon[e]	[r]82	[r]83	[r]164	[r]157	121
Silicon metal[e]	31	36	39	[r]33	33
Ferrochromium[e]	[r]386	[r]728	[r]860	[r]871	827
Ferrochromium-silicon[e]	[r]25	[r]25	[r]26	[r]31	22
Other[e] [21]	([10])	([10])	([10])	([10])	([10])
Total[13]	[r]890	[r]1,260	1,756	1,709	1,554
Spain: Electric furnace:					
Ferromanganese	156	148	163	132	101
Silicomanganese	70	120	138	136	69
Ferrosilicon	75	108	132	102	101
Silicon metal[e]	18	22	22	22	20
Ferrochromium	18	15	22	18	19
Other	([10])	([10])	[e]1	[e]1	1
Total[13]	337	413	478	411	311
Sweden: Electric furnace:					
Silicomanganese	--	--	--	--	--
Ferrosilicon	25	1	--	--	--
Silicon metal	14	10	[e]18	[e]18	18
Ferrochromium	148	183	209	208	210
Ferrochromium-silicon	9	5	32	22	24
Other	2	2	3	3	3
Total[13]	198	201	262	251	255
Switzerland: Electric furnace:					
Ferrosilicon[e]	6	[r]7	6	6	6
Silicon metal[e]	3	3	3	3	3
Total[e]	9	[r]10	9	9	9
Taiwan: Electric furnace, ferrosilicon	27	33	41	39	[r]44
Thailand: Electric furnace:					
Ferromanganese	1	1	1	([10])	([10])
Ferrosilicon	--	2	2	([10])	([10])
Total	1	3	3	([10])	([10])
Turkey: Electric furnace:					
Ferromanganese[e]	1	1	1	1	1
Ferrosilicon[e]	3	3	3	3	3
Ferrochromium[e]	[r]39	44	33	[r]35	36
Total[e]	[r]43	48	37	[r]39	40
U.S.S.R.:					
Blast furnace:					
Spiegeleisen	[r]83	[r]83	[r] [e]55	[r] [e]50	44
Ferromanganese	[r]800	[r]800	[r] [e]605	[r] [e]605	595
Other	110	110	[e]110	[r] [e]80	80
Electric furnace:[22]					
Ferromanganese[e]	610	[r]810	[r]1,000	[r]1,300	1,300
Silicomanganese[e]	33	33	33	35	35
Ferrosilicon[e]	661	683	694	695	700
Silicon metal[e]	52	52	63	65	65
Ferrochromium[e]	[r]590	[r]610	[r]610	[r]700	710
Ferrochromium-silicon[e]	11	11	11	11	11
Other[15]	198	204	[r]214	[r]220	230
Total	[r]3,148	[r]3,396	[r]3,395	[r]3,761	3,770
United Kingdom:					
Blast furnace, ferromanganese	107	76	151	57	101
Electric furnace, undistributed[e]	16	18	18	13	14
Total	123	94	169	70	115

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]	1977	1978	1979	1980[p]	1981[e]
United States: Furnace type unspecified:[23]					
Ferromanganese	334	273	317	189	[7]193
Silicomanganese	120	142	165	188	[7]173
Ferrosilicon	776	703	712	559	[7]550
Silicon metal	118	116	145	127	[7]130
Ferrochromium	217	195	269	[24]239	[7]227
Ferrochromium-silicon	53	24	26	([24])	([24])
Other[25]	136	213	241	244	[7]219
Total[26]	1,754	1,666	1,875	1,547	[7]1,493
Uruguay: Electric furnace, ferrosilicon	([10])	([10])	([10])	--	--
Venezuela: Electric furnace:					
Ferromanganese	--	--	1	2	2
Silicomanganese	--	--	1	2	2
Ferrosilicon	[e]12	31	43	24	24
Total	[e]12	31	45	28	28
Yugoslavia: Electric furnace:					
Ferromanganese	60	41	50	[e]49	60
Silicomanganese	10	31	32	[r e]31	32
Ferrosilicon	61	66	75	[r e]74	75
Silicon metal	30	34	35	[r e]34	37
Ferrochromium	40	[r]56	72	[r e]69	74
Ferrochromium-silicon	6	9	7	[r e]8	9
Other	2	3	4	[e]3	4
Total	209	[r]240	275	268	[7]291
Zimbabwe: Electric furnace:					
Ferromanganese[e]	NA	NA	3	3	2
Ferrochrome[e]	220	220	220	220	285
Total	220	220	223	223	287
Grand total[26]	[r]14,845	[r]15,537	[r]17,656	[r]17,410	16,542
Of which:					
Blast furnace:					
Spiegeleisen[27]	[r]112	[r]105	77	78	60
Ferromanganese[27]	[r]1,695	[r]1,736	1,715	1,601	1,465
Other[28]	206	196	197	151	135
Total blast furnace	[r]2,013	[r]2,037	1,989	1,830	1,660
Electric furnace:[29]					
Ferromanganese[30]	[r]2,867	[r]3,081	3,523	3,723	[7]3,687
Silicomanganese[30 31]	[r]994	[r]1,084	1,264	1,302	[7]1,200
Ferrosilicon	[r]3,382	[r]3,425	3,836	3,632	[7]3,390
Silicon metal	501	[r]516	604	630	[7]624
Ferrochromium[32]	[r]2,667	[r]2,931	3,316	[24]3,426	[7 24]3,274
Ferrochromium-silicon[32]	[r]127	[r]94	129	[24]108	[7 24]95
Ferronickel[33]	[r]527	[r]441	637	586	[7]537
Other[33]	[r]750	[r]853	949	959	[7]916
Undistributed	24	26	28	22	[7]23
Total electric furnace	[r]11,839	[r]12,451	14,286	14,388	[7]13,746

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]	1977	1978	1979	1980[p]	1981[e]
Furnace type unspecified:					
Ferromanganese and total[29]	[r]993	[r]1,049	1,381	1,192	1,136

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available.
[1]Table includes data available through June 28, 1982.
[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 as blast furnace ferromanganese and spiegeleisen but believed to be electric furnace output.
[7]Reported figure.
[8]Includes silicomanganese.
[9]Includes ferrochromium-silicon and ferronickel, if any was produced.
[10]Less than 1/2 unit.
[11]Includes ferrochromium-silicon, if any was produced.
[12]Colombia is reported to also produce ferromanganese, but output is not reported quantitatively and no basis is available for estimation.
[13]Total for 1977-80 represents an estimate for silicon metal plus a reported total for all other types.
[14]Includes silicospiegeleisen.
[15]Includes ferronickel, if any was produced.
[16]Series excludes calcium silicide.
[17]It appears likely that the Republic of Korea produced silicomanganese during 1977-81; during 1977-79, silicomanganese output presumably was included in reported output, but whether it was included with ferromanganese or with ferrosilicon is not clear; in 1980 and 1981, it presumably was included with "Other."
[18]Estimates for 1977-79 represent ferrotungsten only; figures for 1980 and 1981 presumably include silicomanganese as well as other unspecified ferroalloys, possibly ferrochromium, but available information is inadequate to permit distribution by type.
[19]Based on exports; additional quantities may be consumed in the Philippines.
[20]Estimated figures based on reported exports and an allowance for domestic use.
[21]Ferrovanadium only; other minor ferroalloys may be produced, but no basis is available for estimation.
[22]Soviet production of electric furnace ferroalloys is not reported; estimates provided are based on crude source material production and availability for consumption (including estimates) and upon reported ferroalloy trade, including data from trading partner countries.
[23]U.S. production of ferromanganese cannot be separated by furnace type in order to conceal corporate proprietary information. Similarly, ferronickel production cannot be separately reported. All U.S. ferroalloy production except a portion of ferromanganese output in 1977 is from electric furnaces or metallothermic operations.
[24]U.S. output of ferrochromium-silicon included with ferrochromium.
[25]Includes ferronickel.
[26]Data may not add to totals shown because of independent rounding.
[27]Spiegeleisen for the Federal Republic of Germany is included with blast furnace ferromanganese.
[28]Includes the following quantities specifically identified as ferrosilicon: 1977—96; 1978—86; 1979—87; 1980—71; 1981-55. The remainders are not identified except that they are not spiegeleisen or ferromanganese.
[29]Although furnace type has not been specified for any ferroalloy production for China, North Korea, the Republic of South Africa, and the United States, all output of these countries has been included under electric furnace (and metallothermic) output except for their production of ferromanganese, which is reported separately below.
[30]Ferromanganese includes silicomanganese (if any was produced) for countries carrying footnote 8 on ferromanganese data line.
[31]Includes silicospiegeleisen for France.
[32]Ferrochromium includes ferrochromium-silicon (if any was produced) for countries carrying footnote 11 on ferrochromium data line.
[33]"Other" includes ferronickel production for France, Norway, the U.S.S.R., and the United States.

Albania.—Fondmetall AB signed its first multiyear contract with Albania to market Albania's ferrochrome production of 28,000 tons per year. Fondmetall AB is a metals and steel trading company in Sweden.[2]

Australia.—Agnew Clough Ltd. announced plans for a $51.5 million silicon metal plant with an initial capacity of 30,000 tons per year. The plant would be built at Wundowie, Western Australia, and will be Australia's first silicon smelter. Production was to commence in 1983.[3]

Belgium.—The Belgian Government was to contribute toward the establishment of a new ferromanganese-producing company that would absorb Sadaci's operations and fixed assets.[4] Sadaci, a subsidiary of Sadacem Ltd., had several years of problems with its ferromanganese operations at its Langerbruggekaai plant.

Brazil.—Ferroalloy capacity in Brazil continued to expand. In the 2-year period, 1980-81, capacity for all ferrosilicon increased 50% to 146 megavolt-amperes, and capacity for 75% ferrosilicon doubled.[5]

Canada.—Construction of a 50,000-ton-per-year ferrosilicon plant in Kimberly, British Columbia, was expected to be announced by a consortium of five companies including Cominco Ltd. and Mitsui & Co. Production was scheduled to begin in 1984.[6]

A joint feasibility study on production of ferrosilicon in British Columbia was also being conducted by SKW Canada Ltd. and Japan's Sumitomo Corp. Production capacities of either 28,000 or 55,000 tons per year were being considered. Most of the plant's output would be consumed by the Japanese iron and steel industry.[7]

Norwegian groups led by Elkem AS obtained an option to acquire two Union Carbide Corp. ferroalloy plants in Quebec before 1988. The Quebec plants, Beauharnois and Chicoutimi, primarily produce ferromanganese and ferrosilicon, respectively.[8]

China.—China has changed from being a net importer to a net exporter of ferroalloys. Exports of ferrosilicon and silicon metal to Japan were especially strong during the year. China's total ferroalloy capacity was estimated at 750,000 tons per year.[9]

Dominican Republic.—At midyear, Falconbridge Dominicana C. por A. began operating its Dominicana ferronickel operation at 50% capacity. The company was considering converting its expensive oil-based operation to a less costly coal-based one.[10]

Greece.—A $65 million ferrochromium plant with a capacity of 30,000 tons per year was being constructed in Greece by Outokumpu Oy of Finland. Elsi-Greek Ferroalloys S.A. was managing the project. Elsi is a subsidiary of Elevine, a Greek industrial and mining company. Part of the cost was to be financed by Finnish export credits. The plant was scheduled for completion by the end of 1983.[11]

India.—A proposal to build a charge chrome plant which will have an annual capacity of 55,000 tons was submitted by Indian Metals & Ferro Alloys Ltd. for Government consideration. In addition, the Karnataka Government-owned Mysore Minerals Ltd. was considering the construction of a charge chrome plant at Byrapura. Most of India's charge chrome production is slated for export.[12]

Uniferro International, Ltd., a subsidiary of Universal Ferro & Allied Chemicals, Ltd., started producing ferromanganese in 1981 at its new 65,000-ton-per-year plant in Tumsar.[13]

Indonesia.—Japan's Pacific Metals Co. Ltd. and Indonesia's state-owned PT Aneka Tambang reached an agreement to erect jointly a 17,000- to 22,000-ton-per-year ferrosilicon plant in Celebes by 1985. The Government was also planning to build a 135,000-kilovolt-ampere hydroelectric power station for its expanding ferronickel operation. The powerplant could also satisfy the energy requirements of the ferrosilicon plant.[14]

Japan.—Production of ferroalloys continued to be restrained because of sharply rising power costs, competition from cheap imports, and weak markets. The most marked reduction in Japanese output involved the power-intensive ferroalloys of silicon and chromium. China flooded the Japanese market with ferrosilicon and silicon metal. Announcements that Fukuden Kogyo Co. Ltd. and Kureha Seitetsu Co. Ltd. would close their 1,900- and 27,000-ton-per-year plants, respectively, continued the trend toward less ferrosilicon production in Japan.[15]

Norway.—Norwegian interests, led by Elkem AS, acquired Union Carbide's ferroalloy plants in Meraker and Sauda, Norway, along with three U.S. plants in a package deal that became effective on July 1. Elkem AS also has an option to purchase two of Union Carbide's ferroalloy plants in Quebec, Canada, before 1988. At its recently acquired 22,000-ton-per-year Meraker plant, Elkem was forced to cut back silicon and ferrosilicon production because of high inventories. Poor economic conditions may result in the permanent closure of the Fesil-Nord & Co. operations. Toward yearend, the Norwegian ferroalloy industry was operating at only 50% to 60% of capacity, and plans to expand operations were curtailed. The Norwegian ferroalloys industry requested the Government's assistance to lower electricial power rates and to postpone pollution abatement requirements.[16]

South Africa, Republic of.—The continued worldwide low level of stainless steel production during 1981 resulted in an excess of ferrochromium capacity in the Republic of South Africa, the world's largest producer. Cutbacks in production, implemented by South African Manganese Amcor Ltd., the world's largest producer of ferroalloys, ranged from 15% to 35% for short periods.[17]

Spain.—Ferroaleaciones Especiales Asturianas S.A. added ferrotitanium to its speciality ferroalloys line in June. The alloy is being produced at the Maqua plant near Aviles in a new 1.7-ton induction furnace that has an annual capacity of 2,000 tons.[18]

Sudan.—A Japanese mission is studying the possibility of building a 5,000- to 15,000-ton-per-year ferrochromium plant in the Ingessana Hills, south of Khartoum, which are reported to have a source of high-quality chrome ore.[19]

United Kingdom.—Ferromanganese production at British Steel Corp. began to recover from the strike that occurred in 1980. Although ferromanganese production in 1981 was up from the low levels of 1980, it was still down compared with that of 1979.

Venezuela.—Fesilven, formerly Venbozel, and its foreign creditors were negotiating a new agreement that would reschedule its foreign debt. The ferrosilicon producer has had a history of financial problems since its startup in 1975.[20]

Yugoslavia.—Dalmacija planned to install a 30-megavolt-ampere ferrosilicon furnace with an annual capacity of 17,000 tons at its ferroalloys complex at Dugi Rat near Split. Startup was slated for 1983.[21]

Zimbabwe.—Zimbabwe Mining and Smelting Co., a subsidiary of Union Carbide Corp., increased its ferrochromium capacity 55% to 230,000 tons by adding two new furnaces rated at 18 megawatts each. The furnaces, capable of a combined annual production of 83,000 tons, are located in Que Que and cost $30 million. One of the furnaces started production in 1981; the other was to come onstream in 1982.[22] Rhodall abandoned plans to double its current 79,000-ton-per-year ferrochromium capacity at its Gwelo plant because of increased production costs and higher wages. The company had planned to build three new ferrochromium furnaces but all plans were shelved despite extensive research into the project.[23]

TECHNOLOGY

Bureau of Mines research to reduce U.S. dependence on imported strategic and critical materials included investigation of novel methods to produce chromium ferroalloys from low-grade domestic resources in the Western States, and to develop substitutes to replace part or all of the chromium in stainless steels and other alloys that contain chromium.

Ferrochromium and silicon metal are currently made in submerged-arc electric furnaces. A unique but different process has been developed for each of these products. The new process for ferrochromium involves the first commercial application of a 10.8-megawatt plasma smelter in the Republic of South Africa at the Middelburg Steel and Alloys (Pty.) Ltd. plant in Krugersdorp. The prototype, a 1.4-megawatt experimental model, was developed and tested by Tetronics Research and Development of the United Kingdom in association with Foster Wheeler Energy Limited. A plasma furnace smelts materials by subjecting them to high temperatures created by partially ionizing a gas between two or more electrodes.[24] The new process for silicon metal was developed and patented by scientists at Stanford University in California. This high-temperature electrolytic process extracts silicon from diatomaceous earth and is analogous to the Hall process for aluminum production. Stanford reported that the process yields silicon metal that is 99.98% pure.[25]

A promising new development in casting ferroalloys and silicon metal is the Granshot method, developed by Uddeholms AB of Sweden, and marketed by Elkem AS of

Norway.The process consists of tapping the metal into a tundish and allowing the stream produced at the spout to strike a refractory brick. At this point, the molten metal disperses and the droplets fall into a water-filled tank. The noise and pollution from the crushing operations are eliminated when this method is used.[26]

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Fluorspar

By Lawrence Pelham[1]

Domestic shipments of finished fluorspar increased in 1981 for the first time in 5 years. Reported domestic consumption decreased in 1981, the third consecutive year of declining fluorspar consumption, primarily because of economic conditions and their impact on the U.S. production of steel. Byproduct fluosilicic acid (H_2SiF_6) recovery by domestic phosphoric acid plants was below 1980 production. In the chemical industry, H_2SiF_6 augments fluorspar as a source of fluorine. Prices for all grades of Mexican fluorspar increased by 15% on January 1. Most other world prices remained near 1980 levels.

The United States continued to depend on foreign sources to supply over 85% of its fluorspar requirements. Mexico remained the major supplier of metallurgical- and acid-grade fluorspar. The Republic of South Africa was a significant source of acid-grade material in 1981. China showed potential for increasing its capacity as a supplier of metallurgical- and acid-grade material.

Table 1.—Salient fluorspar statistics[1]

	1977	1978	1979	1980	1981
United States:					
Production:					
Mine production ____ short tons	613,000	447,876	407,054	372,092	415,862
Material beneficiated ____ do	538,000	447,560	355,655	321,219	419,058
Material recovered ____ do	164,600	124,947	106,099	88,831	111,281
Finished (shipments) ____ do	169,489	129,428	109,299	92,635	115,404
Value f.o.b. mine ____ thousands	$16,479	$13,261	$12,162	$12,611	$18,412
Exports ____ short tons	6,642	8,267	14,454	17,865	11,261
Value ____ thousands	$975	$978	$1,339	$1,660	$1,194
Imports for consumption ____ short tons	971,355	916,703	1,021,085	899,219	826,783
Value[2] ____ thousands	$69,457	$67,569	$80,090	$94,103	$104,938
Consumption (reported) ____ short tons	1,162,336	1,203,448	1,135,451	976,644	932,855
Consumption (apparent)[3] ____ do	1,191,000	1,062,988	1,090,665	1,017,559	897,572
Stocks, Dec. 31:					
Domestic mines:					
Crude ____ do	204,466	121,329	166,619	213,204	200,698
Finished ____ do	12,243	4,322	5,400	8,930	12,924
Consumer ____ do	226,320	201,158	226,423	182,853	216,207
World: Production ____ do	[r]4,830,684	[r]5,136,957	5,096,315	[p]5,435,873	[e]5,507,580

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

Legislation and Government Programs.—On March 13, 1981, President Reagan announced the beginning of a major purchase program for the national defense stockpile. Fluorspar was listed as a priority material to be acquired. The current U.S. Government stockpile goals for fluorspar are 1.4 million tons for acid grade and 1.7 million tons for metallurgical grade. At yearend, the Government stockpile inventory was 895,983 tons of acid grade and 411,738 tons of metallurgical grade.

The controversy over depletion of the ozone layer by chlorofluorocarbons (CFC) continued. Congressional hearings were held in July to take testimony concerning the Environmental Protection Agency proposal (October 7, 1980, Federal Register) that CFC production be held to the amount of material produced in 1979. The ban on the sale and manufacture of "nonessential" aerosol products containing CFC, which was instituted in April 1979, continued in effect. The ban was instituted because of the uncertainty of the role of CFC in the depletion of stratospheric ozone.

As in previous years, a 22% depletion allowance was granted against Federal income tax applied to the mining of domestic fluorspar compared with a 14% allowance for foreign production.

DOMESTIC PRODUCTION

Shipments of finished fluorspar from domestic mining operations increased to 115,400 short tons in 1981, the first increase in 5 years. Illinois was the leading producing State in 1981, accounting for well over 90% of all U.S. shipments. Statistics on shipments of fluorspar by State and by grade are withheld to avoid revealing company proprietary data.

For most of the year, the Inverness Mining Co. operated the Minerva Mines north of Cave-In-Rock, Ill., which it had acquired from Allied Chemical Corp. Production from these mines was a significant reason for the overall increase in domestic production in 1981 over that of 1980. Crude ore was also produced from the Spivy Mine.

Ozark-Mahoning Co., the Nation's largest fluorspar producer, maintained a high production level from its mines and plants in Pope and Hardin Counties, Ill.

The only other active fluorspar producer in Illinois was the Hastie Trucking and Mining Co. operating near Cave-In-Rock. Hastie's primary products were metallurgical gravel spar and construction aggregate.

In the west, J. Irving Crowell, Jr. and Sons operated its Crowell-Daisy Mine in Nye County, Nev. D & F Minerals Co. continued operations at its Paisano Mines south of Alpine, Tex. Spor Brothers reported development work on a fluorspar mine in Juab County, Utah.

Reported production of fluorspar briquets for use in steel furnaces was approximately 127,000 tons; 1980 production was approximately 130,000 tons. Flurospar briquets, made mostly from imported concentrates, vary in calcium fluoride (CaF_2) content from 25% to 95% and contain various combinations of manganese dioxide, ferric oxide, alumina, dolomite, hydrated lime, flue dust, feldspar, soda ash, olivine, ilmenite, and mill scale sweepings along with binding agents.

Eight plants processing phosphate rock for the production of phosphoric acid recovered nearly 43,000 tons of H_2SiF_6 in 1981 compared with nearly 58,000 tons in 1980. Total H_2SiF_6 shipments were 40,170 tons in 1981; 49% was used for water fluoridation chemicals, 41% for aluminum fluoride (AlF_3) and cryolite, and 10% for other chemicals. The H_2SiF_6 shipments were equivalent to 70,000 tons of acid-grade fluorspar.

CONSUMPTION AND USES

Different grades of fluorspar are consumed depending on the end use. Acid-grade fluorspar, containing greater than 97% CaF_2, is used as feedstock in the manufacture of hydrofluoric acid (HF), a key ingredient in the aluminum, fluorchemical, and uranium industries. Ceramic-grade fluorspar, containing 85% to 95% CaF_2, is used in the ceramics industry for the production of glass and enamel. Metallurgical-grade fluorspar, containing between 60% and 85% or more CaF_2, is used primarily by the iron and steel industry as a neutral flux. Traditionally, U.S. steelmakers have used metallurgical-grade fluorspar containing a minimum of 70% effective CaF_2; however, lower grade material and briquets have gained widespread usage.

The HF and steel industries accounted for 57% and 41%, respectively, of the 1981 reported fluorspar demand. The American Iron and Steel Institute (AISI) reported that raw steel production was 119.9 million tons in 1981, 8.1 million tons more than 1980. Comparing the AISI data with fluorspar consumption data received by the Bureau of Mines from the steel producers, the calculated fluorspar consumption rate for the domestic steel industry was 6.02 pounds per ton of raw steel in 1981. 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 ton)		
	1979	1980	1981
Open hearth	9.3	8.90	9.90
Basic oxygen	8.10	7.08	6.59
Electric	5.35	4.20	3.20
Industry average	7.59	6.51	6.02

Seven companies operating 11 plants produced HF in 1981. Data collected by the U.S. Department of Commerce, Bureau of the Census, indicated the HF "produced and withdrawn from system" amounted to approximately 171,500 short tons on an anhydrous basis in 1981 compared with 213,100 short tons in 1980. Imports of 70% HF augmenting domestic production amounted to 105,600 short tons in 1981.

The CFC production in 12 plants by 5 producing companies was a major end use for HF. According to data collected by the U.S. International Trade Commission on select CFC, the 1981 production of trichlorofluoromethane (F-11) was 78,900 tons, dichlorodifluoromethane (F-12) output was 148,800 tons, and chlorodifluoromethane (F-22) production was 118,700 tons. Compared with production in 1980, F-11 production increased 4.4%, F-12 output increased by 3.5%, and F-22 production increased by 8.5%. The major uses of CFC were refrigerants, foam-blowing agents, and fluorinated solvents. The use of CFC as propellants in aerosol sprays was restricted to essential products and by and large had been replaced by hydrocarbons and carbon dioxide.

Fluorine chemicals used in the reduction of alumina to primary aluminum by the Hall process was another major end use of HF. Six major companies accounted for most of the domestic production of AlF_3 and synthetic cryolite used by the aluminum industry. Domestic primary aluminum production was 4,948,000 short tons in 1981. An estimated 48 pounds of fluorine was consumed for each ton of aluminum produced, amounting to about 118,700 tons of fluorine. Fluosilicic acid supplemented fluorspar as a source of fluorine. The fluorine content in H_2SiF_6 shipped to consumers for the manufacture of fluorine chemicals used in aluminum production was 16,600 tons in 1981.

Hydrofluoric acid was consumed in the concentration of uranium isotope U-235 for use as nuclear fuel energy. The U_3O_8 concentrate from ore is reacted with HF to produce UF_4, which is then converted to gaseous UF_6 through the additions of fluorine gas. Hydrofluoric acid was consumed in diverse applications, including 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.

In the ceramics industry, fluorspar was used in the production of flint glass, white or opal glass, and enamels. Fluorspar acts both as a flux and as an opacifier in these uses. Fluorspar was used in the manufacture of fiberglass, was added directly in small amounts in aluminum production, and was used in the melt shop by the foundry industry and by cement and brick producers.

Table 2.—Reported domestic consumption of fluorspar, by end use and grade

(Short tons)

End use or product	Containing more than 97% CaF_2		Containing not more than 97% CaF_2		Total	
	1980	1981	1980	1981	1980	1981
Hydrofluoric acid	587,380	525,764	--	--	587,380	525,764
Glass and fiberglass	6,103	5,510	4,241	4,715	10,344	10,225
Enamel and pottery	220	W	404	1,224	624	1,224
Welding rod coatings	551	728	746	1,122	1,297	1,850
Primary aluminum and magnesium	549	526	--	--	549	526
Iron and steel castings	--	--	10,047	12,304	10,047	12,304
Open-hearth furnaces	--	--	58,107	66,595	58,107	66,595
Basic oxygen furnaces	--	W	242,778	241,156	242,778	241,156
Electric furnaces	13,372	18,056	50,510	53,159	63,882	71,215
Other	--	119	1,636	1,877	1,636	1,996
Total	608,175	550,703	368,469	382,152	976,644	932,855
Stocks, Dec. 31	91,892	68,264	90,961	147,943	182,853	216,207

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

Table 3.—Reported consumption of subacid grades of fluorspar in 1981, by end use and form

(Short tons)

End use or product	Containing not more than 97% CaF_2		
	Flotation concentrates	Lump or gravel	Briquets or pellets
Chemicals and allied products: Welding fluxes	1,227	--	--
Glass, ceramic, bricks:			
Glass	4,703	W	--
Other glass, clay products	1,248	--	--
Primary metals:			
Steel mills:			
Open-hearth furnaces	144	66,269	178
Basic oxygen furnaces	2,397	140,961	97,798
Electric furnaces	567	48,257	4,335
Other steel furnaces	--	229	--
Iron and steel foundries	--	4,024	8,284
Other identified end uses	33	1,498	--
Total	10,319	261,238	110,595

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

Table 4.—Fluorspar (domestic and foreign) consumed in the United States, by State

(Short tons)

State	1980	1981
Alabama, Kentucky, Tennessee	76,974	78,637
Arizona, Colorado, Utah	28,601	23,473
Arkansas, Kansas, Louisiana, Missouri	157,291	133,696
California	20,330	22,833
Connecticut, Massachusetts, New York, Rhode Island	16,915	12,565
Illinois	31,022	31,147
Indiana	49,347	50,461
Iowa and Wisconsin	257	W
Michigan	21,397	12,286
New Jersey	20,555	19,525
Ohio	95,200	101,341
Oregon and Washington	682	516
Pennsylvania	92,053	104,462
Texas	305,667	275,806
West Virginia	39,249	38,772
Other[1]	21,104	27,335
Total	976,644	932,855

W Withheld to avoid disclosure of company proprietary data; included with "Other."
[1]Includes Delaware, Georgia, Maryland, North Carolina, Oklahoma, and Virginia.

STOCKS

The 1981 yearend mine stocks of finished fluorspar totaled 12,900 short tons, 45% higher than that at yearend 1980. Consumer stocks increased from 182,900 tons in 1980 to 216,200 tons in 1981. Government stockpiles of fluorspar remained unchanged and included 896,000 short tons of acid-grade fluorspar (of which 630 tons was considered nonstockpile grade) and 411,700 tons of metallurgical-grade fluorspar (of which 116,860 tons was of nonstockpile grade).

PRICES

Domestic producers reported no change in the price of metallurgical-grade shipments, and the price for acid-grade shipments settled at the upper value of the range reported in 1980. Mexican producers on January 1 increased the price for all grades of fluorspar by 15%, the third price increase in 13 months. The January prices held for the remainder of the year. Yearend price quotations by the Engineering and Mining Journal are presented in table 5; price quotations serve as a general guide but do not necessarily reflect actual transactions.

For most of 1981, HF prices were stable. Yearend price quotations were $72 per 100 pounds, f.o.b. plant, tank cars for anhydrous HF. For aqueous HF, 70% in 55-gallon tanks or 30-gallon drums, f.o.b. plant, prices were quoted as $56 per 100 pounds. Yearend prices for cryolite and AlF_3 as listed by the Chemical Marketing Reporter were unchanged from 1980, at $550 per ton and 17.5 cents per pound, respectively, in bulk, ex-works. However, industry sources indicate that AlF_3 sold for as high as 50 cents per pound. The Bureau of Mines does not have information concerning actual contract prices.

Table 5.—Prices of domestic and imported fluorspar

(Dollars per short ton)

	1980	1981
Domestic, f.o.b. Illinois-Kentucky:		
Metallurgical: 70% effective CaF_2 briquets	110	110
Ceramic, variable calcite and silica:		
88% to 90% CaF_2	100	100
95% to 96% CaF_2	140	165
97% CaF_2	165-175	165 -175
Acid, dry basis, 97% CaF_2:		
Carloads	160-171	171
88% effective CaF_2 briquets	168-179	179
European and South African:[1] Acid, term contracts	140-175	175 -180
Mexican:[2]		
Metallurgical:		
70% effective CaF_2, f.o.b. vessel, Tampico	97.25	111.84
70% effective CaF_2, f.o.b. cars, Mexican border	93.39	107.40
Acid, bulk: 97+%, Mexican border	121.79	135.47-140.05

[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, December 1980 and 1981.

FOREIGN TRADE

U.S. fluorspar exports totaled 11,300 short tons in 1981, about 6,600 tons less than exports in 1980. Domestic exports are not reported by grade. Exports may have been acid-, ceramic-, or metallurgical-grade fluorspar and may include briquets manufactured from domestic ore. Synthetic cryolite exports totaled 29,000 short tons valued at $9.56 million in 1981.

U.S. imports of fluorspar declined 8% from those of 1980 to 826,800 short tons in 1981. Acid-grade imports were down 10%, while imports of subacid-grade material were down 2.5% compared with those of 1980. Imports from Mexico, the largest foreign supplier, totaled 60% of all 1981 U.S. fluorspar imports. The Republic of South Africa supplied 30%, Italy 4.1%, Spain 3.2%, and China 3.1%. Small quantities were also imported from Canada.

U.S. imports of cryolite decreased in 1981 by 42% to 7,200 tons. Denmark, Canada, and Japan were the leading suppliers in 1981. Imports from China were reduced by 85%. Imports of HF increased 7% to 105,600 tons. Mexico and Canada continued to be the major suppliers of imported HF in 1981. Data on exports and imports of AlF_3 were not available.

Table 6.—U.S. exports of fluorspar

Country	1980		1981	
	Quantity (short tons)	Value	Quantity (short tons)	Value
Australia	--	--	49	$4,939
Canada	16,767	$1,515,532	10,078	995,400
Chile	--	--	118	11,766
Dominican Republic	462	69,666	447	81,589
Germany, Federal Republic of	--	--	23	2,266
Ghana	96	11,385	15	1,474
Japan	--	--	28	2,800
Mexico	--	--	6	534
Peru	13	1,302	166	55,862
Suriname	95	13,914	--	--
Taiwan	22	4,265	--	--
United Kingdom	247	24,695	--	--
Venezuela	163	18,811	331	36,870
Total	17,865	1,659,570	11,261	1,193,500

Table 7.—U.S. imports for consumption of fluorspar, by country and customs district

Country and customs district	1980 Quantity (short tons)	1980 Value (thousands) Customs	1980 Value (thousands) C.i.f.	1981 Quantity (short tons)	1981 Value (thousands) Customs	1981 Value (thousands) C.i.f.
CONTAINING MORE THAN 97% CALCIUM FLUORIDE (CaF_2)						
Canada:						
Cleveland	6,554	$640	$693	--	--	--
El Paso	1,953	87	162	--	--	--
Laredo	147	15	15	664	$93	$93
Total	8,654	742	870	664	93	93
Italy: Galveston	34,261	3,939	4,673	33,826	4,381	5,178
Germany, Federal Republic of: Laredo	448	27	27	--	--	--
Kenya: Houston	16,949	1,506	2,188	--	--	--
Mexico:						
Buffalo	11	2	3	--	--	--
El Paso	90,413	8,889	9,514	85,219	11,396	11,484
Galveston	10,417	1,191	1,331	--	--	--
Laredo	207,159	19,682	19,712	178,209	21,681	21,790
New Orleans	5,664	616	724	--	--	--
Philadelphia	11,581	1,194	1,336	10,978	1,424	1,479
Total	325,245	31,574	32,620	274,406	34,501	34,753
Morocco: Cleveland	2,976	400	401	--	--	--
South Africa, Republic of:						
Galveston	9,121	964	1,205	7,123	1,052	1,284
Houston	11,902	1,126	1,447	40,708	4,640	5,745
Laredo	[r]6,085	598	780	15,273	1,535	1,916
New Orleans	192,406	17,570	22,711	163,101	20,151	24,008
Philadelphia	8,637	920	1,074	9,035	1,147	1,214
Total	228,151	21,178	27,217	235,240	28,525	34,167
Spain:						
Cleveland	13,289	1,788	2,008	19,211	2,488	2,793
Laredo	--	--	--	7,636	1,074	1,228
New Orleans	6,910	922	1,171	--	--	--
Total	20,199	2,710	3,179	26,847	3,562	4,021
United Kingdom: Milwaukee	([1])	1	1	--	--	--
Grand total	636,883	62,077	[r]71,176	570,983	71,062	78,212
CONTAINING NOT MORE THAN 97% CALCIUM FLUORIDE (CaF_2)						
Canada:						
Buffalo	150	12	15	19	1	1
Detroit	--	--	--	85	6	8
El Paso	248	15	15	--	--	--
Total	398	27	30	104	7	9
Mexico:						
Baltimore	17,558	1,336	1,787	26,939	2,800	3,280
Buffalo	3,428	270	295	2,533	280	303
Detroit	76	6	6	--	--	--
El Paso	29,755	2,135	2,261	28,234	2,578	2,758
Laredo	130,779	11,147	11,178	120,985	12,484	12,553
Mobile	8,812	753	822	--	--	--
New Orleans	19,800	1,552	1,739	23,085	2,581	3,036
New York	--	--	--	445	48	48
Philadelphia	9,711	809	971	16,937	1,725	2,007
Total	219,919	18,008	19,059	219,158	22,496	23,985
China: New Orleans	27,623	2,011	2,681	25,604	1,460	1,529
South Africa, Republic of:						
Baltimore	2,755	167	215	--	--	--
Detroit	--	--	--	10,933	827	1,202
New Orleans	11,640	728	940	--	--	--
Total	14,395	895	1,155	10,933	827	1,202
Sweden: Houston	--	--	--	1	1	1
Germany, Federal Republic of: Milwaukee	1	1	1	--	--	--
Grand total	262,336	20,942	22,926	255,800	24,791	26,726

[r]Revised.
[1]Less than 1/2 unit.

Table 8.—U.S. imports for consumption of 70% hydrofluoric acid

Country	1980 Quantity (short tons)	1980 Value, c.i.f. (thousands)	1981 Quantity (short tons)	1981 Value, c.i.f. (thousands)
Austria	--	--	17	$22
Canada	37,498	$32,659	39,929	40,915
France	65	264	--	--
Germany, Federal Republic of	257	496	36	56
Japan	5,445	4,681	2,555	2,385
Mexico	55,045	56,218	63,086	68,121
Netherlands	57	87	--	--
Spain	111	115	--	--
United Kingdom	252	401	(1)	13
Total	98,730	94,921	105,623	111,512

[1]Less than 1/2 unit.

Table 9.—U.S. imports for consumption of cryolite[1]

Country	1980 Quantity (short tons)	1980 Value, c.i.f. (thousands)	1981 Quantity (short tons)	1981 Value, c.i.f. (thousands)
Canada	5,291	$2,272	1,782	$1,043
China	5,725	2,986	827	305
Denmark	2,741	2,055	2,595	1,853
Germany, Federal Republic of	3	3	91	67
Greenland	40	18	80	47
Hong Kong	557	249	--	--
Israel	12	8	--	--
Japan	2,353	1,626	1,599	1,199
Netherlands	51	47	68	53
Sweden	21	17	--	--
Switzerland	1	1	6	1
Taiwan	291	160	--	--
United Kingdom	--	--	140	111
Total	17,086	9,442	7,188	4,679

[1]Only the material from Denmark is natural cryolite; all other material is synthetic.

WORLD REVIEW

World production of fluorspar increased 1.3% in 1981 to 5.5 million tons. Mexico, with 22% of the world total, remained the world's leading producer, followed by, in descending order, Mongolia, the U.S.S.R., the Republic of South Africa, China, Spain, and France. Fluorspar was produced commercially in over 30 nations worldwide.

Argentina.—Minera Patagonica S.A. of Buenos Aires has begun to exploit fluorspar ore reserves located 15 kilometers southwest of Sierra Grande in Rio Negro Province. The project includes the Delta Mine development, evaluation of 30 other known ore bodies, and the construction of a processing and briquetting plant at Puerto Madryn, Chubut Province. Reserves were estimated at over 4 million tons of ore averaging 52% CaF_2.

Canada.—Alcan Smelters and Chemicals Ltd. announced plans to increase the production capacity of its planned AlF_3 chemicals plant in Tonquiere, Quebec, from 30,000 to 40,000 tons per year.[2]

Canada has had no fluorspar production since 1977. In British Columbia, Eaglet Mines, Ltd., continued surface exploration and a diamond drill coring program on its fluorite property near Quesnel Lake.

China.—Indications are that China has significantly increased its capacity to produce acid-grade fluorspar. A portion of this capacity results from the conversion of copper processing facilities to process fluorspar. The largest acid-grade facility appears to be the 70- to 80-ton-per-year Dong Feng Mill in Wu Yi County, Zhe Jiang Province.

Mexico.—The nation's nearly 140 fluorspar mines produced over 1.2 million tons in 1981, retaining Mexico's position as the world's largest producer. Eight major producers contributed about 85% of the total output and Compania Minera Las Cuevas S.A., operating the world's largest fluorspar mine, produced nearly 450,000 tons. Fluorspar sales, as reported by the Mexican Fluorspar Institute (Instituto Mexicano de la Florita), declined to 1,097,000 short tons from 1,209,000 short tons in 1980. Mexican fluorspar exports fell from nearly 860,000 short tons in 1980 to 674,000 short tons in 1981 because of the economic downturn in North America.

Table 10 shows sales of Mexican fluorspar for the period 1977-81. It is probable that a large portion of Mexico's sales of submetallurgical-grade fluorspar are upgraded either in Mexico or the United States.

U.S.S.R.—It was announced that a new fluorspar plant has gone into operation at the Yaroslavaiksy mining complex with an annual capacity of around 80,000 tons per year.[3]

Yugoslavia.—A fluorite deposit of 500,000 short tons has been established at Ravnaja near Krupanjn, Serbia. The Metallurgical Association of Serbia is organizing a group of investors to finance the opening of a 25,000-ton-per-year mine and to continue further exploration at deeper levels.[4]

[1]Physical scientist, Division of Industrial Minerals.
[2]Industrial Minerals (London). Alcan Increases AlF_3 Production. No. 168, September 1981, pp. 9-10.
[3]Page 9 of work cited in footnote 2.
[4]Engineering and Mining Journal. V. 182, No. 4, April 1981, p. 216.

Table 10.—Sales of Mexican fluorspar, by grade[1]

(Thousand short tons)

Grade	1977	1978	1979	1980	1981
Submetallurgical	224,512	249,102	196,436	236,470	211,949
Metallurgical	271,971	327,937	306,494	312,218	250,647
Ceramic	36,124	49,726	85,523	96,167	100,620
Acid	460,344	540,259	588,572	564,608	533,987

[1]Courtesy of Instituto Mexicano de la Florita.

Table 11.—Fluorspar: World production, by country[1]

(Short tons)

Country[2] and grade[3]	1977	1978	1979	1980[p]	1981[e]
North America:					
Canada, acid grade[e] [4]	65,600	--	--	--	--
Mexico (all grades)[5]	[r]727,621	[r]1,057,980	1,084,514	1,219,755	1,230,544
United States (shipments):					
Acid grade	100,605	74,880	W	W	W
Metallurgical grade	68,884	54,548	W	W	W
Total	169,489	129,428	109,299	92,635	[6]115,404
South America:					
Argentina:					
Acid grade[e]	14,482	8,845	12,592	5,115	6,440
Metallurgical grade[e]	33,790	20,637	29,380	11,935	15,030
Total	48,272	29,482	41,972	17,050	21,470
Brazil:[7]					
Direct shipping ore, grade unspecified (sales)	[r]14,508	513	106	110	100
Beneficiated product (output):					
Acid grade	[r]30,072	34,363	29,599	36,078	38,600
Ceramic grade	[r]525	--	--	--	--
Metallurgical grade	[r]30,493	33,247	28,161	24,956	27,600
Total	[r]75,598	68,123	57,866	61,144	66,300
Uruguay, grade unspecified	83	125	[e]85	[e]95	90
Europe:					
Czechoslovakia:[e] [4]					
Acid grade	53,000	53,000	53,000	53,000	53,000
Metallurgical grade	53,000	53,000	53,000	53,000	53,000
Total	106,000	106,000	106,000	106,000	106,000

See footnotes at end of table.

Table 11.—Fluorspar: World production, by country[1] —Continued

(Short tons)

Country[2] and grade[3]	1977	1978	1979	1980[p]	1981[e]
Europe —Continued					
France:[8]					
Acid and ceramic grade	[r e]188,300	[r]194,448	173,504	178,106	177,000
Metallurgical grade	[r e]127,000	[r]107,433	112,218	110,241	110,000
Total	[r e]315,300	[r]301,881	285,722	288,347	287,000
German Democratic Republic:[e 4]					
Acid grade	27,600	27,600	27,600	27,600	27,600
Metallurgical grade	82,400	82,400	82,400	82,400	82,400
Total	110,000	110,000	110,000	110,000	110,000
Germany, Federal Republic of (marketable):[4]					
Acid grade[e]	83,086	[r]75,122	62,672	77,533	77,400
Metallurgical grade[e]	9,232	[r]8,347	6,963	8,615	8,600
Total	92,318	[r]83,469	69,635	86,148	86,000
Greece, grade unspecified	551	672	397	440	--
Italy:					
Acid grade	158,000	143,320	148,094	137,540	137,800
Ceramic grade	14,544	14,969	7,589	1,060	1,100
Metallurgical grade	32,209	30,314	45,809	28,912	27,600
Total	204,753	188,603	201,492	167,512	166,500
Romania, metallurgical grade[e 4]	22,000	22,000	22,000	22,000	22,000
Spain:					
Acid grade	233,497	222,121	171,164	225,528	300,400
Metallurgical grade	108,727	109,999	41,469	44,261	44,300
Total	342,224	332,120	212,633	269,789	344,700
Sweden:[4]					
Acid grade[e]	1,464	--	--	--	--
Metallurgical grade[e]	1,197	--	--	--	--
Total	2,661	--	--	--	--
U.S.S.R.:[e 4]					
Acid grade	265,000	270,000	275,000	275,000	280,000
Metallurgical grade	287,000	292,000	298,000	298,000	305,000
Total	552,000	562,000	573,000	573,000	585,000
United Kingdom:[9]					
Acid grade	115,743	143,300	114,640	151,016	110,000
Metallurgical grade	25,353	17,637	13,228	11,023	11,000
Unspecified	72,752	47,400	41,888	26,455	44,000
Total	213,848	208,337	169,756	188,494	165,000
Africa:					
Egypt, grade unspecified	1,548	2,464	730	1,931	2,000
Kenya:					
Acid grade	116,575	103,278	[e]74,727	90,499	87,900
Metallurgical grade	20,111	14,189	[e]10,266	12,433	12,100
Total	136,686	117,467	[e]84,993	102,932	100,000
Morocco, acid grade	44,092	[r]59,745	69,666	70,989	71,600
South Africa, Republic of:					
Acid grade	258,656	328,038	426,930	517,735	[6]497,819
Ceramic grade	72,378	16,432	9,344	9,798	[6]6,744
Metallurgical grade	55,523	89,042	60,991	48,664	[6]42,758
Total	386,557	433,512	497,265	576,197	[6]547,321
Tunisia, acid grade	31,809	36,661	37,267	43,487	37,700
Zambia, grade unspecified	[e]11	84	--	--	55
Zimbabwe, metallurgical grade[4]	[r]575	[r]344	--	--	--

See footnotes at end of table.

Table 11.—Fluorspar: World production, by country[1] —Continued

(Short tons)

Country[2] and grade[3]	1977	1978	1979	1980[p]	1981[e]
Asia:					
China:					
Acid grade[e]	38,600	38,600	68,300	84,900	91,500
Metallurgical grade[e 4]	440,000	440,000	440,000	440,000	440,000
Total	478,600	478,600	508,300	524,900	531,500
India:					
Acid grade	9,997	10,668	12,115	13,612	13,200
Metallurgical grade	6,768	4,794	7,021	9,808	9,900
Total	16,765	15,462	19,136	23,420	23,100
Korea, North, metallurgical grade[e 4]	44,000	44,000	44,000	44,000	44,000
Korea, Republic of, metallurgical grade	14,309	12,531	9,315	7,619	7,700
Mongolia, metallurgical grade[4]	r e352,000	r e480,000	r e 625,000	r e666,000	660,000
Pakistan, grade unspecified	--	369	461	1,305	4,400
Thailand:[10]					
Acid grade	60,435	60,627	62,362	66,258	99,000
Metallurgical grade	213,093	193,490	195,914	190,461	182,000
Total	273,528	254,117	258,276	256,719	281,000
Turkey, metallurgical grade	1,886	1,381	6,834	e6,600	6,600
Total acid grade	r1,896,613	r1,884,616	[11]1,819,232	[11]2,053,996	[11]2,106,959
Total all other grades	r2,934,071	r3,252,341	3,277,083	3,381,877	3,400,621
Grand total	r4,830,684	r5,136,957	[11]5,096,315	[11]5,435,873	[11]5,507,580

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

[1]Table includes data available through May 5, 1982.

[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 available in official reports of the subject country, the data have been entered without qualifying notes; where a secondary source has been used to subdivide production by grade, the source for the basis of this subdivision has been identified by footnote. Where no basis for subdivision is available, the entry has been identified with the notation "grade unspecified."

[4]Information on grade obtained from Bundesanstalt Für Bodenforschung Hannover and Deutsches Institut Für Wirtschaftsforschung Berlin. Untersuchungen über Angebot and Nachfrage Mineralischer Rohstoffe 4. Flusspat, March 1974, p. 39.

[5]Series revised to reflect actual total production of all grades of fluorspar; distribution of this number by grade is not available.

[6]Reported figure.

[7]Official Brazilian sources list crude ore mined as follows in short tons: 1977—127,824 (revised); 1978—139,147; 1979—179,874; 1980—179,897; 1981—not available.

[8]Data for 1977 are marketed production estimated from domestic consumption and trade data; data do not take into account changes in stocks. Figures for 1978-80 are reported marketed output. Total run-of-mine production (direct-shipping plus ore destined for concentration) was as follows in short tons: 1977—586,000; 1978—590,070 (revised); 1979—557,454 (revised); 1980—583,322; 1981—583,000 (estimated).

[9]Includes material recovered from lead-zinc mine dumps.

[10]Acid-grade material listed for Thailand is beneficiated product resulting from processing of reported low-grade material; metallurgical-grade material is run-of-mine material reported under the term "high grade." Recorded production of low-grade material was as follows in short tons: 1977—51,246; 1978—92,875; 1979—90,524; 1980—147,210; 1981—149,000 (estimated).

[11]Total does not include U.S. acid-grade production; data are withheld.

Gallium

By Benjamin Petkof[1]

Domestic gallium consumption in 1981 exceeded that of 1979 but was below that of 1980. Gallium recovered from domestic sources supplied a significant portion of U.S. consumption. Data on world gallium production, consumption, and stocks were not available. Gallium in metal or metallic compounds was used primarily in the production of solid-state electronic devices.

Table 1.—Salient gallium statistics in the United States

(Kilograms unless otherwise specified)

	1977	1978	1979	1980	1981
Production	NA	NA	NA	NA	NA
Imports for consumption	2,884	3,721	6,401	6,175	5,536
Consumption	8,789	8,908	9,461	10,460	9,560
Price per kilogram	\$500-\$600	\$500-\$600	\$510	\$510-\$630	\$630

NA Not available.

DOMESTIC PRODUCTION

Only two domestic companies recovered gallium in 1981. The Aluminum Co. of America, using proprietary technology, recovered gallium as a byproduct of its alumina production process at Bauxite, Ark. Eagle-Picher Industries, Inc., produced gallium metal, oxide, and trichloride from zinc production residues at its Quapaw, Okla., facility. Production data were not available. Based on import and consumption data, total domestic output of gallium metal appeared to be near that of 1980.

CONSUMPTION

Consumption of gallium was high in 1981 but below that of 1980. More than 90% of consumption was used in electronic applications. The remainder was used to produce alloys and in research and development.

General acceptance by industry and the public of electronic devices that use gallium-based components maintained the high demand for gallium. Continued use and development of items such as fiber-optic light transmission cables actuated by gallium-based light-emitting diodes and lasers, gallium-based electronic devices for computers, and ongoing research and development of gallium-based solid-state devices and systems were expected to maintain the high demand for gallium and gallium compounds.

Table 2.—Consumption of gallium, by end use

(Kilograms)

End use	1979	1980	1981
Specialty alloys	5	14	2
Electronics[1]	8,782	9,635	8,865
Research and development	617	754	636
Unspecified	57	57	57
Total	9,461	10,460	9,560

[1]Light-emitting diodes, semiconductors, and other electronic devices.

STOCKS

Consumer stocks of gallium metal for 1980 and 1981 are shown in table 3. Stocks at yearend 1981 were above those of 1979 and 1980.

Table 3.—Stocks, receipts, and consumption of gallium[1]

(Kilograms)

Purity	Beginning stocks	Receipts	Consumption	Ending stocks
1980:				
97.0%-99.9%	106	13	15	104
99.99%	4	14	15	3
99.999%	3	74	73	4
99.9999%-99.99999%	1,637	10,485	10,357	1,765
Total	1,750	10,586	10,460	1,876
1981:				
97.0%-99.9%	104	19	4	119
99.99%	3	16	15	4
99.999%	4	88	87	5
99.9999%-99.99999%	1,765	9,474	9,454	1,785
Total	1,876	9,597	9,560	1,913

[1]Consumers only.

PRICES

The American Metal Market quoted the price for 99.999%-pure metal at $630 per kilogram, in 100-kilogram lots, throughout the year.

FOREIGN TRADE

Data on the exports of gallium metal are not reported separately but are included in the export category "base metals and alloys, not elsewhere classified, wrought or unwrought, waste and scrap." Significant quantities of gallium and gallium compounds are exported as parts of manufactured electronic and electrical components and equipment.

U.S. imports of gallium in 1981 declined in quantity and value from those of 1980. Almost half of U.S. imports came from Switzerland. Other significant sources of U.S. imports were China, Canada, and the Federal Republic of Germany. The average value of imported gallium metal increased from $427 per kilogram in 1980 to $447 per kilogram in 1981.

WORLD REVIEW

Data on production and consumption of gallium for the rest of the world were not available. However, nations with well-developed electronic and electrical industries consumed most of the world gallium supply. It was thought that minimum world gallium consumption was equal to twice that of the United States or at least 20,000 kilograms. World production was thought to be commensurate with world consumption.

Table 4.—U.S. imports for consumption of gallium (unwrought, waste and scrap), by country

Country	1980		1981	
	Kilograms	Value	Kilograms	Value
Belgium	--	--	200	$87,979
Canada	1,449	$675,911	589	303,873
China	409	119,288	916	403,185
France	232	90,521	386	134,964
Germany, Federal Republic of	561	233,107	585	272,941
India	--	--	10	5,714
Italy	--	--	98	16,632
Japan	13	14,861	--	--
Malaysia	--	--	2	1,250
Sweden	--	--	1	680
Switzerland	3,444	1,470,558	2,679	1,215,460
Taiwan	11	2,775	--	--
United Kingdom	56	30,214	70	29,418
Total	6,175	2,637,235	5,536	2,472,096

TECHNOLOGY

A method was described for the extraction of gallium from hydrochloric-acid solutions using diphenyl-2-pyridylmethane as an extractant. The method was stated to be useful as a preconcentration procedure for analytical techniques and for the production of high-purity gallium.[2]

[1]Physical scientist, Division of Nonferrous Metals.

[2]Hasany, S. M., M. Imtaz, and M. Ejaz. Solvent Extraction of Gallium (III) From Hydrochloric Acid Solutions Using Diphenyl-2-Pyridylmethane as an Extractant. J. Less Common Metals, v. 77, No. 2, February 1981, pp. 157-167.

Gem Stones

By J. W. Pressler[1]

The value of gem stones and mineral specimens produced in the United States during 1981 was estimated to be $7.6 million. During the year, turquoise production decreased while tourmaline and sapphire production increased. Amateur collectors accounted for much of the activity in many States. Commercial operators produced rough jade, jasper, agate, sapphire, turquoise, opal, and tourmaline, which they sold mainly to wholesale or retail outlets and also to jewelry manufacturers.

DOMESTIC PRODUCTION

Mines and collectors in 46 States produced gem materials with an estimated value of $1,000 or more in each State in 1981. Ten States supplied 90% of the total value, as follows: Arizona, $3.3 million; Nevada, $1.0 million; Maine, $700,000; Oregon, $600,000; California, $300,000; Wyoming, $250,000; and Arkansas, New Mexico, Texas, and Washington, $200,000 each. In 1981, estimated production increased 33% in New Mexico and Washington, 25% in Texas, 20% in Oregon, 5% in Nevada, and 3% in Arkansas, but decreased 12% in Maine.

Park authorities at the Crater of Diamonds Park in Pike County, Ark., reported that approximately 97,000 people visited the park in 1981 and found 1,327 diamonds with a total weight of 244 carats. This was an increase of 99% compared with the old record of 668 stones found in 1975. The largest was an 8.3-carat white stone of undetermined value. The next three largest diamonds, one brown and two whites, ranged from 5.90 to 6.25 carats. The principal factor contributing to this new record was the introduction of new concentrating and screening techniques that enable diggers to recover more of the smaller (1- to 24-point) diamonds. The average for all diamonds found was 18 points. Ticket sales and total attendance were up substantially from the 75,000 tickets sold in 1980. The "dig for fee" operations remained popular.

In Pala, San Diego County, Calif., Pala Gem Mines produced tourmaline at their Stewart lithia mine. The other small mines, in the same county, continued to produce fine gem-quality and specimen tourmaline, kunzite, and morganite.

Montana continued to lead the other States in the production of corundum, particularly gem-quality sapphire. Gemco International produced 35,000 carats of sapphires in 1980 from Yogo Gulch, Fergus County, with a high percentage of prize blues. A 500-ton-per-day recovery plant was planned to be onstream by 1982. Three other pay-as-you-dig or fee placer operations were active: Eldorado Bar and Castle's Sapphire Mine near Helena, and Gem Mountain Sapphire Mine near Philipsburg. Gem-quality rubies and sapphires are also found in the Cowee Valley near Franklin, N.C. A 163-carat ruby is believed to be one of the largest rubies ever found in the area.

The largest single emerald ever found in North America was a 1,438-carat crystal from the Rist Mine near Hiddenite, N.C., in 1969. Each year, many small emeralds are found by visitors there, as well as from the Crabtree Mine near New Switzerland, N.C.

CONSUMPTION

Domestic gem stone output went to amateur and commercial rock, mineral, and gem stone collections, objects of art, and jewelry. Apparent consumption (domestic production plus imports minus exports and reexports) in 1981 was $1,812 million, 1% more than that of 1980.

PRICES

Yearend domestic sales of commercial-grade gem diamonds (inexpensive commercial-grade stones up to 1 carat) surged during the Christmas season, but there was a reduced market for better quality certificate stones over 1.0 carat.

The U.S. price of 1.0-carat, D-flawless, investment-grade diamond plummeted during the year, decreasing more than 60% from an alltime high in October 1980 of $54,250 to a $20,000-to-$25,000 range at yearend 1981.

Colored stones languished during the year, with commercial materials being more popular, and expensive stones experienced poor sales. Average prices of some high-quality stones—emerald, black opal, and ruby—decreased 30% to 50%, while others—sapphire, star sapphire, tanzanite, and tourmaline—increased 56% to 80%.

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 1981	Median price per carat[3]	
				December 1980	Early December 1981
0.04-0.08	G-I	VS_1	$375- $650	$570	$467
.04- .08	G-I	SI_1	325- 550	520	400
.09- .16	G-I	VS_1	475- 750	655	550
.09- .16	G-I	SI_1	400- 615	585	470
.17- .22	G-I	VS_1	600- 1,205	1,080	837
.17- .22	G-I	SI_1	510- 1,045	975	687
.23- .28	G-I	VS_1	750- 1,375	1,385	900
.23- .28	G-I	SI_1	640- 1,215	1,150	800
.29- .35	G-I	VS_1	875- 1,795	1,550	1,200
.29- .35	G-I	SI_1	740- 1,535	1,375	917
.46- .55	G-I	VS_1	1,300- 2,285	2,738	1,800
.46- .55	G-I	SI_1	1,000- 2,000	1,950	1,500
.69- .79	G-I	VS_1	1,600- 3,010	3,556	2,300
.69- .79	G-I	SI_1	1,200- 2,420	2,530	1,850
1.00-1.15	D	FL	([4])	[5]53,000	26,500
1.00-1.15	E	VVS_1	10,000-16,050	[5]23,000	11,250
1.00-1.15	G	VS_1	4,600- 8,480	[5]8,600	5,075
1.00-1.15	H	VS_2	3,500- 5,700	[5]5,650	3,800
1.00-1.15	I	SI_1	2,600- 4,000	[5]3,550	2,750

[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. 152, No. 1, January 1981, p. 124; v. 153, No. 2, February 1982, p. 150. These figures represent a sampling of net prices that diamond dealers in various U.S. cities charged their customers during the month.
[4]Not enough sales reported to quote prices. Last quoted as $36,000-$44,000 in July 1981 Jewelers' Circular-Keystone. Quoted at yearend in The Diamond Registry Bulletin, New York, N.Y., as $20,000-$25,000.
[5]Representative of early November 1980 sales. December sales are nonrepresentative.

Table 2.—Prices of U.S. cut colored gem stones, by size

Gem stone	Carat weight	Price range per carat 1981	Median price per carat[1] December 1980	Median price per carat[1] Early December 1981
Amethyst	10	$10- $25	$15	$18
Aquamarine	5	40- 300	168	187
Cat's eye	2	(²)	850	(²)
Citrine	10	12- 45	12	16
Emerald:				
Medium to better	1	1,200-4,000	3,500	2,500
Commercial	1	800-2,500	900	1,175
Garnet, green	1	400-1,000	725	625
Opal, black	3	200- 300	500	250
Opal, white	5	45- 125	75	80
Peridot	5	45- 100	55	65
Ruby:				
Medium to better	1	1,200-5,000	2,750	1,650
Commercial	1	600-3,000	850	700
Sapphire:				
Medium to better	1	450-2,500	1,200	1,500
Commercial	1	250- 800	425	750
Star sapphire:				
Sky-blue	5	350- 500	250	450
Gray	5	80- 200	100	102
Tanzanite	5	400-1,000	590	850
Topaz	5	75- 350	245	237
Tourmaline, green	5	45- 150	75	125
Tourmaline, pink	5	65- 200	80	125

[1]Jewelers' Circular-Keystone, v. 152, No. 1, January 1981, p. 126; v. 153, No. 2, February 1982, p. 152. These figures represent a sampling of net prices that colored stone dealers in various U.S. cities charged their cash customers during the month.
[2]Not reported.

FOREIGN TRADE

U.S. imports of rough and polished natural diamonds, excluding industrial diamonds, attained a record $2.2 billion declared custom value in 1981. Total polished diamond imports, principally from Belgium (36%) and Israel (29%), increased 43% to $1.8 billion, a new alltime record. The over-0.5-carat category, mostly from Belgium (42%), Israel (19%), and Switzerland (17%), increased 66% to $760 million, and the less-than-0.5-carat group, mostly from Israel (37%), Belgium (31%), and India (24%), increased 30% to $1.04 billion. However, imports of rough natural diamond, principally from the Republic of South Africa (70%), the United Kingdom (9%), and Sierra Leone (4%), decreased 41% in caratage and 59% in value in 1981 compared with that of 1980. The decrease in carat value from $731 in 1980 to $359 in 1981 for South African imports was an indication that De Beers Consolidated Mines Ltd. was withholding the better quality rough stones from the market.

The total value of emerald imports decreased 7% to $132 million in 1981. The total value of rubies and sapphires imported in 1981 increased 30% to $177 million, compared with the revised figure of $136 million in 1980.

Table 3.—U.S. exports and reexports of diamond (exclusive of industrial diamond), by country

Country	1980 Quantity (carats)	1980 Value (millions)	1981 Quantity (carats)	1981 Value (millions)
Exports:				
Belgium-Luxembourg	31,797	$95.9	47,781	$49.4
Canada	7,041	5.1	9,020	7.1
France	5,112	31.0	5,909	23.0
Germany, Federal Republic of	2,452	7.5	3,037	6.8
Hong Kong	69,927	240.5	47,802	134.8
Israel	21,164	16.2	16,253	11.8
Japan	28,039	64.2	31,415	66.8
Netherlands	739	5.7	371	4.3
Singapore	6,836	13.7	6,585	12.3
Switzerland	24,110	127.3	16,930	98.4
United Kingdom	5,068	19.5	5,278	18.3
Other	8,358	16.7	6,729	8.3
Total	210,643	643.3	197,110	441.3
Reexports:				
Belgium-Luxembourg	333,186	119.2	[1]1,973,297	142.0
France	6,922	6.9	4,315	5.2
Hong Kong	36,345	40.6	55,118	44.9
India	199,201	6.7	323,785	7.2
Israel	262,625	93.2	386,840	79.3
Japan	61,579	7.3	79,813	19.5
Netherlands	42,987	6.8	41,324	3.2
Switzerland	18,323	44.6	28,182	58.5
United Kingdom	109,024	18.4	43,719	39.1
Other	43,918	54.2	81,484	13.9
Total	1,114,110	397.9	3,017,877	412.8

[1]Artificially inflated in 1981 by auction of 1,477,365 carats of U.S. Government stockpile industrial diamond stones with subsequent reexport as gem stones to Belgium-Luxembourg.

Table 4.—U.S. imports of diamond for consumption, by kind and country

Kind and country	1980 Quantity (carats)	1980 Value (millions)	1981 Quantity (carats)	1981 Value (millions)
Rough or uncut, natural:[1]				
Belgium-Luxembourg	32,587	$19.5	28,122	$12.2
Central African Republic	66,308	7.1	19,869	2.2
Israel	23,635	12.5	21,609	6.7
Liberia	5,023	10.5	3,717	2.7
Sierra Leone	85,352	49.2	37,872	23.3
South Africa, Republic of	907,749	662.1	656,362	282.5
Switzerland	18,988	11.6	7,943	4.1
United Kingdom	201,138	193.5	80,010	56.9
Venezuela	204,513	16.8	67,351	6.0
Other	48,310	12.4	10,430	6.5
Total	1,593,603	995.2	933,285	403.1
Cut but unset, not over 0.5 carat:				
Belgium-Luxembourg	531,251	223.6	777,054	319.9
Hong Kong	10,128	3.6	19,370	10.0
India	854,526	198.9	1,120,122	246.0
Israel	787,535	322.8	958,153	383.3
South Africa, Republic of	34,751	25.6	45,150	27.9
Switzerland	9,528	4.6	29,660	13.8
United Kingdom	12,192	5.9	17,571	10.8
Other	30,882	13.4	68,851	25.5
Total	2,270,793	798.4	3,035,931	1,037.2
Cut but unset, over 0.5 carat:				
Belgium-Luxembourg	155,280	242.2	206,171	319.3
Hong Kong	1,298	3.4	5,899	26.2
India	5,155	2.7	11,409	6.3
Israel	89,015	117.8	138,107	146.7
Netherlands	2,555	4.9	8,288	16.0
South Africa, Republic of	28,638	43.1	26,463	48.2
Switzerland	3,678	16.6	18,688	125.6
United Kingdom	5,475	15.4	11,112	40.1
Other	5,011	11.5	11,927	31.4
Total	296,105	457.6	438,064	759.8

[1]Includes some natural advanced diamond.

Table 5.—U.S. imports of precious and semiprecious gem stones, by kind and country

Kind and country	1980 Quantity (carats)	1980 Value (millions)	1981 Quantity (carats)	1981 Value (millions)
Emerald:				
Belgium-Luxembourg	1,777	$0.7	6,645	$3.2
Brazil	240,198	7.5	48,977	5.8
Canada	2,587	.7	18,788	1.2
Colombia	81,910	55.7	121,708	40.2
France	5,073	1.5	9,759	2.2
Germany, Federal Republic of	38,618	3.0	41,795	4.6
Hong Kong	56,073	8.6	120,313	12.2
India	3,025,578	18.6	1,572,510	15.8
Israel	88,234	21.2	96,870	22.8
Pakistan	793	.4	4,651	1.2
South Africa, Republic of	6,200	1.1	14,787	1.4
Switzerland	27,310	12.0	49,721	1.1
Thailand	6,779	.5	31,940	2.6
United Kingdom	6,032	7.2	7,097	4.6
Other	13,728	2.7	152,098	12.7
Total	3,600,890	141.4	2,297,659	131.6
Ruby:				
Belgium-Luxembourg	NA	.2	NA	1.4
Burma		.8		3.3
Canada		.1		1.2
France		.7		1.4
Germany, Federal Republic of		.9		3.1
Hong Kong		13.5		9.1
India		3.1		4.7
Switzerland		3.3		12.0
Thailand		58.1		47.6
United Kingdom		1.3		4.7
Other		3.0		5.3
Total	NA	85.0	NA	93.8
Sapphire:				
Australia	NA	.4	NA	2.6
France		.3		2.2
Germany, Federal Republic of		.6		2.4
Hong Kong		4.9		8.4
India		1.6		3.3
Sri Lanka		6.8		7.5
Switzerland		1.7		11.1
Thailand		31.8		34.8
United Kingdom		.8		5.1
Other		2.0		5.6
Total	NA	50.9	NA	83.0
Other:				
Rough, uncut:				
Australia	NA	2.0	NA	1.2
Brazil		4.5		3.2
Colombia		1.8		2.2
South Africa, Republic of		3.2		1.6
Switzerland		3.5		.7
Zambia		1.9		2.5
Other		3.4		6.3
Total	NA	20.3	NA	17.7
Cut but unset:				
Australia	NA	2.4	NA	3.5
Brazil		17.4		36.4
Germany, Federal Republic of		7.9		11.0
Hong Kong		17.1		17.6
India		2.7		2.4
Switzerland		.4		1.0
Taiwan		1.0		.9
Thailand		1.5		2.8
Other		6.5		5.4
Total	NA	56.9	NA	81.0

NA Not available.

Table 6.—Value of U.S. imports of synthetic and imitation gem stones, by country

(Million dollars)

Country	1980	1981
Synthetic, cut but unset:		
Austria	0.9	1.7
France	.8	1.2
Germany, Federal Republic of	7.5	5.8
Korea, Republic of	5.3	8.2
Switzerland	2.1	2.6
Other	3.1	3.1
Total	19.7	22.6
Imitation:		
Austria	8.5	7.7
Czechoslovakia	.8	.8
Germany, Federal Republic of	3.1	3.8
Other	1.3	1.0
Total	13.7	13.3

Table 7.—U.S. imports for consumption of precious and semiprecious gem stones

(Thousand carats and thousand dollars)

Stone	1980		1981	
	Quantity	Value	Quantity	Value
Diamonds:				
Rough or uncut[1]	1,594	995,212	935	404,354
Cut but unset	2,567	1,255,983	3,474	1,796,908
Emeralds: Cut but unset	3,601	141,413	2,298	131,560
Coral: Cut but unset, and cameos suitable for use in jewelry	NA	3,544	NA	3,630
Rubies and sapphires: Cut but unset	NA	r135,914	NA	176,758
Marcasites	NA	136	NA	498
Pearls:				
Natural	NA	3,829	NA	2,008
Cultured	NA	77,375	NA	105,942
Imitation	NA	1,965	NA	1,966
Other precious and semiprecious stones:				
Rough and uncut	NA	20,323	NA	17,697
Cut but unset	NA	56,927	NA	87,325
Other n.s.p.f	NA	7,430	NA	665
Synthetic:				
Cut but unset[2]	17,848	19,714	28,846	22,646
Other	NA	1,277	NA	961
Imitation gem stones	NA	13,689	NA	13,332
Total	XX	r2,734,731	XX	2,766,250

rRevised. NA Not available. XX Not applicable.
[1]Includes 16,544 carats of other natural diamond, advanced, valued at $1.15 million in 1980, and 1,823 carats valued at $1.26 million in 1981.
[2]Quantity in thousands of stones.

WORLD REVIEW

Angola.—Prior to Angola's independence in 1974, annual diamond production was 2.4 million carats, and by 1979, production had fallen to 840,000 carats. A revitalization of this country's important diamond mining industry, spearheaded by Companhia de Diamantes de Angola (Diamang), bolstered by increasing prices, caused annual production of diamonds to climb to 1.5 million carats, with export earnings of $400 million in 1980. Diamang was 77.1% owned by the Government, with the remainder held by British, South African, United States, Belgian, and Swiss interests, with marketing handled by De Beers.[2]

Australia.—Exploration and evaluation of the Argyle prospect by the CRA-Ashton Joint Venture continued during the year with drilling and bulk sampling of the kimberlite pipe AK-1, and bulk sampling of the Upper Smoke Creek, Lower Smoke Creek, and the Limestone Creek alluvial deposits. Cumulative totals for all work performed (including 1980), indicate that 152,000 carats have been recovered from 37,800 short tons of the AK-1 pipe, and 102,000 carats have been recovered from 52,100 tons of the alluvials. Composite sorting of these diamonds showed a quality of 10% gem, 30% near-gem, and some high-quality industrials, and the balance industrials. A representative sampling has been evaluated by the Central Selling Organization at $8.00 per carat, depending on the bort value assumed.

The final feasibility study commenced at yearend for the design and construction of a large-scale commercial plant with an initial capacity of 2.5 million short tons per year. Large-diameter core drilling for kimberlite sampling and geological continuity of the pipe progressed to depths of 145 meters. With these assumptions, diamond production should start in 1985 at a level of 10 to 15 million carats per year, slightly better in the initial years until the alluvials are processed, and with a project life of 20 to 30 years. This mine alone would easily surpass Zaire as the world's largest producer of industrials and would have a strong impact upon the world market. At yearend, an agreement was made by the Central Selling Organization with the Ashton Joint Venture and the Australian Government to market most of the production, with some concessions to allow domestic sales, and the development of a cutting and polishing center in Perth.[3]

Australia produces five types of precious gem stones—black, gray, and white fire opal, sapphires, diamonds, chrysoprase, and rubies. The Aga emerald mine in Western Australia is a recent development. Although it has been an intermittent producer since 1909 with exports to India, recent exploration revealed an increased potential for emerald production. Recovery of gem-quality was about 11%, and the largest crystal found so far was 9.6 carats. The lower grade emeralds were being sold to the United States.[4]

Belgium.—Total imports of diamonds by Belgium reached 54 million carats in 1981, a 17% increase compared with that of the previous year; however, total value decreased 3.4% compared with that of 1980. Total exports were 48 million carats valued at $3.1 billion, a caratage increase of 8.5% and value increase of 7.4% compared with that of 1980. The major market for Belgium diamonds continued to be the United States, which received 1 million carats in 1981. The Central Selling Organization's share of Belgium's rough stone imports had gradually fallen from 89% in 1977 to 68% in 1981.[5] Price setting of investment-grade diamonds was being done twice daily by an important Antwerp-based diamond dealer.[6]

Botswana.—At yearend 1981, De Beers asked Botswana to stockpile diamonds because of the world slump in prices. De Beers had a 50% interest in De Beers Botswana Mining Co. in the operation of the Orapa and Letlhakane Mines, and the new Jwaneng Mine near Gabarone in the southern part of the state. The Jwaneng Mine, scheduled to have a rated capacity of 5.3 million short tons per year, was to be onstream in the second half of 1982. It is expected to have a higher recovery grade than that of any other mine in the Group, and to produce diamonds of medium quality. De Beers reported it to be probably the most important kimberlite pipe discovered anywhere in the world since Kimberley more than a century ago.[7]

Brazil.—Most of the gem diamond production in Brazil has come from independent prospectors called "garimpeiros" who produce about 120,000 carats per year. A conservative estimate for 1981 indicated total state production of 228,000 carats of gem and 372,000 carats of industrial diamond, mostly from Minas Gerais and Mato Grosso Provinces.[8]

China.—OCTHA, a South African diamond mining, cutting, and marketing group, is investing $3 million in China to establish the first diamond cutting and polishing operation in China.[9]

Colombia.—Econominas, the Colombian state mining organization, reported that legal exports of emeralds in 1980 were valued at $196 million, principally to Japan, the United States, and Taiwan. Emerald exports accounted for almost 50% of the total mineral exports from Colombia. However, it was estimated that this was only 40% of the real amount exported, the remainder being smuggled out of the country illegally.[10]

Ghana.—The Akwatia diamond mine, 65 miles from the Ghanaian capital of Accra, was facing several financial difficulties. The mine, which started operations in 1924, was no longer profitable, and its closing was a possibility. In 1973, the mine had produced 2.4 million carats annually and only produced about 1.0 million carats in 1981. However, at yearend the Government underwrote a $15 million loan to Ghana Consolidated Diamond Co. to modernize its plant and improve its economic viability. Also at yearend, the Government of India announced an agreement to purchase rough diamonds from the Diamond Marketing Corp. of Ghana, and it was estimated that this would result in additional margins for Ghana, compared with the previous sales through the Diamond Trading Co. of London.[11]

Guinea.—A $70 million alluvial diamond venture was being developed in the Kissidougou Banankor area close to the border of Sierra Leone, an area noted for high-quality diamonds. Initial production was expected to begin in August 1983 at an annual production level of 200,000 carats and increase to 500,000 carats per year by 1985. The project was a joint venture between Bridge Oil of Australia (45%) and the Republic of Guinea (50%). The remaining 5% was to be shared by Simonius Vischer and Industrial Diamond Co. of Switzerland, with marketing performed by Aredor Sales managed by Industrial Diamond Co.[12]

A diamond of 800 carats was discovered in Guinea in 1981. The diamond, the largest found in the country since 1958, was of industrial quality.[13]

India.—The discovery of three large diamonds in the Vajrakarur area of Andhra Pradesh has led the Geological Survey of India to embark on a 3-year program of intensive diamond exploration. The Majhagawan diamond mines of the Panna district have yielded a total of 233,000 carats of diamonds worth $20 million since 1960. The Panna area has also produced about 3,200 carats of crude emerald per year.[14]

The Gem and Jewellery Export Promotion Council in India reported that exports of gem stones and jewelry rose by 8% to $700 million in 1980-81. The council fixed a new target of $860 million for 1981-82, with most of the revenue from cut and polished gem diamonds, which ranks as India's top foreign exchange earning commodity. India already led the world in quantity of diamond exports and was ranked third after Israel and Belgium in terms of value.[15]

Israel.—The Israeli diamond cutting, polishing, and trading industry, one of the most important in the world, was severely affected by the recent decline in world gem sales. The industry has been the nation's largest industrial export business, with exports totaling $1.4 billion at its peak. At its peak in 1979, 700 companies employed 12,000 people, compared with about 600 companies employing 8,000 people in 1981. Exports in 1981 were about $950 million, 68% lower than the peak year of 1979.[16]

Israel accounts for about 50% of world production of cut emeralds, and exports have grown in value from $2.6 million in 1971 to $10 million in 1977. It is expected that exports exceeded $50 million in 1981.[17]

Ivory Coast.—Diamond mining of both gem and industrial quality in the Ivory Coast has been centered in the Tortiya and Seguela regions. Société Anonyme de Recherches et d'Exploitations Minières en Côte d'Ivoire's operation at Tortiya began in 1948 and continued until 1975, when it closed because of high costs. The Seguela Mine was successfully operated by the Watson Society from 1971 to 1977. The Ivory Coast has not produced any diamonds in the past 2 years.[18]

Lesotho.—At the Letseng-la-Terai Mine of De Beers Lesotho Mining Co., Ltd., the tonnage treated was down slightly to about 2.1 million short tons, and the grade was practically the same at 2.80 carats per 110 short tons. The percentage of gem diamonds remained high at 93%, and the diamonds larger than 10 carats in size represented 12% of the production.[19] Commercial operations at other diamond-bearing kimberlites in this small, landlocked country surrounded by the Republic of South Africa had been organized into two labor-intensive cooperatives with portable washing plants, which provided profitable work for over 1,100 employees.[20]

The Lesotho Government's Bureau of Statistics reported that 1980 production, 105,245 carats of diamonds, was valued at $274.88 per carat.[21]

Namibia.—Responding to poor market conditions, curtailment of the mining and treatment operations of Consolidated Diamond Mines (Pty.) Ltd., a subsidiary of De Beers, resulted in a 25% reduction in total tonnage treated, and a reduction of 20% in diamond production from 1.6 million carats in 1980 to 1.25 million carats in 1981. These beach placers near Oranjemund yield diamonds of 95% gem-quality, and contributed as much as 18% of De Beers pretax profits in 1979.[22]

The T.O.N.M. Oil and Gas Exploration Corp. has acquired a 50% interest in African Coast Diamond and Minerals (Pty.) Ltd. (ACDM). ACDM has mining rights to 90 square miles along the Atlantic coast of Namibia. A large-scale pilot plant with

Sortex equipment is located between the Hoarusib and Hoanib Rivers. Reserves have been estimated to be 2 to 6 million carats.[23]

It was reported that three kimberlite pipes had been discovered near the western border of the Republic of South Africa with Namibia, and De Beers inaugurated an extensive prospecting program across the frontier in the northeastern corner of Namibia.[24]

Sierra Leone.—During 1981, the National Diamond Mining Co., Ltd. (DIMINCO) of Sierra Leone mined principally alluvial deposits to produce about 595,000 carats of diamonds. Over 50% of the diamonds were of gem-quality, including some very large stones, which has resulted in illicit operations and theft. DIMINCO estimates that as much as 50% of the diamonds mined have been smuggled out. DIMINCO initiated an Alluvial Diamond Mining Scheme to have frequent sights in Freetown with payment in hard currency to detract from the smuggling. In the July sights, DIMINCO sold almost 45,000 carats for $188 per carat, not including a special sale of a 119-carat diamond for $1.1 million. A new joint venture of the Sierra Leone Government (60%), the Kuwait Foreign Trading, Contracting and Investment Co. (30%), and Sierra Leone Selection Trust (10%) was formed to mine the diamond-bearing kimberlites in the Kono area, to be initiated in 1981 and fully operational by 1985.[25]

South Africa, Republic of.—De Beers continued its widespread reconnaissance and prospecting program in the Republic of South Africa without the discovery of any new important kimberlite provinces. Shaft sampling of a kimberlite cluster on the Venetia farm, with bulk sample treatment by a heavy media separation plant, progressed during the year. Sampling for reserve extension of existing mines in Namaqualand continued.

The Namaqualand Div. of De Beers suspended operations in the Tweepad area for the last 7 months of 1981, and production at Annexe Kleinzee and the Koingnaas complex was reduced by 10% for the remainder of the year. Diamond recovery declined 15% to a level of 1.2 million carats with an average grade of 18.6 carats per 110 short tons.

At the Finsch Mine, operation of the new treatment plant for the full year at a high throughput and improved diamond recovery efficiency resulted in a 50% increase of diamond production in 1981 compared with 1980. The open pit mine, presently producing from the 160- to 220-meter levels, was scheduled to change over to underground production in 1988. Vertical shaft sinking to 763 meters was completed in August 1981.[26]

Leichardt Exploration of Australia discovered more diamonds on Farm "C" at the Reads Drift prospect, confirming expectations that higher grades exist at depth.[27]

The Octha diamond group was expanding its investment program to $160 million in South Africa, to create an integrated diamond mining, cutting, marketing, and retailing operation. Included in its operations was a Namaqualand Mine and four mines in the Kimberley area. Production in 1981, about 100,000 carats of 85% gem-quality, was expected to be increased to 1 million carats per year 50% gem-quality, by 1986.[28]

Sweden.—Two diamonds, each about 0.3 millimeter, were found in an area of kimberlite on the Baltic island of Alnon, just off the east coast of Sweden near Sundsvall. Washing of 12 short tons of ore yielded one diamond. This was the first confirmed diamond find ever made in western Europe.[29]

Thailand.—Thailand continued to be one of the most important centers of gem stone cutting and polishing in the world, principally diamonds, rubies, and sapphires. Export value of all precious stones in 1980 was approximately $2.5 billion.[30]

U.S.S.R.—The Siberian platform of the Soviet Union in north-central Asia has emerged as one of the most remarkable kimberlite and diamond areas on earth. Since the pioneering days 25 years ago, over 400 kimberlite pipes have been discovered within an oval belt 300 miles long and 250 miles wide southwest of the Lena River, a kimberlite province comparable with the Diamond Belt of southern Africa. Twelve principal kimberlite and/or diamond regions have been delineated, and the state has concentrated on these for maximum production development. The famous Mir diamond mine is in the Malo Botuoba region and was one of the richest pipes. However, it is questionable whether the full potential of this remote area will ever be realized, because at least 5 of the 12 principal regions are well within the Arctic Circle, where deep permafrost prevails along with long winters and extremely sub-Arctic temperatures. In one case at Mirnyy, construction engineers were fortunate in finding a dolerite sill upon which to build a milling and recovery plant.[31]

A new diamond mine was under develop-

Table 8.—Diamond (natural): World production, by country and type[1]

(Thousand carats)

Country	1977 Gem	1977 Industrial	1977 Total	1978 Gem	1978 Industrial	1978 Total	1979 Gem	1979 Industrial	1979 Total	1980[p] Gem	1980[p] Industrial	1980[p] Total	1981[e] Gem	1981[e] Industrial	1981[e] Total
Africa:															
Angola	265	88	353	r488	r162	r650	630	211	841	1,125	375	1,500	1,050	350	1,400
Botswana	404	2,287	2,691	r420	r2,379	r2,799	659	3,735	4,394	765	4,336	5,101	744	4,217	[2]4,961
Central African Republic	178	119	297	199	85	284	205	110	315	227	123	350	200	100	300
Ghana	230	1,717	1,947	142	1,281	1,423	125	1,128	1,253	126	1,132	1,258	100	900	1,000
Guinea[e]	25	55	80	25	55	80	27	58	85	12	26	38	12	26	38
Ivory Coast	r20	r19	[2]39	r22	r23	r45	24	24	48	--	--	--	--	--	--
Lesotho	39	3	42	62	5	67	48	4	52	50	4	54	49	4	[2]53
Liberia[3]	163	163	326	128	180	308	170	132	302	123	175	298	117	169	[2]286
Namibia	1,901	100	2,001	1,803	95	1,898	1,570	83	1,653	1,482	78	1,560	1,186	62	[2]1,248
Sierra Leone	423	538	961	353	426	779	419	436	855	317	275	592	320	275	595
South Africa, Republic of:															
Finsch Mine	r365	r2,061	2,426	r403	r2,227	2,630	465	2,120	2,585	465	2,442	2,907	1,002	3,463	[2]4,465
Premier Mine	r378	r1,632	2,010	r380	r1,603	1,983	468	1,613	2,081	407	1,632	2,039	510	1,530	[2]2,040
Other De Beers properties[4]	r1,216	r1,441	2,657	r1,254	r1,395	2,649	1,850	1,370	3,220	1,550	1,489	3,039	1,603	1,069	[2]2,672
Other	r372	r178	550	r320	r145	465	403	95	498	391	44	435	314	35	349
Total	r2,331	r5,312	7,643	r2,357	r5,370	7,727	3,186	5,198	8,384	2,813	5,607	8,420	3,429	6,097	[2]9,526
Tanzania	204	204	408	r141	r141	r282	157	157	314	137	137	274	140	140	280
Zaire	533	10,681	11,214	640	10,603	11,243	294	8,440	8,734	345	9,890	10,235	260	7,240	7,500
Other areas:															
Australia	--	--	--	--	--	--	--	--	--	--	48	48	[2]21	[2]184	[2]205
Brazil	r236	r384	r620	r236	r384	r620	236	384	620	253	414	667	228	372	600
Guyana	7	10	17	7	10	17	6	10	16	4	6	10	4	6	10
India	15	3	18	14	2	16	14	2	16	e12	e2	e14	12	2	14
Indonesia[e]	3	12	15	3	12	15	3	12	15	3	12	15	3	12	15
U.S.S.R.[e]	2,100	8,200	10,300	2,150	8,400	10,550	2,200	8,500	10,700	2,250	8,600	10,850	2,120	8,480	10,600
Venezuela	204	483	687	r271	r549	r820	247	556	803	238	483	721	[2]102	[2]388	[2]490
Total	r9,281	r30,378	r39,659	r9,461	r30,162	r39,623	10,220	29,180	39,400	10,282	31,723	42,005	10,097	29,024	39,121

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

[1]Table includes data available through May 7, 1982. 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 (1980-81), Central African Republic (1977-78), Liberia (1977-78), Sierra Leone (1977-78), and Venezuela (1978-81), 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. China also produces some natural diamond, but output is not reported.

[2]Reported figure.

[3]Total exports.

[4]All company output from the Republic of South Africa, except for that credited to the Finsch and Premier Mines for the years indicated; excludes De Beers Group output from Botswana, Lesotho, and Namibia.

ment near Mirnyy in the Yakutsk Autonomous Soviet Socialist Republic . The mine, which was the first Soviet underground diamond mine, was to go into operation during the period 1983-85. Twin 21-foot shafts will be sunk by freezing techniques in the unconsolidated formation below permafrost—one for ore removal and the other for ventilation. Both shafts will be approximately 3,300 feet deep.[32]

Zaire.—Zaire is the largest producer of industrial diamonds in the world. Production by Société Minière de Bakwanga (Miba) progressively dropped from a record 18 million carats in 1961 to an estimated 7.5 million carats in 1981. Illegal mining and smuggling have been reported to represent 50% of official production by Miba.

Faced with higher operating costs and declining grades, Miba was seeking financing for a new mine, as well as modernization and expansion of current alluvial operations. The plant was to treat primary kimberlite and to purchase two dredges to work deposits in riverbeds and adjoining areas. The Miba deposits at Mbuji-Mayi are about 1,400 kilometers east of Kinshasa in Kasai Oriental Province. The deposits were first worked over 60 years ago; recent exploitation has been equally divided between alluvial deposits and primary kimberlite deposits to depths of 60 meters.[33]

In 1981, Sozacom, the Zairean state marketing agency, announced a break with De Beers' Central Selling Organization, which had exclusive marketing rights for the last 14 years. At yearend, Sozacom announced that they had marketed 10 millions carats for 1981, as demand for industrials and low-grade gems had held up better in a recession year compared with the demand for larger gems.[34]

At yearend, three companies—International Diamond Co. of London, and Caddi Sprl and Glasol NV of Belgium—who had agreed to market Zaire's diamonds in cooperation with Sozacom, also agreed to assist a local diamond cutting and polishing industry by constructing a $2 million plant.

TECHNOLOGY

The labeling of the so-called reconstructed or reconstituted Geneva ruby, produced in the early development of synthetic ruby in 1903-04, has been convincingly proven incorrect. The most popular production technique explanation—that of fusing small pieces of genuine ruby together by flame fusion such as with Verneuil torch—has been discounted by scientific experiments. Genuine reconstructed products from these experiments do not resemble in any way the boules or cut stones of the original reconstructed ruby. The originals can now be attributed to multiple-step boule production under less than ideal conditions.[35]

The quality of synthetic ruby has now so improved that the new synthetic Kashan ruby is so similar to the natural that only professional laboratories can distinguish the difference. Heretofore, a professional with a 10-power hand lens could distinguish between natural rubies with crystal and Saturn-like inclusions, coarse twinning, and wispy fingerprints, and synthetic ruby with bubble inclusions and curved striae, but 45-power microscopic observation by a professional is now necessary.[36]

Zircon-based age-dating of six different Siberian kimberlite pipes have indicated a geological age ranging from 148 to 450 million years. Diamond-bearing eclogite examination presented definite conclusions that the diamonds were formed in a medium close to normal basalt in chemical composition, the only difference being that the formation of diamonds took place at a depth of about 200 kilometers. Isolation and separate examination of diamond-bearing inclusions such as red garnet and chrome diopside indicated that the morphology of the enclosed mineral is a perfect copy of the morphology of the diamond itself, and confirm the age of the diamond.[37]

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Gold

By J. M. Lucas[1]

As a result of exploration for new gold deposits over the past several years, the discovery of many millions of ounces[2] of gold reserves at new or existing locations, especially in the Southwestern United States, were reported during 1981. Large, low-grade deposits of micron-sized gold that escaped the attention or interest of most earlier explorers and that favor modern, improved low-cost mining and recovery techniques have been the principal targets of these exploration efforts. The success of these continuing efforts, which have been encouraged by unprecedented gains in the price of gold over recent years, has resulted in a steady increase in domestic mine production since 1979 with production during 1981, at 1.4 million ounces, approaching its highest level in nearly a decade. There has also been a similar, though less dramatic, growth in total world mine production since 1979.

Table 1.—Salient gold statistics

	1977	1978	1979	1980	1981
United States:					
Mine production thousand troy ounces	1,100	999	[r]964	[r]970	1,378
Value thousands	$163,192	$193,324	[r]$296,550	[r]$594,050	$633,359
Ore (dry and siliceous) produced:					
Gold ore thousand short tons	5,806	4,292	7,046	[r]9,893	10,451
Gold-silver ore do.	481	738	756	872	1,006
Silver ore do.	800	992	962	[r]1,925	4,435
Percentage derived from:					
Dry and siliceous ores	60	58	[r]58	[r]66	71
Base-metal ores	38	40	[r]41	32	27
Placers	2	2	1	[r]2	2
Refinery production:					
Domestic ores thousand troy ounces	956	962	795	773	801
Secondary (old scrap) do.	1,040	1,384	1,675	2,184	1,590
Exports:					
Commercial do.	7,011	5,509	16,499	6,119	6,437
Monetary do.	1,660	NA	NA	NA	NA
Imports for consumption do.	4,454	4,690	4,630	4,542	4,652
Gold contained in imported coins do.	1,614	3,736	2,790	3,081	2,612
U.S. Treasury gold medallion sales[1] do.	--	--	--	338	189
Net sales from foreign stocks in Federal Reserve Bank do.	6,406	1,569	40	1,785	1,181
Stocks, Dec. 31:					
Monetary million troy ounces	277.6	276.4	264.6	264.3	264.1
Industrial[2] thousand troy ounces	1,976	1,672	[r]868	872	630
Consumption in industry and the arts do.	4,863	4,738	4,785	3,215	2,793
Price:[3] Average per troy ounce	$148.31	$193.55	$307.50	$612.56	$459.64
World:					
Production thousand troy ounces	[r]38,906	[r]38,983	[r]38,769	[p]39,141	[e]40,785
Official reserves[4] million troy ounces	[r]1,170.8	[r]1,162.9	[r]1,143.3	[r]1,146.9	1,146.6

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available.
[1]Sales program began July 15, 1980.
[2]Unfabricated refined gold held by refiners, fabricators, and dealers.
[3]Engelhard Industries quotations.
[4]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	1977	1978	1979	1980	1981
Commodity Exchange, Inc	New York	98.17	373.40	654.15	788.72	1,041.67
New York Mercantile Exchange	do	.03	.85	.21	(1)	--
International Monetary Market	Chicago	90.82	281.30	355.87	254.35	251.82
Chicago Board of Trade	do	1.33	5.49	10.30	7.15	1.47
Mid-America Commodity Exchange	do	.09	1.50	6.65	14.86	15.59
Total		190.44	662.54	1,027.18	1,065.08	1,310.55

[1]Less than 5,000 troy ounces. Trading in gold futures terminated in January 1980.

The rate of decline in the domestic demand for gold in fabricated products during 1980 continued in 1981 but slowed as markets adjusted to higher prices and changing economic conditions. Conversely, the reported demand for gold in the other market-economy countries rose sharply, exceeding supplies of newly mined gold by about 1.6 million ounces.

Legislation and Government Programs.—On March 19, the State of South Dakota imposed a new severance tax on precious metals mined in that State. The legislation increases the previous severance tax, based on pretax earnings, to a 6% tax on gross revenues from the sale of precious metals produced from South Dakota sources. The tax does not apply to producers mining less than 1,000 ounces of metal in any one calendar year.

In mid-1981, pursuant to legislation introduced in late 1980, the Congress established a Gold Commission to study U.S. policy with respect to the role of gold in the domestic and international monetary systems and to also consider the question of returning to a gold standard. Hearings were conducted in late 1981; the final report and conclusions of the Commission were scheduled for release in March 1982.

Legislation appropriating $20 million for a mining loan fund was signed by the Governor of Alaska on July 23, 1981. State residence and 5 years of mining or prospecting experience in the State is required before individuals may be considered for a loan. A broader range of requirements determines the eligibility of partnerships and corporations to obtain loans. The legislation specified that repayment of the loan for lode or placer operations shall begin 5 years and 2 years, respectively, following the date of initial production.

On October 1, 1981, Public Law 94-450, the Gold Labeling Act of 1976, which amended the National Stamping Act of June 13, 1906, and reduced permissible deviation in gold content of articles made in whole or part of gold became effective. The tolerance was reduced from one-half of one karat to three parts per thousand for most articles, or if soldered, to seven parts per thousand. The act, also referred to as the "plumb gold" amendment, was designed to take effect 5 years after the date of enactment to enable jewelry manufacturers to clear their stocks of gold pieces labeled under the previous regulations. The purpose of the act was to assist the domestic industry in meeting the requirements of foreign countries, thereby increasing U.S. exports.

DOMESTIC PRODUCTION

Domestic gold mine production, stimulated by the higher metals prices of recent years, increased for the second consecutive year. Many new or rehabilitated gold mines under development for the past several years began producing or reached full capacity during 1981 and, in spite of the decline in the gold price from its historic high of the previous year, corporate exploration for new deposits, especially in the West, continued at a brisk pace. The volume of material washed for gold by placer operators increased threefold over that washed in 1980. Exploration, both inside and outside of established gold mining districts, continued to be directed toward high-grade vein and placer deposits, as well as large low-grade disseminated gold deposits amenable to improved heap leaching and bulk haulage techniques. The lower 1981 price did not appear to have dampened the enthusiasm of either the amateur or the professional prospector to search for gold or to reap the recreational benefits associated with this popular outdoor activity.

Approximately one-half of domestic gold mine output was accounted for by five mines—Homestake, Utah Copper (Bingham Canyon), Carlin, Battle Mountain, and Alligator Ridge. The 25 largest mines (table 5) accounted for 89% of domestic production in 1981.

Gold production in 1981 was reported by 241 mines, of which 32 were placer mines, 78 were lode mines producing from precious metal ores or tailings, and 131 were lode byproduct producers. About 71% of the gold came from precious metal ores, 26% came from base metal ores, and 2% came from placers (figure 1, table 6). The methods by which gold was extracted from its ores reflected the nature of the ores; thus, most of the gold was recovered by cyanidation of precious metal ores and by smelting of base metal ores, while minor quantities were recovered by amalgamation and by gravity methods (tables 7-9). The average recovery grade of gold ores mined in lode mines was 0.09 ounce per 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	1977	1978	1979	1980	1981
Alaska	18,962	18,652	6,675	r12,881	25,316
Arizona	90,167	92,989	101,840	r79,631	100,339
California	5,704	7,480	r5,010	r4,078	6,271
Colorado	72,668	32,094	13,850	39,447	51,069
Idaho	12,894	20,492	24,140	W	W
Montana	22,348	19,967	24,050	48,366	54,267
Nevada	324,003	260,895	250,097	r278,495	524,802
New Mexico	13,560	9,879	r14,966	r15,847	65,749
Oregon	675	340	W	W	2,830
South Dakota	304,846	285,512	245,912	r267,642	278,162
Tennessee	13	W	--	--	W
Utah	210,501	235,929	260,916	179,538	227,706
Washington	24,006	W	W	W	W
Other	--	14,603	r16,934	r43,857	41,435
Total	1,100,347	998,832	r964,390	r969,782	1,377,946

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

Table 4.—Mine production of gold in the United States, by month

(Troy ounces)

Month	1977	1978	r1979	r1980	1981
January	90,768	82,304	71,827	77,922	98,887
February	81,705	89,695	68,850	78,301	93,385
March	93,498	87,198	75,567	87,040	115,200
April	87,294	89,196	75,222	89,477	110,366
May	94,166	81,305	76,153	93,054	108,291
June	86,924	84,701	76,500	83,279	119,383
July	82,238	69,119	79,557	59,595	126,365
August	93,690	83,502	92,974	57,130	125,198
September	85,855	85,600	88,654	73,888	124,324
October	99,402	94,090	92,331	84,161	123,201
November	101,034	80,506	85,370	83,366	119,386
December	103,773	71,616	81,385	102,569	113,960
Total	1,100,347	998,832	964,390	969,782	1,377,946

rRevised.

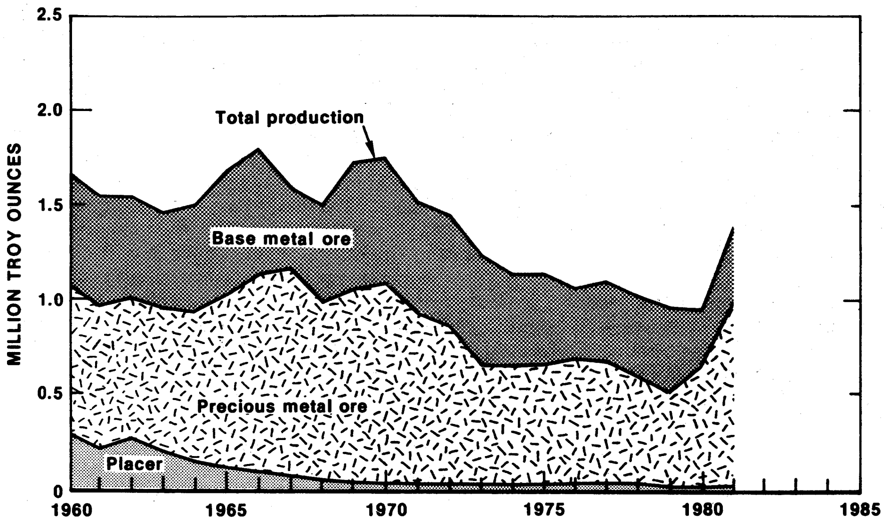

Figure 1.—Gold mined in the United States.

Several years of intensive exploration and development by various mining interests culminated in the opening of many new gold or gold-silver mines in Nevada during 1981 and for the second consecutive year, the State retained its ranking as the leading gold producing State. Exploration in Nevada added over 18 million ounces of new gold to that State's sizable reserves during 1981. Production, at 524,802 ounces, was 246,307 ounces or 88% greater than production reported the previous year. The last year in which Nevada's gold mine production exceeded that of 1981 was 1915. Nine mines in Nevada were among the top 25 gold producers in the Nation during the year. Louisiana Land & Exploration Co. announced the discovery of substantial additional reserves of gold and silver at a new ore body under evaluation adjacent to its Smokey Valley Mining Div.'s Round Mountain Mine in Nye County, about 45 miles north of Tonopah. Reserves at the new deposit, the limits of which have yet to be defined, are 8.4 million ounces of gold and 15.7 million ounces of silver. Overburden stripping was underway at yearend. Mining is expected to begin in early 1984 and reach full capacity at about 300,000 ounces per year by 1986. Following dedication ceremonies in June, Amselco Minerals Inc. began heap leaching operations on ore mined from their Alligator Ridge Mine located 70 miles northwest of Ely in White Pine County. When fully operational the mine, which is operated by Amselco, a joint venture between Selection Trust Ltd. and Occidental Minerals Corp., is expected to produce about 100,000 ounces of gold per year from three adjacent open pits.

The Pinson Mining Co., a joint venture between the U.S. subsidiaries of Lacana Mining Corp., Rayrock Resources Ltd., and United Siscoe Mines, began open pit mining and milling operations at their new mine in Humboldt County. The new computer-controlled, carbon-in-pulp mill is capable of processing 1,000 tons of ore per day for a yield of about 45,000 ounces of gold per year. Near Hawthorne, Nev., Houston International Minerals Corp., a subsidiary of Tenneco Inc., dedicated its New Borealis Mine and heap leaching complex in early November. From an identified ore reserve of nearly 3 million tons, the company expects to mine 780,000 tons of ore per year for an annual yield of 30,000 ounces each of gold and silver. Also in November, the Duval Corp., the mining subsidiary of the Pennzoil Corp., announced the discovery of a significant gold and silver deposit on a Duval-owned property near its existing Battle Mountain Mine in Lander County. The new ore body contains an estimated 2.4 million ounces of gold and 9.3 million ounces of silver in proven and probable ore reserves of about 6 million tons. Overburden stripping to prepare for open pit mining began before the end of the year. Elsewhere in Lander County, Placer Amex Inc. completed reactivation of its Cortez Gold Mine and modernization of its 200-ton-per-day mill located southeast of Battle Mountain. United Mining Corp. dedicated a newly constructed Chollar ventilation shaft and escape raise at the New Savage gold and silver mine on the Comstock Lode in Storey County. The new construction will permit underground mining to begin.

Output from the Carlin Mine, west of Elko, from three open pits and two ore leaching operations increased to about 136,600 ounces. Newmont Mining Corp., parent of the Carlin Gold Mining Co., announced that its gold exploration program had resulted in several significant discoveries during the year. Drilling in progress on the Gold Quarry deposit near Carlin resulted in identifying mineralization containing 8 million ounces of gold and a new discovery south of Gold Quarry, the Rain deposit, has thus far been credited with 700,000 ounces of metal. Metallurgical investigations currently underway will determine the recovery process to be used in a new milling and heap leaching facility to be built to serve the Gold Quarry project. At yearend, Carlin's total reserves of milling-grade ore, including Maggie Creek's milling ore but excluding Gold Quarry, were 6,988,000 tons containing 0.165 ounce of gold per ton. On July 4, the Freeport Gold Co., a subsidiary of Freeport-McMoRan Oil & Gas Co., poured the first bar of gold at its new Enfield Bell (Jerritt Canyon) mining and milling complex. The mine is a joint venture of Freeport Gold Co. and FMC Gold and is located in the Independence Mountains about 50 miles north of Elko. The new project is expected to reach its full designed production capacity of about 200,000 ounces per year by mid-1982. Proven and probable reserves at yearend were about 2,900,000 ounces of gold contained in oxide and carbonaceous ores. The new mill incorporates dual recovery circuits to simultaneously process both of the ore types. The average grade of the Jerritt Canyon ore is about 0.22 ounce per ton and recovery is expected to be about 87.5%.

In California, the exploration division of the Homestake Mining Co. elevated the status of its new McLaughlin project from the advanced exploration stage to that of development. The company also announced that exploration of the deposit had more than tripled the previous year's ore reserve estimates to a mininum of 3.2 million ounces contained in 20 million tons of ore bearing 0.16 ounce of gold per ton. Homestake also announced the discovery of higher grade gold mineralization at depth, some of which occurs below the limits of the proposed open pit. Evaluation of this higher grade occurrence, which would require underground mining methods, is continuing. Mining at McLaughlin, located in a remote area of Napa County northeast of San Francisco, is expected to startup in 1985. Near Marysville, Yuba Natural Resources, Inc., formerly Yuba Goldsfield, Inc., in a joint venture with Placer Service Corp., a subsidiary of the St. Joe Minerals Div. of the Fluor Corp., placed their recently rehabilitated gold dredge in operation on gold-bearing gravels and dredge tailings along the Yuba River. The dredge, the deepest-digging dredge in the Western World, was rebuilt after several decades of inactivity and is expected to process 4.5 million cubic yards of gravel per year for an annual yield of about 25,000 ounces of gold.

In Tuolumne County, New Jersey Zinc, a division of the Gulf + Western Natural Resources Group, continued exploration of five old mining properties in the Sonora-Jamestown area. Results to date indicate a sizable reserve of low-grade gold ore. Construction at Noranda's Gray Eagle open pit gold-silver mine in northern California was well underway at yearend. The mine and mill complex, which is designed for a production capacity of 500 tons per day, is expected to startup in 1982. Northcal Gold Inc. of Northair Mines Ltd., Vancouver, British Columbia, Canada, obtained all the necessary consents to commence drilling of their Bully Hill gold-silver and base metal deposit near Redding. Pending favorable results, a decision to begin production will be made in 1982. Throughout California many companies and individual prospectors maintained the previous year's high level of exploration and reexamination of the many long-abandoned mines and prospects located throughout the State.

The Homestake Mine at Lead, S. Dak., retained its position as the Nation's largest gold mine, producing 267,392 ounces of gold from 1.8 million tons of ore hoisted and milled. The average recoverable grade of the Homestake ore is 0.150 ounce per ton. The cost per ounce of gold produced at the

Lead facility in 1981 was $342, compared with $308 in 1980. Mining is currently being conducted to a depth of 6,800 feet and plans are proceeding to extend mining to the 8,000-foot level. Exploration for gold by Homestake and other companies continued in promising areas of the State. Several companies conducted experimental heap leaching operations at new discoveries or on tailings and dumps left by past producers.

Kennecott Copper Corp.'s Utah Copper (Bingham Canyon) Mine, near Salt Lake City, the largest copper mine in the Nation, was again the second largest gold producer during the year. At Utah Copper, gold is recovered as a byproduct of copper production. Kennecott Minerals Co., a division of Kennecott Copper, continued exploration for precious metals on lands leased in the East Tintic mining district, Juab County, Utah. The leased area includes lands occupied by the Trixie Mine. Exploration drilling along the Homansville Fault area by Kennecott was completed during the year. In Tooele County, about 50 miles southwest of Salt Lake City, Getty Mineral Resources, a wholly owned subsidiary of Getty Oil Co., was developing its gold project at Mercur Canyon. Open pit mining at a rate of 3,000 tons per day is expected to commence in mid-1983. A new process to recover the micron-sized gold was developed initially with participation of the U.S. Bureau of Mines Research Center in Salt Lake City. The Mercur Canyon project is a joint venture between Getty and Gold Standard Inc. Anaconda Mining Co., Denver, Colo., plans to treat and process tailings and dumps for base and precious metals on lands leased in the East Tintic mining district. In November, Anaconda Minerals Co., formerly Anaconda Copper Co., temporarily suspended mining operations at its Carr Fork Mine near Tooele. Development work and engineering studies were unaffected by the suspension.

Canadian Superior Mining (U.S.), Ltd., has nearly completed development of an open pit gold heap leach operation at the old mining town of Stibnite in Valley County, Idaho. The company expects to recover about 1 ounce of gold per 10 to 20 tons of ore processed during the 8-month working season. The property was last worked for gold during the 1940's. In Idaho County, following a favorable geological evaluation indicating over 120,000 tons of ore containing about 0.5 ounce of gold per ton, Center Star Gold Mines Inc. contracted with several firms to rehabilitate, explore, and develop the old Center Star gold mine near Elk City. In Custer County, Sunbeam Mining Co. announced plans to develop a heap leaching operation at the old Golden Sunbeam Mine, which was a major gold producer in the early 1900's. In January, Mapco Minerals Corp. purchased all mining and mineral-related properties of Earth Resources Co., including the Delamar Mine in Owyhee County. The Delamar ranked 13th in domestic gold production in 1981. Many lode and placer deposits in Idaho, mostly abandoned past producers, were under investigation or development during 1981.

Over 50 major exploration companies and numerous individual prospectors searched for gold, silver, and base metals in Montana during the year. Helicopters and occasional pack horse strings were used to gain access to several remote roadless areas. In August, Placer Amex Inc. a subsidiary of Placer Development Ltd. of Vancouver, British Columbia, Canada, announced that it will place its Golden Sunlight property, located near Whitehall, into production by mid-1983. Open pit production is expected to average 72,000 ounces of gold per year for at least 13 years. This development will be followed by underground operations to tap the deeper portions of the ore body. The property is reported to contain about 26 million tons of ore with a grade of 0.05 ounce of gold per ton. Road and site development were underway during the latter half of the year.

Placer Amex also purchased an option from U.S. Minerals Co. of Arvada, Colo., to explore and develop U.S. Mineral's Montana Tunnels property near Helena. The property has a probable reserve of 25 million tons of gold, silver, lead, and zinc ore. Ranchers Exploration and Development Corp. of Albuquerque, N. Mex., completed drilling at their Golden Grizzly property near Cooke City; results indicate an open pit reserve of about 453,000 tons of ore containing 0.15 ounce of gold per ton and 1.17% copper. Throughout Montana both experimental and operational heap leaching was performed on crude ore as well as old tailings and dumps of past producers; one indoor, all-weather, leaching facility began operations near Phillipsburg. Placer mining by small mine operators and prospectors was conducted in Missoula, Powell, Ravalli, Meagher, Mineral, and Lincoln Counties.

The Cripple Creek mining district appeared to again be the focal point of gold activity in Colorado during the year. Near the end of 1981, Cripple Creek and Victor Gold Mining Co., a joint venture of Texasgulf, Inc., and Golden Cycle Corp., began limited ore production at their recently reopened Ajax and Cresson Mines. Test milling is being performed at the nearby Carlton mill; the 350-ton-per-day mill, which had been closed for over 20 years, was extensively reequipped prior to beginning test runs in late 1981. Gold mines were also under lease, development, or evaluation in the Cripple Creek district by Standard Metals Corp., Gold Run Joint Venture, Gold Ore Ltd., Silver State Mining, Yellow Gold of Cripple Creek Inc., and Newmont Minerals. In the Idaho Springs district, recently formed Equity Gold, Inc., began shipping ore from the old Stanley Mine to the nearby Black Eagle mill. Equity is also rehabilitating the Glory Hole Mine and mill and is operating mines in the Freeland Group under a leasing agreement. Cobb Resources of Albuquerque N. Mex., in a joint venture with HNG Fossil Fuels Co., a subsidiary of Houston Natural Gas Corp., is developing the old London Mine near Fairplay. Many other gold properties and prospects received attention in Colorado during the year.

Ranchers Gold & Silver Exploration Program, a New Mexico limited partnership in which Ranchers Exploration and Development Corp. has a 60% interest, continued exploration of its Mystic property, 9 miles north of Sun City, near Phoenix, Ariz. Drilling and surface sampling at the property indicate high-grade gold in a number of targets widely distributed over the property. Much additional drilling is required to fully evaluate the prospect. At Bisbee, the Small Mines Div. of the Phelps Dodge Corp., was attempting to develop additional gold and silver reserves in low-grade copper zones left unmined when the Bisbee copper mines were closed in 1975. The company, in a joint venture with Verde Explorations Ltd., was also preparing to reenter the Little Daisy Mine in Yavapai County to explore from the old workings for overlooked extensions of gold- and silver-bearing ore and to pull copper- and precious metal-bearing pillars left behind when the mine was closed in 1938. Mining and exploration companies interested in precious metals pursued their objectives in most of the mining districts of Arizona, especially those in Yavapai and Yuma Counties.

From January through November the number of new mining claims staked in Alaska rose to over 26,000, which exceeds the record number staked in 1978 and 1980.[3] A large percentage of these claims were staked by individual gold prospectors. In 1981, the Alaska State Div. of Geological and Geophysical Surveys conducted a field survey of 153 Alaskan gold producers and estimated that over 128,000 ounces of gold were produced during that year; of this total, all except 5,200 ounces was from placers. The total number of active gold mining operations were estimated at over 400. Conversely, the much lower total reported on a voluntary basis by producers and tabulated in tables 3 and 6, reflects a seasonal reporting problem aggravated by the remote location of most of the mining operations. In the Chandalar district north of Fairbanks, Jan-Drew Holding Ltd. of Edmonton, Alberta, Canada, continued their seasonal gold lode and placer mining operations on properties of the Little Squaw Gold Mining Co. Placer gold was also produced by TriCon Mining, Inc., in the nearby Wiseman district. TriCon also continued lode mining at the Grant Mine west of Fairbanks. Near Fairbanks, Placid Oil Co. and St. Joe American continued testing and tunneling work on their various gold properties. The Alaska Gold Co. operated three dredges at Nome and Hogatza and Tuluksak Dredging Ltd. had two dredges working on the Tuluksak River. On Livengood Creek, 60 miles north of Fairbanks, Livengood Joint Venturers, which has the largest placer gold reserves in Alaska, began using a DC-10 tractor, the largest made, to improve the efficiency of their mining. During the winter, when gravel washing is not possible, the company rips and repositions frozen pay gravel and overburden, materials, which are more manageable as large frozen chunks than as thawed loose material. On Unga Island near the south end of the Alaska Peninsula, Catalina Energy and Resources Ltd., continued exploration of the lode gold properties of Apollo Mines. Cook Inlet Exploration and Development Co. prepared to commence suction dredging operations on its tidal and offshore placer tracts in Cook Inlet near the Anchorage International Airport.

Cusac Industries Ltd., of Vancouver, British Columbia, Canada, plans to construct a 700- to 1,000-ton-per-day pilot plant to develop a suitable process for recovering gold from their beach sand claims along the Gulf of Alaska at Cape Yakataga. Ranchers Exploration and Development Corp. expanded its placer operations on Slate Creek on the south flank of the Alaska Range. The company expected to recover between 4,000 and 5,000 ounces of gold from 300,000 cubic yards of gravel during the 1981 season. Coronado Mining Co. began underground mining at the old Independence Mine in the Willow Creek district and several placer operations were active in the Yentna-Cache Creek area west of Talkeetna.

In the Mormon Basin-Basin Creek areas west of Baker, Oreg., Veta Grande Co. Inc. of Northridge, Calif., was operating a dragline and washing plant to recover gold values from two adjacent placer deposits. Gold was produced at the Pyx and Thomason Mines in eastern Oregon. Also in eastern Oregon, Texasgulf Inc. was trucking 150 tons per day of gold, silver, and copper-bearing sulfides from their Iron Dyke Mine to the Silver King flotation mill at Cuprum, Idaho. The company reported that gold production from the mine amounted to over 2,900 ounces during 1981. Several lode and placer mines were reported to be operating in western Oregon. Other mining and exploration companies pursuing gold in Oregon during the year included UNC Resources, Hanuman (Galactic Resources Ltd.), Comanche Petroleum and Blue Diamond Energy Resources, Noranda Exploration Co., Brooks Minerals Inc., Amax, Baretta Mining Inc., and Homestake Mining Co.

In Washington State, 1981 gold production at the Republic Unit (formerly the Knob Hill Mine) at Republic in Ferry County, declined slightly owing to a 1-month shutdown during October and November to make needed repairs to the main hoist and concentrator; 55,812 tons of ore bearing 0.23 ounce of gold and 1.43 ounces of silver per ton were produced during the year. In 1981, Hecla Mining Co. acquired the properties and assets of Day Mines, Inc., owners and operators of the Republic Unit. The mine has been operating since 1935 from a deposit discovered in 1896. Elsewhere in Ferry County, Rocky Mines of Republic started a heap leaching operation for gold and silver and the Astra Corp. of Spokane, Wash., was planning to recover gold from the tailings and dumps at the old First Thought Mine near Orient, an intermittent producer of free-milling gold since 1904. In Okanogan County a small gold and silver leaching operation was begun at the Minnie Mine near Carlton and Western Land Resources was blocking out ore reserves at the old Bodie Mine near Wauconda. Houston International Minerals Corp., a subsidiary of Tenneco Inc., continued exploration in the Bodie-Wauconda area and in the area southwest of the town of Twisp an exploration drilling project was underway by the lease holders at the Alder Mine. Lion Mines Ltd. (N.P.L.) of Vancouver, British Columbia, Canada, continued seasonal exploration and development work at their New Lite property in Whatcom County. Small-scale placer operations were conducted at a number of localities statewide, most notable in the Liberty district of Kittitas County along Swauk, Williams, and Boulder Creeks; in Okanogan County on the Similkameen River placers; in northern Stevens County along the Columbia River; and in Asotin County along the Snake River.

In the south, a small production of gold was reported from South Carolina and many companies and individuals were investigating the prospects for new gold deposits in Virginia, North Carolina, Georgia, Alabama, and Texas. Elsewhere in the Nation, Callahan Mining Corp. continued their exploration and evaluation program at the old Ropes gold mine in Marquette County in the Upper Peninsula of Michigan. Gold exploration and development projects were also reported to be proceeding in Minnesota, Wyoming, and elsewhere in Michigan.

Refinery production of gold extracted from foreign and domestic ores in 1981 increased only about 2% from production reported during the previous year. Gold refined from old scrap and new (manufacturer's) scrap declined 27% and 11%, respectively, from 1980 production levels.

Table 5.—Twenty-five leading gold-producing mines in the United States in 1981, in order of output

Rank	Mine	County and State	Operator	Source of gold
1	Homestake	Lawrence, S. Dak	Homestake Mining Co	Gold ore.
2	Utah Copper	Salt Lake, Utah	Kennecott Copper Corp	Copper ore.
3	Carlin	Eureka, Nev	Carlin Gold Mining Co	Gold ore.
4	Battle Mountain	Lander, Nev	Duval Corp	Do.
5	Alligator Ridge	White Pine, Nev	Amselco Minerals Inc	Do.
6	Pinson	Humboldt, Nev	Pinson Mining Co	Do.
7	Round Mountain	Nye, Nev	Copper Range Co	Do.
8	Maggie Creek Pit	Eureka, Nev	Carlin Gold Mining Co	Do.
9	Ortiz	Santa Fe, N. Mex	Gold Fields Operating Co	Do.
10	Enfield Bell (Jerritt Canyon)	Elko, Nev	Freeport Gold Co	Do.
11	Sunnyside	San Juan, Colo	Standard Metals Corp	Do.
12	Cortez	Lander, Nev	Cortez Gold Mines	Do.
13	Delamar	Owyhee, Idaho	Earth Resources Co	Gold-silver ore.
14	San Manuel	Pinal, Ariz	Magma Copper Co	Copper ore.
15	Argo	Phillips, Mont	Zortman Mining Co	Gold ore.
16	Morenci	Greenlee, Ariz	Phelps Dodge Corp	Copper ore.
17	Magma	Pinal, Ariz	Magma Copper Co	Do.
18	Carr Fork	Tooele, Utah	The Anaconda Company	Do.
19	New Cornelia	Pima, Ariz	Phelps Dodge Corp	Do.
20	Berkeley Pit	Silver Bow, Mont	The Anaconda Company	Do.
21	Pegasus	Phillips, Mont	Landusky Mining Co	Gold ore.
22	Sterling	Nye, Nev	Saga Exploration Co	Do.
23	Knob Hill	Ferry, Wash	Hecla-Day Mines Corp	Do.
24	Leadville Unit	Lake, Colo	Asarco Incorporated	Lead-zinc ore.
25	Nome Unit	Seward Peninsula, Alaska	Alaska Gold Co	Placer.

Table 6.—Gold produced in the United States, by State, type of mine, and class of ore

State	Placer (troy ounces of gold)	Lode: Gold ore: Short tons	Lode: Gold ore: Troy ounces of gold	Lode: Gold-silver ore: Short tons	Lode: Gold-silver ore: Troy ounces of gold	Lode: Silver ore: Short tons	Lode: Silver ore: Troy ounces of gold	Lode: Copper ore: Short tons	Lode: Copper ore: Troy ounces of gold
1979: Total	[r]9,527	7,045,714	516,747	756,220	35,184	962,289	5,816	[r]234,631,289	[r]383,348
1980: Total	[r]16,968	[r]9,892,599	[r]599,506	872,019	33,428	[r]1,924,939	[r]5,472	[r]197,292,230	[r]272,665
1981:									
Alaska	25,217	301	99	--	--	--	--	--	--
Arizona	--	1,683	204	14,851	1,850	118,118	367	183,828,115	95,496
California	2,225	27,755	3,645	1,445	312	168	14	--	--
Colorado	W	W	W	106,000	889	231,891	1,619	--	--
Montana	8	593,987	38,786	4,532	414	584,928	273	15,130,877	14,403
Nevada	W	6,608,303	508,212	W	W	2,523,111	10,927	W	W
Oregon	--	462	130	--	--	--	--	26,646	2,700
South Dakota	200	1,848,303	277,962	--	--	--	--	--	--
Other[1]	62	1,369,814	93,363	879,293	35,395	976,946	3,237	65,370,819	240,169
Total	27,712	10,450,608	922,401	1,006,121	38,860	4,435,162	16,437	264,356,457	352,768
Percent of total gold	2	XX	67	XX	3	XX	1	XX	25

State	Lode: Lead and zinc ores: Short tons	Lode: Lead and zinc ores: Troy ounces of gold	Lode: Copper-lead, lead-zinc, copper-zinc, and copper-lead-zinc ores: Short tons	Lode: Copper-lead, lead-zinc, copper-zinc, and copper-lead-zinc ores: Troy ounces of gold	Lode: Old tailings, etc.: Short tons	Lode: Old tailings, etc.: Troy ounces of gold	Total[2]: Short tons	Total[2]: Troy ounces of gold
1979: Total	3,379,021	434	1,002,073	12,497	42,493	837	[r]247,819,099	[r]964,390
1980: Total	3,410,956	1,887	1,145,259	37,092	67,623	2,764	[r]214,605,625	[r]969,782
1981:								
Alaska	--	--	--	--	--	--	301	25,316
Arizona	37	9	--	--	173,174	2,413	184,135,978	100,339
California	--	--	--	--	790	[3]75	30,158	6,271
Colorado	--	--	W	W	W	W	1,103,512	51,069
Montana	600	8	--	--	9,000	375	16,323,924	54,267
Nevada	--	--	--	--	111,935	412	9,302,469	524,802

Oregon	--	--	--	--	--	--	27,108	2,830
South Dakota	--	--	--	--	--	--	1,848,303	278,162
Other[1]	1	13	3,152,611	11,582	66,689	4,881	70,991,432	334,890
Total	638	30	3,152,611	11,582	361,588	8,156	283,763,185	1,377,946
Percent of total gold	XX	([4])	XX	1	XX	1	XX	100

[r]Revised. W Withheld to avoid disclosing company proprietary data; included in "Other." XX Not applicable.
[1]Includes Idaho, New Mexico, South Carolina, Tennessee, Utah, Washington, and items indicated by symbol W.
[2]Data may not add to State totals because of items withheld to avoid disclosing company proprietary data.
[3]Includes byproduct gold recovered from tungsten ore.
[4]Less than 1/2 unit.

Table 7.—Gold produced in the United States from ore, old tailings, etc., by State and method of recovery

State	Total ore, old tailings, etc., treated[1] (thousand short tons)	Ore and old tailings to mills: Thousand short tons[1]	Recoverable in bullion: Amalgamation (troy ounces)	Recoverable in bullion: Cyanidation (troy ounces)	Concentrates smelted and recoverable metal: Concentrates (short tons)	Concentrates smelted and recoverable metal: Troy ounces	Crude ore, old tailings, etc., to smelters[1]: Thousand short tons	Crude ore, old tailings, etc., to smelters[1]: Troy ounces
1979: Total	305,566	304,747	1,238	518,554	5,859,021	r415,968	819	19,103
1980: Total	r263,309	r262,564	9,015	r603,255	r5,569,699	r324,132	745	16,412
1981:								
Alaska	(2)	(2)	--	--	4	99	--	--
Arizona	[3]217,231	[3]216,846	--	913	3,801,815	95,481	385	3,945
California	[3] [4]30	[3] [4]29	33	321	3,293	3,349	1	343
Colorado	[3]1,207	[3]1,199	14,912	3,300	60,598	31,724	8	[5]1,133
Montana	[3]16,342	[3]16,321	--	38,353	260,995	15,149	21	757
Nevada	[3] [6]11,861	[3] [6]11,859	--	524,064	5,149	446	2	[5]292
Oregon	27	27	--	--	2,924	2,706	(2)	124
South Dakota	1,848	1,848	--	277,962	--	--	--	--
Utah	40,629	40,474	--	--	824,169	218,462	156	9,244
Other	35,538	35,436	--	67,829	1,274,367	37,334	102	2,021
Total[7]	324,715	324,040	14,945	912,742	6,233,314	404,750	675	[5]17,859

rRevised.
[1]Includes some nongold-bearing ores not separable.
[2]Less than 1/2 unit.
[3]Includes tonnages from which gold was recovered by heap leaching.
[4]Excludes tonnage of tungsten ore from which gold was recovered as a byproduct.
[5]Includes a small amount of placer production to avoid disclosing company proprietary data.
[6]Includes tonnages from which gold was recovered by vat leaching.
[7]Data may not add to totals shown because of independent rounding.

Table 8.—Gold produced at amalgamation and cyanidation mills in the United States and percentage of gold recovered from all sources

Year	Bullion and precipitates recovered (troy ounces): Amalgamation	Bullion and precipitates recovered (troy ounces): Cyanidation	Gold recovered from all sources (percent): Amalgamation	Gold recovered from all sources (percent): Cyanidation	Gold recovered from all sources (percent): Smelting[1]	Gold recovered from all sources (percent): Placers
1977	26,615	597,633	2.4	54.3	41.2	2.1
1978	2,254	532,670	.2	53.3	44.3	2.2
1979	1,238	518,554	.1	r53.8	r45.1	r1.0
1980	9,015	r603,255	.9	r62.2	35.1	r1.8
1981	14,945	912,742	1.1	66.2	30.7	2.0

rRevised.
[1]Crude ores and concentrates.

Table 9.—Gold produced at placer mines in the United States, by method of recovery

Method and year	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:						
1977	3	4	1,377	12	$1,742	$1.265
1978	2	3	1,010	11	2,187	2.164
1979	2	3	475	3	977	2.056
1980	2	3	170	3	1,719	r10.111
1981	3	5	[1]2,190	15	6,731	3.073

See footnotes at end of table.

Table 9.—Gold produced at placer mines in the United States, by method of recovery —Continued

Method and year	Mines producing	Washing plants	Material washed (thousand cubic yards)	Gold recoverable: Thousand troy ounces	Value (thousands)	Average value per cubic yard
Dragline dredging:						
1977	[r]1	7	[2]10	[3]2	$311	[4]$5.932
1978	[r]3	9	[2]60	[3]3	519	[4]4.339
1979	3	[r]10	[r] [2]86	[r] [3]4	[r]1,110	[4]4.019
1980	3	[r]11	[2]55	[r] [3]6	[r]3,379	[4]5.780
1981	1	7	[2]30	[3]3	1,200	[4]13.023
Hydraulicking:						
1977	12	13	273	5	754	2.762
1978	10	10	233	4	784	3.367
1979	8	8	176	2	613	3.480
1980	14	14	453	4	2,657	5.869
1981	7	7	157	1	526	3.354
Nonfloating washing plants:						
1977	[r]5	7	[2]106	[3]3	477	[4]2.319
1978	[r]9	11	[2]152	[3]4	812	[4]2.448
1979	7	8	[2]42	[3]1	225	[4]2.988
1980[r]	7	10	[2]314	[3]4	2,605	[4]7.811
1981	8	11	[2]694	[3]8	3,880	[4]5.467
Underground placer, small-scale mechanical and hand methods, and suction dredge:						
1977	7	7	41	1	159	3.901
1978	5	5	1	([5])	13	13.431
1979	3	3	4	([5])	5	1.281
1980	2	2	3	([5])	33	12.473
1981	6	7	108	1	401	3.728
Total placers:[6]						
1977	[r]28	38	[2]1,807	[3]23	3,443	[4]1.638
1978	[r]29	38	[2]1,456	[3]22	4,314	[4]2.483
1979	23	[r]32	[2]784	[r] [3]10	[r]2,930	[4]2.639
1980[r]	28	40	[1] [2]994	[3]17	10,394	[4]7.220
1981	25	37	[1] [2]3,179	[3]28	12,738	[4]3.723

[r]Revised.
[1]Does not include platinum-bearing material from which byproduct gold was recovered.
[2]Excludes tonnage of material treated at commercial sand and gravel operations recovering byproduct gold.
[3]Includes gold recovered at commercial sand and gravel operations.
[4]Gold recovered as a byproduct at sand and gravel operations not used in calculating average value per cubic yard.
[5]Less than 1/2 unit.
[6]Data may not add to totals shown because of independent rounding.

Table 10.—U.S. refinery production of gold

(Thousand troy ounces)

Source	1977	1978	1979	1980	1981
Concentrates and ores:					
Domestic	956	962	795	773	801
Foreign	62	71	83	14	4
Old scrap[1]	1,040	1,384	1,675	2,184	1,590
New scrap	1,414	1,701	1,208	1,640	1,465
Total	3,472	4,118	3,761	[2]4,612	3,860

[1]Excludes upgrading of U.S. Government-owned gold (mostly coin gold) by the U.S. Assay Office, amounting to 316,137 ounces in 1977; 2,386,874 ounces in 1978; 3,000,068 ounces in 1979; 2,921,587 ounces in 1980; and 2,476,628 ounces in 1981. Refining activity suspended from September 1981 through the end of the year.
[2]Data do not add to total shown because of independent rounding.

CONSUMPTION

Domestic consumption of refined gold, as measured by its conversion into fabricated and semifabricated forms, declined for the second consecutive year to a level 42% below that reported for 1979 (figure 2, table 11). Jewelry and arts usage accounted for 52% of consumed gold, industrial uses for 39%, and dental uses for about 8%. Compared with the previous year, declines were registered in nearly all demand categories, except for industrial karat gold applications which rose 18% and the use of gold in gold-filled jewelry which registered a gain of less than 1%. Rapidly rising gold prices in late 1979 and early 1980 had a severe impact on consumption in those years, as users, to conserve their inventories of refined gold, turned to less expensive substitutes and used fewer units of gold per product. Thus, electronics manufacturers were substituting palladium, tin, and other suitable metal for gold where possible, and jewelry makers were reportedly beginning to shift away from karat golds to gold-filled, rolled gold, gold-plated, and gold-silver combinations. In 1981, however, the benefits accruing to demand by moderating gold prices were apparently more than offset by continuing substitution, factors relating to the prolonged economic recession, and the continuing high cost of borrowed money required to maintain manufacturer or consumer inventories.

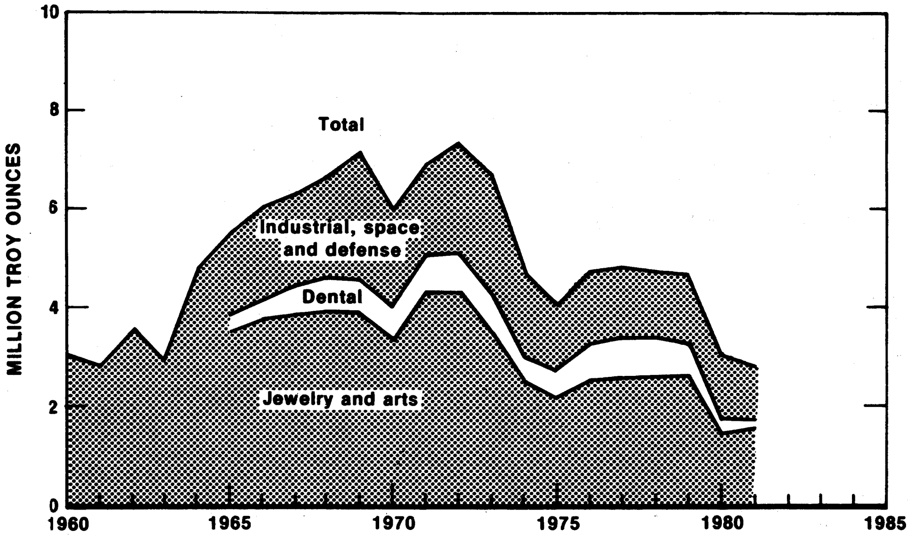

Figure 2.—Consumption of gold in the United States.

Table 11.—U.S. consumption of gold, by end use[1]

(Thousand troy ounces)

End use	1977	1978	1979	1980	1981
Jewelry and arts:					
Karat gold	2,236	2,224	2,276	1,249	1,203
Fine gold for electroplating	37	42	32	30	24
Gold-filled and other	385	385	380	226	228
Total	2,658	2,651	2,688	1,505	1,455
Dental	728	706	646	341	221
Industrial:					
Karat gold	60	64	64	38	45
Fine gold for electroplating	656	687	797	592	528
Gold-filled and other	494	562	545	657	523
Total[2]	1,209	1,313	1,406	1,287	1,095
Small items for investment[3]	268	68	45	82	22
Total consumption[2]	4,863	4,738	4,785	3,215	2,793

[1]Gold consumed in fabricated products only. Does not include monetary bullion.
[2]Data may not add to totals shown because of independent rounding.
[3]Fabricated bars, medallions, coins, etc.

Although data are not reported on the purchase, or "consumption" of gold bullion by the private sector, the quantities purchased annually are believed to be represented approximately by the sizable supply surpluses that occurred each year from 1975 through 1979 and 1981. In 1975, the supply surplus was 52,000 ounces which grew to 4.1 million ounces in both 1978 and 1979 and 1.3 million ounces in 1981. In 1980 a deficit of about 0.7 ounces of bullion was registered largely because of completion, in that year, of the International Monetary Fund (IMF) auctions and suspension of Department of the Treasury sales. Also, the flow of gold coins, mostly "bullion coins," into the United States has been substantial since the purchase of nonnumismatic coins in quantity was authorized in 1974. Estimated imports of gold coins, in millions of ounces were: 1975, 1.7; 1976, 1.3; 1977, 1.6; 1978, 3.7; 1979, 2.8; 1980, 3.1., and 1981, 2.6. In mid-1980, the Department of the Treasury began public sales of gold medallions bearing the images of celebrated American artists; a total of 189,000 ounces of gold in medallions was sold during 1981.

STOCKS

Official.—There were no public bullion auctions by the Department of the Treasury during 1980 or 1981. Stocks of bullion held by the Department at yearend 1981 were 214,000 ounces less than stocks on hand at yearend 1980. The decline was attributed in part to the use of bullion stocks to satisfy the minting requirements of the Department's gold medallion sales program.

There was no gold bullion distributed under the restitution provision of the IMF Gold Accord during 1981. The fourth and final restitution took place during December 1979 and January 1980, when 1.4 million ounces were restituted to the United States.

Official gold reserves of the market-economy countries, including stocks held by the IMF and the Bank for International Settlements, totaled 1.147 billion ounces at yearend. IMF bullion stocks at yearend 1981 were essentially unchanged from stocks held at the close of 1980.

Commercial.—Industrial stocks of refined gold held by U.S. refiners, fabricators, and dealers were drawn down substantially from 0.872 million ounces at yearend 1980 to 0.630 million ounces at the close of 1981. These yearend inventories, at their lowest level in several decades, reflect the further impact of relatively higher metal prices and the continuing economic recession on demand as well as high interest and operating costs that existed throughout the year. Futures exchange stocks, at 2.45 million ounces, were considerably less than those at yearend 1980 and more in line with levels posted in earlier years (table 12).

Table 12.—Stocks of gold in the United States, end of period

(Thousand troy ounces)

	1977	1978	1979	1980	1981
Treasury Department[1]	277,570	276,433	264,614	264,330	264,116
Industry	1,976	1,672	868	872	630
Futures exchange	1,835	2,752	2,473	4,998	2,449
Earmarked gold[2]	378,683	366,248	359,285	354,453	350,640

[1]Includes gold in Exchange Stabilization Fund.
[2]Gold held for foreign and international official accounts at New York Federal Reserve Bank.

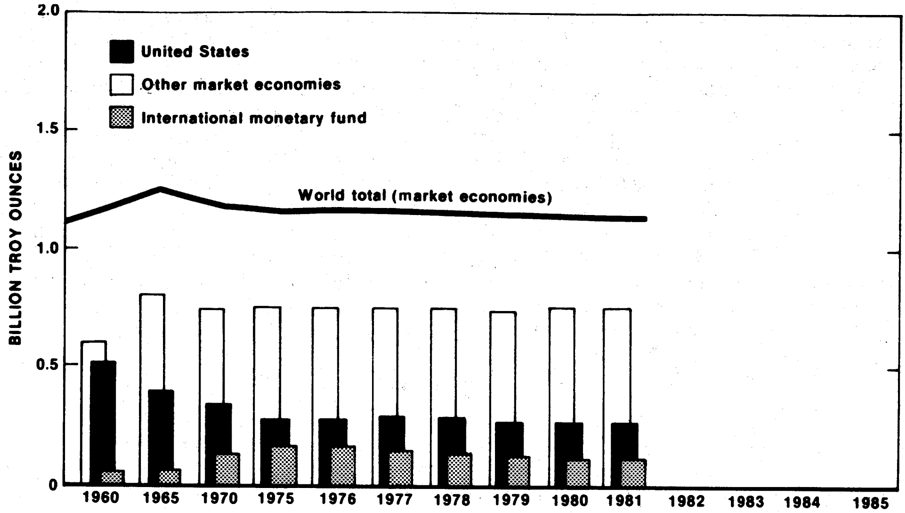

Figure 3.—World monetary gold stocks.

PRICES

After attaining record levels in January 1980, the price of refined gold (figure 4, table 13) seesawed downward and by year-end 1981 still remained well above levels reached in 1978 and early 1979. The average Engelhard Industries price of unfabricated gold in 1981 was $459.64 per troy ounce.

Since 1979, many of the industrialized nations have adopted market-related prices for valuation of their bullion reserves; again, the United States was the only holder of large gold stocks still valuing its bullion at a fixed price ($42.22 per ounce).

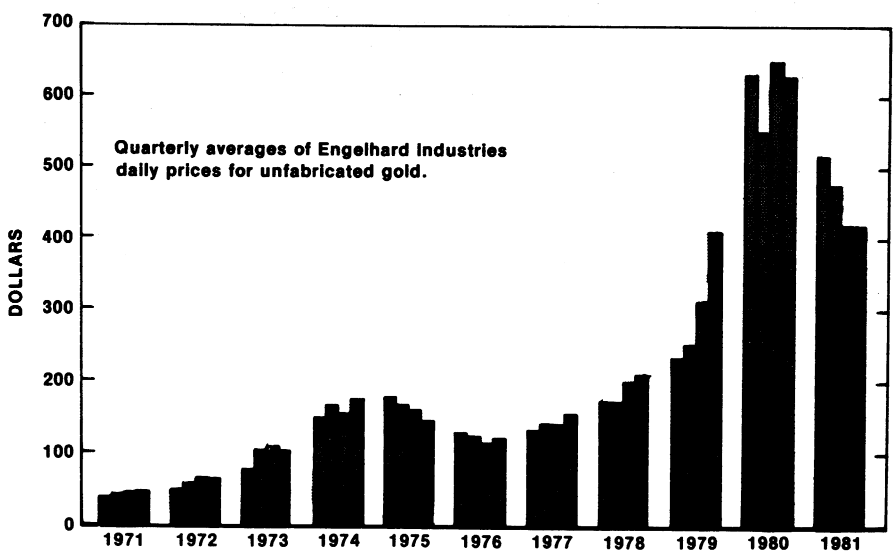

Figure 4.—U.S. gold prices.

Table 13.—U.S. monthly gold prices[1]

(Dollars per troy ounce)

Month	1980			1981		
	Low	High	Average	Low	High	Average
January	559.80	850.00	675.36	493.75	599.25	557.39
February	606.00	710.50	665.32	489.00	519.50	500.26
March	481.50	643.50	553.58	461.50	539.50	498.76
April	485.75	554.00	516.77	473.75	533.75	494.90
May	490.00	535.50	513.97	466.50	493.00	479.79
June	552.50	653.50	600.72	426.00	483.25	460.76
July	606.00	687.50	643.27	397.75	422.00	408.88
August	605.00	645.25	627.45	391.25	431.50	410.90
September	636.75	711.00	675.76	421.50	463.50	444.10
October	629.00	690.00	661.15	424.50	453.50	437.76
November	596.00	652.00	622.44	396.75	431.25	412.86
December	558.00	635.00	594.92	394.74	426.00	409.32
Year	481.50	850.00	612.56	391.25	599.25	459.64

[1]Engelhard Industries daily quotation.

FOREIGN TRADE

In spite of the completion of bullion auctions by the IMF in early 1980 and the absence of bullion sales by the Department of the Treasury during 1981, exports of refined gold were about 500,000 ounces greater than the 4.7-million-ounce level achieved during 1980. In 1981, the United Kingdom received 70% of the refined total, compared with 37% in the previous year, followed by Canada and Mexico with 23% and 2%, respectively. Of the gold in all forms imported into the United States in 1981, 60% came from Canada, followed by the Republic of South Africa and Switzerland with 10% and 6%, respectively. An estimated 2.6 million ounces of gold in coins was imported during the year; of this total, 30% came from the Republic of South Africa, compared with over 50% from that source during the previous year. Important amounts also came from Canada, Mexico, and Switzerland, with Mexican coins gaining in popularity toward the end of the year.

Table 14.—U.S. exports of gold in 1981, by country

Country	Ore, base bullion, and scrap		Refined bullion		Total	
	Troy ounces	Value (thousands)	Troy ounces	Value (thousands)	Troy ounces	Value (thousands)
Belgium-Luxembourg	123,581	$58,045	2	$1	123,583	$58,046
Canada	786,613	373,839	1,186,744	560,702	1,973,357	934,541
France	61,534	29,478	91,470	45,596	153,004	75,074
Germany, Federal Republic of	52,866	25,095	32,715	18,332	85,581	43,427
Italy	2,312	955	14,123	6,207	16,435	7,162
Japan	6,596	2,731	16,517	8,059	23,113	10,790
Mexico	4	2	101,758	56,826	101,762	56,828
South Africa, Republic of	14,142	8,273	5	2	14,147	8,275
Switzerland	23,583	11,367	88,808	38,536	112,391	49,903
United Kingdom	115,650	54,601	3,645,677	1,738,895	3,761,327	1,793,496
Other	12,540	6,164	59,766	28,182	72,306	34,346
Total[1]	1,199,421	570,549	5,237,585	2,501,337	6,437,006	3,071,886

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

Table 15.—U.S. imports for consumption of gold in 1981, by country

Country	Ore, base bullion, and scrap		Refined bullion		Total	
	Troy ounces	Value (thousands)	Troy ounces	Value (thousands)	Troy ounces	Value (thousands)
Argentina	1,366	$560	72,266	$33,143	73,632	$33,703
Brazil	16,077	7,001	143,532	65,105	159,609	72,106
Canada	103,410	45,039	2,682,009	1,268,993	2,785,419	1,314,032
Chile	3,697	1,660	97,733	45,951	101,430	47,611
Dominican Republic	201,853	91,898	542	216	202,395	92,114
Guyana	8,771	3,191	860	490	9,631	3,681
Japan	10,075	4,569	117,289	56,584	127,364	61,153
Mexico	2,294	1,047	12,759	5,387	15,053	6,434
Panama	61,840	26,764	18,284	7,650	80,124	34,414
Peru	10,638	4,566	49,290	23,615	59,928	28,181
South Africa, Republic of	592	263	446,645	187,738	447,237	188,001
Switzerland	3,281	1,498	281,353	132,361	284,634	133,859
U.S.S.R	1,452	746	38,245	21,368	39,697	22,114
United Kingdom	6,683	2,072	12,329	6,093	19,012	8,165
Uruguay	--	--	127,884	56,012	127,884	56,012
Yugoslavia	3,288	1,138	33,493	16,895	36,781	18,033
Other	52,358	22,915	29,963	14,959	82,321	37,874
Total	487,675	214,927	4,164,476	1,942,560	4,652,151	2,157,487

Table 16.—Value of U.S. gold trade

(Thousand dollars)

Year	Exports	Imports[1]
1977	1,112,711	674,026
1978	1,113,794	903,024
1979	4,907,864	1,480,203
1980	3,647,932	2,750,120
1981	3,071,886	2,157,487

[1]Value of general imports for 1977. Value of imports for consumption for 1978-81; values of general imports were $921,504,188 (1978), $1,506,716,888 (1979), $2,795,549,207 (1980), and $2,157,486,432 (1981).

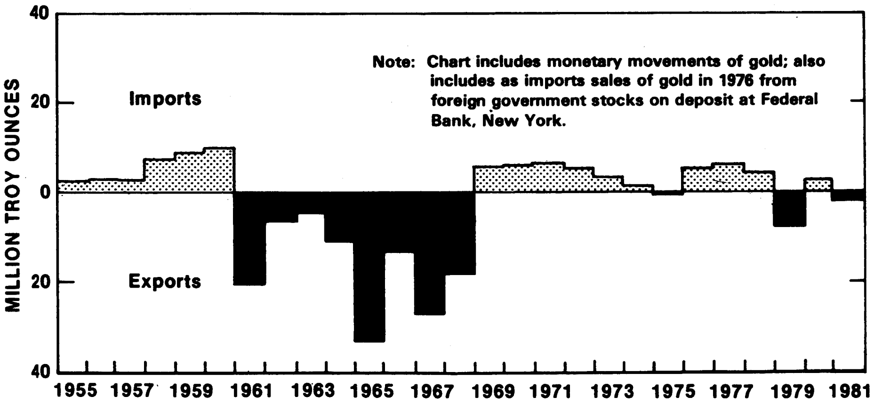

Figure 5.—Net U.S. trade in gold.

WORLD REVIEW

Estimated world gold mine production increased to about 40.8 million troy ounces in 1981. Production in the United States increased substantially as many new mines in the Western States started up or reached full-scale production. Except for developments in Brazil and Peru the pattern of production established in recent years remained essentially unchanged, with the Republic of South Africa accounting for 52% of the world mine output, followed by the U.S.S.R., China, Canada, the United States, Brazil, and 56 other countries for the remainder (figure 6, table 17).

The supply of gold (excluding most secondary gold) available to official and commercial purchasers in the market-economy countries in 1981 as reported in Consolidated Gold Fields annual summary[4] was about 40 million ounces, of which 30.9 million ounces was mined in the market-economy countries and 9.1 million originated as net trade with the centrally planned economy countries. When net purchases of gold for official or governmental financial purposes, 8.4 million ounces, were excluded, the supply available to the commercial sectors of the market-economy countries was about 31.6 million ounces. 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 funneled through Switzerland, England, and other Western European countries. Nearly 0.5 million ounces of raw alluvial gold of unspecified African origins was reported to have been processed by European refiners during the year. Much of the gold flowing from the United States to Europe in 1980 was bullion auctioned from IMF stocks; there were no bullion sales by the Department of Treasury during 1980, nor were there any IMF or Department of Treasury sales during 1981.

The tendency of gold to move from the official sector to the private sector, as occurred between 1973 and 1979, was reversed in 1980, and consequently, in 1981, official purchases of gold exceeded official sales by an estimated 8.4 million ounces. Demand for gold in the commercial sector of the market-economy countries during 1981 was estimated at 33.3 million ounces, a 91% increase over estimated 1980 demand, and for the first time since 1972, the demand for new gold in jewelry, coins, and industrial products exceeded the supply by about 1.6 million ounces. Gold consumed in the developed and developing countries of the market-economy world was divided, in millions of troy ounces, between the following end use categories (figures for the developing countries are in parentheses): jewelry 12.0 (7.1); electronics 2.7 (0.03); dental 2 (0.03); other industrial and decorative uses 2 (0.13); medallions and unofficial coins 0.42 (0.48); and official coins 4.8 (1.6). The totals for all categories were 23.92 (9.4) million troy ounces.

Table 17.—Gold: World mine production, by country[1]

(Troy ounces)

Country[2]	1977	1978	1979	1980[p]	1981[e]
North America:					
Canada	1,733,609	1,735,077	1,644,265	1,627,477	[3]1,512,526
Costa Rica[e]	12,200	15,900	16,718	[e]16,000	16,000
Dominican Republic	342,755	342,830	352,982	369,603	412,982
El Salvador	2,156	3,619	2,720	2,492	1,000
Honduras	2,481	[e]2,500	1,501	2,027	3,000
Mexico	212,709	202,003	190,364	195,991	185,000
Nicaragua	65,764	[r]73,947	61,086	[e]60,000	50,000
United States	1,100,347	998,832	964,390	969,782	[3]1,377,946
South America:					
Argentina	5,509	[r]5,600	10,140	10,956	10,900
Bolivia	24,293	24,660	30,319	52,075	55,600
Brazil[4]	279,520	300,898	319,258	1,300,000	1,200,000
Chile	116,376	[r]102,287	111,405	219,773	297,000
Colombia	[r]257,070	[r]246,446	269,369	510,439	535,000
Ecuador	8,124	2,734	3,215	3,537	3,700
French Guiana	4,823	[r] [e]5,000	[e]5,000	[e]4,000	4,000
Guyana	11,899	[r]15,404	10,593	11,003	[3]19,263
Peru	104,393	103,069	141,656	148,890	220,000
Suriname	[r]386	[r]289	300	350	380
Venezuela	17,403	13,384	14,989	16,519	17,500
Europe:					
Finland	27,392	29,096	28,325	41,828	40,000
France	50,444	59,640	54,109	[e]50,000	49,000

See footnotes at end of table.

Table 17.—Gold: World mine production, by country[1] —Continued

(Troy ounces)

Country[2]	1977	1978	1979	1980[p]	1981[e]
Europe—Continued					
Germany, Federal Republic of	2,392	2,119	2,357	2,964	2,900
Hungary[e]	115,000	60,000	60,000	60,000	60,000
Portugal	[r]8,841	[r]9,131	10,706	8,855	11,000
Romania[e]	65,000	65,000	65,000	65,000	65,000
Spain	117,800	102,882	91,404	108,154	105,000
Sweden	67,934	76,294	[e]70,000	[e]70,000	70,000
U.S.S.R.[e]	7,850,000	8,000,000	8,160,000	8,300,000	8,425,000
Yugoslavia[5]	164,226	142,556	138,987	[e]138,000	138,000
Africa:					
Burundi	[e]450	[e]450	133	130	100
Cameroon	182	[e]200	147	72	50
Central African Republic	[e]100	[e]965	2,181	2,000	1,500
Congo[e]	7,000	7,000	7,000	7,000	7,000
Ethiopia	7,725	[e]8,000	[6]7,970	[e]9,000	12,000
Gabon	2,572	965	964	553	550
Ghana	480,884	402,034	362,000	353,000	330,000
Kenya	135	205	[e]200	125	100
Liberia	NA	NA	1,086	7,243	7,000
Madagascar	76	125	125	114	110
Mali[e]	932	965	1,000	1,500	1,500
Mauritania	28,000	8,000	--	--	--
Rwanda	1,814	1,125	472	944	800
South Africa, Republic of	22,501,886	22,648,558	22,617,179	[3]21,669,468	[3]21,121,157
Sudan[e]	300	300	300	300	300
Tanzania	23	[r]133	322	246	250
Zaire	80,418	76,077	69,992	[3]39,963	70,000
Zambia	[e]11,250	8,457	7,933	10,576	10,000
Zimbabwe	401,884	398,990	388,000	368,000	371,000
Asia:					
China[7]	100,000	150,000	200,000	225,000	1,700,000
India[5]	96,902	89,186	84,781	78,834	80,000
Indonesia[8]	82,300	66,166	57,452	60,231	56,000
Japan	149,004	145,240	127,626	102,339	[3]99,314
Kampuchea[e]	1,000	--	--	--	--
Korea, North[e]	160,000	160,000	160,000	160,000	160,000
Korea, Republic of[5]	[r]21,392	[r]27,397	24,077	41,204	35,000
Malaysia:					
Peninsular Malaysia	4,172	5,805	5,273	4,621	5,800
Sarawak	742	971	1,062	[3]379	100
Philippines	558,554	586,531	535,166	589,965	670,000
Taiwan	14,995	13,407	14,243	13,278	53,300
Oceania:					
Australia	[r]624,270	647,579	596,910	544,022	530,000
Fiji	49,067	28,065	25,656	[e]26,000	26,500
New Zealand	7,168	7,011	6,998	6,419	6,300
Papua New Guinea	739,730	751,265	630,496	451,707	[3]540,325
Solomon Islands	372	[e]400	1,076	1,093	1,050
Total	[r]38,906,145	[r]38,982,769	38,768,978	39,141,041	40,784,803

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

[1]Table includes data available through June 2, 1982.

[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. The 1977 and previous editions of this table listed Angola and Nigeria as gold producers, but output of these countries for 1976 and later years has been revised to zero.

[3]Reported figure.

[4]All figures except that for 1978 differ substantially from those appearing in latest available official Brazilian sources owing to the inclusion of estimates for unreported production by small mines (garimpos). Offically reported figures are as follows, in troy ounces; major mines: 1977—121,047; 1978—128,860; 1979—107,158; 1980—131,500; small mines (garimpos); 1977—51,120; 1978—172,038; 1979—36,234; 1980—357,645.

[5]Refinery output.

[6]Data are for year ending July 6 of that stated.

[7]Very conservative estimate of output 1977-80; total national production probably is much greater than these estimates, but no basis for quantification of the balance of output is available. 1981 estimate prepared by the Gold Institute, Washington, D.C.

[8]Excludes production from so-called people's mines.

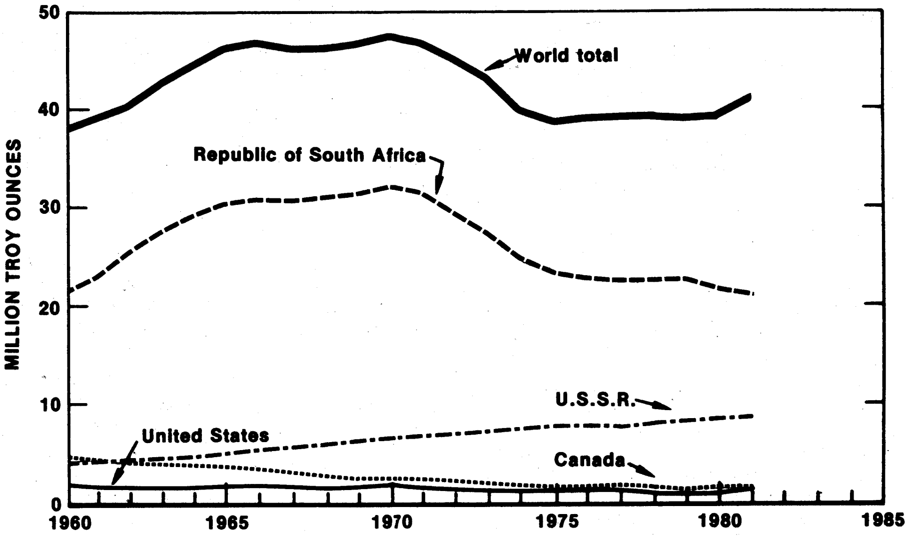

Figure 6.—Gold: World mine production.

The Goldfields report went on to note that in 1981, identified investment hoarding of gold bars totaled over 9 million ounces, the highest figure recorded since the company's annual survey began in 1970. Contrasting with the strong demand for physical gold in the market-economy countries, there was also an apparent total absence of any large-scale investment or speculative interest in gold at the sophisticated end of the market. The report concluded that in order to satisfy the increased demand for fabrication and bar hoarding, approximately 10.6 million ounces of gold must have been sold from investment holdings during the year. This high volume of disinvestment during a period of rising demand may help to explain why the price of gold during 1981 failed to follow the upward path established by demand.

Australia.—Australian gold production declined from production reported during the previous year. Exploration and development of both new and established gold deposits continued at a high level, especially in the State of Western Australia. Western Mining Corp. Holdings Ltd. commissioned a 550,000-ton-per-year carbon-in-pulp gold extraction plant at Kambalda, south of Kalgoorlie, Western Australia, for treatment of gold ores from the region, including ore produced from the Sand King open pit near Menzies, north of Kalgoorlie. The company also continued underground development at the Lancefield Mine near Windara and the Hunt gold-nickel mine at Kambalda and began development of an open pit at the Victory Mine south of Kambalda. Hill 50 Gold Mine N.L. and Western Mining began mining and/or further development of the Morning Star, Hill 50, and Saturn deposits in the Mount Magnet mining district of Western Australia. Exploration by the consortium at nearby Water Tank Hill outlined two ore shoots. Kalgoorlie Mining Associates (KMA) continued expansion of the Mount Charlotte Mine, including preparations to sink a new deep haulage-service shaft to gain access to ore bodies below the Flanagan Fault; KMA continued development of their Fimiston leases at Kalgoorlie and opened a 430,000-ton-per-year refractory ore treatment plant there.

At the Marvel Loch Mine near Southern Cross, Kia Ora Gold Corp. N.L. announced steadily improving results since the mine was reopened in 1980; Kia Ora plans to extend the depth of the main shaft to expand the development of the mine. Preliminary drilling results by the joint owners of the Big Bell Mine near Cue indicated 11 million tons of ore bearing 0.14 ounce of gold and 0.12 ounce of silver per ton; metallurgical studies are in progress and a decision to proceed further is expected in early 1982. An open pit mine is planned by Forest Gold at the Labouchere Prospect north of Meekathara. During the year, various companies were exploring new and old gold deposits near Menzies, Leonora, Wiluna, Coolgardie, Norseman, Marble Bar, and elsewhere in the goldfields of Western Australia.

In Queensland, Peko Wallsend Ltd. closed their Mount Morgan Mine after exhausting the remaining ore. The company also increased gold production at the Mount Chalmers open pit and erected a new plant to recover gold from the Mount Morgan tailings. Placer Exploration Ltd. announced completion of a feasibility study on their Kidston gold property west of Townsville. Minable reserves at the property were computed to be 43.3 million tons grading 0.06 ounce of gold and 0.65 ounce of silver per ton. In the Goonumbla area of New South Wales, Peko Wallsend continued detailed exploration on its Parkes project, a large copper-gold porphyry deposit. Exploration in central Victoria by C.R.A. Exploration Pty. Ltd. has defined two major zones of deep gold mineralization, and drilling has indicated the existence of at least three additional zones. At Roxby Downs in South Australia, Western Mining Corp. and their joint venture partners continued development of their large Olympic Dam copper-uranium-gold project.

Brazil.—Brazil continued in the grip of gold fever for another year, as the metal's lure drew hundreds of alluvial gold miners, or garimpeiros, and camp followers to remote villages springing up along the routes of the new mining activity. Brazilian gold production during 1981 was estimated to have declined slightly from the 1980 high of 1.3 million ounces to 1.2 million ounces in 1981. This difference reflects a large decline in production from the Serra Pelada deposit in the State of Pará and a lesser increase in production by garimpeiros elsewhere. Production at Serra Pelada, the site of a classic gold rush during 1980, was reduced largely through the imposition of Government restrictions on mining there, which included a temporary shutdown to alleviate unsafe working conditions and the inevitable response of the garimpeiros to the news of gold strikes and rushes elsewhere in tropical Brazil. Preliminary official Government estimates of production for 1981, which includes production from established underground and mechanized surface mines and some garimpeiro production, was about 515,000 ounces. Of the total, Brazil's largest underground mine, the Morro Velho Mine at Nova Lima, produced an estimated 160,000 ounces. The Morro Velho, which is operated by the Anglo American Corp. do Brazil Limitada (Ambras), has been operating continuously since 1835. The company, together with Mineração Morro Velho, also plans to reopen the old Cuiba-Raposas Mine in the State of Minas Gerais. Ambras announced during the year that a decision has been taken to proceed with development of a 22,000-ton-per-year mine at their Jacobina gold project in the State of Bahia.

Placer mining activities by the garimpeiros were concentrated along the Middle Tapajós River in the States of Pará and Amazonas. There was also considerable activity along the Rio Madeira in the Federal Territory of Rondônia and along drainages in the Federal Territory of Amapá and the State of Mato Grosso. Along waterways suitable for floating dredges, garimpeiros are using compact, mechanized, homemade suction dredges consisting of two small motor boats between which a sluice box and motorized suction pump have been mounted. The suction hose inlet is directed to gold-bearing sediments on the river bottom by a scuba diver. During the year, two Government-controlled exploration companies, Dosegeo and the Companhia de Pesquisas de Recursos Minerais, were granted permission to explore for gold and other minerals on Brazilian Indian reservations which have heretofore been off limits to such activity. In September, in an attempt to stem the flow of newly mined gold, which was apparently being exported illegally from the country, and to bolster the country's national gold stockpile, Brazil's National Monetary Council approved a new policy banning the export of Brazilian gold. The new proposal authorizes the country's Central Bank to buy and sell gold to the domestic markets at international prices.[5] The new policy will also aid the Government in locating and controlling unregistered gold mining activities, a source of many illegal gold transactions. For those disinclined to go prospecting, a gold futures exchange market, the Bolsa de Mercadorias, began operations in São Paulo on July 30. Only gold of Brazilian origin is deliverable against the contracts.

Canada.—At the close of 1981 there were 36 lode gold mines in Canada compared with 29 mines operating at the end of the previous year; however, reported gold production declined for the third consecutive year as miners continued to process greater tonnages of leaner ores. Ontario remained the leading gold producing Province with 33% of the total followed by Quebec with a fraction of a percentage point less, then British Columbia and the Northwest Territories with 16% and 7%, respectively. Though 4 lode mines closed during the year, 10 mines were opened—3 in Quebec, 5 in British Columbia, and 1 each in Ontario and the Northwest Territories. Other mines were completing mill construction and mine development programs and will be in full production in early 1982. The intense level of exploration that developed in 1980 was sustained throughout 1981 and a number of new discoveries were announced during the year. Dome Mines announced that preliminary drilling at a new discovery on Opapimiskan Lake, Ontario, indicated over 220,000 ounces of gold. The production of placer gold increased again over production reports during 1980, with most of the production increase attributed to placers operating in the Yukon. Details of the operations of individual mines and highlights of exploration and development were published in the Canadian Minerals Yearbook.

Chile.—In the Coquimbo area at an elevation of about 14,000 feet, St. Joe International Corp. began full-scale mining at their El Indio gold-silver-copper mine. When fully operational in 1982, the mine will produce 1,400 tons of ore per day and annual metal production is expected to be about 175,000 ounces of gold, 1.5 million ounces of silver, and 1,300 tons of copper. Prior to the development of the El Indio Mine most of the gold produced in Chile was produced as a byproduct of copper mining. In the Paihuano Commune, about 70 miles east of La Serena near the El Indio property, Chevron Exploration Corp. (Standard oil of California) in a joint venture with the Chilean subsidiary of St. Joe purchased the Libra and Mena gold-silver-copper deposits. Exploration at these properties was expected to begin in late 1981; the venture team was also considering the possible acquisition of two other precious metals properties in the region. Several other gold prospects are under study by various companies elsewhere in Chile. A new organic mining law was prepared by the Chilean Ministry of Mines in 1981. The law is scheduled for approval and release by early 1982.[6]

China.—Actual gold production in China is unknown, and may vary considerably from the estimates shown. A more realistic appraisal of China's gold production will not be possible until more precise data become available. To meet the immediate expenses required to implement new economic policies and to provide a means for readily accumulating foreign currency, China has placed the highest priority on the development of its gold resources. China's current policy is to expand geological exploration and the development of both new and established gold mines; accordingly, various reports originating from China during the year included announcements of new discoveries in nearly all Provinces including those of Yunnan, Inner Mongolia, Zinjiang, and Shandong.

Costa Rica.—Following 6 years of planning and construction, the Santa Clara gold mine in Puntenaras Province began production at a rate of about 1,500 tons of ore per day. The open pit, heap leaching operation is a joint venture between Canadian Barranca Corp. Ltd. of Edmonton, Alberta, and United Hearne Resources Ltd. of Vancouver, British Columbia, operators of the mine. Ore reserves at the mine are estimated to be about 4.0 million tons averaging 0.51 ounce of gold per ton.

Dominican Republic.—The output of the Pueblo Viejo gold and silver mine, the sole gold producer in the country, increased over that of 1980. The mine, which has been state-owned since 1979, is managed under a contract with the Dominican Government by Rosario Dominicana, S.A. (a subsidiary of AMAX Inc.). At present, only doré, a mixture of gold and silver, is produced; however, the Government has commissioned the construction of a domestic refinery to handle the output of the mine. The new facility is expected to start production in 1982.

Ghana.—On August 11, 1981, the Government of Ghana adapted their new Investment Code, 1981.[7] The new code, which was incorporated to liberalize and stimulate investment, particularly from foreign sources, consolidates various existing investment laws and is designed to create an economic environment that assures both the foreign and Ghanian investor protection of, and a fair rate of return on, their investment. All mining operations are accorded certain special benefits under the new code, including tax exemptions and deduction of some costs incurred for scientific research and development. Gold mining is individually addressed and incorporates a sliding-scale royalty based on the gross value of metal produced.

Guinea.—A private Canadian firm, Somig Inc., exploring a large block of lands leased from the Government of Guinea in the northeastern part of the country, announced the discovery of what may prove to be extensive placer deposits with associated quartz lode deposits. The presence of ancient gold mine workings provided the initial clues which led to the discovery. The placer deposits may be both eluvial and alluvial in origin. The company expected to begin a bulk sampling and testing program in late 1981.

Haiti.—The potential of three possible lode gold deposits discovered by an earlier geochemical survey were under investigation by a United Nations Technical Cooperation for Development team in northern Haiti near the border of Haiti with the Dominican Republic. Project activities during the year included mapping, sampling, drilling, and trenching of targeted areas.

India.—In response to declining production of gold and gold ore reserves in India's principal gold producing area, the Kolar and Hutti Goldfields, the Government of India launched an intensive 5-year gold exploration program focusing on the States of Karnataka, Andhra Pradesh, Bihar, Orissa, Kerala, and Maharashtra. The plan, to be executed jointly by the Geological Survey of India (GOI) and Mineral Exploration Corp., includes mapping, sampling, and exploration drilling as well as exploratory mining. The GOI is also exploring gold mining areas that were abandoned earlier for economical or operational reasons. The Ramagiri gold mines in the State of Andhra Pradesh, closed since 1929, are also being reopened.

Mexico.—Reported Mexican gold production in 1981 declined from that of the previous year. Nearly all production is recovered as a byproduct or coproduct with silver or other metals. At mid-year the Government of Mexico eliminated the variable-rate tax on gold and silver which had been adopted in early 1980.

Papua New Guinea.—Bougainville Copper Ltd., which in 1981 completed a decade of operations at their open pit mine on Bougainville Island, increased production over the 1980 level. Measured ore reserves at the property, which were recalculated at the end of 1981 from recently completed geostatistical copper and gold ore body models based on an updated ultimate pit design, amounted to about 882 million tons averaging 0.40% copper and 0.015 ounce of gold per ton. Early in the year the consortium developing the Ok Tedi gold and copper project in the Star Mountains near the Indonesian border, advised the Government of Papua New Guinea of their decision to proceed with development of the project and to form a new company, Ok Tedi Mining Ltd., to direct the development of the $1.6 million project. Construction of the project will proceed in three stages with mining of the gold-rich cap—containing an estimated 1 million ounces of gold to highlight the first stage of development which is scheduled to begin in 1984. Later stages will focus on copper production. Another consortium continued exploration at the Frieda River copper-gold prospect in the West Sepik Province, northeast of the Ok Tedi project. Exploration and engineering studies were continued by a third consortium at the Porgera project located near Mount Hagen in Western Enga Province. The Porgera gold-silver deposit is estimated to contain about 110 million tons of ore. On Misima Island in the Louisiade Archipelago southeast of the New Guinea mainland, Placer (PNG) Pty Ltd., a subsidiary of Placer Development Ltd., reported favorable exploration and drilling results on their Misima gold property. Twenty-five million tons of potentially economic mineralization are indicated. The project is a 50-50 joint venture with C. R. A. Exploration Pty. Ltd.

Peru.—Not unlike a similar situation extant in Brazil, where the quest for gold has lured many people to remote areas of the country in search of their fortune, several areas of Peru have likewise become the focal point of gold rushes precipitated by the high price of gold in recent years. On the coast of Peru, north of Chimbote, 1,500 or more prospectors and adventurers rushed in during the second half of 1981 to establish claims and work the newly discovered deposits of alluvial gold exposed by a relatively recent shift in the coastal position of the mouth of the Rio Santa. In the jungles of southeastern Peru, in the remote

Province of Madre de Dios, placer mining, which may be responsible for an estimated 50% of Peru's total annual gold production, is pursued by a large number of gold prospectors using hand mining methods as well as several Government and private gold mining companies using advanced exploration techniques and mechanized mining methods. Although the original Peruvian gold boom began in 1978 when the Government of Peru issued a special law to promote gold mining, mining activity peaked in 1980 and has since leveled off with the remaining mines settling down to a more carefully planned approach oriented toward long-term mining. One small town, 3-year-old Labertino, which sprang up at a gold deposit on the Madre de Dios River, now has 15,000 inhabitants, all engaged in gold panning or timbering. The Madre de Dios area is so remote that all heavy equipment and most essential supplies must be flown in at great expense. In spite of Peruvian laws requiring that newly mined gold must be sold to the state-owned Banco Minero, it has been estimated that only 50% of the actual production is so handled; the remainder is presumably sold to private individuals or smuggled out of the country.

Philippines.—Gold production at mines in the Philippine Islands increased over 1980 levels. At the Banquet Corp.'s Dizon Mine in Zimbales Province, the average monthly production rate was 8,671 ounces compared with 8,495 ounces during 1980, which was the first full year of production at the new facility. Expansion of the company's Balatoc gold mill near Bagio, which began in 1980, will, when completed, raise the average monthly output of gold from about 8,500 ounces to about 10,000 ounces per month. The expansion was expected to be completed in early 1982. Philippine Eagle Mines, Inc. (formerly Metals Exploration Asia, Inc.), continued development of their new Longos gold mine in Camarines Norte Province on Luzon; the company also acquired financing to begin construction of a gold mill at the mine site. The new facility is expected to be operational in late 1982 or early 1983. In December, the Government of the Philippines announced that it would establish a fund to assist mining companies impacted by poor world demand for copper; the fund is aimed especially at copper companies with little or no compensatory gold output. The Philippine Ministry of Natural Resources, Bureau of Mines, and Geo-Sciences continued their project aimed at accelerating the assessment, exploration, and evaluation of gold deposits in selected areas of the country; technical assistance which may be granted to qualified gold claimholders includes geological mapping, exploration drilling and metallurgical testing, chemical analyses, engineering and planning services, and technical and economic feasibility studies.

Saudi Arabia.—Gold Fields Mahd-ad-Dhahab, a joint venture between Consolidated Gold Fields Ltd. and the Saudi Arabian Petroleum and Mining Agency (Petromin), completed its study of the gold and silver deposit at Mahd-ad-Dhahab located about 200 miles north-northeast of Jiddah. The company expects to embark on a 3-year plan to develop an underground mine to produce over 130,000 tons of ore per year for an annual yield of about 95,000 ounces of gold. Several other potential gold producing properties are under investigation by other companies elsewhere within the Arabian Shield.

South Africa, Republic of.—Gold production in South Africa during 1981 amounted to 52% of world gold mine production. For the fourth consecutive year, the South African gold mining industry flourished as relatively high metal prices continued to spur activity and expansion in all sectors of the industry from exploration to refining. Many mines that had recently closed or were threatened with closure were being actively developed in response to the increased value of their product. The 36 mines and 1 metallurgical recovery operation that were members of the Chamber of Mines accounted for 96.8% of all South African production. The total ore milled, including ore milled by producers of byproduct and coproduct uranium, amounted to 101.3 million tons, averaging 0.22 ounce of gold per ton, compared with 1980 when 99.1 million tons averaging 0.23 ounce per ton were milled, for a total yield of 21.7 million ounces. Working costs for South African gold mines in 1981 averaged, in South African rands (R) R177.88 (US$185.96) per ounce and ranged from R96.70 (US$101.09) per ounce at East Driefontein to R426.83 (US$446.21) per ounce at Wit Nigel. Production by the six major mining groups was as follows in million ounces; Anglo American Corp. of South Africa, Ltd., 7.7; Gold Fields of South Africa, Ltd., 4.5; General Mining Union Corp., Ltd., 3.5; Rand Mines Ltd., 2.3; Johannesburg Consolidated Investment

Corp., Ltd., 1.3; and Anglo Transvaal Consolidated Investment Co. Ltd., 1.2.

The largest producing mines, in terms of millions of ounces of gold output, were Vaal Reefs, 2.4; Western Holdings, 1.3; West Driefontein, 1.3; and Western Deep Levels, 1.2. Nine gold mines and two metallurgical recovery units also produced uranium during 1981. Vaal Reefs was the largest uranium producer, with a yield of 1,867 tons of uranium oxide. Estimates of fully developed or blocked-out gold ore reserves reported by the Chamber of Mines at the close of 1981 totaled 511 million tons, containing an average of about 0.29 ounce of gold per ton. The world's largest gold mine, in terms of gold production, was formed on July 1, by the merger of the East Driefontein Gold Mining Co. Ltd. and the West Driefontein Gold Mining Co., both members of the Consolidated Gold Fields Group. The new company, Driefontein Consolidated Ltd., will produce over 2.5 million ounces of gold annually. On July 1, the establishment of the Anglo American Group's Western Holdings complex became effective. The complex, which resulted from the three-way merger of three mines—those of Free State Saaiplaas Gold Mining Co. Ltd., Welkom Gold Mining Co., Ltd., and Western Holding Ltd., was undertaken to increase production efficiency and to jointly exploit a gold- and uranium-bearing area located near the three existing mines. The combined ore treatment capacity of the new complex makes Western Holding the largest gold mine in the world in terms of the quantity of ore processed. Anglo American's Western Deep Levels Ltd. announced an expansion plan that includes surface and sublevel shaft systems, a new gold recovery plant, and personnel housing projects. The plan is expected to take over 10 years to complete. In spite of escalating costs and depressed gold prices in 1981 compared with 1980, a number of South African gold mining companies announced plans to expand or streamline their production capabilities over the next several years.

U.S.S.R.—Soviet gold production was estimated to have increased over estimated 1980 production. The export of gold by centrally planned economy countries to market-economy countries was estimated to have amounted to up to 6.5 million ounces in 1981 compared with exports of 7.4 million ounces in 1979 and 2.9 million ounces in 1980. Because nearly all of that gold, which was exported to gain essential foreign exchange, came from the U.S.S.R., the decline in Soviet gold exports between 1978 and 1980 may indicate that during that period the Soviet Union was able to satisfy a growing percentage of its exchange requirements from other exports such as oil and gas. In 1981, however, reduced demand for these products in the market-economy countries was apparently responsible for reversing this trend in declining gold exports. Nearly 40,000 ounces of Soviet gold, mostly in the form of refined bullion, was imported into the United States during 1981. No direct imports of Soviet gold were received by the United States during 1980, however, 35% of U.S. gold imports during 1979 were from that source.

A 1981 study by the U.S. Bureau of Mines estimated that Soviet gold production could rise about 1.1% per year to between 9.3 and 11.2 million ounces by 1990.[8] Assuming that consumption and some stockbuilding absorb an average of 20% of the annual production, the U.S.S.R. could be selling 7.4 to 9 million ounces per year in the 1980's and still have extra reserves for emergency grain purchases.

TECHNOLOGY

The Bureau of Mines conducted further research aimed at improving the recovery of precious metals from low-grade resources and industrial waste and scrap. In 1981, a summary of recent Bureau of Mines results concerning in situ mining research was published. The principles associated with gold and silver leach mining, problems confronting potential leaching operations, and leaching projects in progress to resolve these problems were addressed.[9] The Bureau investigated methods for the recovery of byproduct heavy minerals from sand and gravel operations in Oregon and Washington. Samples from more than 40 locations were subjected to a variety of separation techniques and gold and heavy minerals were identified in the resultant concentrates. Recovery rates for the individual mineral products ranged from 67% to 95%.[10] The Bureau also reported on the development of economic methods for recovering copper and associated metals, including precious metals, from three categories of complex electronic scrap. A means of effecting an initial separation and upgrading to produce a high-grade cement copper containing all or most of the precious metals was developed.[11] A process for improving the heap leaching characteristics of some gold and silver ores was developed and patented by the Bureau. Solution flow rates through ore heaps are effectively increased by agglomerating fine particles in the ore with a binder such as cement or lime, water, and an aging or curing step.[12] A new process for the recovery of gold from sulfide residues by roasting and leaching with thiourea was developed and patented.[13]

The Gold Bulletin, a quarterly journal of the Chamber of Mines of South Africa, contained a variety of articles on new gold uses and technology.[14]

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[1]Physical scientist, Division of Nonferrous Metals.

[2]Ounce means troy ounce.

[3]Eakins, G. R. Mineral Activity in Alaska, 1981. Pres. at Northwest Min. Association Ann. Convention, Spokane, Wash., Dec. 5, 1981.

[4]DuBoulay, L. Gold 1982. Pub. by Consolidated Gold Fields, PLC., London. May 1982.

[5]Gold Regulations and Taxes for Mining, Refining, Manufacturing and Trade in Thirteen Countries. Pub. by the Gold Institute/L'Institut De L'or, Washington, D.C., 1981, 87 pp.

[6]Martino, O., D. Hyde, and P. Velasco. Mineral Industries of Latin America. BuMines MP, 1981, p. 31.

[7]Work cited in footnote 5.

[8]Grichar, J. S., R. Levine, and L. Nahai. The Nonfuel Mineral Outlook for The U.S.S.R. Through 1990. BuMines MI, 1981, pp. 14-15.

[9]Staff, Bureau of Mines. In Situ Mining Research. Proceedings, Bureau of Mines Technology Transfer Seminar, Denver, Colo., 1981. BuMines IC 8852, 1981, 107 pp.

[10]Martinez, G. M., J. M. Gomes, and M. M. Wong. Recovery of Byproduct Heavy Minerals From Sand and Gravel Operations in Oregon and Washington. BuMines RI 8563, 1981, 14 pp.

[11]Salisbury, H. B., L. J. Duchene, and J. H. Bilbrey. Recovery of Copper and Associated Precious Metals From Electronic Scrap. BuMines RI 8561, 1981, 16 pp.

[12]Heinen, H. J., G. E. McClelland, and R. E. Lindstrom. Leaching Agglomerated Gold-Silver Ores. U.S. Patent 4,256,705, Mar. 17, 1981.

[13]Bodson, F. J. J. Metal Recovery From Sulfur-Containing Material. French Demande 2476137. Aug. 21, 1981, 11 pp.

[14]Chamber of Mines of South Africa Research Organization (Johannesburg). Gold Bull., v. 14, Nos. 1, 4, 1981.

Graphite

By Harold A. Taylor, Jr.[1]

Consumption of natural graphites, all imported, increased 9% in 1981 to 57,364 short tons. Imports of natural crystalline and amorphous graphite increased 14% in quantity from the 1980 level. Natural crystalline flake graphite became generally more available, and a shift in usage from amorphous to crystalline flake was indicated by the import data. Prices of imported graphites generally rose during the year, although some prices began to drop around yearend.

Production of manufactured graphite in 1981 increased slightly to 372,223 tons valued at $935 million. Production of graphite fibers increased 75% to 830 tons valued at $49 million.

Table 1.—Salient natural graphite statistics

	1977	1978	1979	1980	1981
United States:					
Apparent consumption[1] ____short tons__	[2]73,773	90,396	77,562	52,438	57,364
Exports ____do____	13,783	9,595	8,623	8,880	11,344
Value ____thousands__	$2,662	$2,304	$3,741	$3,695	$4,433
Imports for consumption[3] ____short tons__	87,556	99,991	86,185	61,318	68,708
Value ____thousands__	$8,058	$11,700	$13,035	$15,765	$23,998
World: Production ____short tons__	[r]543,925	[r]582,511	[r]684,826	[p]653,639	[e]655,288

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Excludes domestic production.
[2]Revised to include some manufactured graphite imported for consumption.
[3]Includes some manufactured graphite; see table 9.

Legislation and Government Programs.—National stockpile goals for strategic graphite, changed in 1980 to reflect specification revision, were unchanged in 1981. Stockpile goals and inventories for each type of graphite are shown in table 2. There were no acquisitions or disposals of strategic graphite in 1981.

Table 2.—Government stockpile goals and yearend stocks of natural graphite in 1981, by type

(Short tons)

Type	Goal	National stockpile inventory
Madagascar crystalline flake	20,000	17,895
Sri Lanka amorphous lump	6,300	5,443
Crystalline, other than Madagascar and Sri Lanka	2,800	1,933
Non-stockpile-grade, all types	--	935

Source: General Services Administration. Inventory of Stockpile Materials as of Dec. 31, 1981.

DOMESTIC PRODUCTION

The one U.S. mine, near Burnet, Tex., owned by the Southwestern Graphite Co., a division of Joseph Dixon Crucible Co., made no shipments from stocks and thus completed its closure. Other domestic graphite deposits, such as those in Alabama, Montana, and Alaska, received little attention from investigators contemplating the development or redevelopment of any mines. Therefore, no mine openings seemed likely in the near future.

Reported production of manufactured graphite increased slightly to 372,223 tons in 1981. Manufactured graphite was produced at 32 plants in 1981, with some additional production for in-house use likely.

Production of all kinds of graphite fiber and cloth increased 75% to 830 tons in 1981. The value per pound of high-modulus fibers expressed as an index (1976 = 100) was 48 in 1981, compared with 52 in 1980, 62 in 1979, 72 in 1978, and 85 in 1977. The value per pound of cloth and low-modulus fibers expressed as an index (1976 = 100) was 121 in 1981, compared with 116 in 1980, 107 in 1979, 112 in 1978, and 118 in 1977.

The Department of Energy has released a new study of the Narragansett Basin anthracite-amorphous graphite resources. On the basis of 28 drill holes and previous knowledge of the regional geology, it was estimated that resources total 17.1 million tons of anthracite-amorphous graphite in the Rhode Island part of the basin where the amorphous graphite is concentrated. Amorphous graphite was last mined in Rhode Island in 1957 and was used in foundry facings, as a carbon raiser in steel, and as a paint pigment.[2]

Domestic plant capacity for graphite fiber continued to grow. Hercules, Inc., announced that it would increase the capacity of its Utah plant to 550 short tons annually by early 1982 and 1,250 short tons by 1984. Celanese Corp. announced that it would begin production at its new 200-ton-per-year plant near Rock Hill, S.C., in April 1982.[3] It planned to expand the new plant by an additional 500 to 800 tons annual capacity by the end of 1983.[4]

Union Carbide Corp. made some changes in its graphite operations. The Acheson plant at Niagara Falls, N.Y., was to be closed and its graphite specialties operations moved to the Clarksburg, W. Va., plant. Two other plants at Niagara Falls were to be modernized and expanded. Some electrode production facilities were to be moved from the Clarksburg plant to the Columbia, Tenn., plant.[5] The biggest change planned was a $40 million expansion program for the Yabucoa, P.R., plant that would improve handling of the raw materials and petroleum coke and pitch and would increase environmental protection.[6] The new Clarksville, Tenn., plant of Union Carbide came onstream in 1981.

Sigri Carbon Corp. started a major expansion of its Hickman, Ky., graphite electrode plant and acquired Polycarbon, Inc., of North Hollywood, Calif., a producer of graphite fiber and cloth.[7]

Airco, Inc., the wholly owned U.S. subsidiary of the BOC group of the United Kingdom, announced its intention to invest $247 million to expand its synthetic graphite-related operations. It planned to build a new 15,000-ton-per-year graphite electrode plant at Ridgeville, S.C., and a petroleum needle coke facility at Seadrift, Tex. The new electrode plant would get its raw material from the petroleum coke plant, which will meet 90% of the company's needs in the 1980's. The new electrode plant, plus expansions at the existing plants, will raise company capacity in the U.S. for graphite electrodes by 20% to 120,000 tons per year. Plans to construct an electrode plant at Tallulah, La., were canceled because of foundation problems encountered upon beginning plant construction.[8]

A comprehensive article on graphite electrodes indicated that the Airco expansion, along with previously announced recent expansions by other graphite electrode manufacturers, will serve a fairly rapidly expanding market for graphite electrodes created by the electric arc furnace steelmakers.[9] These steelmakers comprise one of the few growth areas in the steel industry. Although North America has been the best market for electrodes in the last few years, the rest of the world market is expected to recover. The long-term future for electrodes looks good; the electric arc furnace portion of world steel output, now 22%, is expected to grow substantially. However, adoption of a composite electrode with a water-cooled upper section made of metal could potentially reduce graphite electrode consumption by 20% in a steel plant, if proven to be feasible.

The Stackpole Corp. installed a new furnace for carbonization that will drastically cut its natural gas consumption per pound of product to a small fraction of the present amount. Most of the other major producers of synthetic graphite have also taken determined action to curb their natural gas consumption.

Table 3.—Principal producers of manufactured graphite in 1981

Company	Plant location	Product[1]
Airco Carbon, a division of Airco, Inc	Niagara Falls, N.Y	Anodes, electrodes, crucibles, motor brushes, refractories, unmachined shapes, powder.
Do	Punxsutawney, Pa	
Do	St. Marys, Pa	
Avco Corp., Avco Specialty Materials Div	Lowell, Mass	High-modulus fibers.
The Carborundum Co., Graphite Products Div.	Sanborn, N.Y	Motor brushes, unmachined shapes, cloth.
Celanese Corp., Celanese Research Lab	Summit, N.J	High-modulus fibers.
Fiber Materials, Inc	Biddeford, Maine	Do.
Fiber Technology Corp	Provo, Utah	
BF Goodrich Co., Engineered Systems Div., Super Temp Operation.	Santa Fe Springs, Calif	Other.
Great Lakes Carbon Corp	Elizabethton, Tenn	Anodes, electrodes, powder, high-modulus fibers.
Do	Morganton, N.C	
Do	Niagara Falls, N.Y	
Do	Ozark, Ark	
Do	Rosamond, Calif	
Hercules Inc	Salt Lake City, Utah	High-modulus fibers.
HITCO Materials Group, ARMCO Inc	Gardena, Calif	Cloth and high-modulus fibers.
Pfizer Minerals, Pigments & Metals Div	Easton, Pa	Other.
Poco Graphite, Inc	Decatur, Tex	Unspecified.
Polycarbon, Inc	North Hollywood, Calif	Cloth.
Sigri Carbon Corp	Hickman, Ky	Electrodes and other.
The Stackpole Corp., Carbon Div	Lowell, Mass	High-modulus fibers, anodes, motor brushes, unmachined shapes, powder.
Do	St. Marys, Pa	
Superior Graphite Co	Chicago, Ill	Powder and other.
Do	Hopkinsville, Ky	
Ultra Carbon Corp	Bay City, Mich	Other.
Union Carbide Corp., Carbon Products Div.	Clarksburg, W. Va	Anodes, electrodes, unmachined shapes, motor brushes, powder, cloth, high-modulus fibers, other.
Do	Clarksville, Tenn	
Do	Columbia, Tenn	
Do	Fostoria, Ohio	
Do	Greenville, S.C	
Do	Niagara Falls, N.Y	
Do	Yabucoa, P.R	

[1]Cloth includes low-modulus fibers; electric motor brushes include machined shapes; crucibles include vessels.

Table 4.—Production of manufactured graphite in the United States, by use

Use	1980		1981	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Synthetic graphite products:				
Anodes	17,848	$42,364	18,816	$42,445
Cloth and fibers (low-modulus)	r169	r11,254	216	15,293
Crucibles, vessels, refractories	W	W	W	W
Electric motor brushes and machined shapes	W	W	W	W
Electrodes	258,453	527,949	257,938	641,709
Graphite articles	--	44,482	--	45,432
High-modulus fibers	r306	r17,379	614	33,828
Unmachined graphite shapes	12,625	27,533	17,508	32,931
Other	r51,729	r93,622	40,196	96,749
Total	r341,130	r764,583	335,288	908,387
Synthetic graphite powder and scrap	25,940	11,226	36,935	26,252
Grand total	r367,070	r775,809	372,223	934,639

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

Table 5.—Production of graphite fibers in the United States

Year	Cloth and low-modulus fibers		High-modulus fibers		Total	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1974	W	W	W	W	[e]150	[e]$14,000
1975	168	[e]$12,000	[e]30	[e]$3,500	[e]198	[e]15,500
1976	163	11,376	[r]37	[r]3,870	200	15,246
1977	[r]136	[r]8,800	[r]49	[r]4,330	185	13,130
1978	[r]141	[r]8,720	[r]149	[r]11,804	290	20,524
1979	169	[r]10,089	[r]194	[r]13,031	363	23,120
1980	[r]169	[r]11,254	[r]306	[r]17,379	475	28,633
1981	216	15,293	614	33,828	830	49,121

[e]Estimated. [r]Revised. W Withheld to avoid disclosing company proprietary data.

CONSUMPTION AND USES

Apparent consumption of natural graphite, all imported, increased 9% to 57,364 tons. Reported consumption of natural graphite in 1981 (table 6) increased 9% to 48,046 tons. The three major uses of natural graphite—refractories, foundries, and steelmaking—accounted for 55% of reported consumption in 1980 and 58% in 1981.

The actual amount of natural graphite consumed was greater than that shown in table 6, which lists only the results of a canvass of major known consumers. While this canvass probably gives some indication of consumption patterns, caution is advised in using these data owing to incomplete coverage.

Arc Technologies System Ltd. marketed a new holder for graphite electrodes that was said to reduce graphite electrode consumption by 30% to 40% in electric arc furnace operation.[10]

Most new applications for graphite fiber composites will reportedly require improved manufacturing and fabricating methods, especially for new applications in the automobile. After several methods were examined, it was concluded that most methods do not easily lend themselves to mass production, although some new methods do look promising.[11]

Graphite fiber has been chosen for several important new uses. The National Aeronautics and Space Administration-Lockheed Space Telescope, scheduled for launching in the mid-1980's, will use structural booms made of 60% aluminum-40% graphite fiber composite material and will have one of the highest stiffness-to-weight ratios of any structure ever built.[12] The Food and Drug Administration approved the use of graphite fiber in clinical trials to enhance the regrowth of tendons and ligaments.[13]

Table 6.—Consumption[1] of natural graphite in the United States, by use

Use	Crystalline		Amorphous[2]		Total	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1980						
Batteries	W	W	W	W	W	W
Brake linings	933	$959	[r]1,677	[r]$1,261	[r]2,610	[r]$2,220
Carbon products[3]	[r]272	[r]328	[r]381	[r]349	[r]653	[r]677
Crucibles, retorts, stoppers, sleeves, nozzles	5,188	3,360	--	--	[r]5,188	[r]3,360
Foundries	[r]1,393	[r]1,098	[r]5,394	[r]2,113	[r]6,787	[r]3,211
Lubricants[4]	867	1,176	[r]1,751	[r]1,330	[r]2,618	[r]2,506
Pencils	[r]1,706	[r]2,103	[r]659	[r]364	[r]2,365	[r]2,467
Powdered metals	288	361	112	182	400	543
Refractories	1,062	225	[r]8,863	[r]2,049	[r]9,925	[r]2,274
Rubber	31	25	241	168	272	193
Steelmaking	386	165	[r]6,880	[r]1,964	[r]7,266	[r]2,129
Other[5]	[r]4,211	[r]3,280	[r]1,627	[r]2,449	[r]5,838	[r]5,729
Total[6]	[r]16,338	[r]13,080	[r]27,585	[r]12,230	[r]43,923	[r]25,309

See footnotes at end of table.

Table 6.—Consumption[1] of natural graphite in the United States, by use —Continued

Use	Crystalline Quantity (short tons)	Crystalline Value (thousands)	Amorphous[2] Quantity (short tons)	Amorphous[2] Value (thousands)	Total Quantity (short tons)	Total Value (thousands)
1981						
Batteries	W	W	W	W	W	W
Brake linings	834	$778	1,915	$1,787	2,749	$2,565
Carbon products[3]	287	545	260	468	547	1,013
Crucibles, retorts, stoppers, sleeves, nozzles	5,307	3,578	--	--	5,307	3,578
Foundries	563	324	5,387	2,613	5,950	2,937
Lubricants[4]	984	1,259	2,020	1,816	3,004	3,075
Pencils	1,912	2,336	632	372	2,544	2,708
Powdered metals	342	490	147	279	489	769
Refractories	1,928	441	9,682	2,782	11,610	3,223
Rubber	64	85	183	96	247	181
Steelmaking	391	166	9,792	2,493	10,183	2,659
Other[5]	3,852	2,656	1,564	1,905	5,416	4,561
Total	16,464	12,658	31,582	14,611	48,046	27,269

[r]Revised. W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Consumption data incomplete. Small consumers excluded.
[2]Includes mixtures of natural and manufactured graphite.
[3]Includes bearings and carbon brushes.
[4]Includes ammunition, packings, and seed coating.
[5]Includes paints and polishes, antiknock and other compounds, drilling mud, electrical and electronic products, insulation, magnetic tape, small packages, miscellaneous, and uses indicated by symbol W.
[6]Data may not add to totals shown because of independent rounding.

PRICES

Actual graphite prices are often negotiated between the buyer and seller, and published price quotations are given as a range of prices, such as those shown in table 7. Another source of information for imported graphite is the average customs value per ton of the different classes of imports, which can be derived from table 9. However, it should be noted that these mainly represent shipments of unprocessed graphite.

Average prices of graphite imports increased in 1981. Prices for crystalline flake rose from $585 per short ton in 1980 to $662 per short ton in 1981. Prices for Mexican amorphous graphite rose from $42 per short ton in 1980 to $66 per short ton in 1981. Prices for all types of Sri Lankan lump graphite rose from $971 per short ton in 1980 to $1,509 per short ton in 1981. Prices for other natural graphite (mostly fine crystalline flake and dust) rose from $440 per short ton in 1980 to $520 per short ton in 1981.

Representative yearend prices of several types of imported graphite, as published in the Engineering and Mining Journal, are shown in table 7.[14] All prices are f.o.b. the foreign port or border station and have been converted from metric tons.

Table 7.—Representative yearend graphite prices[1]

(Per short ton)

	1980	1981
Flake and crystalline graphite, bags:		
China	$272-$1,361	$272-$1,542
Germany, Federal Republic of	381- 2,177	318- 2,540
Madagascar	272- 816	227- 635
Norway	318- 726	354- 635
Sri Lanka	816- 2,268	816- 2,268
Amorphous, nonflake, cryptocrystalline graphite (80% to 85% carbon):		
Korea, Republic of (bags)	71- 82	71- 82
Mexico (bulk)	54- 77	59- 91

[1]F.o.b. foreign port or border.

Source: Engineering and Mining Journal, v. 182, No. 12, December 1981, p. 23.

FOREIGN TRADE

Exports of natural graphite in 1981 increased while exports of artificial graphite decreased.

Imports of natural graphite increased 14% to 65,659 short tons in 1981. Brazilian exports of both natural and artificial graphite gained significantly, rising from 4,305 short tons in 1980 to 6,593 short tons in 1981.

Imports of graphite electrodes for consumption totaled 46,351 short tons worth $64.8 million in 1981, of which 21,421 tons ($42.1 million) came from Japan, 3,065 tons ($3.7 million) from France, 5,981 tons ($2.2 million) from Canada, 6,158 tons ($5.6 million) from the Federal Republic of Germany, 6,387 tons ($7.4 million) from Italy, and the balance from other sources. Exports of graphite electrodes in 1981 totaled 70,527 short tons worth $140.0 million, of which 6,293 tons ($11.8 million) went to Canada, 14,187 tons ($33.3 million) to Venezuela, 8,236 tons ($18.6 million) to Brazil, 6,998 tons ($17.4 million) to Argentina, 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
1980	8,880	$3,695,315	9,281	$5,637,810	18,161	$9,333,125
1981:						
Canada	6,764	2,009,707	1,456	393,174	8,220	2,402,881
Germany, Federal Republic of	775	614,943	823	471,391	1,598	1,086,334
Italy	766	282,952	406	169,480	1,172	452,432
Japan	167	197,743	846	614,981	1,013	812,724
Mexico	848	321,476	633	195,562	1,481	517,038
Netherlands	13	15,730	796	325,566	809	341,296
United Kingdom	360	145,473	314	151,513	674	296,986
Venezuela	554	309,369	20	53,509	574	362,878
Other[2]	1,097	535,444	1,973	1,096,227	3,070	1,631,671
Total	11,344	4,432,837	7,267	3,471,403	18,611	7,904,240

[1]Amorphous, crystalline flake, lump or chip, and natural, not elsewhere classified.
[2]Includes 41 other recipient countries to which varying, but lesser, tonnages of natural and/or artificial graphite were exported.

Table 9.—U.S. imports for consumption of natural and artificial graphite, by country

Country	Natural: Crystalline flake		Natural: Crystalline lump, chip or dust		Natural: Other natural crude and refined		Artificial[1]		Total[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)
1979	5,970	$2,334	435	$151	76,363	$7,657	3,419	$2,893	86,185	$13,035
1980:										
Austria	--	--	--	--	18	5	--	--	18	5
Belgium-Luxembourg	--	--	--	--	17	19	--	--	17	19
Brazil	2,921	1,634	--	--	345	168	1,039	582	4,305	2,385
Canada	530	152	22	5	451	130	518	127	1,521	414
China	228	152	--	--	2,222	943	--	--	2,450	1,095
France	199	116	--	--	3	12	--	--	202	129
Germany, Federal Republic of	160	166	--	--	800	697	32	428	992	1,291
Hong Kong	88	104	--	--	165	95	--	--	253	198
India	55	37	--	--	--	--	--	--	55	37
Japan	--	--	--	--	346	307	191	1,050	537	1,357
Madagascar	2,011	1,063	--	--	462	144	--	--	2,473	1,207

See footnotes at end of table.

Table 9.—U.S. imports for consumption of natural and artificial graphite, by country —Continued

Country	Natural: Crystalline flake: Quantity (short tons)	Natural: Crystalline flake: Value (thousands)	Natural: Crystalline lump, chip or dust: Quantity (short tons)	Natural: Crystalline lump, chip or dust: Value (thousands)	Natural: Other natural crude and refined: Quantity (short tons)	Natural: Other natural crude and refined: Value (thousands)	Artificial[1]: Quantity (short tons)	Artificial[1]: Value (thousands)	Total[2]: Quantity (short tons)	Total[2]: Value (thousands)
1980 —Continued										
Mexico	137	$106	--	--	40,277	$1,677	--	--	40,414	$1,784
Netherlands	18	6	--	--	--	--	3	$1	21	7
Norway	71	28	--	--	173	95	--	--	244	122
South Africa, Republic of	137	83	--	--	279	144	--	--	416	227
Sri Lanka	597	541	77	$43	1,036	1,076	--	--	1,710	1,661
Sweden	--	--	--	--	18	53	--	--	18	53
Switzerland	(3)	3	--	--	--	--	1,905	2,585	1,905	2,588
Taiwan	--	--	--	--	55	27	--	--	55	27
U.S.S.R	--	--	--	--	3,594	1,089	--	--	3,594	1,089
United Kingdom	36	12	--	--	82	45	(3)	12	118	69
Venezuela	--	--	--	--	(3)	1	--	--	(3)	1
Total[2]	7,188	4,203	99	48	50,343	6,728	3,688	4,787	61,318	15,765
1981:										
Australia	--	--	--	--	12	6	(3)	2	12	8
Austria	--	--	--	--	17	72	--	--	17	72
Belgium-Luxembourg	18	8	--	--	--	--	--	--	18	8
Brazil	4,606	3,159	--	--	1,755	1,170	232	161	6,593	4,490
Canada	1,126	427	--	--	3,124	1,239	347	98	4,597	1,764
China	1,536	796	--	--	5,042	2,371	--	--	6,578	3,167
Comoros	40	23	--	--	--	--	--	--	40	23
Dominican Republic	--	--	--	--	--	--	5	52	5	52
France	537	286	--	--	166	84	--	--	703	370
Germany, Federal Republic of	68	81	(3)	1	1,005	673	82	126	1,155	881
India	386	232	--	--	118	108	--	--	504	340
Japan	14	12	--	--	317	337	210	1,414	541	1,763
Madagascar	1,955	1,561	--	--	1,133	592	--	--	3,088	2,153
Mexico	287	206	--	--	39,184	2,576	--	--	39,471	2,782
Netherlands	--	--	--	--	(3)	1	(3)	1	(3)	2
New Zealand	--	--	--	--	--	--	(3)	4	(3)	4
Norway	36	15	--	--	563	289	--	--	599	304
South Africa, Republic of	81	44	--	--	161	82	--	--	242	126
Sri Lanka	304	421	--	--	1,167	1,799	--	--	1,471	2,220
Switzerland	--	--	--	--	4	7	2,173	3,049	2,177	3,056
Taiwan	--	--	--	--	401	205	--	--	401	205
U.S.S.R	--	--	--	--	341	132	--	--	341	132
United Kingdom	--	--	--	--	159	78	--	--	159	78
Total[2]	10,991	7,274	(3)	1	54,668	11,819	3,049	4,905	68,708	23,998

[1]Includes only that received in raw material form; excludes products made of graphite.
[2]Data may not add to totals shown because of independent rounding.
[3]Less than 1/2 unit.

WORLD REVIEW

World production of natural graphite increased slightly from 1980 to 1981. Supplies of all types of graphite were sufficient to meet demand in 1981, and markets were firm but not tight. China was very active in world graphite markets in 1981. World graphite fiber production is expected to expand rapidly in the next several years as new plants come onstream.

Canada.—Orrwell Energy Corp. Ltd. did extensive drilling, testing, and evaluation of their crystalline flake graphite properties located near Mont Laurier, Quebec, and Perth, Ontario. Both properties were previously known but inactive. The Mont Laurier property was further along the road to development, having had 6,300 feet of diamond drilling by yearend. Another 2,000 feet of drilling was planned, and then the Ontario property was to be drilled. Orrwell estimated that there is about 400,000 tons of ore averaging 10% graphite, a large portion of which is coarser No. 1 flake, in the main vein, and about 1 million tons of lower quality material in other veins. Orrwell indicated that previous work at the Ontario property showed 1 million tons of ore averaging 9% graphite and that flotation tests on previously mined material indicate that a salable product could be made. At yearend, Orrwell was continuing work on establishing commercial feasibility, locating financing, and negotiating sales of the future product.[15]

The mine opened by Asbury Graphite Mills, Inc., in 1980 near Mont Laurier, Quebec, continued to operate.

China.—Chinese crystalline flake graphite and other natural graphites, mostly crystalline flake dust, have been rapidly increasing in importance on the world market and did well in 1981. For example, exports to Japan increased from 2,130 short tons in 1978 to 23,200 short tons in 1980 to an estimated 23,000 short tons in 1981. Exports to the Federal Republic of Germany increased from 4,380 short tons in 1978 to 5,420 tons in 1980 to an estimated 11,000 tons in 1981. Exports to the United States changed from about 3,046 short tons in 1978 to 2,450 short tons in 1980 and 6,578 short tons in 1981. The Chinese continued to actively seek a greater market share for their natural graphite products. In addition, the Chinese were reported at yearend to be seeking U.S. markets for their graphite electrodes, which they have been selling in Far Eastern markets at low prices for the past 2 years.[16]

Czechoslovakia.—Production was centered in southern Bohemia, where a fine flake graphite is produced, and northern Moravia, where microcrystalline and amorphous graphites with flakes sized under 0.1 millimeter are produced. The graphite ore is concentrated by flotation to yield a concentrate containing 80% to 96% carbon in a plant at Netolice. The concentrate is further refined by leaching and melting to obtain a graphite with 99.9% carbon in a plant at Tyn nad Vitarou. The major end use for the macrocrystalline (flaky) graphite was in steel plants (37%), and the major end use for microcrystalline graphite was in foundries for molding of sand and inner mold coating (34%) and in lubricants (8%). A significant amount of microcrystalline graphite was exported.[17]

France.—Two joint ventures are planning to build graphite fiber plants. Hercules formed a joint venture with Pechiney Ugine Kuhlmann (PUK) after an arrangement with Hexcel Corp. fell through. The joint venture was planning to construct a 200-ton-per-year plant that would come onstream in the third quarter of 1983 and produce fiber mostly for the aerospace industry, but also for the automotive and sporting goods markets. The raw material would be polyacrylonitrile imported from Japan. Both partners have had experience with graphite fibers. Hercules, which holds 40% of the venture, is the largest U.S. producer, and PUK, which holds 60% of the venture, has a fiber-producing French subsidiary.[18]

The other joint venture was composed of Société Nationale Elf Aquitaine, Union Carbide, and Toray Industries Inc. (Japan). They were considering the possibility of constructing a 300- to 360-ton-per-year plant based on polyacrylonitrile, probably in southwestern France.[19]

Japan.—A number of small low-grade graphite deposits exist in Japan, but they have provided very little or no production in recent years. The Japanese market for natural graphite is large and has been growing in recent years, mostly because of strong demand for carbon-magnesite brick.

Over 275,000 short tons of synthetic graphite was produced in 1979, of which about 240,000 short tons was electrodes.[20]

The Japanese graphite fiber industry has been expanding rapidly. Toray Industries, the largest producer, announced that it would triple its plant capacity to almost 1,500 short tons per year by 1982. Other producers have also been expanding their capacity or have expected to do so shortly. The producers continued to view graphite fiber production as a high-growth, high-profit area.[21]

Kenya.—The Intermediate Technology Development Group of the United Kingdom was considering the establishment of a crystalline flake graphite operation near Nyahurura Falls, 100 miles north of Nairobi, based on local deposits. The deposits could be developed by sometime in 1982 to produce 16- to 60-mesh, high-carbon crystalline flake graphite for pencils and crucibles; much of the product would go to export markets.[22] There are a number of small graphite deposits scattered about Kenya, but mostly in the south near Voi and Tsavo on the Nairobi-Mombasa railroad.[23]

Mexico.—The new crystalline flake graphite mine and plant of Grafito de Mexico S.A. de C.V. in Oaxaca that had startup problems in 1980 did better in 1981.[24] Exports of Mexican crystalline flake to the United States was 287 tons in 1981, compared with 137 tons in 1980.

Sri Lanka.—The Asian Development Bank was to begin providing technical assistance to the State Mining & Mineral Development Corp. for rehabilitating and expanding the corporation's existing mines and for investigating new resources. Output of graphite ore would be increased by an additional 18,700 short tons, more than doubling the Nation's production.[25]

Switzerland.—Lonza Ltd., a member of the Alusuisse group, is preparing to double the capacity of its synthetic graphite powder plant at a cost of $17 million (28 million Swiss francs). This special graphite powder is made from petroleum coke or anthracite and has many of the crystallinity characteristics of natural varieties while being higher in purity and more consistent in its properties. It is likely to become more competitive as natural graphite becomes more expensive.[26]

Yugoslavia.—Crystalline flake graphite deposits have been discovered near Bosiljgrad, Serbia. The largest deposit is estimated to contain 220,000 tons of ore averaging 12% graphite and is near the Ljubata River.[27]

Table 10.—Graphite: World production, by country[1]

(Short tons)

Country[2]	1977	1978	1979	1980[p]	1981[e]
Argentina	94	[r]9	11	6	8
Austria	38,898	44,645	44,664	40,454	38,600
Brazil (marketable)	10,127	11,417	13,753	[3]18,090	25,350
Burma[4]	106	309	295	219	330
China[e]	66,000	88,000	200,600	176,000	176,000
Czechoslovakia[e]	49,600	49,600	49,600	49,600	49,600
Germany, Federal Republic of[e] [5]	9,178	7,034	4,047	6,270	6,300
India (mine)[6]	[r]53,523	70,310	58,225	53,787	55,100
Italy	4,210	4,528	4,522	4,362	4,400
Korea, North[e]	22,000	22,000	28,000	28,000	28,000
Korea, Republic of:					
Amorphous	68,904	59,288	59,789	65,209	60,600
Crystalline flake	3,799	2,793	2,704	1,575	2,200
Madagascar	17,336	18,326	15,699	13,506	13,200
Mexico:					
Amorphous	64,410	57,611	56,086	48,860	44,900
Crystalline flake	--	--	--	200	500
Norway	10,028	12,292	13,109	11,883	12,000
Romania[e]	6,600	6,600	6,600	6,600	6,600
Sri Lanka	9,783	11,581	10,364	8,591	5,700
South Africa, Republic of	1,004	643	434	--	--
Thailand	[r]25	25	--	2,286	2,200
U.S.S.R.[e]	105,000	110,000	110,000	110,000	116,000
United States	W	W	W	--	--
Zimbabwe	[r] [e]3,300	[r] [e]5,500	6,324	8,141	7,700
Total	[r]543,925	[r]582,511	684,826	653,639	655,288

[e]Estimated. [p]Preliminary. [r]Revised. W Withheld to avoid disclosing company proprietary data.
[1]Table includes data available through May 26, 1982.
[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]Includes 6,000 short tons of crude product that was marketed and used directly in 1980.
[4]Data are for fiscal year beginning Apr. 1 of that stated.
[5]Series revised; data now presented represents 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.

TECHNOLOGY

Technological advances with potentially significant commercial applications were made in 1981, especially for graphite fibers.

Several ways of using graphite fibers in construction emerged this year, possibly laying the groundwork for graphite fiber moving into an entirely new market. The U.S. Army awarded contracts to Fiber Technology Corp. to design and produce planks and a launch beam, a major structural member, for a transportable bridge. The bridge will be 40% lighter, much stronger, and much easier to erect.[28] Sumitomo Metal Industries Ltd. and Kajima Corp. have developed a graphite fiber-reinforced concrete that contains 1% to 5% fiber and is 5 times stronger and 50 times more plastic than ordinary concrete.[29]

Some recent research may help to bring intercalated graphite into more general use.

Intercalated cobalt-graphite catalysts display an unusual product selectivity during hydrogenation of carbon monoxide; their use for this purpose is dependent on their adaptation to a flow-type reaction system and the effect of pressure on product selectivity.[30] Graphite intercalated with platinum-group metals hexafluorides or pentafluorogermanates has an oxidizing potential close to that of fluorine, making it a good electrode material in a solid-state galvanic cell. The cell uses the graphite fluorometallate in combination with a superionic fluoride-ion-conducting solid electrolyte.[31]

Mitsui Coke and Toray Industries, both Japanese firms, announced the joint development of a process to make graphite fiber from a byproduct of solvent-refined coal at one-half the cost of present methods. A pilot plant using this process and with a 35- to 60-ton-per-year capacity was to come onstream in mid-1983 at Omuta; if successful, a 3,000-ton-per-year plant was scheduled to be built by 1985.[32]

Graphite fiber has been modified to increase and decrease its electrical resistivity. Treating polyacrylonitrile-based graphite fiber with either aluminum chloride or nitric acid mixtures increased resistivity by 10% to 50% without any adverse effect on the tensile strength or the Young's modulus.[33] Japanese scientists have developed a graphite fiber that contains particles of iron, nickel, and cobalt and is 5 times harder and has one-tenth to one-hundredth of the resistivity of presently available graphite fibers. A chemical firm, Showa Denko, planned to commercialize it by 1984.[34]

Georgia Institute of Technology has set up a graphite fiber processing laboratory in its School of Textile Engineering. The facility can be utilized to prepare the polyacrylonitrile polymer, fiberize it, heat treat it, and convert it to graphite-carbon fiber, all under carefully controlled conditions of time, temperature, and tension.[35]

Two major studies on graphite fibers appeared in 1981. One was on markets for advanced composites and included data on costs and cost trends of fibers, properties of the fibers, comparative advantages and disadvantages of the different fibers, and advantages and disadvantages of the different matrix materials; fibers studied included several kinds of graphite, boron, aluminum oxide, an organic fiber (Du Pont Kevlar), and silicon carbide.[36] The other was on the possibility of placing controls on the transfer overseas of composite technology. This study included a description of the current state of graphite fiber composite technology in most major nations, possible new developments, new technology needed, major firms involved and their products, methods of fiber and composite production and equipment required, and fiber availability and plant capacity.[37]

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Gypsum

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The gypsum industry, suffering from a 2-year recession in housing demand, with 1.3 million housing unit starts (public and private) in 1980 and 1.1 million starts in 1981, ended the year with the lowest shipments of gypsum wallboard since 1976, 13.8 billion square feet, a decrease of 3% compared with 1980 shipments. However, preliminary data for 1981 indicated an increase of value of additions and alterations to residential buildings, and in the consumption of gypsum wallboard for trailer and modular-type homes, which mitigated the impact of the decline in housing starts. In 1981, output of crude gypsum decreased 7% to 11.5 million tons. Production of calcined gypsum decreased 1% to 11.7 million tons. Sales of gypsum products decreased 3% to 19.0 million tons, and total value of gypsum products sold decreased 4% to $1.2 billion. Imports for consumption of crude gypsum increased 3% in 1981 to 7.6 million tons. Total value of gypsum product exports increased 30% to $35.4 million.

Table 1.—Salient gypsum statistics

(Thousand short tons and thousand dollars)

	1977	1978	1979	1980	1981
United States:					
Active mines and plants[1]	115	116	113	r114	113
Crude:					
Mined	13,390	14,891	14,630	12,376	11,497
Value	$74,341	$92,726	$99,868	$103,059	$98,101
Imports for consumption	7,074	8,308	7,773	7,365	7,593
Byproduct gypsum sales	797	669	828	663	696
Calcined:					
Produced	12,590	14,041	14,543	11,848	11,687
Value	$277,835	$387,010	$442,157	$270,324	$243,140
Products sold (value)	$910,526	$1,248,013	$1,391,993	$1,241,949	$1,196,236
Exports (value)	$15,703	$19,804	$22,388	$27,222	$35,434
Imports for consumption (value)	$31,398	$63,882	$65,079	$51,880	$51,720
World: Production	r82,134	r86,698	r89,684	p86,310	e84,982

eEstimated. pPreliminary. rRevised.

[1]Each mine, calcining plant, or combination mine and plant is counted as 1 establishment; includes plants that sold byproduct gypsum.

DOMESTIC PRODUCTION

The United States was the world's leading producer of gypsum, accounting for 14% of the total world output.

In 1981, 45 companies mined crude gypsum at 70 mines in 22 States. Output decreased 7% compared with that of 1980. Leading producing States were Texas, California, Iowa, Oklahoma, and Michigan. These five States produced more than 1 million tons each and together accounted for 60% of the total domestic production. Stocks of crude ore at mines and plants at yearend 1981 were 3.6 million tons.

Leading companies in 1981 were United States Gypsum Co. with 12 mines, National Gypsum Co. and Georgia-Pacific Corp. with 6 mines each, Celotex Div. of Jim Walter Corp. and Genstar Building Materials Co. with 3 mines each, and Weyerhaeuser Co. with 1 mine. These 6 companies, operating

31 mines, produced 78% of the total crude gypsum in 1981.

Leading individual mines in 1981 were United States Gypsum's Plaster City Mine, Imperial County, Calif.; United States Gypsum's Sweetwater Mine, Nolan County, Tex.; National Gypsum's Tawas Mine, Iosco County, Mich.; United States Gypsum's Southard Mine, Blaine County, Okla.; United States Gypsum's Shoals Mine, Martin County, Ind.; Weyerhaeuser's Briar Mine, Howard County, Ark.; and National Gypsum's Shoals Mine, Martin County, Ind. These seven mines accounted for 34% of the national total. Average output per mine in 1981 for the 70 U.S. mines was 164,200 tons compared with 169,500 tons per mine in 1980.

In 1981, 14 companies calcined gypsum at 72 plants in 30 States. Output decreased from 11.8 million tons of calcine valued at $270 million in 1980 to 11.7 million tons valued at $243 million in 1981; a tonnage decrease of 1% and a value decrease of 10%. Output in 1981 was the lowest since 1976. Leading States were California, Texas, Iowa, and New York. These 4 States, with 23 plants, accounted for 37% of the national output.

Leading companies were United States Gypsum with 22 plants, National Gypsum with 19 plants, Georgia-Pacific Corp. with 9 plants, Genstar with 6 plants, and Celotex Div. of Jim Walter Corp. with 4 plants. These 5 companies, operating 60 plants, accounted for 85% of the national output in 1981.

Leading individual plants were United States Gypsum's Plaster City plant, Imperial County, Calif.; Weyerhaeuser's Briar plant, Howard County, Ark.; United States Gypsum's Sweetwater plant, Nolan County, Tex.; United States Gypsum's Stony Point plant, Rockland County, N.Y.; United States Gypsum's Shoals plant, Martin County, Ind.; United States Gypsum's Jacksonville plant, Duval County, Fla.; United States Gypsum's Fort Dodge plant, Webster County, Iowa; Georgia-Pacific's Acme plant, Hardeman County, Tex.; United States Gypsum's Southard plant, Blaine County, Okla.; and Pacific Coast Building Products' Apex plant, Clark County, Nev. These 10 plants accounted for 28% of the national output. Average calcine output for the 72 U.S. plants in 1981 was 162,300 tons, a 1% decrease compared with the 164,600 tons per plant in 1980.

In 1981, the following companies sold a total of 696,000 tons of byproduct gypsum, valued at $6.6 million, for agricultural purposes: Occidental Petroleum Corp., Allied Chemical Corp., and SimCal Chemical Co., all in California; Occidental Petroleum Corp. in Florida; Texasgulf Inc. in North Carolina; and American Cyanamid Co. in Georgia.

One new gypsumboard plant and several plant expansions and improvements increased the national production capacity an additional 470 million square feet per year. The available capacity of operating gypsumboard plants in the United States at yearend 1981 was 19.14 billion square feet per year, a 3% increase compared with that of yearend 1980. Total 1981 gypsumboard production in the United States was 13.8 billion square feet. This indicated a 72% national utilization of capacity for the year.

United States Gypsum completed a major wallboard expansion project at the Jacksonville, Fla., plant in 1981. The company added 290 million square feet of gypsumboard capacity to the plant, and its total capacity of 600 million board feet per year ranked it next to the company's Plaster City, Calif., plant. United States Gypsum also added 190 million square feet of wallboard capacity to its Sweetwater, Tex., plant, onstream in 1981. United States Gypsum purchased the dormant Kaiser Gypsum Co.'s Delanco gypsum wallboard plant in Delanco, N.J. United States Gypsum planned to use the facility, which has been closed since 1975, only as part of its warehousing consolidation program.[2]

Domtar Gypsum America Inc.'s new $19 million wallboard plant in Tacoma, Wash., came onstream in 1981 with a capacity of 300 million square feet of gypsumboard per year. Gypsum rock was imported from Domtar Gypsum's mine on San Marcos Island, Baha California Sur, Mexico. Domtar Gypsum had the largest capacity of any gypsum wallboard manufacturer on the Pacific coast when combined with its other two plants in Long Beach and Antioch, Calif.[3]

Owing to poor markets in the housing sector, two small wallboard plants closed indefinitely during 1981—Three Rivers Gypsum, Inc.'s Longworth plant in Fisher County, Tex., with an annual capacity of 150 million square feet; and Western Gypsum Co.'s Rosario Mine and plant in Santa Fe County, N. Mex., with an annual capacity of 70 million square feet. Domtar Industries Inc. of Montreal, Canada, purchased the Grand Rapids Gypsum Co. mine and plant in Grand Rapids, Mich., which had recently filed bankruptcy proceedings.[4]

Table 2.—Crude gypsum mined in the United States, by State

State	1980 Active mines	1980 Quantity (thousand short tons)	1980 Value (thousands)	1981 Active mines	1981 Quantity (thousand short tons)	1981 Value (thousands)
Arizona	4	209	$2,017	4	213	$2,594
Arkansas, Kansas, Louisiana	5	1,040	6,047	5	1,059	7,090
California	8	1,644	12,763	8	1,456	13,948
Colorado	6	227	3,409	6	203	2,346
Idaho, Montana, South Dakota, Washington	6	128	1,431	5	97	915
Indiana, New York, Virginia	4	1,501	13,646	4	1,371	10,904
Iowa	6	1,468	13,136	6	1,383	12,706
Michigan	5	1,382	8,605	4	1,066	6,762
Nevada	4	852	8,276	4	778	6,914
New Mexico	3	182	1,688	3	166	2,256
Ohio	1	136	1,346	1	148	1,566
Oklahoma	6	1,326	11,230	5	1,177	9,870
Texas	7	1,681	14,124	7	1,783	14,900
Utah	5	287	2,612	5	300	2,705
Wyoming	3	312	2,731	3	299	2,625
Total[1]	73	12,376	103,059	70	11,497	98,101

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

Table 3.—Calcined gypsum produced in the United States, by State

State	1980 Active plants	1980 Quantity (thousand short tons)	1980 Value (thousands)	1981 Active plants	1981 Quantity (thousand short tons)	1981 Value (thousands)
Arizona, Colorado, New Mexico, Utah	6	461	$12,048	6	470	$9,847
Arkansas, Illinois, Indiana, Kansas, Louisiana, Oklahoma	12	2,293	48,313	12	2,277	45,337
California	7	1,457	24,776	7	1,331	29,719
Delaware, Maryland, North Carolina, Virginia	6	1,154	29,702	6	1,192	25,624
Florida	3	637	15,998	3	637	13,627
Georgia	3	621	18,455	3	613	13,612
Iowa	5	912	17,505	5	932	18,167
Massachusetts, New Hampshire, New Jersey, Pennsylvania	5	674	15,425	5	658	14,267
Michigan	4	386	10,764	3	321	6,248
Montana, Washington, Wyoming	4	373	10,261	5	358	7,844
Nevada	3	576	10,653	3	518	9,846
New York	5	768	21,626	5	839	18,777
Ohio	3	302	7,191	3	288	6,030
Texas	6	1,235	27,608	6	1,254	24,197
Total[1]	72	11,848	270,324	72	11,687	243,140

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

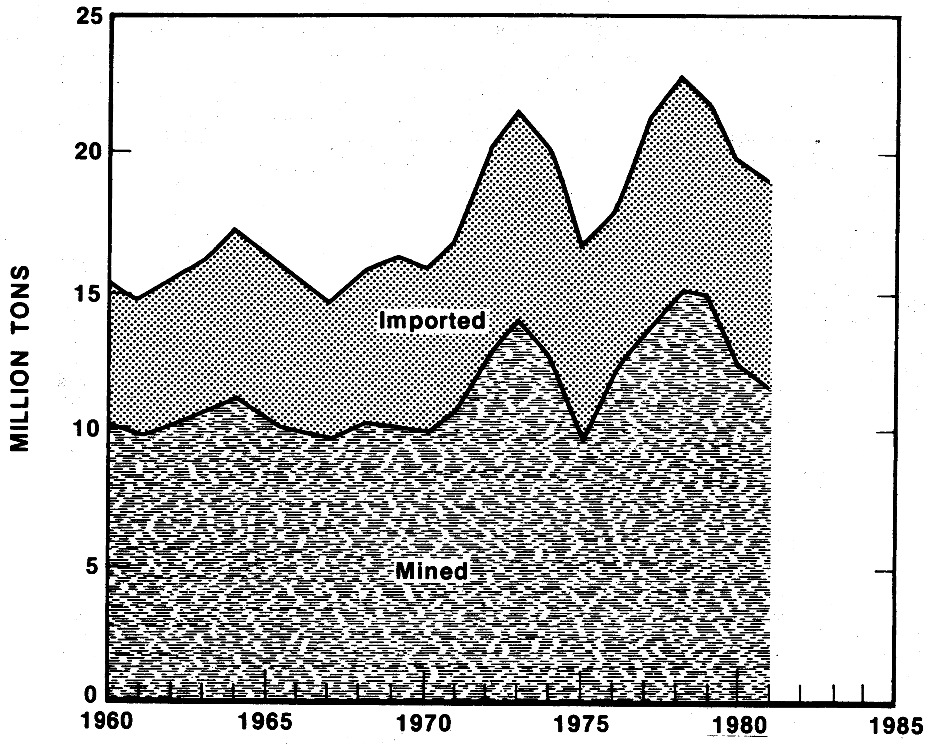

Figure 1.—Supply of crude gypsum in the United States.

CONSUMPTION AND USES

Apparent consumption of crude gypsum in 1981, production plus imports minus exports, decreased 4% to 18.9 million tons. Imports provided 40% of the crude gypsum consumed. Apparent consumption of calcined gypsum in 1981 decreased 2% to 11.5 million tons.

Stocks of crude gypsum at mines and calcining plants at yearend 1981 were 3.5 million tons. Of this, 2.3 million tons, 66%, was at calcining plants in coastal States.

Of the total gypsum products sold or used in 1981, 5.3 million tons, 28%, was uncalcined. Of the total uncalcined gypsum, 3.6 million tons, 69%, was used for portland cement, and 1.5 million tons, 29%, was used in agriculture. The leading sales regions in 1981 for gypsum used in cement were the West South-Central, Pacific, and West North-Central; these three regions accounted for 52% of the total. For agricultural gypsum, the Pacific sales region accounted for 69% of the total.

Of the total calcined gypsum in 1981, 94% was used for prefabricated products and 6% for industrial and building plasters. Of the prefabricated products, 69% was regular gypsumboard, 24% was fire-resistant Type X gypsumboard, 3% was veneer base, and 2% was sheathing and predecorated wallboard. Of the regular gypsumboard, 82% was 1/2 inch and 10% was 5/8 inch. The leading sales regions for prefabricated products were the South Atlantic, West South-Central, and Pacific, accounting for 53% of the total. For industrial and building plasters, the Pacific, East North-Central, and Middle Atlantic regions accounted for 53% 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	1980 Quantity	1980 Value	1981 Quantity	1981 Value
Uncalcined:				
Portland cement	3,885	41,440	3,634	41,530
Agriculture[1]	1,658	19,121	1,525	20,736
Fillers and miscellaneous	135	4,353	113	4,891
Total[2]	5,678	64,914	5,273	67,157
Calcined:				
Industrial plaster	393	28,296	360	29,689
Building plaster:				
Regular base coat	r232	r14,642	238	16,984
Poured gypsum cement and concrete	r57	r3,663	60	4,303
Veneer plaster	79	7,942	75	8,706
Gaging plaster and Keene's cement	30	2,733	26	2,730
Other	r(3)	31	(3)	40
Total[2]	398	29,011	398	32,764
Prefabricated products[4]	13,025	1,119,728	12,927	1,066,626
Total calcined[2]	13,816	1,177,035	13,686	1,129,078
Grand total[2]	19,494	1,241,949	18,958	1,196,236

rRevised to conform to new format, which includes "Mill-mixed base coat" with "Regular base coat" and establishes "Poured gypsum cement and concrete" as a new entry.
[1]Includes 662,987 tons of byproduct gypsum in 1980 and 696,245 tons in 1981.
[2]Data may not add to totals shown because of independent rounding.
[3]Less than 1/2 unit.
[4]Includes weight of paper, metal, or other materials.

Table 5.—Prefabricated gypsum products sold or used in the United States

Product	1980 Thousand square feet	1980 Thousand short tons[1]	1980 Value (thousands)	1981 Thousand square feet	1981 Thousand short tons[1]	1981 Value (thousands)
Lath:						
3/8 inch	75,319	58	$6,323	56,980	44	$4,978
1/2 inch	3,730	3	308	14,970	14	1,178
Total	79,049	61	6,631	71,950	58	6,156
Veneer base	338,362	353	26,051	328,213	339	24,607
Sheathing	199,416	176	17,487	199,405	184	18,844
Regular gypsumboard:						
3/8 inch	710,998	548	51,058	651,596	531	46,024
1/2 inch	8,910,714	7,763	644,931	8,171,442	7,269	570,657
5/8 inch	822,033	755	73,437	963,834	873	83,832
1 inch	32,034	49	5,960	53,672	85	7,889
Other[2]	74,881	54	9,606	118,527	121	9,561
Total[3]	10,550,660	9,169	784,992	9,959,071	8,879	717,962
Type X gypsumboard	2,637,933	2,998	231,539	2,778,482	3,107	238,086
Predecorated wallboard	118,838	105	35,224	133,040	126	34,915
5/16-inch mobile home board	219,975	164	17,802	269,213	220	22,981
Other	--	--	--	14,880	15	3,073
Grand total[3]	14,144,233	13,025	1,119,728	13,754,254	12,927	1,066,626

[1]Includes weight of paper, metal, or other material.
[2]Includes 1/4-, 7/16-, and 3/4-inch gypsumboard.
[3]Data may not add to totals shown because of independent rounding.

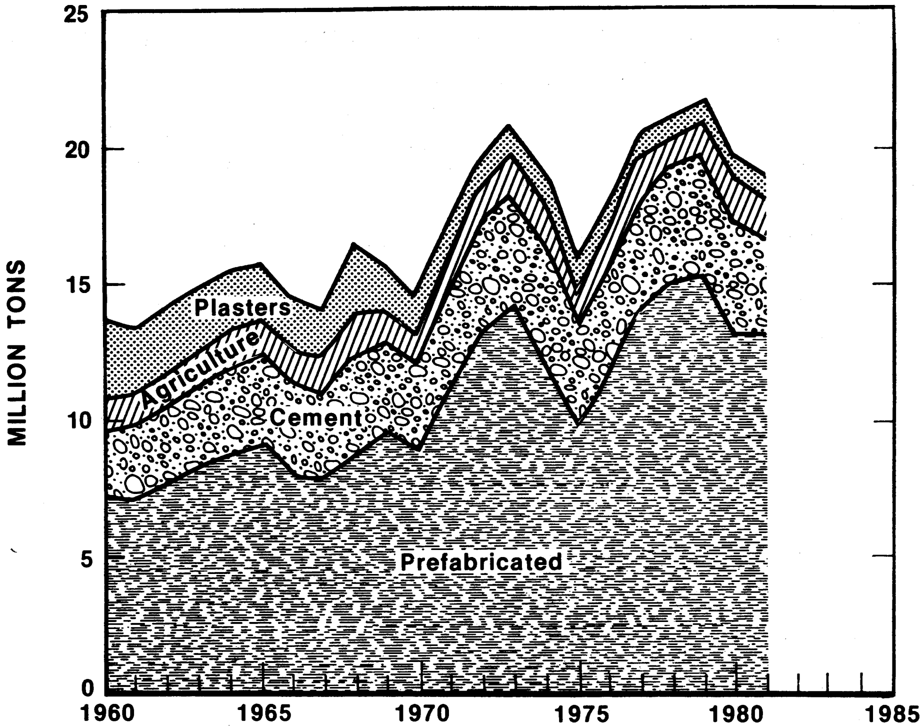

Figure 2.—Sales of gypsum products, by use.

ENERGY

Although the gypsum industry's national operational capacity was only 72% for 1981, efficient production scheduling, superior insulation, and energy-saving processing equipment such as one-step drying and calcining combined to approximate the same utilization of energy per unit of wallboard as in 1980. The Gypsum Association reaffirmed its improvement target of 22% by 1985, compared with the base year of 1972. In 1981, British thermal unit (Btu) consumption per thousand square feet of gypsum wallboard sales was 2.63 million compared with 2.65 million Btu in 1980.

As reported by the Gypsum Association, fuel sources for the gypsum industry at yearend 1981 were natural gas, 78.7%; electricity, 6.1%; propane, 1.4%; fuel oil, No. 2, 5.9%; fuel oil, No. 4 and No. 6, 4.9%; and coal, 3.0%.

PRICES

The average value of crude gypsum increased from $8.33 per ton in 1980 to $8.53 in 1981. The average value of calcined gypsum decreased from $22.82 per ton in 1980 to $20.80 in 1981. The average value of byproduct gypsum sold increased from $8.56 per ton in 1980 to $9.42 in 1981.

The average value of gypsum products sold or used was $63.10 per ton in 1981 compared with $63.71 in 1980. In 1981, prefabricated products were valued at $82.51 per ton, industrial plaster at $82.47 per ton, building plaster at $82.32 per ton, and uncalcined products at $12.74 per ton.

Quoted prices for gypsum products are published monthly in Engineering News-Record. Prices at yearend 1981 showed a wide range, based on truck lots delivered to the job. Regular 1/2-inch wallboard prices ranged from $78 per thousand square feet at Dallas, Tex., to $152 at Boston, Mass. Average price at yearend for 19 cities was

$122.33 per thousand square feet, with some minor discounts for prompt settlement. Prices for building plaster in 1981 ranged from $98 per ton at Denver, Colo., to $183 at New York City.

FOREIGN TRADE

In 1981, the gypsum industry continued to rely on imports for 40% of apparent consumption. Imports for consumption of crude gypsum were from Canada, 72%; Mexico, 22%; Spain, 4%; and the Dominican Republic, Jamaica, and Ghana, the remaining 2%. Imports increased 3% from the 1980 level to 7.6 million tons. Most of the imported crude gypsum was mined by subsidiaries of U.S. companies in Canada and Mexico. For 1981, total value of gypsum and gypsum products imported was $51.7 million, virtually the same as that of 1980. In 1981, 116 million square feet of wallboard was imported from Canada, 22% less than that of 1980. Total value of gypsum product exports to all countries was $35.4 million in 1981, a 30% increase compared with the 1980 value.

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		
1979	91	10,891	11,497	22,388
1980	88	11,774	15,448	27,222
1981	157	14,590	20,844	35,434

[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)	Plasterboard[2] (value)	Other manufactures, n.s.p.f.[3] (value)	Total value
	Quantity	Value	Quantity	Value				
1979	7,773	34,095	2	194	2,319	25,379	3,092	65,079
1980	7,365	35,664	2	231	1,959	10,958	3,068	51,880
1981	7,593	39,266	2	339	1,169	8,419	2,527	51,720

[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).

Table 8.—U.S. imports for consumption of crude gypsum, by country

(Thousand short tons and thousand dollars)

Country	1980		1981	
	Quantity	Value	Quantity	Value
Canada[1]	5,463	[r]25,606	5,436	27,497
Dominican Republic	69	623	83	918
Ghana	--	--	12	55
Jamaica	11	71	66	847
Mexico	1,565	8,030	1,696	8,112
Spain	250	1,271	300	1,818
Other	7	63	([2])	19
Total	[r]7,365	[r]35,664	7,593	39,266

[r]Revised.
[1]Includes anhydrite.
[2]Less than 1/2 unit.

WORLD REVIEW

Canada.—Canada was the second leading producer of crude gypsum in 1981, accounting for 10% of the world total with shipments of 8.6 million tons, valued at $3.9 million, an 8% increase in tonnage compared with that of 1980. In 1980, 67% of the crude gypsum was shipped from Nova Scotia, followed by Ontario, 11%; British Columbia, 10%; Newfoundland, 9%; and the remaining 3% from Manitoba and New Brunswick. All mining of gypsum was conducted by open pit operations, with the exception of three underground mines in Ontario at Hagersville, Caledonia, and Drumbo. Exports in 1980 were 5.5 million tons to the United States, valued at $22 million. Imports were 132,000 tons, principally from San Marcos Island, Mexico, shipped to British Columbia. In 1980, 18 gypsum product plants included 1 each in Newfoundland and Nova Scotia. The crude gypsum produced in Ontario was used in the seven product plants in Quebec and Ontario, serving the urban concentrations there. Nine gypsum product plants served the western provinces, with three each in British Columbia and Alberta, two in Manitoba, and one in Saskatchewan.[5] All Canadian gypsum wallboard manufacturers were members of the Gypsum Association in the United States, which announced that Canadian wallboard capacity as of yearend 1981 was 3.66 billion board feet. Geological and mining production information were discussed in detail for all gypsum and anhydrite deposits in the Canadian Provinces.[6] Reserves are extremely large and are conservatively estimated at over 2 billion tons.[7]

China.—The State Statistical Bureau of China reported that 3,567,000 tons of gypsum was produced in 1979. As cement production was 81.5 million tons for that year, apparently most of the gypsum was used as a cement set-retarder.[8]

Egypt.—The Egyptian Gypsum, Marble and Quarries Co., Egypt's largest gypsum producer, has signed a contract for the supply of a 1,000-ton-per-day gypsum plant with the Claudius Peters Industrieanlagen GmbH of Hamburg, Federal Republic of Germany.[9]

Germany, Federal Republic of.—Fels-Werke Peine-Salzgitter GmbH of Goslar, part of the state-owned Salzgitter Group, had constructed a fully automatic plant for the production of gypsum fiber plates with a capacity of 200 million square feet per year. Total plant investment was $8 million.[10]

Ireland.—An extensive deposit of gypsum in the Kingscourt area has been known since 1879. It has been passed through several companies and is currently owned by Gypsum Industries Ltd., a subsidiary of British Plasterboard (Holdings) Ltd. Two mines were operated in the counties of Cavan and Monaghan, and production has been fairly consistent over the last few years in the range of 350,000 to 400,000 tons per year. A wide range of gypsum products were manufactured, including plasterboard, plaster, woodwool slabs, jointing and finishing compounds, and some pulverized gypsum supplied for agricultural purposes.[11]

Japan.—In 1962, Japanese output of natural gypsum was 880,000 tons per year, and by 1978, production was completely phased out. Use of synthetic gypsum had replaced that of natural gypsum and had reached a total annual consumption by 1981 of 6.8 million tons. In 1970, phosphogypsum, a byproduct of the acidulation of phosphate rock in the production of phosphoric acid, corresponded to over 80% of total synthetic gypsum production. However, by 1979 this percentage had decreased to 58%, with byproduct gypsum from desulfurization of industrial stack gases responsible for the difference. In 1979, the major consumption of gypsum in Japan was for cement, 44%; gypsum wallboard, 36%; construction plaster, 8%, and other, 12%.[12]

Pakistan.—Pakistan's gypsum production has ranged from 300,000 to 600,000 tons per year in recent years. The Government announced in 1981 a plan to increase production threefold over the next 5 years. The Punjab Mineral Development Corp. was responsible for the exploration, mining, processing, and marketing of the deposits near Daud Khel, Punjab. Export markets to the Arabian Gulf and East Africa were being investigated.[13]

Qatar.—The Qatar Industrial Development Technical Centre (ITDC) announced in 1981 the discovery of large deposits of gypsum in Qatar. ITDC described the gypsum in several bedded deposits at Al Nafkah.[14]

Sudan.—A gypsum deposit near the Red Sea Hills containing an estimated 240 million tons was being mined by the state-owned Sudanese Mining Corp. (SMC). SMC produced 6,600 tons in 1981, and two small private operations produced a similar tonnage in 1981. Total gypsum output was used principally by cement plants at Atbara and

Rabak.[15]

Tanzania.—Bedded deposits of high-grade gypsum associated with Jurassic limestones and shales were discovered at Kilwa in the south of Tanzania. Gypsum and anhydrite were also found in thicknesses up to 660 feet near Mbaru. Extensive superficial deposits of gypsite also occurred near Mkomazi with only some from Mkomazi sold as a cement set-retarder.[16]

Yugoslavia.—The Yugoslavian news agency, Tanjug, reported the discovery of a gypsum deposit in the Republic of Bosnia and Herzegovina, estimated to contain 1.4 million tons. At Bratunac, a new plant for the production of ceramic wall tiles had been placed into operation with a capacity of 27 million square feet per year.[17]

Table 9.—Gypsum: World production, by continent and country[1]

(Thousand short tons)

Continent and country[2]	1977	1978	1979	1980[p]	1981[e]
North America:					
Canada[3 4]	7,974	8,901	8,927	7,947	[5]8,598
Cuba[e]	100	105	100	134	145
Dominican Republic	249	190	193	206	200
El Salvador	8	8	8	10	7
Guatemala	35	42	28	37	30
Honduras	20	[e]25	[e]25	25	20
Jamaica	237	148	64	105	105
Mexico	1,649	1,938	2,228	1,884	[5]2,076
Nicaragua[e]	40	40	40	44	35
United States[6]	13,390	14,891	14,630	12,376	[5]11,497
South America:					
Argentina	603	674	648	1,028	[5]748
Bolivia	[r e]1	[e]1	[e]1	1	[5]1
Brazil[7]	[r]599	[r]523	512	668	695
Chile	[r]162	[r]192	179	218	[5]293
Colombia	231	281	283	289	300
Ecuador	46	38	[e]40	39	40
Paraguay	15	10	12	13	15
Peru	[r]157	[r]186	239	309	385
Venezuela	[r]184	[r]206	287	129	[5]240
Europe:					
Austria[3]	892	844	880	919	915
Belgium[3]	185	202	212	192	180
Bulgaria	325	375	341	343	340
Czechoslovakia	752	768	809	834	830
France[3]	[r]7,385	[r]6,692	6,878	[e]6,600	6,950
German Democratic Republic	375	385	397	397	400
Germany, Federal Republic of (marketable)[3]	2,445	2,467	2,481	[e]2,580	2,480
Greece	[r]685	[r]601	666	[e]500	550
Ireland	[r]377	432	460	421	400
Italy	[r]4,608	[r e]4,630	[e]4,630	[e]4,630	4,400
Luxembourg	3	1	1	1	1
Poland[e 7]	[r]1,477	[r]1,488	1,500	1,433	1,430
Portugal	194	[r]230	265	226	220
Spain	6,042	5,918	5,815	5,757	5,730
Switzerland[e]	[r]77	[r]77	77	88	95
U.S.S.R.[e 8]	5,700	5,800	6,000	6,000	6,000
United Kingdom[3]	3,648	3,662	3,858	3,748	3,420
Yugoslavia	532	554	626	[e]630	640
Africa:					
Algeria[e]	190	190	210	220	220
Angola[e]	22	28	28	28	22
Egypt	[r]561	[r]880	877	1,036	1,050
Ethiopia	7	1	1	1	1
Kenya[3]	29	[e]33	33	33	35
Libya	320	198	200	198	200
Mauritania	11	15	18	[e]19	18
Niger	3	3	3	[e]3	3
South Africa, Republic of	485	429	416	499	[5]612
Sudan[3]	[e]17	[e]22	71	11	3
Tanzania	9	[r]22	10	12	13
Tunisia	44	44	66	83	85
Zambia	5	2	([9])	--	--
Asia:					
Afghanistan	NA	7	--	--	--
Burma[10]	37	39	42	40	34
China	1,100	1,700	4,000	3,700	3,800
Cyprus	[r]105	[r]67	51	48	46
India	858	974	949	943	1,040

See footnotes at end of table.

Table 9.—Gypsum: World production, by continent and country[1] —Continued

(Thousand short tons)

Continent and country[2]	1977	1978	1979	1980[p]	1981[e]
Asia —Continued					
Iran	[r]7,606	[e]8,800	7,700	7,700	6,600
Iraq[e]	180	180	180	190	190
Israel	220	220	80	[e]90	110
Japan[8]	6,118	6,387	6,915	6,730	[5]6,765
Jordan	24	40	40	77	85
Korea, Republic of[e 8]	660	680	680	700	700
Lebanon	17	12	11	11	10
Mongolia[e]	[e]31	[e]31	31	33	35
Pakistan	312	279	378	626	265
Philippines[8]	123	123	121	121	120
Saudi Arabia	22	231	331	331	390
Syrian Arab Republic	94	[e]95	70	79	80
Taiwan[8]	8	4	3	9	[5]7
Thailand	419	310	388	454	500
Turkey	72	67	[e]70	80	80
Vietnam[e]	13	15	15	17	17
Oceania: Australia	1,010	[r]1,045	1,356	1,427	1,435
Total	[r]82,134	[r]86,698	89,684	86,310	84,982

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available.
[1]Table includes data available through June 30, 1982.
[2]Gypsum is also produced by Romania, but production data are not available.
[3]Includes anhydrite.
[4]Shipments.
[5]Reported figure.
[6]Excludes byproduct gypsum.
[7]Series revised to represent sum of (1) mine product sold without beneficiation and (2) output of concentrates.
[8]Includes byproduct gypsum. (In the case of Japan, byproduct gypsum was virtually all gypsum consumed during 1977-81.)
[9]Less than 1/2 unit.
[10]Data are for years beginning Apr. 1 of that stated.

TECHNOLOGY

Reinforced gypsum was a potentially attractive indigenous material for housing in Egypt. A paper presented strengths and related properties of experimental gypsum panels reinforced with jute, wire mesh, glass wool, polypropylene fiber, and Nile reeds.[18]

Arklow Gypsum Co., a wholly owned subsidiary of Nitrigin Eireaan Teoranta in Ireland, was manufacturing wallboard from synthetic gypsum obtained from its fertilizer plant at Arklow, County Wicklow.[19]

The Florida phosphate industry has had to contend with disposal of large quantities of byproduct gypsum from phosphoric acid plants for many years. Little use has been found except as a soil moderator and stimulant for fertilizer utilization in agriculture. Technology is available to use this material in wallboard manufacturing and as a set-retarder in cement, as is evident from the large-scale use of byproduct gypsum for these purposes in Japan. A bill was before the Florida State government proposing to study gypsum to determine if it should be included in the State's hazardous waste laws. If this became a law, it would impose an extra burden on the phosphate rock industry and preclude any further utilization of this material, including any other potential industrial application.[20]

A patent (Ger. Offen. 2,940,785) was issued on April 16, 1981, to Peter Eckhardt of Hoechst AG, Federal Republic of Germany, for porous gypsum and construction elements containing it. The porous plaster elements were produced by a foaming mixture of α-hemihydrate gypsum, a polyurethane pre-adduct, a catalyst, and possibly other conventional additives in the presence of polyvinyl alcohol and boric acid. After casting, a volume weight of 360 grams per liter, good bending-tensile, and compressive strengths were claimed.[21]

Drill core samples from nine stockpiles of the phosphogypsum produced by the Florida phosphate industry were characterized using chemical, X-ray diffraction, emission spectrographic, radiological, and physical means. Data developed indicated that the phosphogypsum was not a corrosive or toxic hazardous waste as defined by the Environmental Protection Agency criteria. Radium concentration averaged 21 picocuries per gram, and its content was inversely related to particle size.[22]

C. F. Industries was experimenting with byproduct gypsum from its phosphate fertilizer operation for use in building an 8-inch base for an entrance road to its plant, 40 miles southeast of Tampa, Fla. It was considered as an alternative to the use of shell or limerock.[23]

Detailed economic and geologic descriptions of the gypsum resources of New Mexico were published. Large deposits of potential commercial value occur in the north-central, south-central, and southeastern sections of the State. Reserves of high-purity gypsum in New Mexico are enormous, certainly in the billions of tons.[24]

The Dowa Mining Co., Ltd., flue gas desulfurization (FGD) process is one of the double alkali processes using basic aluminum sulfate with slurried limestone (80% minus 200-mesh) to maintain basicity and air oxidation and precipitation of gypsum with quality satisfactory for wallboard manufacturing. It is simple in design and has low construction and operating costs. Since 1970, nine commercial plants in Japan and one in China have been built, and were treating a variety of waste gases, including those from oil-burning boilers, smelters, and sulfuric acid plants. A lime-scrubbing FGD process at Dowa's Kosaka smelter was converted into one using the Dowa FGD process, which reduced raw materials costs by 50% and provided additional income from sales of commercial byproduct gypsum.[25]

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[1]Physical scientist, Division of Industrial Minerals.

[2]Burlington County Times. U.S. Gypsum Buys Shutdown Delanco Plant. Willingboro, N.J., Aug. 18, 1981, p. 1.

[3]Rock Products. Industry News. Wallboard Plant Starts Production. V. 84, No. 12, December 1981, p. 29.

[4]Rock Products. Industry News. V. 84, No. 6, June 1981, p. 38.

[5]Industrial Minerals (London). 'IM' Canada Supplement '81. No. 167, August 1981, pp. 57-58.

[6]Pages 11, 13, 17, 22, and 35 of work cited in footnote 5.

[7]Stonehouse, D. H. Gypsum and Anhydrite. Can. Miner. Yearbook, 1980, p. 6 (preprint).

[8]U.S. Embassy, Beijing, China. U.S. State Department Airgram A-85, Sept. 14, 1981.

[9]Industrial Minerals (London). Industry News & Mineral Notes. No. 165, June 1981, p. 59.

[10]Page 57 of work cited in footnote 9.

[11]Industrial Minerals (London). Industrial Minerals of Ireland. No. 174, March 1982, pp. 46-47.

[12]Fujii, N. The Industrial Minerals of Japan. Ind. Miner. (London), No. 170, November 1981, pp. 48-49.

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[14]Work cited in footnote 13.

[15]Mining Week. Optimism for Mining. Min. J. (London), v. 298, No. 7660, June 11, 1982, p. 433.

[16]Jones, G. K. The Industrial Minerals of Tanzania. Ind. Miner. (London), No. 166, July 1981, p. 37.

[17]Industrial Minerals (London). Minerals in the News. No. 165, June 1981, p. 18.

[18]Youssef, M. A., and A. G. H. Dietz. Reinforced Gypsum for Egyptian Housing. ASCE Ann. Conv. and Exposition, Portland, Oreg., Apr. 14-18, 1980, Preprint 80-169, 20 pp.

[19]Page 47 of work cited in footnote 11.

[20]Industrial Minerals (London). No. 176, May 1982, p. 11.

[21]Chemical Abstracts. CA Selects—Zeolites. No. 21, 1981, p. 4.

[22]May, A., and J. W. Sweeney. Assessment of Environmental Impacts Associated With Phosphogypsum in Florida. BuMines RI 8639, 1982, p. 19.

[23]U.S. Bureau of Mines. Minerals & Materials—A Monthly Survey. March 1982, p. 8.

[24]Dickson, T. Gypsum Resources of New Mexico. 17th Industrial Mineral Forum—A Report From the Albuquerque Meeting. Ind. Miner. (London), No. 167, August 1981, p. 50.

[25]Konada, T., and J. Nagao. Application of the Dowa Process to Smelter Gases. J. Met., v. 33, No. 3, March 1981, pp. 57-60.

Helium

By Philip C. Tully[1]

Grade-A helium (99.995% or better) sales volume in the United States by private industry and the Bureau of Mines was 866 million cubic feet (MMcf) in 1981.[2] Grade-A helium exports by private producers were 389 MMcf for total sales of 1,255 MMcf of U.S. helium. The Bureau's price, f.o.b. plant, for Grade-A helium was $35 per thousand cubic feet (Mcf), unchanged since 1961. The price of Grade-A helium gas sold by private producers was $27 per Mcf at the end of the year, and the price of liquid helium averaged $32 per Mcf gaseous equivalent.

Legislation and Government Programs.—On June 18, 1981, Bureau representatives testified before the House Subcommittee on Energy Conservation and Power of the Committee on Energy and Commerce about H.R. 3877, the Helium-Energy Act of 1981. The primary purpose of this bill was to provide for additional helium conservation by the Government. No future action by the Congress during 1981 was indicated.

DOMESTIC PRODUCTION

In 1981, there were nine privately owned domestic helium plants, which were operated by seven companies. One new plant was under construction (table 1). Seven privately owned plants and two Bureau plants extracted helium from natural gas. Private and Bureau plants use a cryogenic extraction process. The Bureau and four of the five private plants that produce Grade-A helium; i.e., Cities Service Cryogenics, Inc., Ulysses, Kans.; Kansas Refined Helium Co., Otis, Kans.; Phillips Petroleum Co., Elkhart, Kans.; and Union Carbide Corp., Linde Div., Bushton, Kans., have helium liquefaction facilities. Air Products and Chemicals, Inc., is building a 250-MMcf-per-year helium plant in Hansford County, Tex., which is expected to be completed in 1982.

The volume of crude (a gas mixture containing about 50% to 80% helium) and Grade-A helium recovered from natural gas for 1977-81 is summarized in table 2, and the combined volumes recovered and sold are plotted in figure 1. All of the natural gas processed for helium extraction came from the gasfields shown in figure 2. Supply and disposal of helium for 1979-81 at the Bureau's helium plants are summarized in table 3.

The Bureau awarded a contract for a pressure swing adsorption helium purification unit in 1979. The unit was installed at the Masterson, Tex., (Exell) plant during 1980 and accepted in 1981. A new cryogenic helium purification unit and helium liquefier, also purchased under contract, were installed at the Bureau's Exell plant. The liquefier was accepted, and performance tests on the purifier were in progress at the end of 1981.

Table 1.—Ownership and location of helium extraction plants in the United States, in 1981

Category and owner or operator	Location	Product purity
Government-owned:		
Bureau of Mines	Masterson, Tex	Crude and Grade-A helium.[1]
Do	Keyes, Okla	Do.[2]
Private industry:		
Air Products and Chemicals, Inc	Hansford County, Tex	Grade-A helium[1] (under construction).
Cities Service Cryogenics, Inc	Scott City, Kans	Crude helium.[3]
Do	Ulysses, Kans	Grade-A helium.[1]
Cities Service Helex, Inc	do	Crude helium.
Kansas Refined Helium Co	Otis, Kans	Grade-A helium.[1]
Navajo Refined Helium Co	Shiprock, N. Mex	Grade-A helium.
Northern Helex Co	Bushton, Kans	Crude helium.
Phillips Petroleum Co	Elkhart, Kans	Grade-A helium.[1]
Do.[4]	Hansford County, Tex	Crude helium.
Union Carbide Corp., Linde Div	Bushton, Kans	Grade-A helium.[1]

[1]Including liquefaction.
[2]Operated through September 1981 and placed in standby at the end of the year.
[3]Output is piped to Cities Service Cryogenics, Inc., plant at Ulysses, Kans., for purification.
[4]A portion of the output is piped to Elkhart, Kans., for purification.

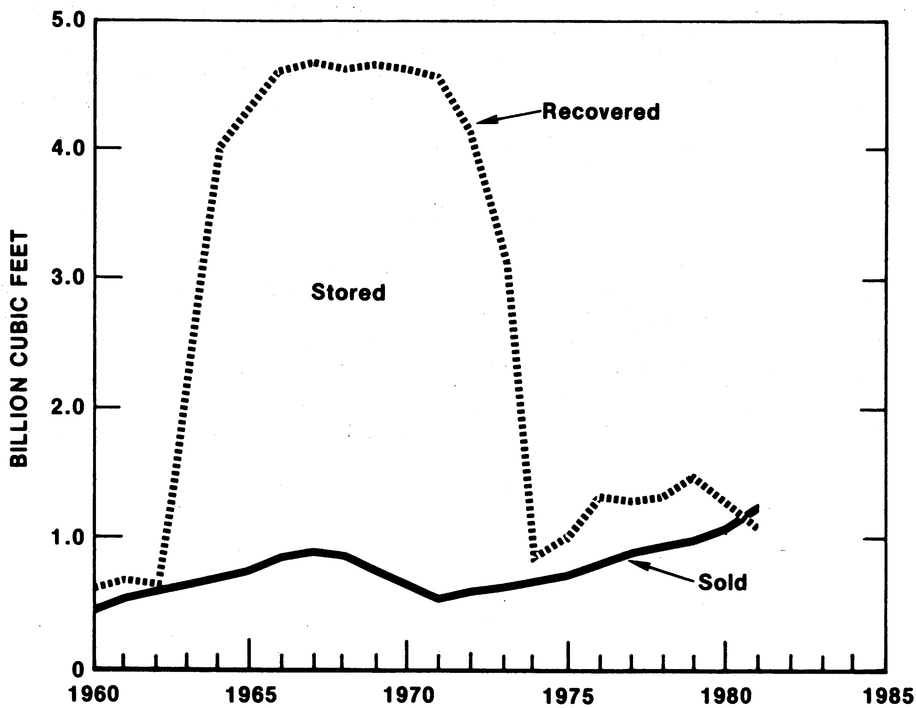

Figure 1.—Helium recovery in the United States, 1960-81.

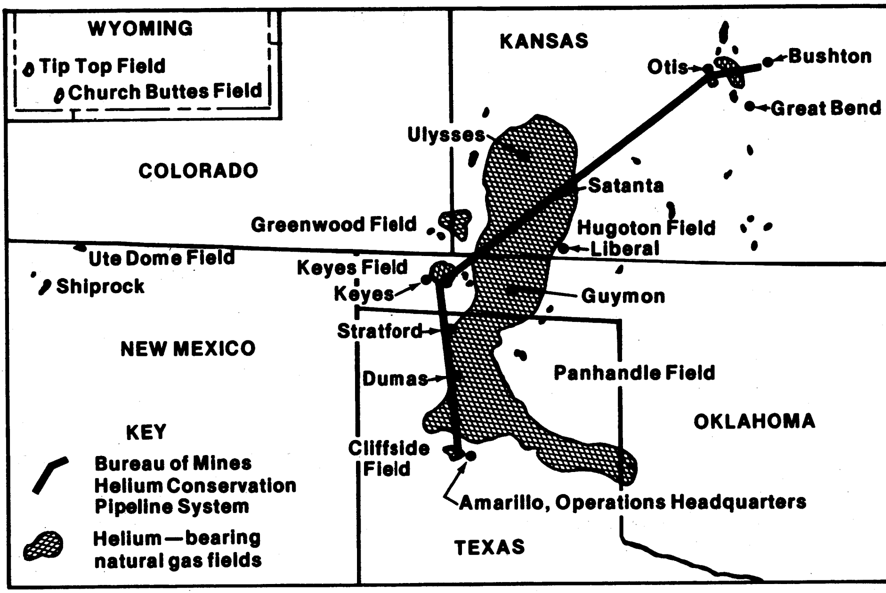

Figure 2.—Major U.S. helium-bearing natural gas fields.

Table 2.—Helium recovery in the United States[1]

(Thousand cubic feet)

	1977	1978	1979	1980	1981
Crude helium:					
Bureau of Mines:					
Total storage	116,715	42,483	34,868	22,887	-257,799
Private industry:					
Stored by Bureau of Mines	582,935	723,788	787,123	633,956	452,880
Withdrawn	-108,062	-157,716	-180,840	-266,898	-304,987
Total private industry storage	474,873	566,072	606,283	367,058	147,893
Total crude helium	591,588	608,555	641,151	389,945	-109,906
Stored private crude helium withdrawn from storage and purified by the Bureau of Mines for redelivery to industry	-204,948	-229,512	-222,320	-200,612	-80,208
Grade-A helium:					
Bureau of Mines sold	213,472	208,252	209,680	187,735	240,880
Private industry sold	727,908	779,434	890,160	986,601	1,014,543
Total sold	941,380	987,686	1,099,840	1,174,336	1,255,423
Total stored	386,640	379,043	418,831	189,333	-190,114
Grand total recovery	1,328,020	1,366,729	1,518,671	1,363,669	1,065,309

[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, Tex.

Table 3.—Summary of Bureau of Mines helium plant operations

(Thousand cubic feet)

	1979	1980	1981
Supply:			
Inventory at beginning of period[1]	18,066	16,326	14,510
Helium recovered:			
Exell plant:			
Crude[2]	-60,103	-70,275	-280,174
Grade-A	38,222	35,063	[3]237,719
Total[2]	-21,881	-35,212	-42,455
Keyes plant:			
Crude	94,971	93,162	22,375
Grade-A[4]	394,946	348,912	49,346
Total	489,917	442,074	71,721
Total recovered	468,036	406,862	29,266
Helium returned in containers (net)[2]	-2,894	r2,556	33,888
Total supply	483,208	r425,744	77,664
Disposal:			
Sales of Grade-A helium	209,680	187,735	240,880
Redelivered to private producers	222,334	r200,612	80,208
Net deliveries to helium conservation system[2]	34,868	22,887	-257,799
Inventory at end of period[1]	16,326	14,510	14,375
Total	483,208	r425,744	77,664

rRevised.
[1]At Amarillo and Exell helium plants.
[2]Negative numbers denote net withdrawal from Government's underground helium storage facility.
[3]Includes 67,591 Mcf purified for private industry in 1981.
[4]Includes 222,334 Mcf purified for private industry in 1979, 200,612 Mcf in 1980, and 12,617 Mcf in 1981.

CONSUMPTION AND USES

The major domestic end uses of helium in 1981 were cryogenics, welding, and pressurizing and purging, as shown in figure 3. Minor uses included synthetic breathing mixtures, chromatography, leak detection, lifting gas, heat transfer, and controlled atmospheres. Annual helium sales volumes for 1977-81 are shown in table 4. The Pacific and Gulf Coast States were the principal areas of demand.

Federal agencies purchase their major helium requirements from the Bureau. Direct helium purchases by the Department of Energy, the Department of Defense, the National Aeronautics and Space Administration (NASA), and the National Weather Service constituted most of the Bureau's Grade-A helium sales (table 5). All of the remaining sales to Federal agencies were through private helium distributors, which purchased equivalent volumes of Bureau helium under 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 of Mines price, f.o.b. plant, of Grade-A helium in 1981 was $35 per Mcf, unchanged since the Government established that price in 1961. Private producers' price for Grade-A helium gas was $27 per Mcf at the end of the year. The price of liquid helium averaged $32 per Mcf gaseous equivalent.

Table 4.—Total sales of Grade-A helium in the United States

(Million cubic feet)

Year	Volume
1977	779
1978	811
1979	817
1980	863
1981	866

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 from the Amarillo and Exell helium plants and in 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.

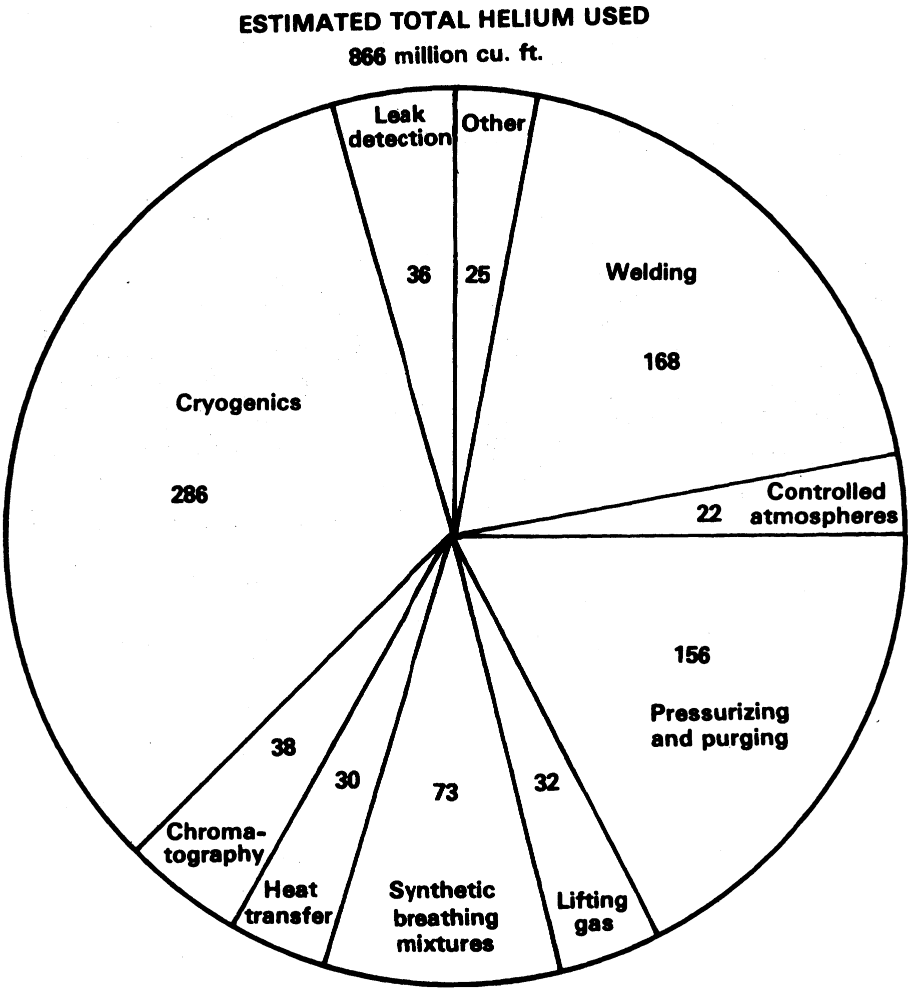

Figure 3.—Helium consumption by end use in the United States in 1981 (million cubic feet).

Table 5.—Bureau of Mines sales of Grade-A helium, by purchaser[1]

(Thousand cubic feet)

Purchaser	1979	1980	1981
Federal agencies:			
Department of Energy	23,634	24,894	29,441
Department of Defense	114,050	103,267	92,405
National Aeronautics and Space Administration	27,555	24,059	44,221
National Weather Service	1,483	1,301	1,002
Other	1,916	2,464	2,661
Total	168,638	155,985	169,730
Federal agency sales supplied by private-contract helium distributors[2]	38,478	29,478	68,551
Commercial sales	2,564	2,272	2,599
Grand total	209,680	187,735	240,880

[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.

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, Tex., totaled over 40 billion cubic feet (Bcf) at the end of 1981 (table 6). The conservation storage system contains crude helium purchased by the Bureau of Mines under contract, Bureau helium extracted in excess of sales, and privately owned helium stored under contract. During 1981, 453 MMcf of private helium was delivered to the Bureau's helium conservation storage system and 385 MMcf was withdrawn, for a net increase of 68 MMcf of private helium in storage.

Table 6.—Summary of Bureau of Mines helium conservation storage system[1] operations

(Thousand cubic feet)

	1979	1980	1981
Helium in conservation storage system at beginning of period:			
Stored under Bureau of Mines conservation program[2]	37,825,559	37,860,427	37,883,314
Stored for private producers under contract	2,031,567	2,415,532	2,582,426
Total	39,857,126	40,275,959	40,465,740
Input to system:			
Net deliveries from Bureau of Mines plants[3] [4]	34,868	22,887	-1,745,704
Stored for private producers under contract[4]	787,125	634,309	1,940,492
Total	821,993	657,196	194,788
Redelivery of helium stored for private producers under contract[3]	-403,160	-467,415	-385,194
Net addition to system[3]	418,833	189,781	-190,406
Helium in conservation storage system at end of period:			
Stored under Bureau of Mines conservation program	[2]37,860,427	[2]37,883,314	36,137,610
Stored for private producers under contract	2,415,532	2,582,426	4,137,724
Total	40,275,959	40,465,740	40,275,334

[1]Crude helium is injected into or withdrawn from the Government's underground helium storage facility, a partially depleted natural gas reservoir in Cliffside Field near Amarillo, Tex.
[2]Includes 1,518,008 Mcf of helium accepted in 1973 under court order.
[3]Negative numbers denote net withdrawal from storage.
[4]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 helium resources as of January 1, 1981 (the latest figures available), are estimated to be 346 Bcf. The resources included measured and indicated resources estimated to be 163 Bcf and 37 Bcf, respectively, in natural gas with a minimum helium content of 0.3%. The measured reserves included 40 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 55 Bcf. Indicated helium resources in natural gas with a helium content of less than 0.3% are estimated to be 91 Bcf. Approximately 95% of the domestic helium resources under Federal ownership or control are in the Tip Top and Church Buttes Fields in Wyoming, the Keyes Field in Oklahoma, and the Cliffside Field in Texas.

The majority of domestic helium resources are located in the midcontinent and Rocky Mountain regions of the United States. The measured and indicated helium resources are located in approximately 76 gasfields in 10 States. About 89% of these reserves are contained in the Hugoton Field in Kansas, Oklahoma, and Texas; the Keyes Field in Oklahoma; the Panhandle and Cliffside Fields in Texas; and the Tip Top Field in Wyoming. The Bureau analyzed a total of 242 natural gas samples from 18 States during 1981 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, increased by 30% in 1981 to 389 MMcf (table 7). Nearly 53% of the exported helium was shipped to Europe. The United Kingdom, Belgium-Luxembourg, and France, collectively, received more than 95% of the European helium imports from the United States. Fourteen percent of the U.S. helium exports went to Asia, 3% to North America, 22% to Central and South America, 3% to Australia and New Zealand, 4% to the Middle East, and less than 1% each to Africa and the Caribbean. The shipments of large volumes of helium to Western Europe in 1981 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. Exploration in Mexico and Brazil accounted for the large increase in Central and South America.

Table 7.—Exports of Grade-A helium from the United States

(Million cubic feet)

Year	Volume
1977	168
1978	190
1979	245
1980	298
1981	389

Source: U.S. Bureau of the Census.

WORLD REVIEW

World production of helium, excluding the United States, was estimated to be 120 MMcf. This production was attributed to the central-economy countries, part of which was extracted in Poland.

TECHNOLOGY

Two successful launches of the Columbia Space Shuttle of NASA's Space Transportation System were made using Bureau helium.

The 4,000-liter-per-hour helium liquefier, the world's largest, at Fermi National Accelerator Laboratory continued operation. Liquid helium was circulated to satellite liquefiers. Magnet testing is nearly complete.

The Bureau's helium-4 pilot plant produced a dozen cylinders of the isotopically purified gas containing an average helium-3 content of 3 parts per billion. Normally helium contains about 200 parts per billion helium-3. Two cylinders have been sold to universities for research purposes.

Superconducting magnet development for fusion and magnetohydrodynamic systems is proceeding. Los Alamos National Laboratory completed a superconducting magnet for energy storage for the Bonneville Power Administration.

The Electric Power Research Institute has entered into a $19 million, cost-sharing contract with Westinghouse Electric Corp. for the design and construction of a 270-megawatt superconducting electric generator. The project has reached the development stage. The generator will be the largest of its kind and will be partially cooled by liquid helium to maintain the near-absolute-zero temperature (-452° F) necessary to achieve the superconducting state. Superconducting generators are smaller, lighter, and more efficient than conventional generators of the same capacity.

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[1]Chemical engineer, Division of Helium Operations, Amarillo, Tex.

[2]All helium volumes herein are reported at 14.7 pounds per square inch absolute at 70° F.

Iron Ore

By F. L. Klinger[1]

U.S. production of iron ore increased in 1981, as demand from the iron and steel industry recovered briefly from the low level of 1980. Demand remained relatively weak, however, and by yearend, output of ore had again been drastically cut and the prospects of recovery in 1982 were uncertain.

The situation of iron ore industries in the rest of the world was similar to that of the United States. Iron ore production and trade continued to decline in 1981 as production of iron and steel was reduced by most of the industrialized countries. Ocean freight rates declined, and there was a downward pressure on iron ore prices although costs of production continued to rise. New markets for iron ore continued to grow, however, among developing countries.

Table 1.—Salient iron ore statistics

(Thousand long tons and thousand dollars unless otherwise specified)

	1977	1978	1979	1980	1981
United States:					
Iron ore (usable,[1] less than 5% manganese):					
Production	55,750	81,583	85,716	69,613	73,174
Shipments[2]	54,053	83,207	86,218	69,594	72,181
Value[2]	$1,422,696	$2,401,387	$2,814,440	$2,544,121	$2,915,239
Average value at mines, dollars per ton	$26.32	$28.86	$32.64	$36.56	$40.39
Exports	2,143	4,213	5,148	5,689	5,546
Value	$62,760	$136,721	$178,749	$230,568	$244,685
Imports for consumption	37,905	33,616	33,776	25,058	28,328
Value	$956,584	$845,039	$923,426	$772,844	$947,977
Consumption (iron ore and agglomerates)	116,034	124,797	125,431	98,879	104,385
Stocks, Dec. 31:					
At mines[3]	14,811	12,359	11,266	r11,725	12,734
At consuming plants	42,271	39,301	38,969	35,706	36,203
At U.S. docks	2,979	3,569	5,416	6,095	6,571
Manganiferous iron ore (5% to 35% manganese): Shipments	193	279	215	155	157
World: Production	r827,816	r833,894	r889,988	p881,720	e847,184

eEstimated. pPreliminary. rRevised.
[1]Direct shipping ore, concentrates, agglomerates, and byproduct ore.
[2]Includes byproduct ore.
[3]Excludes byproduct ore.

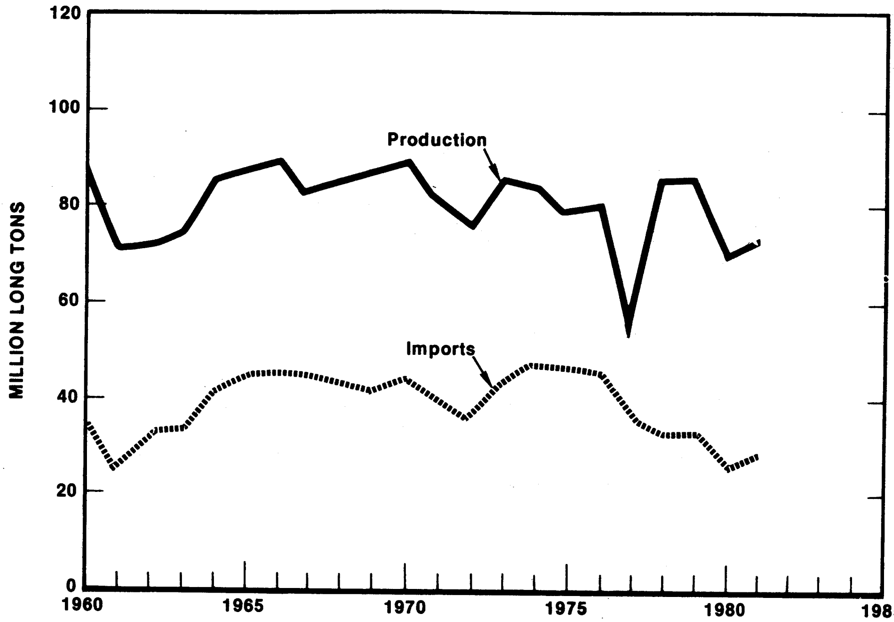

Figure 1.—United States iron ore production and imports for consumption.

EMPLOYMENT

Statistics on employment and productivity in the U.S. iron ore industry in 1981 are shown in table 2. 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 in table 2 include persons employed at mines and ore processing plants but do not include 2,133 engaged in management, research, or office work.

Total employment and number of hours worked in the industry in 1981 were not significantly different from those of the previous year, even though production of crude ore increased by 7% and production of usable ore increased by about 5% in 1981. Productivity for usable ore increased by 5% in the Lake Superior district and by 4% for the industry as a whole. The increase of productivity occurred because the larger, more mechanized taconite mines contributed a larger share of production in 1981 than in the previous year.

DOMESTIC PRODUCTION

U.S. mine production and shipments of iron ore increased moderately in 1981, compared with those of the previous year, but demand from the iron and steel industry remained relatively low. The 1981 gains in production and shipments occurred mainly between May and October, when demand was substantially higher than in the corresponding period of 1980. Demand fell sharply in the last quarter, however, and production of ore in November was the lowest since the strike-bound months of 1977 and before that, since 1963.

Iron ore was produced from 31 open pit mines and 1 underground mine during 1981. Two mines were closed during the year, owing to depletion of ore reserves, but production of many others was reduced or temporarily suspended, owing to low demand. For example, in the Lake Superior district, 8 of the 13 taconite operations were closed for periods ranging from 2 weeks to 11 months; production at 3 others was sharply reduced; and by December 1, production of iron ore pellets had dropped to about 50% of production capacity.

Crude ore production totaled 227 million tons,[2] almost all of which was extensively beneficiated to obtain ore suitable for blast furnace use.[3] An average of 3.10 tons of crude ore was mined for each ton of usable ore produced compared with 3.05 tons in 1980 and 2.93 tons in 1979. The annual increase of this ratio was due to the decline in production of direct-shipping ore and increasing production of low-grade ore of the taconite type. Most crude ore produced in 1981 contained 20% to 28% of recoverable iron. The average iron content of usable ore was 63.6%, compared with 63.0% in 1980 and 62.6% in 1979.

Iron ore pellets and other agglomerates made up nearly 96% of mine output of usable ore in 1981. Unagglomerated concentrates made up 4%, and direct-shipping ores made up less than 1%. Pellets were produced by 16 plants, including 8 in Minnesota, 4 in Michigan, and 1 each in California, Missouri, Wisconsin, and Wyoming. The Humboldt pelletizing plant in Michigan was not operated in 1981. Iron ore pellets made up more than 99% of the agglomerates produced.

The Lake Superior district produced 92% of all usable ore produced in 1981. Minnesota produced 70%; Michigan and Wisconsin 22%; and the remainder was produced in eight other States. U.S. production capacity for usable ore at the end of 1981 was estimated at 105 million tons per year, including about 92 million tons of capacity for pellets.

In Minnesota, the Canisteo and Arcturus natural-ore mines were closed in 1981 owing to depletion of ore reserves. Both facilities were located on the western Mesabi Range and produced hematite concentrates by gravity methods. The Canisteo Mine, closed June 13 by Cleveland-Cliffs Iron Co., had produced about 53 million tons of concentrates since it was opened in 1907. The Arcturus Mine, closed October 22 by United States Steel Corp. (USS), was opened in 1917 and had produced about 15 million tons. USS awarded contracts for dismantling three major natural-ore processing facilities, including the Trout Lake and Sherman concentrators near Coleraine and Chisholm, respectively, and the Rouchleau crushing and screening plant near Virginia. Elsewhere on the Mesabi, four of the eight taconite mining operations were temporarily closed during 1981. The Minorca facility of Inland Steel Co. was closed from October 4 to November 14. The Butler Taconite and National Steel Pellet projects, operated by Hanna Mining Co., were closed from October 18 to December 13. The pelletizing plant of National Steel Pellet Co. was operated at about 60% of capacity during most of 1981. Pickands Mather & Co. closed the Hibbing Taconite facility for 2 weeks at the end of the year. On October 11, USS reduced production of its Minntac facility to about 40% of capacity for an indefinite period. These actions resulted in a temporary layoff of about 4,000 employees in 1981. Reserve Mining Co. announced plans to suspend production for 11 weeks in 1982.

In Michigan, Hanna Mining Co. closed the Groveland Mine in January for an indefinite period. The mine remained closed for the rest of the year. Cleveland-Cliffs Iron Co. closed the Republic Mine from July 5 to August 11, and from October 3 through the end of the year. Production at the Empire and Tilden Mines was reduced by 25% and 50%, respectively, at the end of August, and on November 14 the Empire Mine was closed for an indefinite period. Normal production was resumed at the Tilden Mine on December 21. These actions affected about 2,500 employees.

Elsewhere in the Lake Superior district, Inland Steel Co. closed its mine and pelletizing plant at Black River Falls, Wis., from November 8 to December 6, idling about 250 employees.

In California, Kaiser Steel Corp. announced plans to close the Eagle Mountain Mine and to terminate production of iron at Fontana, Calif., by the end of 1983. The mine was closed for 2 weeks in late December, affecting about 1,000 employees of whom about 150 were laid off permanently.

In Utah, the Comstock Mine, operated by Utah International, Inc., for CF&I Steel Corp., was closed in January for an indefinite period and was not reopened in 1981. Utah International also announced in January that its mine and concentrator at Iron Springs were closed owing to lack of demand. The company's contract to supply ore to the Geneva Works of USS reportedly expired in late 1980. USS suspended production at the Mountain Lion Mine but continued to ship ore from stockpiles at Desert Mound. Production from the Iron Springs district was therefore suspended during most of 1981.

In other developments, Nevada-Barth Corp. continued to ship ore to Geneva, Utah, in 1981 from its mine stockpile near Carlin, Nev., but production reportedly ended in 1980 owing to exhaustion of ore reserves. In Wyoming, the Sunrise underground mine of CF&I Steel Corp. remained idle in 1981. In Missouri, the Pea Ridge underground mine was operated throughout the year. St. Joe Minerals Corp. continued to study the feasibility of building a coal-based direct-reduction plant to process Pea Ridge pellets, but a decision was not announced by yearend.

CONSUMPTION

Following a brief surge in demand for iron and steel that began in late 1980, monthly consumption of iron ore in 1981 rose to 9.3 million tons in March, then declined gradually to 6 million tons in December. Despite this decline, consumption in 1981 increased compared with that of the previous year because a much steeper decline had occurred in 1980. Thus, by the end of September, consumption in 1981 was 15% more than during the corresponding period of 1980. The net increase for the year, however, was only about 5% owing to a further decline in the last quarter.

Consumption of iron ore and agglomerates in 1981 totaled about 104 million tons, of which 99% was consumed in the manufacture of iron and steel. Consumption of primary ore totaled about 94 million tons, including 75 million tons of pellets, 14 million tons of fines and concentrate consumed in production of sinter, 4 million tons of natural ore charged directly to ironmaking and steelmaking furnaces, and 1 million tons used in the manufacture of miscellaneous products. Consumption of pellets was 12% more than in 1980; consumption of sinter was relatively unchanged; and consumption of natural ores in ironmaking and steelmaking furnaces was the lowest in many years. Of the primary ore consumed by the iron and steel industry, approximately 71% was supplied from domestic mines, 20% came from Canadian mines, and 9% came from other countries.

Consumption data are shown in tables 10 and 11. The data do not include iron ore fines or concentrate used to produce pellets or other agglomerates at mine sites. In table 11, the difference in weight between iron ore consumed and agglomerates produced is due to the elimination of moisture, as well as the addition of other raw materials to the sinter mix. Consumption of other materials reported in sinter plants in 1981 included (in million tons): Flue dust, 1.5; mill scale, 3.5; slag, 2.3; limestone, dolomite, and other fluxes, 5.6; and coke breeze, 1.2.

STOCKS

Stocks of iron ore and agglomerates reported at U.S. mines, receiving docks, and consuming plants on December 31, 1981, totaled 55.5 million tons, 2 million tons more than at the beginning of the year. About one-half of the increase occurred at the mines because 1981 shipments were less than production. The rest of the increase was due to accumulation of imported ore at receiving docks and consuming plants, because consumption of domestic ore was proportionately higher in 1981. Of the total stocks on hand at receiving docks and consuming plants at yearend, 61% consisted of domestic ores, 22% consisted of Canadian ores, and 17% consisted of other foreign ores.

PRICES

Published prices for Lake Superior iron ores, delivered rail-of-vessel at lower lake ports, continued to increase in 1981. In January, the price of iron ore pellets rose to 80.5 cents per long ton unit (ltu) of iron, natural, and remained at that level for the rest of the year. The new price was about 9% higher than that previously quoted. Cleveland-Cliffs Iron Co. was the first to announce the increase, and was followed within the next week by Hanna Mining Co. and Oglebay Norton Co. According to Hanna Mining Co., the increase only partly offset rising costs of fuel, labor, power, and supplies. Oglebay Norton Co. stated that the new price included transportation and unloading charges, and fuel surcharges, in effect on December 31, 1980, and that any increases in these charges after that date were to be borne by the buyer. In June, USS announced that its price for Mesabi nonbessemer ore (basis 51.5% Fe, natural) would be $32.53 per long ton, effective June 30. The new price, which was equivalent to 63.17 cents per ltu, applied to both coarse ore and fines, and represented an increase of about 14% compared with the price in effect since mid-1980. Cleveland-Cliffs' price for the same ore was $32.25 per ton, effective April 27. In late July, the published prices for manganiferous ore and Old Range nonbessemer ore increased to $32.78 per ton, equivalent to 63.65 cents per ltu. The new price, which was unchanged during the rest of the year, represented an increase of 14% for Old Range nonbessemer ore, but 32% for maganiferous ore, because prior to the 1981 increase, a difference of $3.90 per ton existed between the base prices of these ores. During 1981, the price of semitaconite fines was unchanged at $21.54 per ton, equivalent to 41.83 cents per ltu.

The average f.o.b. mine value of usable iron ore shipped from domestic mines in 1981 was estimated at $40.39 per long ton, equivalent to about 63.4 cents per ltu, an increase of about 10% compared with the average value in 1980. Average values are mainly based on producers' statements and are believed to approximate the average commercial selling price less the cost of mine-to-market transportation; however, owing to the concentration of iron ore production in the Lake Superior district and the relatively high value of the principal product (pellets), the average value of ores and concentrates shipped by producers in other States may be considerably different.

Published prices for most Canadian and other foreign ores marketed in the United States were not available. The price of Canadian (Wabush) pellets, f.o.b. Pointe Noire, Quebec, was 63.5 cents per ltu in 1981, compared with 58.25 cents in 1980. The average f.o.b. value of Canadian ore imported by the United States in 1981, as determined from data released by the U.S. Bureau of the Census, was $37.57 per long ton, equivalent to about $0.60 per ltu. The average f.o.b. value of ores imported from Venezuela and Brazil, based on U.S. Bureau of the Census data, was $27.79 and $30.07, respectively, per long ton. Both of the latter values were equivalent to an estimated $0.46 per ltu. Prices for Canadian and other foreign iron ores are usually lower than prices for U.S. Lake Superior ores, partly because foreign ore prices are quoted on an f.o.b. basis while U.S. prices include transportation charges to receiving ports. Also, value estimates based on U.S. Customs data are only approximate because the Tariff Schedule of the United States does not classify imported iron ores by physical structure or iron content.

The published price of direct-reduced iron (DRI), f.o.b. Georgetown, S.C., during 1981 was $125 to $135 per metric ton. This price range was the same as in October 1980 but $10 to $20 higher than that quoted in previous months. F.o.b. prices of DRI at Contrecoeur, Quebec, and Point Lisas, Trinidad, during the last half of 1981 were $115 and $120 per metric ton, respectively.

TRANSPORTATION

Vessel shipments of iron ore from U.S. ports on the upper Great Lakes in 1981 totaled 61.8 million tons, including 37 million tons from Minnesota, 14.1 million tons from Michigan, and 10.7 million tons from Wisconsin. An estimated 92% of the total was destined for domestic ironmaking and steelmaking plants and the rest was exported, principally to Canada. Shipments of iron ore from Canadian ports, including those on the Gulf of St. Lawrence, to destinations on the Great Lakes totaled 13.1 million tons, of which an estimated 10 million tons was destined for U.S. ports.

Ore shipments from ports in Minnesota and Wisconsin increased by about 9% in 1981, compared with those of the previous year, while shipments from ports in Michigan were about 9% less. Tonnage shipped from each port during 1981 is shown in the accompanying tabulation:

Port	Date of first shipment	Date of last shipment	Total tonnage (thousand long tons)
Duluth, Minn	Apr. 1	Dec. 16	13,071
Two Harbors, Minn	Apr. 2	Dec. 28	9,996
Taconite Harbor, Minn	Apr. 13	Dec. 10	7,644
Silver Bay, Minn	Apr. 8	Dec. 10	6,351
Superior, Wis	Apr. 12	Dec. 16	10,669
Escanaba, Mich	Apr. 3	Dec. 18	8,743
Marquette, Mich	Mar. 28	Dec. 30	5,342
Total[1]	----	----	61,814

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

Source: American Iron Ore Association, and Skillings' Mining Review (various issues).

Lake freight rates for iron ore during the 1981 shipping season were about 16% higher than those in 1980. Bulk vessel freight rates announced by Interlake Steamship Co., effective April 1, 1981, were as follows, per ton: From the head of the lakes to lower lake ports, $7.13; from Marquette to lower lake ports, $5.88; from Escanaba, Mich., to Lake Erie, $5.42; and from Escanaba to lower Lake Michigan, $4.28. An additional $0.40 per ton was charged for shipments requiring more than 24 hours to unload, or delivery to docks not capable of handling vessels of more than 23 feet draft. Dock handling and storage charges at lower lake ports in late 1981 were about 15% to 20% higher than in 1980.

Rail freight rates for iron ore in 1981 were 10% to 15% higher than those in 1980 for most mine-to-dock and dock-to-consumer major haulage routes, although rates for all-rail shipments from mines to consuming points appeared unchanged. Examples of rates in late 1981 were as follows:

From	To	Rate (per long ton)
Nashwauk and Keewatin, Minn.	Superior, Wis. (Allouez).	$4.07
Marquette Range	Escanaba, Mich	2.11
Black River Falls, Wis	Chicago, Ill	6.23
Mesabi Range	Minnequa, Colo	21.83
Lake Erie ports	Pittsburgh and Wheeling districts.	8.85
Philadelphia, Pa. or Baltimore, Md	Pittsburgh district.	13.00
Philadelphia, Pa	Bethlehem, Pa	7.05
Burnside, La	Lone Star, Tex	11.85
Winton Junction, Wyo	Geneva, Utah	5.24

Sources: Skillings' Mining Review. V. 70, No. 47, Nov. 21, 1981, p. 14; and Cleveland-Cliffs Iron Co.

Published freight rates for ocean shipments of iron ore from eastern Canada to U.S. ports north of Hatteras ($3.50 to $3.75 per ton) and to U.S. gulf coast ports ($7.50 to $8 per ton) were unchanged in 1981, but it was evident that some rates had declined. Two shipments of 50,000 tons or more from Sept-Iles to Houston were reportedly contracted for $3.50 to $3.75 per ton in late 1981.

Two new 1,000-foot, self-unloading ore carriers began service on the Great Lakes in 1981. The *William J. DeLancey,* operated by Interlake Steamship Co., loaded its first cargo at Silver Bay, Minn., on May 12. The *Columbia Star,* operated by the Columbia Transportation Division of Oglebay Norton Co., loaded its first cargo at the same port on June 1. Twelve vessels of this type are now in service.

A $33 million terminal for transfer and storage of pellets was completed by Chessie System, Inc., at the Port of Toledo, Ohio, in 1981. Operations at the facility began in June, with the transfer of a cargo of pellets to railway cars for delivery to steelworks of Armco Inc. at Hamilton, Ohio, and Ashland, Ky. The terminal was designed to accommodate 1,000-foot vessels.

Tolls on the Montreal-Welland Canal section of the St. Lawrence Seaway were scheduled to increase by an average of 18% (cargo-ton basis) at the beginning of the 1982 ore shipping season. A further increase of 10% was scheduled for 1983. The increased revenue was reportedly needed to offset deficits forecast for the 1981-83 period owing to reduced traffic and increased costs of operation. The additional tolls were expected to increase iron ore transportation costs by 16 cents per ton in 1982 and 9 cents per ton in 1983.

FOREIGN TRADE

U.S. exports of iron ore declined slightly in 1981, compared with those in 1980. Exports totaled 5.5 million tons valued at $245 million. The average value was $44.12 per ton, compared with $40.51 in 1980. Exports consisted almost entirely of iron ore pellets from Michigan and Minnesota, shipped by way of the Great Lakes to Canadian steel companies participating in U.S. taconite projects.

U.S. imports of iron ore for consumption increased moderately in 1981, compared with those of the previous year. Imports in 1981 totaled 28.3 million tons, valued at $948 million. The average value was $33.46 per ton, compared with $30.84 in 1980. Canada remained the principal supplier, with 18.8 million tons, followed by Venezuela with 5.1 million tons. Approximately 54% of all imports from Canada entered the United States at ports on the Great Lakes, whereas almost all imports from other countries were landed at U.S. ports on the east and gulf coasts. Customs districts of Philadelphia, Baltimore, and Cleveland continued to receive the largest tonnages.

WORLD REVIEW

World iron ore production and trade in 1981 declined by 4% and 5%, respectively, compared with that of 1980. Production was estimated at 847 million tons and trade was estimated at 358 million tons. The declines were mainly due to lower demand in Japan and Western Europe. Imports of iron ore by Japan and the European Communities (EC) (excluding intra-EC trade) totaled about 230 million tons, 14 million tons less than in 1980.

Exports of iron ore by Australia, France, India, and Sweden were 10% to 15% less than in 1980, as demand declined in their principal markets. Brazil was the world's leading exporter of iron ore in 1981, followed by Australia, Canada, and the U.S.S.R.

Production of iron ore pellets remained relatively low, owing to depressed markets and rising costs of fuel. World output in 1981 was estimated at 190 million tons, about 70% of production capacity. Two plants remained closed in Australia and additional closures were reported in Canada, Brazil, Sweden, and Japan. New plants were completed in Sweden and Nigeria, and others were under construction in Mexico, India, the U.S.S.R., and Bahrain.

Direct reduction of iron ore continued to increase, although world output was probably about 50% of capacity. Production of DRI for steelmaking was estimated at 8.4 million tons, of which more than 50% was produced in Latin America. Plants were completed in Nigeria and the Federal Republic of Germany in 1981. Others were under construction in at least eight countries, including Nigeria, Libya, Saudi Arabia, Indonesia, and Malaysia, all of which had access to natural gas but will require imports of iron ore. The rising cost of natural gas and relatively low prices of ferrous scrap continued to impede growth of production capacity in the United States and Western Europe. Coal-based plants for steelmaking-grade DRI were under construction in India and the Republic of South Africa.

Prices for most iron ores marketed in Japan increased by about 8% in 1981, but prices for most ores marketed in Europe were unchanged or slightly lower than 1980 prices. The 1981 prices (f.o.b., per ltu of contained iron) ranged from about 23 to 34 cents for sinter fines, 26 to 35 cents for lump ore, and 42 to 57 cents for pellets. The price of pellet feed for Japan from Brazil and Peru ranged from 22 to 27 cents. The price of beach-sand concentrates (titaniferous magnetite) for Japan from New Zealand was 18.8 cents.

Ocean freight rates declined during 1981. Spot rates published by *Metal Bulletin* indicated declines of 30% to 60% in rates from major iron ore loading ports to destinations in Japan, Western Europe, and the United

States by late 1981. Rates for shipments of 50,000 to 70,000 tons to Western Europe in late 1981 were approximately $5.75 per ton from West Africa, $7 per ton from Brazil, and $9 per ton from Venezuela. For shipments of 115,000 to 140,000 tons, rates were about $2 per ton from Narvik, Norway, $4 per ton from eastern Canada, and $9 per ton from Western Australia.

Angola.—Iron ore production facilities at Cassinga were being restored in 1981 by a subsidiary of Vöest Alpine AG, under an agreement with a state company. About 150,000 tons of ore was shipped by rail to Mocamedes and exported to Austria. This was the first shipment reported from Angolan mines since 1975, when production was halted because of civil war; previously, annual exports of iron ore totaled as much as 6 million tons.

Australia.—Production and exports of iron ore in 1981 declined about 10% compared with that of the previous year. Exports totaled about 71 million tons, the least since 1972. Domestic consumption was estimated at 11.3 million tons. The decline of production and exports was attributed to reduced demand from export markets in Asia and Western Europe, and to industrial strikes in Australia. Hamersley Holdings Ltd. stated that strikes were the principal cause of the company's 10-million-ton drop in production of iron ore in 1981. The company also reported that shipments of ore to Japan were only 66% of minimum contractual tonnages.

Shipments of iron ore products by Australian producers in 1981 were as follows, in million tons: Hamersley Iron Pty. Ltd., 28.6; Mt. Newman Mining Co. Pty. Ltd., 27.4; Cliffs Robe River Iron Associates, 12.4; Goldsworthy Mining Ltd., 5.3; Broken Hill Pty. Co. Ltd., 3.4; and Savage River Mines, 2.1. Hamersley's concentrator produced 3.5 million tons of high-grade lump ore and fines in 1981. The Hamersley and Robe River pelletizing plants were not operated in 1981.

Goldsworthy Mining Ltd. ended mining operations at Shay Gap late in 1981. Mining was then confined to the Goldsworthy and Sunrise Hill Mines, where 32 million tons of additional high-grade reserves were proven by drilling in 1981.

Negotiations were continued with Japanese steel companies for sales contracts needed to develop new iron mines in Western Australia, but owing to depressed markets for steel and excess production capacity for iron ore, no commitments for new projects were made.

Bahrain.—Under a contract signed in 1981 by Arab Iron & Steel Co. and Kobe Steel Ltd., a pelletizing plant with production capacity of 4 million tons per year was to be built at Bahrain by early 1984. Contracts for feed to the plant were reportedly signed with producers in India, Brazil, and Peru. Most of the plant's output was expected to be sold to DRI plants.

Brazil.—Exports of iron ore totaled 79 million tons in 1981, a new record. In addition, about 23 million tons were reportedly shipped for domestic consumption but this was believed to include about 8 million tons of fines destined for pelletizing plants at Tubarão. Domestic consumption was estimated at 17 million tons in 1981.

Companhia Vale do Rio Doce (CVRD) reported exports of 63.4 million tons of ore from Tubarão and shipments of 14.4 million tons for domestic consumption. The exports included 45.2 million tons produced by CVRD, 9.9 million tons shipped for Ferteco Mineração S.A. and S.A. Mineração da Trindade (SAMITRI), and 8.3 million tons of pellets for the Nibrasco, Itabrasco, and Hispanobras joint ventures.

Mineracoes Brasileiras Reunidas S.A. (MBR) shipped 13 million tons of ore products including 11.6 million tons for export. MBR's plan to increase production capacity to 30 million tons per year by the mid-1980's was approved by the Government in 1981.

Ferteco Mineração S.A. sold 9.1 million tons of ore products including 2.6 million tons of pellets produced at the Fabrica Mine. SAMITRI shipped 6.4 million tons of ore including 4.2 million tons from the Alegria Mine. Samarco Mineração S.A. shipped 4 million tons including 3 million tons of pellets from Ponta Ubu. Companhia Siderurgica Nacional produced 3 million tons of ore from the Casa de Pedra Mine, for consumption at Volta Redonda. The Capanema Mine, being developed by CVRD and Kawasaki Steel Corp. in Minas Gerais, was expected to begin shipping ore in 1982. The mine was reported to have a production capacity of about 10 million tons annually.

CVRD continued construction at the Carajas iron mining project in northern Brazil. A pilot beneficiation plant with production capacity of 1 million tons per year was operated at the mine site in 1981. A deepwater port for large carriers was under construction near São Luis, and the roadbed for the 560-mile railway from São Luis to the mine site was reportedly completed. Production capacity of the mine was expected to be 35 million tons per year of ore averaging 66% iron.

Canada.—Exports of iron ore in 1981 totaled about 40 million tons. Imports of iron ore, mostly pellets from the Lake Superior district of the United States, totaled about 5.7 million tons. Domestic consumption was about 15 million tons. A protracted labor strike at the Hamilton steelworks of Stelco Inc. led to buildups of pellet stockpiles at the Wabush and Griffith pelletizing plants, and both mines were closed for 3 weeks in December 1981. Earlier in the year, 3-year labor contracts were successfully negotiated at all iron mines except for the Adams and Sherman Mines where contracts come up for renewal in 1982.

Shipments of iron ore products by Canadian producers in 1981 were as follows, in million tons: Iron Ore Co. of Canada (IOC), 21.0 including 11.2 of pellets, 7.0 of concentrates, and 2.8 of direct-shipping ore; Quebec Cartier Mining Co. (QCM), 13.3 from Mount Wright; Pickands Mather & Co., 5.2 from Wabush Mines and 1.5 from the Griffith Mine; Sidbec-Normines Inc., 4.7 of pellets; Cleveland-Cliffs Iron Co., 2.3 of pellets including 1.2 from the Adams Mine; Algoma Steel Corp. Ltd., 1.5 of sinter; and Inland Steel Co., 0.15 of natural ore from stockpiles at Thunder Bay. Algoma's sinter was produced at Wawa, Ontario, from 1.9 million tons of siderite ore produced at the MacLeod underground mine and conveyed to the surface through a 3-mile, 10° incline.

Owing to weak demand for iron ore, IOC closed its concentrator and pelletizing plant at Sept-Iles, Quebec, on May 9 for an indefinite period. QCM suspended production at Mount Wright for 6 weeks in the summer. Sidbec-Normines closed its concentrator at Gagnon for 1 month, and its pelletizing plant at Port Cartier for 6 weeks. Stelco's direct-reduction plant at Bruce Lake remained idle during 1981, but the Sidbec plants at Contrecoeur, Quebec, produced about 1 million tons of DRI during the year.

Chile.—Shipments of iron ore by Cía. de Acero del Pacifico in 1981 totaled 7.5 million tons, 11% less than in 1980. The shipments included 3.4 million tons of coarse and fine ores from El Romeral, 3.1 million tons of Algorrobo pellets, and 1 million tons of ore from Santa Fe. About 1 million tons was shipped for domestic consumption and the rest was exported.

European Communities (EC).—Iron ore production, trade, and consumption continued to decline in 1981. Production of iron ore in France declined by about 25%, and exports of Lorraine ores to Belgium-Luxembourg, and the Federal Republic of Germany declined to a total of 6.3 million tons. Imports of iron ore by the EC from other countries totaled about 109 million tons, including about 44 million tons by the Federal Republic of Germany, 16 million tons by France, 16 million tons by Italy, 13 million tons by the United Kingdom, and 7 million tons by the Netherlands. The cost of imported ore increased in 1981 owing to weakened exchange rates for the U.S. dollar. Imports of ore by the United Kingdom increased sharply in 1981 as the steel industry experienced a relatively normal year following the long strike in 1980. In the Netherlands, ore handling facilities were being increased at Rotterdam. At Emden, Germany, the 880,000-ton-per-year direct-reduction plant of Norddeutsche Ferrowerke GmbH was completed, and shipments of sponge iron were reported to France, Spain, Italy, and the German Democratic Republic. The DRI plant of Hamburger Stahlwerke was closed, because of rising prices for natural gas.

Guinea.—A subsidiary of USS was reported in 1981 to have agreed to manage construction and mining at the Mifergui-Nimba iron ore project, but a firm contract had not been announced by yearend. The project was designed to produce 15 million tons per year of ore averaging 66.5% iron from proven reserves of 350 million tons. The ore would be transported through Liberia on the railway owned by the Liberian-American-Swedish Minerals Co. (LAMCO), for export from the Liberian Port of Buchanan. An 11-mile extension of the railway was required to reach the proposed mine shipping point. Development of the project was expected to require 3 years.

India.—Exports of iron ore in 1981 totaled 23 million tons, about 10% less than in 1980. The decline was due to reduced shipments to the U.S.S.R. and Japan. Exports from Goa declined to 11.2 million tons, and exports by the National Mineral Development Corp. totaled about 7.2 million tons.

A Romanian firm, Uzine Export-Import, was awarded a contract in 1981 to provide a 3-million-ton-per-year pelletizing plant for Kudremukh Iron Ore Co. Ltd. at Mangalore. Engineering and construction are to be done by Lurgi Chemie und Huttentechnik GmbH, and the plant was to be completed by 1984. Under a separate contract, the Romanian Government agreed to buy 1 million tons per year of Kudremukh concentrate for 3 years beginning in November 1981. Additional contracts for future exports of Kudremukh products, reportedly negotiated in 1981, included 1.5 million tons per year of concentrate for a pelletizing plant in Bahrain and exchange of Kudremukh pellets for DRI produced in Indonesia.

Japan.—Imports of iron ore in 1981 totaled about 121 million tons. Australia supplied 44% of the total; Brazil, 22%; and India, 13%. Consumption of iron ore totaled 115 million tons including about 10 million tons of pellets. Production of pellets in Japan declined to 3 million tons from 4.1 million tons in 1980. The pelletizing plant operated by Nippon Steel Corp., which had a production capacity of 2.5 million tons per year, was closed in September 1981.

Korea, Republic of.—Imports of iron ore in 1981 were estimated at more than 10 million tons, as output of iron and steel continued to grow rapidly. Consumption of ore in 1981 was estimated at 12 million tons. The principal supplying countries were Australia, India, Peru, and Brazil.

Liberia.—Exports of iron ore increased to 20 million tons in 1981. Shipments by LAMCO rose to 11.3 million tons, while those by Bong Mining Co. totaled about 7.9 million tons including 2.8 million tons of pellets. Shipments by the National Iron Ore Co. Ltd. again declined by about 30%, to 1.2 million tons in 1981, and the company continued to seek financial assistance from the World Bank.

Mauritania.—Exports of iron ore totaled about 8.8 million tons, of which more than 80% was destined for EC countries. The producing company continued to develop the Guelbs magnetite deposits for production by 1984, to replace depleting reserves at Zouerate. Completion of the pelletizing plant at Nouadhibou appeared to have been postponed.

Mexico.—Two projects were under construction in 1981 to supply iron ore for expansions of ironmaking and steelmaking capacity at Monclova and Lázaro Cárdenas. In northern Mexico, concentrators were being built at the La Perla and Hercules Mines. The La Perla plant will have a production capacity of 1.5 million tons of concentrates per year, and the plant at the Hercules Mine will have a production capacity of 3 million tons per year. Slurried concentrate from La Perla is to be pumped through an 8-inch, 87-mile pipeline to the Hercules plant, from which the combined output of both plants is to be pumped to Monclova through a 14-inch, 303-mile pipeline. A pelletizing plant was under construction at Monclova, with a production capacity of 3 million tons per year. Two-thirds of the concentrate is to be pelletized at Monclova, and the remainder is to be shipped by rail to Monterrey for pelletizing in the existing plant of Fundidora de Monterrey S.A. Completion of these facilities was expected in 1983.

In Michoacán, a 3-million-ton-per-year pelletizing plant and a 2-million-ton-per-year direct-reduction plant were under construction at the Lázaro Cárdenas steelworks. Pellet feed was to be supplied by pipeline from a concentrator near the Ferrotepec Mines, about 28 miles from the steelworks. Completion of these facilities was expected by 1984.

Nigeria.—A pelletizing plant, a direct-reduction plant, and an electric steelmaking furnace were reportedly completed at the Delta Steel project near Warri in 1981. Production of pellets and DRI was expected to begin in 1982, using iron ore imported from Brazil and Liberia. At Ajaokuta, construction of an integrated steelworks was continued.

Peru.—Exports of iron ore declined to 5.3 million tons in 1981. Exports included 3.2 million tons of sinter fines and 1.2 million tons of pellets. Only one of the two pelletizing lines was operated during 1981, owing to lack of demand. Ore shipments for domestic consumption totaled about 325,000 tons.

South Africa, Republic of.—Exports of iron ore in 1981 were estimated at 14 million tons. Domestic consumption was estimated at 11.3 million tons. Iron ore shipments by Iscor Ltd. totaled 22.1 million tons including 12.7 million tons for export and 9.3 million tons for consumption at the company's steelworks. Domestic shipments included 7.3 million tons from the Sishen Mine and 2.1 million tons from the Thabazimbi Mine.

Highveld Steel and Vanadium Corp. Ltd. produced 1.9 million tons of magnetite ore from the Mapochs Mine for consumption at Highveld. Mine output was scheduled to increase by 25% in 1983. The company began operating a 10th prereduction kiln at Highveld in June 1981 and ordered 3 more kilns, each with a production capacity of 250,000 tons per year, to be installed by 1984.

Contracts for construction of two coal-based direct-reduction plants were awarded in 1981. Scaw Metals Ltd. contracted with the Davy McKee firm of the United Kingdom for construction of a 75,000-ton-per-year reduction plant at Germiston. The plant is to use a process developed by Direct Reduction Corp. of New York. Iscor Ltd. contracted with Lurgi Chemie and Huttentechnik GmbH for construction of a 600,000-ton-per-year reduction plant at Vanderbijlpark. The plant is to consist of four kilns, each with a production capacity of 150,000 tons per year, and was scheduled for completion in 1984.

Sweden.—Production and exports of iron ore declined by about 15% in 1981, compared with those of 1980. Exports totaled 17.4 million tons, and 2.5 million tons was shipped for domestic consumption. Stocks of iron ore increased to 10.5 million tons, the highest in several years.

Luossavaara-Kiirunavaara AB (LKAB) produced 20.3 million tons of ore including 4 million tons of pellets. The company began operating its new pelletizing plant at Kiruna in December 1981. LKAB's production capacity for pellets was increased to 9.5 million tons per year.

Iron ore production in central Sweden was estimated at 2.6 million tons, including 550,000 tons from the Dannemora Mine and an estimated 1.7 million tons at Grangesberg. Svenskt Stal AB closed the Strassa pelletizing plant April 30, 1981, and ceased production of coarse concentrate at yearend. At Grangesberg, the company planned to modify the plant formerly used to produce cement-bonded pellets, for production of a new product called "granulated concentrates" in 1982.

U.S.S.R.—After 5 years of construction, the first stage of the Kostamus iron ore project in Soviet Karelia was expected to begin production of pellets in 1982. Production capacity of the first stage was about 3 million tons annually. Completion of the second and third stages was expected by 1987. Part of the output was scheduled for delivery to Finland, and the rest was reportedly scheduled for consumption at the Cherepovets steelworks.

Exports of iron ore from the U.S.S.R. in 1981 were estimated at 35 million tons, about 2 million tons less than in 1980. Almost all exports were destined for countries in Eastern Europe.

Venezuela.—Exports of iron ore in 1981 were estimated at 12 million tons. CVG Ferrominera Orinoco C.A. reported production of 14.5 million tons, and sales of 15 million tons of which 40% was sold to EC consumers and 35% to U.S. firms. Domestic consumption of ore was estimated at 3.4 million tons, most of which was consumed in direct-reduction plants. Fior de Venezuela S.A. reported exports of about 240,000 tons of DRI briquets, of which 190,000 tons was destined for the United States. The Minorca HIB direct-reduction plant produced about 200,000 tons of briquets in 1981, about one-third of its production capacity, and may be closed by Ferrominera in 1982.

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[1]Physical scientist, Divison of Ferrous Metals.

[2]Unless otherwise specified, the unit of weight used in this chapter is the long ton of 2,240 pounds.

[3]Because very little crude ore is now shipped direct to consumers, the table "Crude iron ore shipped from mines in the United States in 19—, by district, State, and disposition" has been deleted from this chapter.

Table 2.—Employment at iron ore mines and beneficiating plants, quantity and tenor of ore produced, and average output per worker in 1981, 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:									
Minnesota	12,189	23,744	164,950	51,025	32,507	63.7	6.95	2.15	1.37
Michigan and Wisconsin	3,868	6,672	47,498	16,437	10,579	64.4	7.12	2.46	1.59
Total or average	16,057	30,416	212,448	67,462	43,086	63.9	6.98	2.22	1.42
Missouri	315	594	1,695	1,134	751	66.2	2.85	1.91	1.26
Other States[1]	1,788	3,339	12,858	4,578	2,702	59.0	3.85	1.37	.81
Total or average	2,103	3,933	14,553	5,712	3,453	60.5	3.70	1.45	.88
Grand total or average	18,160	34,349	227,001	73,174	46,539	63.6	6.61	2.13	1.35

[1]Includes California, Colorado, Montana, Nevada, New York, Texas, Utah, and Wyoming.

Table 3.—Crude iron ore mined in the United States in 1981, by district, State, and mining method

(Thousand long tons and exclusive of ore containing 5% or more manganese)

District and State	Open pit	Underground	Total quantity
Lake Superior:			
Michigan	W	--	W
Minnesota	164,950	--	164,950
Wisconsin	W	--	W
Total reportable	164,950	--	212,448
Other States:			
Missouri	--	1,695	1,695
Other[1]	12,858	--	12,858
Total	12,858	1,695	14,553
Total withheld	47,498	--	47,498
Grand total	225,306	1,695	227,001

W Withheld to avoid disclosing company proprietary data; included with "Total withheld" and "Total quantity."
[1]Includes California, Colorado, Montana, Nevada, New York, Texas, Utah, and Wyoming.

Table 4.—Crude iron ore mined in the United States in 1981, by district, State, and variety

(Thousand long tons and exclusive of ore containing 5% or more manganese)

District and State	Number of mines	Hematite	Limonite[1]	Magnetite	Total quantity
Lake Superior:					
Michigan	4	W	--	W	45,131
Minnesota	14	4,099	--	160,851	164,950
Wisconsin	1	--	--	2,367	2,367
Total reportable	19	4,099	--	163,218	212,448
Other States:					
Missouri	1	--	--	1,695	1,695
Other[2]	12	W	[3]W	W	12,858
Total reportable	13	--	--	1,695	14,553
Total withheld	--	23,958	[3]W	34,030	--
Grand total	32	28,057	[3]W	198,943	[4]227,001

W Withheld to avoid disclosing company proprietary data; included with "Total withheld" and "Total quantity."
[1]Includes siderite ore.
[2]Includes California, Colorado, Montana, Nevada, New York, Texas, Utah, and Wyoming.
[3]Included with hematite ore.
[4]Data do not add to total shown because of independent rounding.

Table 5.—Usable iron ore produced in the United States in 1981, by district, State, and variety

(Thousand long tons and exclusive of ore containing 5% or more manganese)

District and State	Hematite	Limonite[1]	Magnetite	Total quantity[2]
Lake Superior:				
Michigan	W	--	W	15,583
Minnesota	1,681	--	49,344	51,025
Wisconsin	--	--	854	854
Total reportable	1,681	--	50,198	67,462
Other States:				
Missouri	--	--	1,134	1,134
Other[3]	W	[4]W	W	4,578
Total reportable	--	--	1,134	5,712
Total withheld	8,902	[4]W	11,259	--
Grand total[2]	10,583	[4]W	62,590	73,174

W Withheld to avoid disclosing company proprietary data; included with "Total withheld" and "Total quantity."
[1]Includes siderite ore.
[2]Data may not add to totals shown because of independent rounding.
[3]Includes California, Colorado, Montana, Nevada, New York, Texas, Utah, and Wyoming.
[4]Included with hematite ore.

Table 6.—Usable iron ore produced in the United States in 1981, by district, State, and type of product

(Thousand long tons and exclusive of ore containing 5% or more manganese)

District and State	Direct-shipping ore	Concen-trates	Agglomer-ates	Average iron content (natural), percent
Lake Superior:				
Michigan	W	--	W	64.3
Minnesota	--	1,698	49,327	63.7
Wisconsin	--	--	854	65.3
Total reportable	--	1,698	50,181	63.9
Other States:				
Missouri	--	W	1,080	66.2
Other[1]	W	W	W	59.0
Total reportable	--	--	1,080	66.0
Total withheld	194	1,330	18,690	--
Grand total[2]	194	3,029	69,952	63.6

W Withheld to avoid disclosing company proprietary data; included with "Total withheld."
[1]Includes California, Colorado, Montana, Nevada, New York, Texas, Utah, and Wyoming.
[2]Data may not add to totals shown because of independent rounding.

Table 7.—Shipments of usable iron ore from mines in the United States in 1981

(Thousand long tons and thousand dollars exclusive of ore containing 5% or more manganese)

District and State	Gross weight of ore shipped				Iron content of ore shipped				Total value[1]
	Direct-shipping ore	Concen-trates	Agglomer-ates	Total quantity[1]	Direct-shipping ore	Concen-trates	Agglomer-ates	Total quantity[1]	
Lake Superior:									
Michigan	W	--	W	14,193	W	--	W	9,099	W
Minnesota	--	2,719	47,457	50,176	--	1,490	30,339	31,829	2,062,118
Wisconsin	--	--	853	853	--	--	555	555	W
Total reportable	--	2,719	[1]48,311	65,222	--	1,490	30,894	41,483	2,062,118
Other States:									
Missouri	--	52	1,291	1,344	--	35	848	882	56,138
Other[2 3]	W	1,514	W	5,615	W	870	W	3,291	134,206
Total reportable	--	1,566	1,291	6,959	--	[1]904	848	4,173	190,344
Total withheld	1,012	--	17,283	--	558	--	10,962	--	662,777
Grand total[3]	1,012	4,285	66,885	72,181	558	[1]2,395	42,704	45,656	2,915,239

W Withheld to avoid disclosing company proprietary data; included with "Total withheld."
[1]Data may not add to totals shown because of independent rounding.
[2]Includes California, Colorado, Nevada, New Jersey, New Mexico, New York, Texas, Utah, Virginia, and Wyoming.
[3]Includes byproduct ore.

Table 8.—Usable iron ore produced in 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]
1854-1975	439,123	318,149	320,334	103,528	3,046,489	70,336	8,149	5,203	4,311,309
1976	14,663	2,318	--	--	49,764	--	--	668	67,413
1977	W	W	--	--	30,943	--	--	690	43,952
1978	W	W	--	--	55,316	--	--	660	72,727
1979	W	W	--	--	59,320	--	--	698	77,151
1980	W	W	--	--	45,162	--	--	699	62,282
1981	W	W	--	--	51,025	--	--	854	67,462
Total	523,116	329,344	320,334	103,528	3,338,019	70,336	8,149	9,472	4,702,296

W Withheld to avoid disclosing company proprietary data; included in "Total."
[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
1975	64,174	60.91	0.030	6.72	0.28	0.39	3.53
1976	64,928	61.38	.029	6.72	.26	.43	3.20
1977	43,239	61.66	.028	6.60	.28	.44	2.99
1978	74,307	62.26	.025	6.44	.27	.40	2.61
1979	77,837	62.55	.031	6.24	.22	.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

[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. Iron Ore, 1981, p. 90.

Table 10.—Consumption of iron ore and agglomerates in the United States in 1981

(Thousand long tons and exclusive of ore containing 5% or more manganese)

State	Iron ore and concentrates[1]		Agglomerates[2]		Miscellaneous[3]	Total reportable
	Blast furnaces	Steel furnaces	Blast furnaces	Steel furnaces		
Alabama, Kentucky, Texas	418	W	8,179	W	W	8,597
California, Colorado, Utah	357	W	5,240	--	W	5,597
Ohio and West Virginia	165	W	18,795	W	W	18,960
Illinois, Indiana, Michigan	672	W	38,821	W	W	39,493
Maryland, New York, Pennsylvania	1,905	169	27,716	39	W	29,829
Undistributed	--	40	--	470	1,399	1,909
Total[4]	3,516	209	98,752	510	1,399	104,385

W Withheld to avoid disclosing company proprietary data; included with "Undistributed."
[1]Not including pellets or other agglomerated products.
[2]Includes 63,679,034 tons of pellets produced at U.S. mines and 11,364,870 tons of foreign pellets.
[3]Includes iron ore consumed in production of cement and direct reduced iron, and iron ore shipped for use in manufacture of paint, ferrites, heavy media, cattle feed, refractory and weighting materials, and in lead blast furnaces.
[4]Data may not add to totals shown because of independent rounding.

Table 11.—Iron ore consumed in production of agglomerates at iron and steel plants in 1981

(Thousand long tons)

State	Iron ore consumed[1]	Agglomerates produced
Alabama, Kentucky, Texas	1,701	2,849
California, Colorado, Utah	1,370	845
Ohio and West Virginia	755	1,787
Illinois, Indiana, Michigan	3,975	8,594
Maryland, New York, Pennsylvania	6,348	9,838
Total	14,149	[2]23,914

[1]Includes domestic and foreign ores.
[2]Data do not add to total shown because of independent rounding.

Table 12.—Beneficiated iron ore shipped from mines in the United States[1]

(Thousand long tons and exclusive of ore containing 5% or more manganese)

Year	Beneficiated ore	Total iron ore	Proportion of beneficiated ore to total (percent)
1976	74,848	76,697	97.6
1977	52,061	53,880	96.6
1978	80,875	82,826	97.6
1979	84,489	86,130	98.1
1980	68,272	69,562	98.1
1981	71,169	72,181	98.6

[1]Beneficiated by further treatment than ordinary crushing and screening. Excludes byproduct ore.

Table 13.—Production of iron ore agglomerates[1] in the United States, by type

(Thousand long tons)

Type	Agglomerates produced	
	1980	1981
Sinter	[2]24,351	[3]24,327
Pellets	64,218	69,538
Total	88,569	93,865

[1]Production at mines and consuming plants.
[2]Includes 10,840,615 tons of self-fluxing sinter.
[3]Includes 10,683,505 tons of self-fluxing sinter.

Table 14.—Stocks of usable iron ore at mines,[1] December 31, by district

(Thousand long tons)

District	1980	1981
Lake Superior	[r]6,439	8,670
Other States	5,286	4,064
Total	[r]11,725	12,734

[r]Revised.
[1]Excluding byproduct ore.

Table 15.—Average value of usable iron ore[1] shipped from mines or beneficiating plants in the United States in 1981

(Dollars per long ton)

Type of ore	Lake Superior district	Other States[2]
Direct-shipping	W	[e]15.42
Concentrates	W	22.12
Pellets	42.79	32.46

[e]Estimated. 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, New Jersey, New York, Texas, Utah, and Wyoming.

Table 16.—U.S. exports of iron ore, by country

(Thousand long tons and thousand dollars)

Country	1979		1980		1981	
	Quantity	Value	Quantity	Value	Quantity	Value
Canada	5,108	177,069	5,652	228,868	5,529	243,527
France	(1)	7	(1)	48	(1)	2
Germany, Federal Republic of	2	162	1	42	(1)	3
Japan	(1)	4	(1)	6	(1)	2
Mexico	24	914	25	1,212	11	720
Norway	--	--	--	--	(1)	59
Taiwan	(1)	9	(1)	3	--	--
United Kingdom	3	197	(1)	10	(1)	21
Other	11	386	11	379	5	351
Total[2]	5,148	178,749	5,689	230,568	5,546	244,685

[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	1979		1980		1981	
	Quantity	Value	Quantity	Value	Quantity	Value
Australia	183	2,936	(1)	1	--	--
Brazil	3,095	81,446	1,995	62,889	1,738	52,267
Canada	22,602	683,286	17,311	581,759	18,845	707,974
Chile	245	4,458	322	10,293	342	6,329
India	54	1,332	--	--	--	--
Liberia	2,190	38,112	1,590	27,612	2,160	35,505
Norway	44	561	--	--	--	--
Peru	456	14,126	193	6,678	77	2,402
South Africa, Republic of	106	2,551	6	82	--	--
Sweden	171	4,568	33	917	87	2,318
Venezuela	4,563	87,613	3,602	80,981	5,071	140,931
Other	65	2,437	6	1,632	8	251
Total	[2]33,776	923,426	25,058	772,844	28,328	947,977

[1]Less than 1/2 unit.
[2]Data do not add to total 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	1979		1980		1981	
	Quantity	Value	Quantity	Value	Quantity	Value
Baltimore	6,763	207,840	5,230	185,445	5,421	212,960
Buffalo	1,482	41,322	592	10,756	629	13,096
Charleston	--	--	--	--	--	--
Chicago	5,013	141,691	2,811	102,566	3,854	128,320
Cleveland	5,367	135,439	4,333	124,893	4,995	179,616
Detroit	668	16,255	547	8,751	765	25,303
Galveston	--	--	212	5,979	123	2,579
Houston	1,075	35,053	944	34,633	775	30,809
Los Angeles	695	15,388	107	2,745	--	--
Mobile	4,933	130,231	3,675	113,050	3,847	131,445
New Orleans	856	14,641	180	3,465	237	5,177
Philadelphia	6,087	164,775	6,005	166,943	7,218	203,969
Portland, Oreg	199	3,536	--	--	--	--
Wilmington, N.C	638	17,227	406	13,140	425	13,428
Other	(1)	27	16	478	38	1,275
Total[2]	33,776	923,426	25,058	772,844	28,328	947,977

[1]Less than 1/2 unit.
[2]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 continent and country[1]

(Thousand long tons)

Continent and country[2]	Gross weight[3]					Metal content[4]				
	1977	1978	1979	1980[p]	1981[e]	1977	1978	1979	1980[p]	1981[e]
North and Central America:										
Canada[5]	56,727	41,091	58,942	47,984	49,844	35,596	25,814	37,086	30,316	[6]31,400
Mexico[7]	[r]5,296	[r]5,249	5,965	7,510	[6]7,893	[r]3,530	3,500	3,977	5,007	[6]5,209
United States[8]	55,750	81,583	85,716	69,613	[6]73,174	34,489	50,764	53,639	43,888	[6]46,539
South America:										
Argentina	1,014	895	601	430	487	[r]545	[r]482	323	231	262
Bolivia	[e]7	55	25	6	[e]6	4	35	16	4	[e]4
Brazil	80,706	83,643	94,594	112,920	98,400	52,459	54,368	61,486	73,398	63,960
Chile	[r]7,535	[r]6,695	7,006	8,138	7,873	[r]4,596	4,267	4,561	5,203	5,019
Colombia	[r]497	[r]489	391	498	[6]412	[r]229	[r]224	180	229	[6]190
Peru	[r]6,184	4,844	5,358	5,614	5,973	4,000	3,148	3,565	3,735	3,508
Venezuela	13,467	13,302	15,019	15,848	[e]15,286	8,349	8,247	9,312	9,826	[e]9,477
Europe:										
Albania[10] [e]	502	502	521	541	590	176	176	84	189	197
Austria	3,394	2,744	3,149	3,149	3,149	1,052	853	983	970	970
Belgium	[e]6	42	--	--	--	14	13	--	--	--
Bulgaria	2,234	2,413	2,070	1,856	1,968	696	[r]750	641	581	615
Czechoslovakia	1,963	1,991	1,980	1,938	1,870	589	597	539	517	538
Denmark	5	5	9	8	8	2	2	4	3	3
Finland[11]	1,123	1,071	1,126	1,153	1,153	741	700	726	743	743
France	36,051	32,925	31,127	28,522	21,258	10,875	10,147	9,645	8,920	6,673
German Democratic Republic[12]	65	79	69	69	69	[r]27	[r]33	29	29	29
Germany, Federal Republic of (salable)	[r]2,430	[r]1,572	1,622	1,917	1,547	[r]816	[r]510	526	597	[e]477
Greece	2,017	[r]1,658	1,803	1,428	1,378	[r]881	[r]725	788	624	600
Hungary	517	526	524	386	[6]415	[r]116	[r]120	121	90	88
Italy[13]	[r]470	347	215	182	121	[r]201	[r]139	88	73	48
Luxembourg	[r]1,512	822	620	551	492	[r]454	[r]246	186	165	148
Norway	3,577	3,713	4,181	3,746	4,064	[r]2,325	[r]2,413	2,718	2,434	2,642

See footnotes at end of table.

Table 19.—Iron ore, iron ore concentrates, and iron ore agglomerates: World production, by continent and country[1] —Continued

(Thousand long tons)

Continent and country[2]	Gross weight[3]					Metal content[4]				
	1977	1978	1979	1980[p]	1981[e]	1977	1978	1979	1980[p]	1981[e]
Europe —Continued										
Poland	649	521	236	102	98	195	156	71	30	29
Portugal[14]	52	54	59	56	56	26	26	28	25	26
Romania	2,428	[r]2,471	2,483	2,296	2,362	[r]631	[r]642	646	597	614
Spain[8]	8,196	8,444	8,687	9,081	8,430	4,057	3,845	3,931	4,303	4,151
Sweden	24,446	21,147	25,755	26,755	22,858	15,861	13,724	16,714	17,364	14,835
U.S.S.R	238,031	242,362	237,920	240,848	238,177	[r]130,917	[r]133,299	130,856	132,466	130,997
United Kingdom	3,686	4,172	4,202	901	738	[r]899	[r]1,102	1,110	238	195
Yugoslavia	4,381	4,492	4,544	4,458	[6]4,718	[r]1,514	[r]1,621	1,619	[e]1,600	1,680
Africa:										
Algeria	3,132	[r]3,003	3,149	3,248	3,346	1,691	[r]1,622	1,701	1,754	1,807
Egypt	1,387	1,433	1,412	1,748	1,771	693	717	706	874	885
Kenya[15]	16	20	20	14	14	[e]9	[e]12	[e]12	9	9
Liberia	17,381	17,705	18,055	17,900	19,393	[e]10,776	[e]10,978	[e]11,194	11,000	12,000
Mauritania	9,639	6,824	9,225	8,587	[6]8,741	6,217	4,231	5,720	5,248	[6]5,160
Morocco	434	58	61	77	49	278	37	39	49	50
South Africa, Republic of[16]	26,062	23,824	31,066	25,897	[6]27,871	[r]16,680	15,247	19,883	16,574	[6]17,837
Swaziland	1,418	1,246	--	--	--	851	748	--	--	--
Tunisia	338	334	387	383	390	172	[r]173	197	211	202
Zimbabwe	1,157	1,105	1,182	1,596	1,112	[r]706	[r]674	721	973	680
Asia:										
China	49,200	68,900	73,800	73,800	69,000	[r]24,600	34,400	36,900	36,900	34,500
India	41,925	38,224	38,910	40,028	40,470	26,245	23,929	24,357	25,057	25,334
Indonesia	307	230	79	62	[6]85	[r]178	133	46	36	49
Iran[17]	1,083	1,535	[e]600	[e]590	590	660	937	[e]365	360	360
Japan[18]	[r]674	[r]586	453	470	435	[r]400	[r]361	284	294	275
Korea, North[e]	6,800	7,000	7,300	7,900	7,900	2,800	2,900	3,000	3,200	3,200
Korea, Republic of	778	682	629	609	486	[r]436	382	352	342	273
Malaysia	325	315	345	365	[6]524	198	192	210	223	[6]320
Philippines	--	2	3	--	7	--	1	3	--	4
Taiwan	32	--	--	--	--	16	--	--	--	--
Thailand	62	87	101	84	79	34	[r]48	56	46	43
Turkey	[r]3,392	[r]3,157	[e]2,952	2,489	2,460	[r]1,763	[r]1,641	1,532	[r] [e]1,292	1,277
Oceania:										
Australia	94,408	81,821	90,268	94,033	84,641	59,508	51,990	56,440	59,318	53,737

New Zealand[19]	2,908	3,884	3,472	3,336	2,953	1,658	2,214	1,979	1,902	1,683
Total	r827,816	r833,894	889,988	881,720	847,184	r473,415	r476,255	511,895	510,057	491,551

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through June 30, 1982.
[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 from which grades are U.S. Bureau of Mines estimates: Albania, Denmark, Hungary, Zimbabwe, China, and North Korea.
[5]Series revised to represent gross weight and metal content of usable iron ore (including byproduct ore) actually produced, natural weight. (Data in previous edition represented shipments.)
[6]Reported figure.
[7]Gross weight calculated from reported iron content based on grade of 63% Fe.
[8]Includes byproduct ore.
[9]Exports.
[10]Nickeliferous iron ore.
[11]Includes magnetite concentrate, pelletized iron oxide (from pyrite sinter) and roasted pyrite (purple ore).
[12]Includes "roasted ore," presumably pyrite sinter, not separable from available sources.
[13]Excludes iron oxide pellets produced from pyrite sinter.
[14]Includes manganiferous iron ore.
[15]For cement manufacture.
[16]Includes magnetite ore as follows in thousand long tons: 1977—4,971 (revised); 1978—3,821; 1979—4,004; 1980—4,221; and 1981—4,175.
[17]Year beginning Mar. 21 of that stated.
[18]Concentrate including concentrate derived from iron sand as follows in thousand long tons: 1977—124; 1978—66; 1979—2; 1980 and 1981—no production reported.
[19]Largely concentrates from titaniferous magnetite beach sands.

Iron Oxide Pigments

By William I. Spinrad, Jr.[1]

Mine production of crude iron oxide pigments declined, but production of regenerator oxide from steel plant wastes increased. Shipments of finished iron oxide pigments increased in 1981. Consumption in the paint industry declined slightly, while in other industries, such as private nonresidential building construction and manufacture of magnetic tape, consumption increased. U.S. consumption patterns for iron oxide pigments are becoming similar to European end-use patterns as construction materials claim a larger share of total end use. The use of synthetic iron oxides continued to increase, accounting for 57% of total shipments of iron oxide pigments in 1981. Price increases announced in 1981 for a large share of natural and synthetic iron oxides were attributed to rising costs of energy, labor, and transportation. Imports of natural iron oxide pigments increased 33%. Imports of synthetic iron oxides decreased because of increased domestic production.

In 1981, Pfizer Inc. announced a $50 million expansion program to increase production capacity for synthetic iron oxides and a $1 million expansion of research facilities. A new trade association, the Powder Coatings Institute, was formed to promote the use of powder coatings for industrial products.

Table 1.—Salient iron oxide pigments statistics in the United States

	1977	1978	1979	1980	1981
Mine production ____ short tons	59,233	84,796	87,869	49,078	46,213
Crude pigments sold or used ____ do	55,953	75,967	74,548	62,642	67,214
Value ____ thousands	$2,143	$2,799	$2,578	$4,043	$4,142
Iron oxides from steel plant wastes ____ short tons	21,024	20,924	25,186	20,717	20,879
Value ____ thousands	$1,644	$1,396	$1,703	$1,394	$1,637
Finished pigments sold ____ short tons	140,707	152,510	156,036	136,336	141,252
Value ____ thousands	$73,851	$81,830	$94,175	$97,270	$110,859
Exports ____ short tons	6,493	7,064	4,852	5,046	4,967
Value ____ thousands	$4,065	$6,649	$7,359	$9,132	$11,704
Imports for consumption ____ short tons	58,694	70,549	55,377	39,446	39,661
Value ____ thousands	$20,596	$24,706	$24,341	$20,035	$18,915

DOMESTIC PRODUCTION

Mine production of crude iron oxide pigments declined by 6% in 1981, but total domestic shipments of finished iron oxide pigments rose 4% in quantity and 14% in value compared with those of the previous year. Notable increases occurred in shipments of natural brown (including Vandyke brown) and synthetic specialty, yellow, and brown iron oxides. Synthetic iron oxides comprised 57% of total finished iron oxide shipments, 2% more than in 1980. Synthetic iron oxides continued to make inroads in traditional markets for natural iron oxide pigments while dominating specialized markets of their own.

Sales data for finished iron oxide pigments, shown in table 2, were compiled from reports received by the Bureau of Mines from the 19 companies shown in table 3. In 1981, these companies represented 95% of all companies that produce finished natural and/or synthetic iron oxide pigments. Eight of the companies reported increased production in 1981.

Iron oxides recovered from steel plant wastes, reported by four steel companies, were up slightly from those of 1980.

In 1981, Pfizer announced a $50 million capital expansion program to increase production capacity of its plants located in Easton, Pa., and East St. Louis, Ill. A special line of cobalt-modified gamma-ferric oxide for audio and video tape applications will be produced at these plants beginning in late 1982. Pfizer also announced a $1 million expansion of its research facilities in Easton, Pa., for magnetic particle research and development, introduction of new specialty products, and improvement of technical service capabilities. This expansion was to be completed in 1981. Pfizer's new synthetic iron oxide plant at Valparaiso, Ind., which currently produces a gamma-ferric oxide, is expected to start production of a metallic particle exhibiting exceptional recording properties in 1982.

Table 2.—Finished iron oxide pigments sold by processors in the United States, by kind

Kind	1980		1981	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Natural:				
Black: Magnetite	5,402	$635	6,068	$851
Brown:				
Iron oxide[1]	8,123	2,026	13,111	3,720
Umbers:				
Burnt	3,954	2,583	3,723	2,572
Raw	1,383	873	1,344	885
Red:				
Iron oxide[2]	33,136	3,379	27,203	3,186
Sienna, burnt	544	401	567	504
Yellow:				
Ocher[3]	5,214	850	4,970	809
Sienna, raw	630	395	358	297
Total	58,386	[4]11,143	57,344	12,824
Synthetic:				
Brown: Iron oxide[5]	10,328	10,820	11,158	12,595
Red: Iron oxide	31,998	34,791	32,423	40,014
Yellow: Iron oxide	21,703	21,424	23,925	25,982
Other: Specialty oxides	11,044	17,367	13,469	17,501
Total	75,073	84,402	80,975	[4]96,093
Mixtures of natural and synthetic iron oxides	2,877	1,726	2,933	1,942
Grand total	136,336	[4]97,270	141,252	110,859

[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.

Table 3.—Producers of iron oxide pigments in the United States in 1981

Producer	Mailing address	Plant location
Finished pigments:		
BASF Wyandotte Corp., Pigments Div.	100 Cherry Hill Rd. Parsippany, NJ 07054	Wyandotte, Mich.
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.; Monmouth Junction, N.J.; Trenton, N.J.
Combustion Engineering, Inc., CE Minerals Div.	901 East 8th Ave. King of Prussia, PA 19406	Camden, N.J.
DCS Color & Supply Co., Inc	1050 East Bay St. Milwaukee, WI 53207	Milwaukee, Wis.
E. I. du Pont de Nemours & Co	Pigments Dept. Wilmington, DE 19898	Newark, N.J.
Ferro Corp., Ottawa Chemical Div	700 North Wheeling St. Toledo, OH 43605	Toledo, Ohio.

Table 3.—Producers of iron oxide pigments in the United States in 1981 —Continued

Producer	Mailing address	Plant location
Finished pigments —Continued		
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, W. Va.
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, Calif.; East St. Louis, Ill.; Easton, Pa.; Valparaiso, Ind.
Prince Manufacturing Co	700 Lehigh St. Bowmanstown, PA 18030	Quincy, Ill., and Bowmanstown, Pa.
Reichard-Coulston, Inc	15 East 26th St. New York, NY 10010	Bethlehem, Pa.
St. Joe Lead Co., Pea Ridge Iron Ore Co.	7733 Forsyth Blvd. Clayton, MO 63105	Sullivan, Mo.
George B. Smith Chemical Works, Inc.	1 Center St. Maple Park, IL 60151	Maple Park, Ill.
Solomon Grind-Chem Service	Box 1766 Springfield, IL 62705	Springfield, Ill.
Sterling Drug, Inc., Hilton-Davis Chemicals Div.	2235 Langdon Farm Rd. Cincinnati, OH 45237	Cincinnati, Ohio.
Crude pigments:		
Cleveland-Cliffs Iron Co., Mather Mine & Pioneer Plant (closed July 31, 1979; shipping from stockpile).	1460 Union Commerce Bldg. Cleveland, OH 44115	Negaunee, Mich.
Hoover Color Corp	Box 218 Hiwassee, VA 24347	Hiwassee, Va.
St. Joe Lead Co., Pea Ridge Iron Ore Co.	7733 Forsyth Blvd. Clayton, MO 63105	Sullivan, Mo.
New Riverside Ochre Co	Box 387 Cartersville, GA 30120	Cartersville, Ga.
Virginia Earth Pigments Co	Box 1403 Pulaski, VA 24301	Patterson, Va.

CONSUMPTION AND USES

Demand for iron oxide pigments in paint and coatings was 49,124 short tons in 1981, down 3% from that of 1980. This end use accounted for 35% of total iron oxide pigment consumption in 1981. Shipments of paint, varnish, and lacquer in 1981, reported by the U.S. Department of Commerce,[2] totaled 991 million gallons valued at $8.4 billion, down 3% in quantity from that of 1980. Of this total, 505 million gallons were architectural coatings; 302 million gallons were product finishes—original equipment manufacture; and 184 million gallons were special purpose coatings. Iron oxide pigments comprised the largest share of inorganic colored pigments used in coatings.

Consumption in construction materials, which accounted for 23% of iron oxide consumption in 1981, increased 6% compared with that of 1980. Although new housing starts, totaling 1.085 million units in 1981, were at their lowest level since 1946, construction of private nonresidential buildings, measured in 1977 constant dollars, increased 9% in 1981. Increases in this end use have brought U.S. consumption more in line with European usage patterns for iron oxide pigments.

Ferrites and other magnetic and electronic applications accounted for 10% of total domestic consumption of iron oxides in 1981. The increasing market for magnetic iron oxide, which includes audio, video, and computer tape applications, is estimated to have consumed between 30 million and 40 million pounds in 1981.[3] The remaining 32% of iron oxide consumption was used in the manufacture of colorants for plastics, rubber, paper, textiles, glass, and ceramics; industrial chemicals; animal feed and fertilizers; foundry sands; cosmetics; and jeweler's rouge.

The Powder Coatings Institute, a nonprofit, professional organization based in Greenwich, Conn., was formed in 1981 by the principal manufacturers of powder coatings. Its purpose is to promote the use of powder coatings for industrial products. Powder coatings, a dry painting process, uses no solvents or liquid carriers; is said to exhibit superior film qualities, material usage efficiency of 95% or more, and savings in energy consumption and labor costs; and lacks hazardous wastes and volatile organic emissions. Powder coatings can be used on most products that can be baked at 275° to 400° F such as appliances, automobiles and automotive parts, metal furniture, lawn and garden equipment, and electrical apparatus.

No new major end uses were established for iron oxide pigments in 1981, but traditional uses continued to grow. Published forecasts relating to iron oxide pigment consumption include an average annual 2.8% growth for production of paint between 1979 and 1995,[4] a 15% to 20% growth rate for magnetic tape through the first half of the eighties, and a 5% to 10% growth rate in the colored preformed concrete market over the next 5 years.[5]

Table 4.—Percent of iron oxide pigment consumption, by end use

End use	All iron oxides		Natural iron oxides		Synthetic iron oxides	
	1980	1981	1980	1981	1980	1981
Coatings (industrial finishes, trade sales paints, varnishes, lacquers)	37	35	28	27	44	40
Construction materials (cement, mortar, preformed concrete, roofing granules)	22	23	25	24	21	23
Ferrites and other magnetic and electronic applications	9	10	7	6	10	13
Colorants for plastics, rubber, paper, textiles, glass, ceramics	11	11	7	9	13	13
Industrial chemicals (such as catalysts)	7	6	5	5	8	7
Animal feed and fertilizers	7	7	15	14	3	2
Foundry sands	5	6	11	13	--	--
Other (including cosmetics and jeweler's rouge)	2	2	2	2	1	2
Total	100	100	100	100	100	100

PRICES

Reichard-Coulston, Inc., announced price increases for selected natural and synthetic iron oxides on May 15, 1981 and July 25, 1981. The increases in May affected 38% of Reichard-Coulston's iron oxides with the majority held at, or below, 2 cents per pound. Notable were a 3-cent-per-pound increase for burnt siennas and 5-cent-per-pound increases for brown and micaceous iron oxides. Among reported increases in July, umbers increased 3 to 5 cents per pound, and synthetic yellow oxides increased 7 cents per pound. Prices quoted were for 24,000 pounds or more. According to the producer, the price increases were necessary to offset rising costs of energy, labor, and transportation.

High prices for some grades of imported sienna have caused many companies to substitute domestic grades, although domestic siennas lack the transparency and tinting strength of the imported pigments.

Table 5.—Prices quoted on finished iron oxide pigments, per pound, bulk shipments, December 31, 1981

Pigment	Low	High
Black:		
Synthetic	$0.6050	$0.7300
Micaceous	.6875	--
Brown:		
Ground iron ore	--	.1425
Metallic	.1950	.2325
Pure, synthetic	.5750	.6000
Sienna, Italian, burnt	--	.7000
Umber, Turkish, burnt	.3400	.4225
Vandyke brown	--	.4000
Red:		
Domestic primers	.3100	.3350
Pure, synthetic	.5950	.6300
Spanish	.3200	.3600
Yellow:		
Synthetic	--	.5875
Ocher, domestic	.1000	.2200

Source: American Paint Journal.

FOREIGN TRADE

U.S. exports of pigment-grade iron oxides and hydroxides decreased 2% in quantity but increased 28% in value in 1981. Principal destinations were Canada, the United Kingdom, Italy, Mexico, France, and Japan. Exports of other grades decreased 19% in quantity but increased 43% in value. Exports of nonpigment grades went mainly to the Netherlands, Japan, Canada, Mexico, and the Federal Republic of Germany.

U.S. imports for consumption of natural iron oxide pigments, which accounted for 21% of total imports, increased 33% in quantity and 75% in value compared with that of the previous year. Imports of natural iron oxides were received mainly from Cyprus, the Federal Republic of Germany, and Spain. Imports of synthetic iron oxides, which comprised 79% of the total, decreased in quantity and value by 5% and 11%, respectively, reflecting increased production capacity of U.S. synthetic iron oxide plants. Imports of synthetic iron oxides were chiefly from the Federal Republic of Germany, Canada, and Japan. There were no imports of crude or finished siennas from Italy in 1981. This spurred an increase in imports of finished siennas from Cyprus. In 1981, Cyprus supplied virtually all U.S. imports of siennas. U.S. imports of micaceous iron oxides from Austria increased by 30% compared with that of 1980 and amounted to 103 short tons.

Table 6.—U.S. exports of iron oxides and hydroxides, by country

Country	1980				1981			
	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)
Argentina	1	$16	6	$11	10	$24	15	$15
Australia	216	445	131	432	88	231	146	443
Belgium-Luxembourg	142	190	37	42	33	89	176	249
Brazil	398	459	124	227	174	412	53	176
Canada	1,929	1,986	1,622	1,559	2,178	2,386	684	973
Colombia	13	28	--	--	45	41	9	21
Costa Rica	8	14	1	1	7	9	1	2
Denmark	14	65	23	53	1	6	6	5
Dominican Republic	5	6	7	10	2	5	3	4
Ecuador	14	20	8	9	12	27	(1)	1
El Salvador	2	1	--	--	--	--	--	--
Finland	172	155	--	--	4	5	30	33
France	94	173	105	148	213	293	115	149
Germany, Federal Republic of	60	147	264	756	196	325	177	601
Guatemala	4	6	2	1	6	17	(1)	1
Hong Kong	98	119	--	--	76	198	--	--
India	2	7	2	5	6	16	42	81
Indonesia	15	46	--	--	25	182	1	4
Israel	2	5	--	--	--	--	56	253
Italy	277	735	25	32	388	1,164	55	190
Jamaica	1	1	--	--	1	2	--	--
Japan	267	1,264	1,523	4,024	200	1,653	1,651	5,085
Korea, Republic of	289	454	57	208	21	38	41	204
Liberia	7	7	9	8	12	18	10	10
Mexico	25	46	206	344	379	661	356	873
Netherlands	95	279	3,198	2,250	77	272	2,308	5,298
New Zealand	7	20	1	3	11	20	11	10
Pakistan	--	--	--	--	(1)	1	1	20
Philippines	21	20	1	2	8	20	2	4
Poland	--	--	3	15	(1)	2	--	--
Portugal	--	--	22	83	--	--	33	89
Singapore	30	57	66	96	10	35	104	241
South Africa, Republic of	25	86	--	--	8	22	5	6
Spain	32	41	5	20	8	10	--	--
Sweden	22	54	12	19	14	68	25	148
Switzerland	(1)	1	6	23	--	--	1	2
Taiwan	39	142	15	61	5	69	6	24
Thailand	9	8	40	64	7	32	16	13
United Kingdom	391	1,631	188	244	515	2,947	162	494
Venezuela	254	319	117	195	169	271	141	248
Other	66	80	218	376	60	135	86	223
Total[2]	5,046	9,132	8,042	11,318	4,967	11,704	6,527	16,193

[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	1980		1981	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Natural:				
Crude:				
Siennas	151	$73	--	--
Umbers	3,800	444	5,404	$763
Other	10	74	38	247
Total	[1]3,962	591	5,442	1,010
Finished:				
Ochers	1	1	150	80
Siennas	93	43	98	42
Umbers	634	242	515	181
Vandyke brown	687	260	1,070	340
Other	807	224	933	723
Total	2,222	770	2,766	1,366
Synthetic:				
Black	3,694	1,832	2,854	1,576
Red	5,667	3,103	5,241	3,740
Yellow	11,648	8,484	10,768	5,909
Other[2]	12,253	5,255	12,590	5,314
Total	33,262	18,674	31,453	16,539
Grand total	39,446	20,035	39,661	18,915

[1]Data do not add to total shown because of independent rounding.
[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				Synthetic			
	1980		1981		1980		1981	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Austria	79	$57	103	$57	--	--	--	--
Belgium-Luxembourg	--	--	(1)	(1)	163	$68	36	$20
Brazil	--	--	128	66	--	--	--	--
Canada	2	6	69	41	9,750	2,805	11,190	3,258
Cyprus	4,136	551	5,804	894	--	--	--	--
France	1	6	11	172	(1)	(1)	1	2
Germany, Federal Republic of	689	271	1,077	412	16,836	11,595	16,912	8,944
Italy	163	88	--	--	--	--	11	13
Japan	13	74	64	499	5,057	3,481	1,846	3,387
Mexico	--	--	--	--	998	485	1,111	672
Netherlands	--	--	--	--	208	89	--	--
South Africa, Republic of	1	1	--	--	--	--	--	--
Spain	719	142	757	144	40	8	68	23
United Kingdom	360	159	189	87	155	107	179	158
Other	14	6	7	4	56	37	99	64
Total[2]	6,184	1,361	8,208	2,376	33,262	18,674	31,453	16,539

[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.

WORLD REVIEW

World mine production of natural iron oxide pigments was estimated to have decreased in 1981. In addition to the countries listed in table 9, other countries undoubtedly produced iron oxide pigments, but production data were not available.

The principal countries producing natural red iron oxide were India and Spain; those producing yellow ocher included the Republic of South Africa, France, Cyprus, Spain, and the United States. Cyprus was the major producer of sienna and umber.

Japan.—Hercules, Inc., and Japan Magnetics, Ltd., reportedly formed a joint venture company, Sakai Chemical Industries, Ltd., located in Osaka, Japan. The new company is marketing a new line of magnetic particles for video, audio, and computer tape applications. The tapes were reported to offer better performance than other commercially available materials. Production was to commence in 1982 at the rate of 500 short tons per year.

TDK Electronics Corp., of Tokyo, Japan, continued to lead in world production of audio and video tapes. The company was estimated to supply 35% of total world demand for video tape cassettes and 22% of total world demand for audio tape cassettes. TDK was also the world's largest producer of ferrite cores. The company operated two tape-producing facilities in the United States, one located in Irvine, Calif., and the other in Peachtree, Ga., producing audio and video tapes, respectively.

Zimbabwe.—Red iron oxide was produced at the Zoe Mine near Hunters Road, located in the central portion of Zimbabwe. The material was mined by G & W Industrial Minerals, Ltd., and sent to a plant in Salisbury for further grinding. Most of the material was exported to the Republic of South Africa, where it was used to color concrete slabs and roofing tiles. The red iron oxide is found in faulted zones of massive ferruginous quartzites from which silica has been leached and iron oxide has been concentrated by downward percolating waters. Reserves of oxide have been estimated to be 28,000 short tons. Annual production is estimated at 1,200 short tons per year. Iron oxide content was reported to be 79%.

Table 9.—Natural iron oxide pigments: World mine production, by country[1]

(Short tons)

Country[2]	1977	1978	1979	1980[p]	1981[e]
Argentina	230	534	963	1,053	1,050
Australia	68	[r]310	245	248	280
Austria	10,808	[r]11,640	13,556	12,080	11,000
Brazil	7,308	6,833	8,303	8,378	8,380
Burma	254	508	407	364	390
Canada[e]	--	--	3,000	3,100	3,100
Chile	8,979	5,801	2,855	4,906	4,400
Cyprus[e]	[r]30,504	[r]33,069	[r]28,983	[r]30,291	30,000
Egypt	35	270	154	139	140
France	17,529	[e]17,600	[e]18,200	[e]17,600	16,530
Germany, Federal Republic of[3]	29,124	23,672	31,483	27,193	27,600
India	83,704	[r]85,374	109,168	95,017	93,700
Iran[4]	[e]3,900	[e]2,200	[e]1,100	550	550
Italy[e]	1,900	1,500	1,100	[r]1,100	1,100
Morocco	39	[r]22	28	133	110
Pakistan	15,774	5,150	1,133	359	330
Paraguay	132	165	220	220	220
Portugal	68	90	[e]65	72	70
South Africa, Republic of	2,392	2,411	2,492	1,510	1,130
Spain:					
Ocher	13,630	13,478	16,621	15,097	15,400
Red iron oxide	39,971	[r] [e]26,500	[e]27,600	[e]27,600	27,600
United States	59,233	84,796	87,869	49,078	[5]46,213
Zimbabwe[e]	100	100	500	1,000	1,200

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

[1]Table includes data available through May 5, 1982.

[2]In addition to the countries listed, a considerable number of others undoubtedly produce iron oxide pigments, but output is not reported, and no basis is available for formulating estimates of output levels. Such countries include (but are not limited to) China and the U.S.S.R. Because unreported output is probably substantial, this table is not added to provide a world total.

[3]Includes Vandyke brown.

[4]Iranian calendar year (Mar. 21 to Mar. 20), beginning in the year stated.

[5]Reported figure.

TECHNOLOGY

A comprehensive review of patent literature, dealing with the manufacture of inorganic pigments since 1975, was published in 1981. The review includes new pigment compositions, and processes for facilitating the dispersion of pigments in aqueous organic liquids.[6]

A circulation tank attrition mill is claimed to require little operator attention, reduce downtime, and more easily handle iron oxide materials for fine grinding than continuous batch-operating and continuous attrition mills. Batches of iron oxide materials up to 1,000 gallons and greater than 100 mesh can be wet milled to 2 to 3 micrometers by continuous recirculation through grinding media consisting of hardened steel, stainless steel, or ceramic balls.[7]

A regenerative process, developed by Lurgi Apparate-Technik GmbH, of the Federal Republic of Germany, produces ferric oxide and hydrochloric acid from spent pickle liquor. In this process, the spent pickle liquor, an aqueous solution containing ferrous chloride and some unused hydrochloric acid, is decomposed thermally. This is accomplished by first heating the spent pickle liquor to approximately 98° C, concentrating this liquor in a venturi scrubber, and then charging the concentrate into a fluidized bed of granular ferric oxide kept at approximately 850° C. Here, in the presence of oxygen and water, ferrous chloride decomposes to hydrogen chloride gas and ferric oxide. The cooled hydrogen chloride is passed through an absorption column, where it is dissolved in water to form hydrochloric acid. Ferric oxide is continually removed from the bottom of the fluidized bed, thus keeping the bed in equilibrium. The ferric oxide recovered is over 98% pure Fe_2O_3, is dust free, spherical in shape, fairly hard with a bulk density of 3 to 4.5 grams per cubic centimeter, and ranges from 0.2 to 2.00 millimeters in diameter. One of the main uses is in the production of hard ferrites.[8]

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[1]Physical scientist, Division of Ferrous Metals.

[2]Bureau of the Census, U.S. Department of Commerce. Paint, Varnish, and Lacquer. Report M28F, 1981 (monthly).

[3]Chemical Marketing Reporter. Iron Oxide, an Old Workhorse Showing Some Foot. V. 219, No. 22, June 1, 1981, pp. 33-37.

[4]Brown, A. S. Paint Companies Scrape Along. Chem. Marketing Reporter, v. 220, No. 16, Oct. 19, 1981, pp. 8-21.

[5]Work cited in footnote 3.

[6]Gutcho, M. H. Inorganic Pigments Manufacturing Processes. Noyes Data Corp., 1981, 488 pp.

[7]Geiser, B. T., and D. Byrnes. Circulation Tank Attrition Mill Reduces Maintenance Downtime in Grinding Iron Oxide Coatings. Chem. Process., v. 45, No. 2, February 1982, p. 158.

[8]Bilkhu, G. S. Ferric Oxide Production From Spent Pickle Liquor. Iron and Steel Eng., v. 59, No. 3, March 1982, p. 68.

Iron and Steel

By Frederick J. Schottman[1]

Pig iron and raw steel production in the United States recovered slightly in 1981 from the low levels of 1980. Production levels increased in the first half of the year over those of the previous year but then declined in the second half. Although many markets for steel were still weak, demand for oil country tubular goods exceeded capacity. The average composite price for steel rose 11.9% compared with that of the previous year. Imports of steel increased during 1981, and the trigger price mechanism (TPM) continued in effect throughout the year. Several investigations were instituted to determine if imported steel was being dumped or unfairly subsidized.

World production of pig iron and raw steel declined for the second consecutive year. The steel industry of most of the industrialized nations suffered from the weak world steel market. The European Economic Community (EEC) agreed to phase out government subsidies to the steel industry. Within the EEC, pricing agreements and production quotas were, in effect, intended to reduce the financial losses of steel companies. New primary steel production capacity continued to be planned and built in less developed countries, often based on direct-reduced iron.

Table 1.—Salient iron and steel statistics

(Thousand short tons unless otherwise specified)

	1977	1978	1979	1980	1981
United States:					
Pig iron:					
Production	81,494	87,690	86,975	68,699	73,755
Shipments	82,392	88,543	87,781	69,445	74,218
Annual average composite price, per ton	$189.57	$198.31	$203.00	$203.00	$204.66
Exports	51	51	105	73	16
Imports for consumption	373	655	476	400	468
Steel:[1]					
Production of raw steel:					
Carbon	108,130	116,916	116,226	94,689	100,619
Stainless	1,862	1,954	2,107	1,701	1,745
All other alloy	15,341	18,161	18,008	15,445	17,548
Total	125,333	137,031	136,341	111,835	119,912
Capability utilization[2] percent	78.4	86.8	87.2	72.8	77.7
Net shipments of steel mill products	91,147	97,935	100,262	83,853	87,014
Finished steel annual average composite price cents per pound	15.577	17.957	20.006	r21.655	24.224
Exports of major iron and steel products[3]	3,098	3,271	3,400	4,729	3,557
Imports of major iron and steel products[3]	19,930	22,027	18,428	16,355	20,818
World production:					
Pig iron	r537,419	r560,410	r584,402	p562,534	e552,037
Raw steel (ingots and castings)	r741,628	r787,170	r821,237	p787,477	e776,398

eEstimated. pPreliminary. rRevised.
[1]American Iron and Steel Institute (AISI).
[2]Raw steel production capability is defined by AISI as the tonnage capability to produce raw steel for a sustained full order book.
[3]U.S. Bureau of the Census. Figures for 1977 not strictly comparable to those of later years.

Legislation and Government Programs.—The Steel Industry Compliance Extension Act (Public Law 97-23) permitted the Environmental Protection Agency (EPA) to grant steel companies 3-year extensions of the December 31, 1982, compliance deadline for air pollution regulations. The extensions were to be granted on a case-by-case basis and required that money saved by deferring pollution control costs must be used to modernize production facilities. The law was enacted in response to complaints by the steel industry that environmental control expenditures made it difficult financially to make improvements needed to keep the industry internationally competitive.

For the first time, EPA approved a "bubble" plan for air pollution control for a steel plant. In the bubble concept, total emissions of a pollutant from an entire plant are regulated rather than from each source within the plant. The company is allowed to choose the most economical means to meet the overall standard, even though emissions from some of the individual sources may exceed source standards. Late in the year, EPA said that the bubble could be expanded to cover plants of different companies within the area. Companies with pollution control better than that required by standards could sell pollution credits to other companies. EPA also planned to simplify administrative procedures for the approval of bubble plans. After EPA set general guidelines, State pollution control agencies could approve plans that met the guidelines without further Federal action.

EPA issued proposed new regulations for water pollution control by the steel industry. As a result of revisions of the Clean Water Act, the new regulations emphasize control of toxic pollutants.[2]

The Economic Recovery Tax Act (Public Law 97-34) aided the steel industry through changes permitting more rapid depreciation and the sale of unused tax credits to other companies. On the other hand, the U.S. Department of the Treasury ruled that continuous casting equipment did not qualify for a tax credit for energy-saving equipment.

DOMESTIC PRODUCTION

Pig iron and raw steel production was slightly higher in 1981 compared with the low levels in 1980. The recovery in steel production that had begun in the second half of 1980 continued into early 1981. The rate of capability utilization as reported by the American Iron and Steel Institute (AISI) rose to a peak of 88.6% in March. Production declined for the rest of 1981 with capability utilization down to 58.6% in December. Average capability utilization for 1981 was 77.7% compared with 72.8% in 1980.

Shipments to the two most important steel markets, construction and transportation, were lower in 1981 than in 1980. The one particularly strong market was for pipes and tubes, for which shipments increased 13% over those of 1980. This increase was largely due to a boom in oil and gas exploration. Shipments of oil country tubular goods rose over 17% and were limited by lack of capacity.

Total shipments of iron and steel castings were essentially unchanged from those in 1980, according to U.S. Department of Commerce (DOC) reports. Shipments included 9.7 million tons[3] of gray iron, 2.2 million tons of ductile iron, 0.4 million tons of malleable iron, and 1.8 million tons of steel castings.

Wheeling-Pittsburgh Steel Corp. was dropped from the industry bargaining group that negotiates with the United Steelworkers of America. Wheeling-Pittsburgh had privately negotiated contract concessions that deviated from the industry agreement.

Much of the capital investment in 1981 was in facilities for the production of pipes and tubes or for continuous casting of steel. Demand for pipes and tubes exceeded capacity in 1981. Continuous casting offered improved yields, reduced energy consumption, and quality improvements. The domestic steel industry has lagged behind many foreign industries in the use of continuous casting, but the projects announced in 1981 will significantly increase that portion of domestic steel produced using this process.

The United States Steel Corp. (U.S.S.) budgeted $1.325 billion for capital investment in steel in 1981. Major projects included five continuous caster projects, which will raise the portion of the company's steel production that is continuously cast to about 25% or 30%. By the end of the decade, U.S.S. intends to continuously cast 75% of production. New casters are to be installed at Lorain, Ohio; at the South

Works in Chicago, Ill.; at Fairfield, Ala.; and at an unspecified plant of the Eastern Div. The continuous caster at Gary, Ind., will be upgraded. U.S.S. will build a new rail mill at the South Works that will eventually replace rail mills at Gary, Ind., and Birmingham, Ala. A $650 million seamless pipe and tube mill was being built at Fairfield, Ala., to begin operation in late 1983. The mill will be operated by U.S.S. but owned by other investors. A market for the mill's products is assured by long-term contracts from 12 major consumers. U.S.S. was increasing its seamless tube capacity at Gary from 91,000 to 155,000 tons per year (tpy). The company continued the trend to diversification with its purchase of Marathon Oil Co.

Bethlehem Steel Co. started up its new $110 million electric-furnace shop at Johnstown, Pa., and ended production by blast and open-hearth furnaces at Johnstown. Bethlehem was also finishing construction of a new $170 million coke oven battery at Sparrows Point, Md. The company planned $750 million of modernization projects over the next 5 years. New continuous casters at Steelton, Pa., Sparrows Point, Md., and Burns Harbor, Ind., will increase Bethlehem's portion of steel that is continuous cast from 8% to about 33%. Other projects included improvements in rolling mills at Bethlehem, Pa., and at Sparrows Point. The company discontinued production of alloy tool steel because of growing imports.

Wheeling-Pittsburgh started up a new rail mill at Monessen, Pa. The $105 million mill has a capacity of 400,000 tpy. In addition, the company planned two continuous casters. A five-strand bloom caster was to be built to feed the Monessen rail mill, and a slab caster was to be built at Steubenville, Ohio.

Jones & Laughlin Steel Corp. ordered a two-strand, $165 million, slab caster for its Indiana Harbor plant. It was rebuilding coke ovens at Youngstown, Ohio, and a blast furnace at Indiana Harbor, Ind.

Armco Inc. planned to spend $671 million to increase its capacity for oil country tubular goods from 300,000 to 750,000 tpy. The program includes a new seamless pipe mill at Ashland, Ky., improvements to the pipe mill at Ambridge, Pa., and a pipe finishing plant at Gulfport, Miss. A $90 million continuous caster was to be built at Ashland.

CF&I Steel Corp. was doubling its seamless tube capacity at Pueblo, Colo. The $140 million project included a continuous caster and a seamless tube mill, both of which should start up in 1983.

Other continuous casters were planned or being built by Republic Steel Corp. at Cleveland, Ohio, and by Inland Steel Co. at Indiana Harbor, Ind.

The Timken Co. started work on a $500 million electric-furnace plant to be built near its steel plant in Canton, Ohio. It will have a capacity of 550,000 tpy of ingots and will include continuous casting, rolling, and tube mills.

Several minimill-type operations were sold or restarted during the year. Armco sold a plant at Marion, Ohio, to Steel Bar Products Inc., a new company, and sold a plant at Sand Springs, Okla., to HMK Industries Inc. That plant will operate as Sheffield Steel Corp. Newport Steel Corp. restarted the Newport, Ky., plant formerly shut down by Interlake Inc., and Razorback Steel Corp. restarted the Newport, Ark., plant formerly operated by Tennessee Forging Steel Corp. McDonald Steel Corp. restarted a rolling mill in the old U.S.S. McDonald Works. The company has a lease with option to buy. Hunt Energy Corp. planned to spend $80 million to install an electric-furnace shop and a seamless tube mill in the old Jones & Laughlin Brier Hill Works at Youngstown, Ohio.

New minimills were started up by Nucor Corp. at Plymouth, Utah (650,000 tpy); by Florida Steel Corp. at Jackson, Tenn. (400,000 tpy); and by Bayou Steel Corp. at Laplace, La. (650,000 tpy). Structural Metals Inc. at Sequin, Tex., added a new furnace to increase capacity from 200,000 to 300,000 tpy. Chaparral Steel Co. at Midlothian, Tex., was expanding capacity from 450,000 to 1 million tpy. Quanex Corp. planned an $85 million, 280,000-tpy plant for Fort Smith, Ark.; Davis Walker Corp. planned to build a 600,000-tpy plant in Stockton, Calif.

Kaiser Steel Corp. decided to phase out in coming years its coke-oven, blast-furnace, and oxygen-furnace operations at Fontana, Calif., but planned to continue finishing operations using imported slabs. Similarly, Lukens Steel Co. said that it was considering buying carbon steel slabs from outside the company because of high local electrical costs. Alloy steel production would continue.

McLouth Steel Corp. and Penn-Dixie Industries Inc. (owner of Penn-Dixie Steel Corp.) filed for bankruptcy but continued operation under Chapter 11 of the Bankruptcy Act. The Washburn Wire Co. minimill in Rumford, R.I., was closed. The Ford Steel Div. of Ford Motor Co. was made a subsidiary and renamed the Rouge Steel Co.

Materials Used in Ironmaking.—Materials used in ironmaking are shown in tables 3 and 5. Domestic pellets charged to blast furnaces in 1981 totaled 71.2 million tons, and sinter charged amounted to 26.7 million tons. Pellets and other agglomerates from foreign sources amounted to 12.7 million tons. A total of 15.8 million tons of iron ore was consumed by agglomerating plants at or near blast furnaces in producing 26.8 million tons of agglomerates. Other materials consumed by agglomerating plants were 3.9 million tons of mill scale, 1.7 million tons of flue dust, 2.6 million tons of slag, 1.4 million tons of coke breeze, 153,000 tons of anthracite, and 6.4 million tons of fluxes.

Blast-furnace oxygen consumption totaled 24.3 billion cubic feet according to AISI. Blast furnaces, through tuyere injection, consumed 44.2 billion cubic feet of natural gas; 84.2 billion cubic feet of coke oven gas; 272 million gallons of oil; 755 million gallons of tar, pitch, and miscellaneous fuels; 90,000 tons of bituminous coal; and 4,000 tons of anthracite. The revised consumption of bituminous coal in 1980 was 121,000 tons.

Materials Used in Steelmaking.—In addition to the materials shown in tables 8 and 9, steelmaking furnaces, according to AISI, consumed 0.4 million tons of fluorspar, 1.0 million tons of limestone, 7.3 million tons of lime, 0.7 million tons of other fluxes, and 174.0 billion cubic feet of oxygen. Metalliferous materials consumed in domestic steel furnaces, per ton of raw steel produced, averaged 1,189 pounds of pig iron, 1,054 pounds of scrap, 28 pounds of ferroalloys, and 13 pounds of ore and agglomerates. The revised figures for 1980 were 1,172 pounds of pig iron, 1,108 pounds of scrap, 29 pounds of ferroalloys, and 14 pounds of ore and agglomerates.

PRICES

The annual average composite price for finished steel in 1981, as reported by Iron Age, was 24.224 cents per pound, an increase of 11.9% over the average price in 1980. The composite price increased from 22.286 cents per pound in December 1980 to 25.195 cents per pound in December 1981. When the market weakened in the second half of the year, discounting from list prices was reported. The composite price for pig iron, according to Iron Age, increased from $203 to $213 per ton during 1981 with an average of $204.66.

Prices for structural shapes and plates were increased in March and September. The yearend price for structural shapes was 22.90 cents per pound, up 15.0% compared with that of a year earlier, and the price of plates was up 12.8% to 24.25 cents per pound. However, prices were generally weaker in coastal regions where imports restrained prices. The price of special quality bars increased 5.0% to 23.95 cents per pound. Prices for merchant bar and reinforcing bar varied by region and company. Minimills took advantage of low scrap prices and were generally able to price their products below the list prices of the integrated producers. Most minimills reduced prices in the last quarter of 1981 as the market weakened.

During 1981, prices for hot- and cold-rolled sheet increased 12.7% and 12.5%, respectively. Late in the year, service centers and the automobile industry were offered special discounts. Tinplate prices were increased 7.0% on January 1, but a hike announced in September by some producers was rescinded because of weak demand.

Because of heavy demand, prices were strong for oil country tubular goods for most of 1981. Near the end of the year, however, when consumers had built up adequate stocks, demand weakened for at least readily available, lower quality products, and some discounts were offered.

FOREIGN TRADE

Exports of major iron and steel products declined and imports increased in 1981, compared with those of 1980, resulting in an unfavorable trade balance of 17.3 million tons and $7.6 billion. Generally weak markets abroad and excess production capacity encouraged many foreign producers to export to the United States. An increase in the value of the dollar relative to many other currencies made U.S. imports less expensive and made U.S. exports less competitive in foreign markets.

The high level of activity in the U.S. oil and gas drilling industry attracted increased imports of pipe and tubes as U.S. producers were unable to meet demand. Imports of pipe and tube increased by 74% compared with those of 1980, and accounted for 63% of the total increase in imports of steel mill products. Also because of the oil and gas industry, the Gulf Coast States had the largest regional change in imports, an increase of 49%.

The EEC replaced Japan as the leading supplier of imported steel mill products. While imports from Japan increased by only 3.6% to 6.2 million tons, imports from the EEC increased 67% to 6.5 million tons. Of the EEC countries, the Federal Republic of Germany, France, and Belgium-Luxembourg were the leading suppliers to the United States, with exports of 2.2 million, 1.3 million, and 1.1 million tons, respectively. Imports of steel mill products from Canada increased 22% to 2.9 million tons.

The TPM, to discourage dumping of imported steel, was continued throughout 1981. However, industry dissatisfaction with the system grew, especially in the second half of the year, as imports gained a larger share of a declining market. Trigger prices were increased an average of 4.4% for the second quarter of 1981, were left almost unchanged for the third quarter, and increased 1% to 2% for the fourth quarter.

During the year, DOC monitored prices at foreign mills to discourage evasion of TPM by sales between related parties. Steel companies in a number of countries requested preclearance from DOC to export steel to the United States at prices below the trigger prices. The companies claimed that they could document that their production costs were less than the trigger prices based on the costs of Japanese producers. In April, DOC granted preclearance for certain products from Canada and Greece, but the entire preclearance program was eliminated in November.

Monitoring for surges of imports was in effect for products covered by the TPM. For these products, a surge was defined as imports of over 15.2% of the market while domestic capacity utilization was less than 87%. In August, it was announced that there had been surges in imports of specific products from six countries. Oil country tubular goods were not included because of the shortage of these products. In November, major countervailing duty or dumping investigations were begun against imports from France, Belgium, Romania, the Republic of South Africa, and Brazil. Late in the year, U.S. steel companies threatened to file large numbers of their own countervailing duty and dumping cases. The EEC and DOC discussed ways to ease the steel trade problem yet avoid the disruption in trade that might result from the pending cases.

A monitoring program was instituted in January for imports of six groups of specialty steels, including stainless steels. A surge that would result in a DOC investigation was defined as import penetration higher than that for the previous 10-year average and also higher than the level found to be injurious by a 1976 International Trade Commission (ITC) investigation. At various times during the year there were surges in imports of stainless steel sheet and strip, stainless steel bar, stainless steel pipe and tube, and alloy tool steel.

In December, a group of domestic specialty steel producers filed a suit under Section 301 of the Trade Act of 1979 alleging that the specialty steel industries in seven countries were subsidized by their governments in violation of international agreements. The countries involved were Austria, Belgium, Brazil, France, Italy, Sweden, and the United Kingdom.

WORLD REVIEW

Total world pig iron production and steel production were little changed in 1981 compared with those of 1980. Most Western European countries continued to have excess capacity as their home markets remained stagnant and they faced new competition from the new steel industries in developing nations. The industry in Western Europe was faced with the politically and socially difficult task of reducing employment, both to eliminate unneeded capacity and to improve labor productivity.

Belgium.—Cockerill and Hainaut-Sambre S.A. merged to form Belgium's largest steel company, Cockerill-Sambre. The new state-controlled company required continuing financial support from the state, a critical political issue in Belgium with strong union opposition to reductions in jobs.

Canada.—A strike shut down most production for 4 months at the Steel Co. of

Canada Ltd. (Stelco), Canada's largest steel producer. The strike coincided with a weakening market and did not result in serious shortages. The government of Nova Scotia agreed to assume $250 million of debts of the provincially owned Sydney Steel Corp. (Sysco). The provincial government along with the Federal Government have also agreed to provide $80 million for the first stage of a 10-year modernization project.

Algoma Steel Corp. Ltd. planned to spend $1.25 billion over 5 years. The investment would increase raw steel capacity from 3.5 to 4 million tpy and includes a 200,000-tpy seamless tube mill that was under construction and scheduled to begin operation in 1984.

Interprovincial Steel & Pipe Corp., Ltd. (Ipsco), began construction of a $50 million tube plant in Calgary, Alberta. The plant had a planned capacity of 200,000 tpy and will take over the production of oil country tubular goods from other Ipsco plants when it begins operations in 1983. Ipsco also completed improvements at Regina, Saskatchewan, and Edmonton, Alberta, which increased capacity for large-diameter pipe by 300,000 tpy.

China.—Because of a shift in emphasis away from heavy industry and because of a lack of foreign currency, China canceled most of a planned 6-million-tpy steel plant being built in Baoshan. That decision was reversed later in the year with the first stage of the project scheduled to begin operations in 1984, 2 years later than originally planned. The second stage construction will be stretched out, and no target date for the completion was set.

European Communities (EC).—In June, the 10 member nations of the EC reached a compromise agreement on Community policy for restructuring the steel industry. Under the agreement, the governments agreed to end all state aids to the steel industry by the end of 1985. In the meantime, state aid programs would need to be approved by the EC Commission with any plans for such aid to be submitted by September 30, 1982. The European steel industry was strongly divided over the issue of continuing subsidies. Independent steel companies, particularly in the Federal Republic of Germany, claimed that needed reductions in production capacity were being delayed by continuing subsidies. As part of the EEC agreement, production quotas were continued on products making up about 65% of EEC steel production. The agreement also approved over $200 million of aid to relieve social stress resulting from plant closings. Most of the funds were to be used for early retirement programs.

Steel prices within the EEC increased sharply during 1981 as the industry tried to reduce financial losses. The price increases were supported by production cutbacks, pricing agreements between companies, and EEC rules against unofficial discounting from list prices. The EEC also maintained minimum prices on imported steel. The EEC had bilateral agreements with 14 countries that allowed imports at 4% to 6% lower than the usual minimum prices in exchange for quantitative limits.

France.—The newly elected socialist government formally nationalized Union Sidérurgique du Nord et de l'Est de la France (Usinor) and Acieries et Laminoirs de Lorraine (Sacilor), which had been under effective state control since 1978 when the Government provided aid to prevent failure of the companies. Metallurgique de Normandie and Ugine Aciers, privately controlled, were also to be nationalized.

Germany, Federal Republic of.—The Federal Government approved $541 million in aid to the German steel industry. The Government had generally opposed all state aid in the EEC but acted to protect its domestic industry against the subsidized industries in other countries. The Government also proposed special "equalization" duties on subsidized imports from other EEC countries.

Fried. Krupp Hüttenwerke AG and Hoesch Werke AG, part of Estel NV, discussed a possible merger. The Federal Government urged that state-owned Stahlwerke Peine-Salzgitter AG also be included. The merger would involve the breakup of Estel, which was formed in 1972 by combining Hoesch of the Federal Republic of Germany and Hoogovens IJmuiden BV of the Netherlands.

India.—The Steel Authority of India (SAIL) was nearly ready to start construction on two new integrated steelworks. Construction was to start at Visakhapatnam for a 3.7-million-tpy plant. The plant is scheduled for completion in 1985 or 1986 but it has a history of delays. A turnkey contract was let for construction for the first 1.3-million-tpy stage of the Paradip steelworks. However, the project was likely to to be delayed as SAIL considered moving the plant from a coastal site to another site closer to iron ore suppliers.

India's first direct-reduction plant, a 34,000-tpy coal-fired plant, was commissioned at Paloncha, Andra Pradesh. A 330,000-tpy plant in Orissa and a 130,000-tpy plant in Bihar have also received Government approval and several other plants are planned.

Expansion projects were underway at Mukand Iron & Steel Works Ltd. and at the Bhilai State steelworks. New specialty steel capacity was added with the startup of the 35,000-tpy stainless steel rolling mill at Salem and with the startup of an electrical sheet mill with a capacity of 80,000 tpy of electrical steel at Rourkela.

Ireland.—Irish Steel Ltd. restarted steel production at Haulbowline. The plant had been out of production for a year while the plant was rebuilt to double the capacity of the mill to about 380,000 tpy of raw steel.

Japan.—Production by Japan's export-oriented steel industry declined in 1981. Markets in Europe and the United States were still weak, and Japan faced increasing competition in Asian markets from producers in the Republic of Korea and Taiwan. Furthermore, Japan's own imports increased markedly, although they were still small compared with exports.

Seamless pipe was one strong export market with good demand and higher prices. Much of the new investment by the major Japanese steel companies was to expand capacity for high-quality, high-value pipes and tubes. Companies expanding seamless pipe capacity (and their capacity increases) included Nippon Steel Corp. (440,000 tpy), Sumitomo Metal Industries, Ltd. (22,000 tpy), Nippon Kokan KK (NKK) (660,000 tpy), and Kawasaki Steel Corp. (350,000 tpy).

Korea, Republic of.—State-owned Pohang Iron and Steel Co. (POSCO) completed its fourth stage of expansion with the addition of a fourth blast furnace and a second hot-strip mill bringing the company's capacity to 9.4 million tpy. By 1985, the plant capacity will be expanded to 10.6 million tpy. Beginning in 1985, a second plant with an eventual capacity of 13 million tpy is to be built at Kwangyang.

Libya.—Libya signed contracts for the construction of an integrated steel mill at Misurata with a capacity of 1.4 million tpy. The plant will include two Midrex direct-reduction units with a combined capacity of 1.2 million tpy.

Mexico.—Two groups considered building HYL-III direct-reduction plants at Altamira, a port being developed on the gulf coast. Prereducidos Mexicanos S.A. (Premexsa), a group of 10 electric-furnace steel companies, planned a 1-million-tpy plant; Hylsa Group and Nippon Direct Reduction Iron Development Co. conducted a feasibility study for a jointly owned plant to have a capacity of 500,000 tpy.

Siderúrgica Lázaro Cárdenas-Las Truchas S.A. (Sicartsa) plans to triple its steel mill capacity to 3.5 million tpy. The project includes a 2-million-tpy HYL direct-reduction plant due to start up in 1982, a new melt shop, and a continuous caster. A 2-million-tpy plate mill will also be built.

Tubos de Acero de Mexico S.A. announced a $650 million expansion of its works at Veracruz. The project, to be completed in stages by 1986, will increase raw steel capacity to 1.1 million tpy and seamless tube capacity to 700,000 tpy.

New Zealand.—New Zealand Steel Ltd. plans to expand its capacity from 170,000 to 850,000 tpy of billets by 1984. The expansion will add four coal-fired direct-reduction kilns, two electric pig iron furnaces, a Q-BOP converter, and two continuous casters. The company will continue to use titaniferous ironsands as raw material.

Poland.—Because of political unrest, Poland's steel production will be reduced from a normal 22 million tpy to about 1.6 million tpy for the next several years, according to the metallurgy and engineering ministry.[4]

South Africa, Republic of.—South African Iron & Steel Industrial Corp. Ltd. (Iscor) chose Lurgi Chemie & Hüttentechnik to build a four-kiln, 660,000-tpy, coal-fueled direct-reduction plant at Vanderbijlpark. Iscor is also studying a 1-million-tpy direct-reduction plant for its Pretoria steelworks.

Direct Reduction Corp. will build a solid fuel 80,000-tpy direct-reduction plant for Scaw Metals Ltd. Scaw Metals is a private steelmaker with a plant at Germiston.

Taiwan.—China Steel Corp. was expanding its capacity from 1.6 million tpy. New facilities scheduled to be ready in 1982 included a second blast furnace, a third basic-oxygen furnace, a cold-rolling mill, and a hot-strip mill. The company has longer range plans to expand to 6.3 million tpy capacity.

Trinidad and Tobago.—The Iron and Steel Co. of Trinidad and Tobago (ISCOTT) continued to start up operations at its new plant at Point Lisas, 35 miles south of Port-of-Spain. The plant takes advantage of low priced natural gas to convert imported iron ore to direct-reduced iron and steel with about 80% of the product intended for export. The first of two Midrex direct-reduction units operated in 1981 with the second to begin production in 1982 for a total capacity of 1 million tpy. Steelmaking facilities include two 100-ton electric furnaces, continuous casters, and a 660,000-tpy rod mill.

U.S.S.R.—Goals for production by the iron and steel industry in 1985 were published. The target for pig iron was 130 million tons, for raw steel it was 186 million tons, and for finished steel it was 130 million tons.

The 1981-85 5-year plan included the development of the large Stary Oskol steel plant using direct-reduced iron, and a 5,000-cubic-meter blast furnace at Cherepovets. The plan also includes three scrap-based minimills intended to serve local markets.

United Kingdom.—The British Steel Corp. reported that, during the fiscal year ending February 28, 1981, the company had losses of $1.9 billion and employment was reduced by 45,500 to 120,900. Further employment cuts were planned, but they were not expected to be as drastic as in previous years.

TECHNOLOGY

Progress was made in continuous casting processes. Southwire Co. of the United States and Hitachi, Ltd., of Japan have each developed wheel-and-belt casters similar to those used to cast copper. The casters are compact compared with the vertical casters now common and should be relatively inexpensive to build and house. In addition, the billet is cast at a relatively high speed (up to 60 feet per minute) with the intention of feeding directly into a rolling mill. Since no reheating is needed, less energy is required overall. Other companies are working on horizontal casters. The horizontal arrangement reduces the required height of the equipment and building and eliminates the need for equipment to bend or lower the casting from the vertical to horizontal position.[5]

Korf Technologies, Inc., introduced a system of bottom blowing oxygen in open-hearth furnaces. The process reportedly increases productivity, reduces fuel and oxygen consumption, and increases refractory life.[6]

A relatively low-cost method to produce billets and other shapes from powder was introduced by Cyclops Corp. In the process, a glass mold is filled with powder, evacuated, and sealed. The filled mold is placed in a conventional furnace until the powder consolidates to 98% to 99% density. As in other powder metallurgy processes, the product is very fine grained and free from segregation.[7]

Large shapes were built up almost entirely from weld-deposited material by Thyssen AG of the Federal Republic of Germany. The process allows very large shapes such as rotors and pressure vessel components to be built up with well-controlled composition and if desired with different compositions in different locations. Furthermore, in contrast to the forgings with which the welded shapes compete, the welded shapes can have very high yield and require relatively little machining.[8]

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[1]Physical scientist, Division of Ferrous Metals.

[2]Federal Register. V. 46, No. 4, Jan. 7, 1981, pp. 1858-1907.

[3]Tons in this chapter refer to short tons of 2,000 pounds.

[4]Metal Bulletin. Poland Cuts Output Target. No. 6635, Oct. 30, 1981, p. 31.

[5]McManus, G. J. Continuous Casting Continues To Evolve New Techniques. Iron Age, v. 224, No. 4, Feb. 2, 1981, pp. MP-7—MP-11.

[6]Iron and Steel Engineer. High-Productivity Open Hearth Operation Through Bottom Blowing. V. 58, No. 10, October 1981, p. 70.

[7]Lherbier, L. W. Promise in Powder. Am. Metal Market, v. 89, No. 153, Aug. 10, 1981, pp. 12A-13A.

[8]Irving, R. R. Shape Welding: A New Concept in Fabrication. Iron Age, v. 223, No. 33, Nov. 23, 1981, pp. 111-114.

Table 2.—Pig iron produced and shipped in the United States in 1981, by State

State	Production (thousand short tons)	Shipped from furnaces: Quantity (thousand short tons)	Shipped from furnaces: Value (thousands)	Average value per ton at furnace
Alabama	2,656	2,654	$580,869	$218.87
Illinois	4,504	4,503	928,687	206.24
Indiana	18,264	18,273	3,651,952	199.86
Michigan	5,757	5,756	1,108,562	192.59
New York	2,714	2,531	546,594	215.96
Ohio	11,756	11,754	2,579,640	219.47
Pennsylvania	14,176	14,804	3,011,028	203.39
California, Colorado, Utah	4,263	4,249	851,202	200.33
Kentucky, Maryland, Texas, West Virginia	9,666	9,692	2,050,185	211.53
Total[1] or average	73,755	74,218	15,308,719	206.27

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

Table 3.—Foreign iron ore and manganiferous iron ore (excluding agglomerates) consumed in manufacturing pig iron in the United States, by source of ore

(Thousand short tons)

Source	1980[1]	1981[2]
Australia	263	250
Brazil	37	37
Canada	1,042	492
Venezuela	1,871	1,968
Other countries	124	130
Total	3,337	[3]2,878

[1]Excludes 11,448,192 tons used in making agglomerates.
[2]Excludes 11,404,938 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	1980			1981		
	Quantity (thousand short tons)	Value: Total (thousands)	Value: Average per ton	Quantity (thousand short tons)	Value: Total (thousands)	Value: Average per ton
Foundry	740	$153,635	$207.61	429	$87,711	$204.46
Basic	66,916	13,148,597	196.49	71,922	14,810,426	205.92
Bessemer	402	82,594	205.46	411	88,491	215.31
Low phosphorus	W	W	W	W	W	W
Malleable	840	169,719	202.05	931	215,637	231.62
All other (not ferroalloys)	547	101,702	185.93	524	106,454	203.16
Total or average	69,445	13,656,247	196.65	[2]74,218	15,308,719	206.27

W Withheld to avoid disclosing company proprietary data; included with "All other."
[1]Includes molten iron transferred directly to steel furnaces.
[2]Data do not add to total shown because of independent rounding.

Table 5.—Iron ore and other metalliferous materials, coke, and fluxes consumed in blast furnaces, and pig iron produced in the United States, by State

(Thousand short tons unless otherwise specified)

State	Metalliferous materials consumed in blast furnaces: Iron and manganiferous ores: Domestic	Iron and manganiferous ores: Foreign	Agglomerates	Net ores and agglomerates[1]	Net scrap[2]	Miscellaneous[3]	Net total[4]	Net coke	Fluxes	Pig iron produced	Metalliferous materials consumed per ton of pig iron made (short tons): Net ores and agglomerates[1]	Net scrap[2]	Miscellaneous[3]	Net total[4]	Coke and fluxes consumed per ton of pig iron (short tons): Net coke	Fluxes
1980:																
Alabama	W	W	3,408	4,080	20	19	4,120	1,657	257	2,624	1.555	0.108	0.007	1.570	0.631	0.098
Illinois	W	--	6,410	6,548	421	144	7,113	2,577	616	4,376	1.496	.096	.033	1.625	.589	.141
Indiana and Michigan	994	690	32,585	33,758	914	1,284	35,956	11,978	1,010	21,231	1.590	.043	.060	1.694	.564	.048
New York	W	W	3,291	3,350	132	4	3,486	1,238	236	2,129	1.574	.062	.002	1.637	.581	.111
Ohio	377	136	15,691	15,936	350	663	16,949	6,709	1,811	10,692	1.490	.033	.062	1.585	.627	.169
Pennsylvania	826	1,233	20,686	22,390	650	732	23,772	8,615	1,322	14,557	1.538	.045	.050	1.633	.592	.091
California, Colorado, Utah	1,556	W	5,596	7,338	307	81	7,727	2,307	638	4,147	1.769	.074	.020	1.863	.556	.154
Maryland, West Virginia, Kentucky, Texas	W	205	14,282	14,168	202	161	14,531	4,514	465	8,944	1.584	.023	.018	1.625	.505	.052
Total[4]	3,984	3,337	101,949	107,568	2,996	3,088	113,654	39,595	[5]6,355	68,699	1.566	.044	.045	1.654	.576	.093
1981:																
Alabama	W	472	3,906	4,334	5	12	4,351	1,683	192	2,656	1.632	.002	.005	1.638	.634	.072
Illinois	W	--	6,815	7,000	516	79	7,594	2,495	449	4,504	1.554	.115	.018	1.686	.554	.100
Indiana and Michigan	295	204	36,665	36,708	1,552	928	39,190	12,570	1,043	24,021	1.528	.065	.039	1.631	.523	.043
New York	W	W	4,114	4,226	159	--	4,385	1,630	279	2,714	1.557	.059	--	1.616	.601	.103
Ohio	148	117	17,092	17,159	283	914	18,356	6,540	1,467	11,756	1.460	.024	.078	1.561	.556	.125
Pennsylvania	375	1,577	20,555	22,209	490	604	23,303	8,203	1,214	14,176	1.567	.035	.043	1.644	.579	.086
California, Colorado, Utah	316	W	5,869	6,376	215	9	6,600	2,349	580	4,263	1.496	.050	.002	1.548	.551	.136
Maryland, West Virginia, Kentucky, Texas	--	141	15,585	15,368	330	168	15,865	4,909	454	9,666	1.590	.034	.017	1.641	.508	.047
Total[4]	1,583	2,878	110,601	113,380	3,550	2,714	119,644	40,379	[6]5,678	73,755	1.537	.048	.037	1.622	.547	.077

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

[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: 2,865 limestone, 1 burnt lime, 3,250 dolomite, and 239 other fluxes, excluding 3,520 limestone, 13 burnt lime, 3,036 dolomite, and 59 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: 2,701 limestone, 1 burnt lime, 2,827 dolomite, and 150 other fluxes, excluding 2,980 limestone, 26 burnt lime, 3,299 dolomite, and 67 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	1980 In blast[1]	1980 Out of blast	1980 Total	1981 In blast[1]	1981 Out of blast	1981 Total
Alabama	5	1	6	3	3	6
California	4	--	4	3	1	4
Colorado	3	1	4	3	1	4
Illinois	6	6	12	6	2	8
Indiana	16	6	22	18	4	22
Kentucky	2	--	2	2	--	2
Maryland	2	3	5	2	2	4
Michigan	7	2	9	7	2	9
New York	3	6	9	4	5	9
Ohio	16	12	28	14	9	23
Pennsylvania	22	20	42	17	23	40
Texas	2	--	2	2	--	2
Utah	3	--	3	2	1	3
West Virginia	3	1	4	3	1	4
Total	94	58	152	86	54	140

[1]In blast for 180 days or more during the year.

Table 7.—Steel production in the United States, by type of furnace

(Thousand short tons)

Year	Open-hearth	Basic oxygen converter	Electric	Total
1977	20,043	77,408	27,882	125,333
1978	21,310	83,484	32,237	137,031
1979	19,158	83,256	33,927	136,341
1980	13,054	67,615	31,166	111,835
1981	13,452	73,231	33,229	119,912

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] Domestic	Iron ore[2] Foreign	Agglomerates[2] Domestic	Agglomerates[2] Foreign	Pig iron	Ferro-alloys[3]	Iron and steel scrap
1977	112	372	123	102	77,086	[r]1,721	64,231
1978	110	537	441	79	83,577	[r]1,917	70,375
1979	73	409	704	74	81,948	[r]1,978	71,715
1980	45	244	429	50	[r]65,543	[r]1,603	[r]61,930
1981	27	207	537	34	71,284	1,663	63,195

[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.—Consumption of pig iron in the United States, by type of furnace or other use

Type of furnace or other use	1979 Thousand short tons	1979 Percent of total	1980 Thousand short tons	1980 Percent of total	1981 Thousand short tons	1981 Percent of total
Basic oxygen converter	68,526	78.4	56,414	81.7	62,162	82.8
Open-hearth	12,865	14.7	8,606	12.5	8,867	11.8
Electric	905	1.0	855	1.2	583	.8
Cupola	1,026	1.2	698	1.0	685	.9
Air and other furnaces[1]	397	.4	299	.4	254	.3
Direct castings[2]	3,738	4.3	2,182	3.2	2,489	3.3
Total[3]	87,458	100.0	69,053	100.0	75,040	100.00

[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.—Consumption of pig iron[1] in the United States, by State

(Thousand short tons)

State	1980	1981
Alabama	2,559	2,583
Arkansas	2	1
California	1,703	1,751
Connecticut	10	9
Georgia	4	3
Illinois	4,386	5,432
Indiana	15,787	18,287
Iowa	21	24
Kansas	6	7
Kentucky	1,650	1,946
Maine	(2)	(2)
Maryland	3,537	3,892
Massachusetts	18	19
Michigan	5,601	5,869
Minnesota	30	30
Missouri	12	10
Nevada	(2)	(2)
New Jersey	5	4
New York	2,001	2,374
North Carolina	4	3
Ohio	10,847	11,880
Oklahoma	13	13
Pennsylvania	14,583	14,444
Rhode Island	3	3
Tennessee	12	14
Texas	1,378	1,262
Utah	1,622	1,595
Virginia	37	23
Washington	1	3
West Virginia	2,286	2,565
Wisconsin	65	69
Undistributed[3]	870	925
Total	69,053	75,040

[1]Includes molten pig iron used for ingot molds and direct castings.
[2]Less than 1/2 unit.
[3]Includes Colorado, Florida, New Hampshire, Oregon, and South Carolina.

Table 11.—U.S. exports of major iron and steel products

Product	1979 Quantity (short tons)	1979 Value (thousands)	1980 Quantity (short tons)	1980 Value (thousands)	1981 Quantity (short tons)	1981 Value (thousands)
Steel mill products:						
Ingots, blooms, billets, slabs, sheet bars	357,965	$93,696	912,310	$249,092	540,600	$154,511
Wire rods	28,403	14,180	212,823	70,291	102,688	44,878
Structural shapes, 3 inches and over	139,054	73,393	151,075	83,950	131,384	80,328
Structural shapes, under 3 inches	18,234	16,551	25,234	21,196	16,176	16,065
Sheet piling	6,823	4,614	2,677	1,664	7,607	9,654
Plates	207,866	100,986	207,840	119,042	199,536	126,794
Rails and track accessories	38,148	21,565	130,016	65,289	78,325	51,696
Wheels and axles	2,496	9,182	4,520	20,392	7,390	24,785
Concrete reinforcing bars	86,281	28,180	166,171	52,030	137,317	41,927
Bars, carbon, hot-rolled	68,488	28,872	80,913	34,386	91,041	48,587
Bars, alloy, hot-rolled	48,382	41,613	128,587	76,346	58,518	57,793
Bars, cold finished	29,486	30,561	28,442	34,261	28,724	36,498
Hollow drill steel	7,874	6,330	4,241	6,369	4,818	9,379
Pipe and tubing	728,430	791,131	470,168	718,647	472,447	841,474
Wire	34,827	45,243	42,648	55,054	37,360	62,470
Nails, brads, spikes, staples	10,320	26,014	11,600	31,681	11,949	34,152
Blackplate	125,548	35,377	179,459	52,046	89,717	25,711
Tinplate and terneplate	440,399	204,986	707,023	440,671	381,089	220,993
Sheets, hot-rolled	100,527	53,582	211,291	104,937	195,294	105,394
Sheets, cold-rolled	142,507	98,704	145,462	110,958	92,485	89,378
Strip, hot-rolled	15,607	14,932	40,764	27,568	36,598	24,258
Strip, cold-rolled	50,146	65,507	44,320	72,064	51,534	73,855
Plates, sheets, strip, galvanized, coated or clad	130,132	73,236	193,134	108,685	131,266	94,686
Total[1]	2,817,943	1,878,437	4,100,718	2,556,619	2,903,863	2,275,267
Other steel products:						
Plates and sheets, fabricated	22,362	38,417	28,763	52,913	40,244	66,404
Structural shapes, fabricated	121,296	195,258	175,035	313,644	172,388	390,526
Architectural and ornamental work	4,157	8,349	10,405	23,966	10,193	23,998
Sashes and frames	10,237	25,943	12,470	32,283	12,804	39,141
Pipe and tube fittings	42,058	214,369	50,104	259,805	50,716	300,810
Pipe and tubing, coated or lined	14,595	20,173	18,012	21,729	19,470	23,806
Bolts and nuts	95,094	113,687	56,131	123,230	70,254	133,442
Forgings	56,011	72,397	47,413	104,586	58,195	144,420
Cast-steel rolls	3,432	7,008	4,265	7,729	5,074	8,811
Railway track material	4,769	5,723	4,503	7,209	4,458	7,386
Total[1]	374,011	701,325	407,101	947,094	443,796	1,138,745
Iron products:						
Cast-iron pipes, tubes, fittings	66,367	121,517	86,245	140,661	95,386	145,519
Iron castings	141,194	102,740	134,714	83,755	113,521	88,998
Total	207,561	224,257	220,959	224,416	208,907	234,517
Grand total[1]	3,399,515	2,804,018	4,728,778	3,728,129	3,556,566	3,648,528

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

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

Country	1979 Quantity (short tons)	1979 Value (thousands)	1980 Quantity (short tons)	1980 Value (thousands)	1981 Quantity (short tons)	1981 Value (thousands)
Australia	7,880	$1,000	46,482	$6,258	3,707	$470
Belgium-Luxembourg	--	--	--	--	27	12
Brazil	183,925	21,622	84,862	10,123	138,951	15,443
Canada	184,635	28,656	222,365	39,837	267,877	46,658
France	19,579	2,659	8,746	1,303	4,833	771
South Africa, Republic of	41,776	5,193	18,885	2,608	45,988	-6,972
Spain	28,888	3,286	--	--	--	--
Sweden	9,658	834	18,658	2,884	4,526	430
Venezuela	--	--	--	--	2,204	236
Other	--	--	33	24	12	21
Total[1]	476,342	63,251	400,031	63,036	468,125	71,013

[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	1979 Quantity (short tons)	1979 Value (thousands)	1980 Quantity (short tons)	1980 Value (thousands)	1981 Quantity (short tons)	1981 Value (thousands)
Steel mill products:						
Ingots, blooms, billets, slabs, sheet bars	344,690	$91,863	155,345	$51,802	790,062	$212,449
Wire rods	985,401	379,156	829,272	347,210	888,456	388,315
Structural shapes, 3 inches and over	1,881,959	596,769	1,739,543	589,762	1,976,769	727,669
Structural shapes, under 3 inches	231,608	76,162	136,939	49,960	105,412	38,027
Sheet piling	102,812	37,822	89,423	33,750	98,718	40,512
Plates	1,819,805	561,640	2,059,710	670,729	2,447,687	900,595
Rails and track accessories	213,677	74,336	271,164	106,264	282,877	109,788
Wheels and axles	99,550	58,877	142,906	101,150	35,702	30,955
Concrete reinforcing bars	116,958	33,164	78,641	23,770	52,647	15,415
Bars, carbon, hot-rolled	452,433	147,958	366,659	129,253	418,006	163,516
Bars, alloy, hot-rolled	153,894	90,499	129,147	90,054	176,571	119,706
Bars, cold finished	170,510	134,527	146,786	145,251	231,278	219,096
Hollow drill steel	2,023	2,212	1,814	1,742	1,442	1,588
Welded pipe and tubing	1,750,470	724,360	1,862,058	824,876	2,740,842	1,414,377
Other pipe and tubing	1,169,584	716,279	1,914,540	1,262,704	3,827,736	3,157,481
Wire	479,162	369,930	414,429	339,254	412,802	332,389
Wire nails	336,849	188,176	292,169	152,841	303,471	160,045
Wire fencing, galvanized	11,261	7,848	8,318	6,430	8,446	6,419
Blackplate	82,072	30,850	68,250	27,365	97,836	41,353
Tinplate and terneplate	262,781	137,252	309,292	179,232	288,414	180,390
Sheets, hot-rolled	2,161,764	608,111	1,491,791	441,740	1,628,141	526,902
Sheets, cold-rolled	2,412,994	894,821	1,477,122	589,037	1,626,016	720,356
Sheets, coated (including galvanized)	2,139,151	892,511	1,349,790	597,424	1,303,588	604,046
Strip, carbon, hot-rolled	27,345	9,661	15,807	6,762	24,934	10,719
Strip, carbon, cold-rolled	49,581	45,151	46,965	43,023	50,866	50,218
Strip, alloy, hot- or cold-rolled (including stainless)	21,267	36,682	15,341	34,362	23,087	42,832
Plates, sheets, strip, electrolytically coated (other than with tin, lead, or zinc)	38,588	20,124	81,854	41,716	56,565	32,502
Total[1]	17,518,189	6,966,738	15,495,075	6,887,462	19,898,371	10,247,660
Other steel products:						
Plates, sheets, strip, fabricated	6,749	7,582	6,010	5,879	4,832	5,526
Structural shapes, fabricated	154,365	113,101	175,292	170,719	168,779	179,719
Pipe fittings	81,753	107,851	88,329	131,293	131,829	221,691
Rigid conduit	3,095	5,035	2,058	3,705	1,928	3,952
Bale ties made from strip	8,046	3,677	2,050	1,339	1,390	1,190
Nails, brads, spikes, staples, tacks, not of wire	17,071	15,451	14,464	12,174	16,123	12,709
Bolts, nuts, rivets, washers, etc	477,092	496,999	430,011	473,632	445,743	491,230
Forgings	39,246	27,231	34,967	26,962	51,772	38,601
Total[1]	787,417	776,928	753,181	825,702	822,396	954,618
Iron products:						
Cast-iron pipes, tubes, fittings	26,852	25,387	23,859	25,278	25,554	27,515
Iron castings	95,841	53,460	82,712	53,577	71,207	56,442
Total	122,693	78,847	106,571	78,855	96,761	83,957
Grand total	18,428,299	7,822,513	16,354,827	7,792,019	20,817,528	11,286,235

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

Table 14.—Pig iron: World production, by country[1]

(Thousand short tons)

Country[2]	1977	1978	1979	1980[p]	1981[e]
North America:					
Canada	10,649	11,399	12,021	12,327	10,880
Mexico[3]	4,771	5,662	5,541	5,806	6,160
United States	81,494	87,690	86,975	68,699	[4]73,755
South America:					
Argentina[3]	[r]1,527	[r]2,012	2,136	1,991	1,900
Brazil[3]	10,735	11,388	13,137	14,286	[4]12,049
Chile	476	594	674	685	643
Colombia	246	327	265	307	290
Peru	269	[r]262	283	288	[4]195
Venezuela[3]	548	764	1,468	2,609	[4]2,458
Europe:					
Austria	3,268	3,392	4,081	3,842	[4]3,832
Belgium	9,837	10,310	11,878	10,857	[4]10,789
Bulgaria	1,779	1,645	1,598	1,696	1,650
Czechoslovakia	10,709	10,961	10,504	10,824	10,860
Finland	1,944	2,112	2,247	2,226	[4]2,180
France	19,714	19,952	20,906	20,580	[4]18,697
German Democratic Republic[5]	2,896	2,822	2,630	2,709	2,600
Germany, Federal Republic of	[r]31,633	[r]32,916	38,421	37,118	[4]35,137
Greece	485	660	362	[e]385	330
Hungary	2,520	2,568	2,611	2,441	[4]2,417
Italy	12,578	12,500	12,486	13,392	13,513
Luxembourg[5]	3,933	4,102	4,190	3,934	[4]3,183
Netherlands	4,323	5,085	5,307	4,771	[4]5,070
Norway	565	[r]611	717	681	[4]626
Poland	10,490	12,246	12,087	12,787	12,100
Portugal	393	389	403	330	330
Romania	8,580	8,989	9,787	9,934	10,400
Spain	[r]7,299	[r]6,882	7,174	7,408	[4]7,080
Sweden[3]	2,745	2,735	3,343	2,685	[4]1,962
Switzerland	30	38	33	32	33
U.S.S.R	[r]117,389	[r]121,250	119,331	117,515	[4]117,230
United Kingdom	[r]13,542	[r]12,712	14,213	6,958	[4]10,291
Yugoslavia	2,136	2,294	2,603	2,673	[4]3,105
Africa:					
Algeria	473	[r]529	437	440	470
Egypt	[r]606	[r]661	661	717	715
Morocco[e]	13	13	13	13	13
South Africa, Republic of	[r]6,740	[r]6,515	7,750	8,284	[4]8,088
Tunisia	146	148	165	166	175
Zimbabwe[e]	[r]340	[r]660	660	660	440
Asia:					
China	[r]27,613	38,349	40,488	41,910	37,500
India	10,798	10,397	9,664	9,324	[4]10,443
Iran[e]	770	1,000	900	900	550
Israel[e]	([6])	([6])	([6])	([6])	--
Japan	94,673	86,629	92,402	95,946	[4]88,239
Korea, North[e]	3,000	3,100	3,200	3,300	3,300
Korea, Republic of	2,673	3,022	5,581	6,148	[4]8,739
Taiwan	[r]687	[r]1,962	1,940	1,857	[4]1,775
Thailand	22	23	33	20	22
Turkey	1,905	[r]2,014	2,456	2,249	2,150
Oceania:					
Australia	7,444	8,088	8,610	7,675	[4]7,525
New Zealand[e] [3]	13	31	30	149	148
Total	[r]537,419	[r]560,410	584,402	562,534	552,037

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

[1]Table excludes all ferroalloy production except where otherwise noted. Table includes data available through June 2, 1982.

[2]In addition to the countries listed, Vietnam and Zaire have facilities to produce pig iron and may have produced limited quantities during 1977-81, but output is not reported and available general information is inadequate to permit formulation of reliable estimates of output levels.

[3]Includes sponge iron output.

[4]Reported figure.

[5]May include blast furnace ferroalloys.

[6]Revised to zero.

Table 15.—Raw steel:[1] World production, by country[2]

(Thousand short tons)

Country	1977	1978	1979	1980[p]	1981[e]
North and Central America:					
Canada	15,026	16,423	17,723	17,512	[3]16,321
Cuba	364	357	361	335	330
El Salvador	15	[e]15	[e]15	15	11
Mexico	6,174	[r]7,469	7,845	7,884	8,380
Trinidad and Tobago	--	--	--	--	50
United States	125,333	137,031	136,341	111,835	119,912
South America:					
Argentina	[r]2,958	[r]3,071	3,530	2,961	[3]2,800
Brazil	12,306	13,346	15,314	16,885	14,570
Chile	604	[r]658	724	735	700
Colombia	364	431	399	446	435
Ecuador	NA	NA	9	16	[3]30
Peru	418	[r]412	481	519	375
Uruguay	19	10	19	15	11
Venezuela	942	948	1,624	1,966	2,003
Europe:					
Austria	4,511	4,779	5,420	5,097	[3]5,132
Belgium	12,408	13,890	14,817	13,580	[3]13,540
Bulgaria	2,854	2,723	2,736	2,829	2,755
Czechoslovakia	16,605	16,859	16,333	16,783	16,800
Denmark	756	952	886	809	[3]675
Finland	2,420	2,572	2,754	2,765	[3]2,658
France	24,354	25,178	25,750	25,480	[3]23,440
German Democratic Republic	7,551	7,690	7,742	8,056	8,200
Germany, Federal Republic of	42,974	45,474	50,750	48,323	[3]45,870
Greece	837	1,032	1,102	[e]1,100	1,100
Hungary	4,104	4,274	4,308	4,149	4,020
Ireland	52	76	79	2	[3]35
Italy	25,721	26,767	26,731	29,212	[3]27,074
Luxembourg	4,772	5,280	5,456	5,090	[3]4,179
Netherlands	5,431	6,162	6,400	5,811	[3]6,023
Norway	784	[r]895	1,015	1,017	[3]935
Poland	19,666	21,221	21,184	21,478	17,300
Portugal	591	[r]636	715	720	[3]607
Romania	12,629	12,984	14,230	14,523	14,330
Spain	12,238	[r]12,422	13,563	13,874	14,200
Sweden	4,374	4,767	5,101	4,665	[3]4,150
Switzerland	721	864	977	990	980
U.S.S.R	161,685	166,929	164,353	163,076	164,200
United Kingdom	[r]22,498	22,389	23,631	12,431	[3]17,192
Yugoslavia	3,510	[r]3,804	3,899	4,006	4,380
Africa:					
Algeria	[r]452	[r]460	459	589	600
Angola[e]	6	11	11	11	11
Egypt	290	[e]660	[e]700	877	880
Ghana[e]	17	11	6	6	6
Kenya[e]	11	11	11	11	11
Libya[e]	11	11	11	11	11
Morocco[e]	[r]6	[r]7	7	7	7
Mozambique[e]	13	19	22	22	--
Nigeria[e]	17	17	17	17	17
South Africa, Republic of	8,131	8,710	9,775	9,996	[3]9,858
Tunisia	172	175	194	196	200
Uganda	17	17	--	--	--
Zaire[e]	33	NA	NA	NA	NA
Zimbabwe	[r]809	[r]858	815	886	[3]762
Asia:					
Bangladesh[4]	[r]119	[r]129	139	152	150
Burma	44	44	([5])	([5])	([5])
China	26,169	35,031	37,953	40,918	40,000
Hong Kong[e]	83	83	83	83	83
India	10,933	11,009	11,019	10,384	[3]11,883
Indonesia	160	165	550	584	660
Iran[e]	600	860	770	770	550
Iraq[e]	--	55	388	286	50
Israel[e]	[r]80	[r]100	120	121	130
Japan	112,882	112,551	123,181	122,792	112,100
Jordan[e]	[r]46	[r]66	100	100	100
Korea, North[e]	3,400	[r]3,500	3,700	3,900	3,860
Korea, Republic of	[r]4,792	[r]5,477	8,389	9,435	[3]11,854
Lebanon[e]	8	7	--	--	--
Malaysia	214	224	257	220	220
Philippines	401	304	438	462	440
Qatar	--	95	386	496	502
Saudi Arabia[e]	[r]6	[r]6	50	55	80
Singapore	227	309	327	330	330
Syria[e]	127	132	100	110	110

See footnotes at end of table.

Table 15.—Raw steel:[1] World production, by country[2] —Continued

(Thousand short tons)

Country	1977	1978	1979	1980[p]	1981[e]
Asia —Continued					
Taiwan	[r]1,951	[r]3,783	4,685	4,657	[3]3,465
Thailand	331	365	320	472	440
Turkey	[r]2,097	[r]2,394	2,641	2,795	[3]2,655
Vietnam[e]	95	110	120	130	120
Oceania:					
Australia	8,061	8,365	8,956	8,360	8,300
New Zealand	248	249	[e]220	246	250
Total	[r]741,628	[r]787,170	821,237	787,477	776,398

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

[1]Steel formed in first solid state after melting, suitable for further processing or sale; for some countries, includes material reported as "liquid steel," presumably measured in the molten state prior to cooling in any specific form.

[2]Table includes data available through June 2, 1982.

[3]Reported figure.

[4]Data are for year ending June 30 of that stated.

[5]Remelt capacity is 40,000 tons; however, plant output, if any, is not known.

Iron and Steel Scrap

By Franklin D. Cooper[1]

In 1981, scrap consumption was 85.1 million tons,[2] 1.7% more than in 1980; consumption was 8.4 million tons in March and fell to 5.7 million tons in December.

Consumption of direct-reduced iron (DRI) was 611,000 tons compared with 715,000 tons in 1980.

Table 1.—Salient iron and steel scrap and pig iron statistics in the United States

(Thousand short tons and thousand dollars)

	1980	1981
Stocks, Dec. 31:		
Scrap at consumer plants	8,018	8,118
Pig iron at consumer and supplier plants	889	859
Total	8,907	8,977
Consumption:		
Scrap	83,710	85,097
Pig iron	69,053	75,040
Exports:		
Scrap (excludes rerolling material and ships, boats, other vessels for scrapping)	11,168	6,415
Value	$1,225,941	$638,644
Imports for consumption:		
Scrap (includes tinplate and terneplate scrap)	582	556
Value	$61,192	$62,126

Legislation and Government Programs.—The Interstate Commerce Commission (ICC) was directed by the U.S. Court of Appeals in July 1981 to order railroads to reduce rates on recycled materials immediately to the maximum set by the Staggers Rail Act (Public Law 96-448, October 14, 1980) and to prohibit increases that would exceed that level. Consolidated Rail Corp. (Conrail) filed a new rate scale with the ICC for iron and steel scrap shipments, with reductions of as much as 23% from current rail rates and as much as 30% from applicable truck rates. The new rates were effective September 1 for all points on Conrail lines, except in New England.

The Institute of Scrap Iron and Steel (ISIS) in April in letters to Commerce Secretary Baldrige and Trade Ambassador Brock requested that iron and steel scrap be included in the Administration's goal to increase exports. ISIS urged the Senate Finance Committee's Subcommittee on Agriculture and Taxation to adopt Senate bill 750 to increase the present energy tax credit from 10% to 20% and to extend the effective date through December 31, 1986.

The U.S. Department of Energy in September 1981 abandoned its 2-year-old proposal to provide Federal price support for recyclable commodities from municipal solid waste demonstration facilities.

The Army Defense Property Disposal Service planned to furnish descriptions of its contaminated surplus ferrous metals to be sold to the scrap industry in tonnages approximating 450,000 tons per year from the U.S. Defense Department's 215 scrapyards throughout the world.

A November 1981 report of a Bureau of

Mines financed study started in August 1980 by the Battelle Columbus Laboratories concluded that the contaminant level of ferrous scrap has not increased in the past 30 years.[3]

The dispute over ferrous scrap export monitoring between the American Iron and Steel Institute (AISI) and ISIS continued in early 1981. However, AISI reportedly dropped plans in May 1981 to petition the U.S. Commerce Department for export monitoring because depressed levels of scrap exports made it difficult to meet the Commerce Department's criteria showing that exports increased domestic prices, had resulted in a domestic shortage, or had an adverse impact on the economy or a sector thereof.

AVAILABLE SUPPLY, CONSUMPTION, AND STOCKS

The domestic consumption of iron and steel scrap, including stainless scrap and alloy steel scrap, in million tons, increased from 83.7 in 1980 to 85.1 in 1981, ranging from a high of 8.4 in March to 5.7 in December. Consumption by type of furnace in 1981 and the monthly maximums and minimums, in thousand tons, were as follows: Blast furnaces, 4,046 (421 in March, 275 in October); basic oxygen process furnaces, 23,278 (2,239 in March, 1,501 in December); open-hearth furnaces, 7,498 (764 in May, 428 in November); electric furnaces, 39,642 (3,929 in March, 2,751 in December); cupola furnaces, 9,113 (931 in February, 570 in December); and air and other furnaces, 1,520 (157 in March, 97 in November).

Consumption of stainless steel scrap only, in thousand tons in 1981, totaled 934 ranging from 99 in June to 61 in November. Manufacturers of pig iron and raw steel consumed 872, manufacturers of steel castings used 36, and iron foundries and miscellaneous users, 26.

Monthend stocks of purchased and home scrap, including stainless steel scrap, in million tons, averaged 8.20 compared with 7.97 in 1980. Stocks at the end of February were 7.86, increasing to 8.45 on November 30, and declining to 8.12 at yearend 1981 compared with 8.02 at yearend 1980.

Stainless steel scrap stocks on December 31, 1981, were 110,000 tons compared with 102,000 tons at yearend 1980. During 1981, pig iron and raw steel manufacturers increased their stocks by 6,000 tons, and iron foundries and miscellaneous users increased their stocks by 1,000 tons.

Reportedly, a shortage of stainless steel scrap was predicted when the U.S. economy regains normalcy because the generation of this type of scrap had so decreased by October 1981 that there was not enough available to meet any increase in demand.[4] Traditionally, new industrial scrap furnishes 70% to 75% of the scrap consumed, but by October, this supply had decreased to 50% or less. High interest rates discouraged dealers from holding large stocks.

Compared with that of 1980, net receipts of scrap in 1981, in thousand tons, by pig iron and raw steel producers were 876 greater; steel castings manufacturers received 77 less; and iron foundries and miscellaneous users received 226 more.

Domestic receipts of iron and steel scrap from other own-company plants at 7.4 million tons were 168,000 tons less than in 1980.

The production of all types of home scrap in 1981 was 43.3 million tons compared with 42.2 million tons in 1980.

Scrap available for domestic consumption in 1981, in thousand tons, was as follows: Net receipts, 41,981; production of home scrap, 43,260; and imports, 556.

Domestic receipts of iron and steel scrap, in million tons, from brokers, dealers, and other outside sources increased to 40.0 in 1981 from 39.3 in 1980. Pig iron and raw steel manufacturers received 29.7 million tons ranging from 3.1 million tons in May to 1.9 million tons in December. Steel castings producers received 1.8 million tons ranging from 164,000 tons in June to 123,000 tons in July. Iron foundries and miscellaneous users received 8.5 million tons ranging from 795,000 tons in April to 596,000 tons in July.

The Tin Mill Products Producers Committee of AISI reported that about 10 million steel food and beverage cans are reclaimed magnetically daily from domestic refuse and that 2 million steel cans are recovered daily at recycling centers.

In 1981, foundry closures included some of the largest captive foundries including the Ford Motor Co.'s Casting Center at Flat Rock, Mich., and four foundries of the Midland-Ross Corp., whose principal product was steel castings for the railroad industry. Some capacity was added by 20 gray and ductile iron castings producers. Reportedly, domestic ferrous casting capacity, in million tons, decreased from 23 in 1979 to 19 in 1981, during which year the industry shipped 12.8 million tons.[5]

Information from the business manager of Foundry Magazine in early 1981 estimated the number of U.S. foundries as follows: Gray iron, 1,461; ductile iron, 643; malleable iron, 110; and steel, 691. Many of these foundries produced several types of castings.

The 1981 domestic demand for steel and other ferrous products was disappointing to the steel industry. Shipbuilding had a poor year, and railroad car builders delivered only 44,000 new cars, had few new orders, and their backlogs were low. The forging industry had a disappointing year because new models of a smaller number of new automobiles contained few forgings. Construction machinery was one of the hardest hit big capital goods industries, and the farm equipment industry had a huge inventory because of the lack of the usual seasonal sales. Some mining equipment makers had a moderate amount of business. The oil country tubular goods industry competed with 2 million tons of imports. Material handling equipment makers had a good year despite lack of interest by automobile makers. Appliance builders produced 0.25 million more units than in 1980.

The L. B. Foster Co., specializing in the recovery and sale of relay rail, contracted to dismantle about 3,000 miles of track of the Chicago, Rock Island, and Pacific railroad. Scrap will be sold to domestic dealers, and rerolling and relaying rail will be marketed in the United States and abroad. Dismantling will require 3 years after starting in 1982. One million tons of ferrous items worth $150 million were expected to be recovered. The Foster Co. also purchased 234 miles of track and accessories, 50 bridges, all buildings, and the right-of-way from the Erie-Lackawanna Board of Trustees for $10.9 million with the approval of the U.S. Court of Bankruptcy. Dismantling began in April 1981 and was expected to require 2.5 years to complete during which time substantial amounts of ballast, utility poles, and crossties would also be recovered.

Mayer Pollock Steel Corp. completed scrapping the machinery and equipment of the former Firestone Tire and Rubber Co. plant in Pottstown, Pa. Allied Erecting and Dismantling Co. contracted to dismantle the Ohio works of the United States Steel Corp. whereby an estimated 150,000 tons of scrap would be recovered in the 3-year project.

The David J. Joseph Co. completed a new scrapyard provided with a hammer mill shredder at Plymouth, Utah. This yard will supply about 25% of the scrap needed nearby by Nucor's newest minimill with the balance being provided by the Joseph Co. through its brokerage operation. Pacific Steel Co., controlled by a Mexican steelmaker, in September started operation on the San Diego, Calif., site formerly occupied by Scrap Disposal.

Permanent closures of two separate scrap export terminals in Port Newark, N.J., were completed by Luria Bros. & Co., Inc., and Associated Metals and Mineral Corp. The complete ferrous scrap detinning plant of Wisconsin Metals and Chemical Co. was sold at a public auction in July.

Schiavone-Bonomo Corp. and Michael Schiavone & Sons formed a partnership for purchasing, processing, and marketing stainless steel scrap beginning in mid-July from a site in New Haven, Conn.

Luria Bros. & Co., Inc., agreed to furnish onsite services for supplying Wheland Foundry, Chattanooga, Tenn., with 60,000 tons of scrap annually and to also furnish the foundry with hot-processed briquettes. Joseph Behr & Sons, Inc., acquired the scrap processing plant of the Morrow Steel Co., Detroit, Mich. Georgetown Steel Corp. acquired a 50% interest in Addlestone International Corp. having scrapyards in Augusta, Ga., and Georgetown, S.C. Chapparal Steel Co. purchased the 10,000-ton-per-year scrap processing operation of Schwartz Iron & Metal Co., Texas City, Tex.

In December, Steelmet, Inc., Pittsburgh, Pa., one of the world's largest stainless steel processors and brokers, acquired the assets of Louis Usdin, Inc., Newark, N.J.

A revised ISIS booklet released in 1980, "Recycling Iron and Steel Scrap Energy," estimated the number of the following types of scrap processing equipment in the United States and their annual capacity, in million tons: 1,065 guillotine shears, 19.0; 2,150 alligator shears, 5.3; 1,170 balers, 17.7; 200 shredders including 15 wet shredders, 14.6; 155 turnings crushers, 2.4; and 110 briquetters, 1.1. Additionally, domestic scrap processors had a significant investment in blockbusters, conveyors, cranes, dumpsters, flatteners, forklift trucks, front-end loaders, grapples, magnets, scrap containers, tie balers, torches, tractor-trailer trucks, and weight scales.

A subsidiary of ISIS, the ISIS Service Corp., sold three turnkey oomputers designed especially for the scrap industry. Marathon Le Tourneau Co. began marketing its new, all-electric, 360° rotation, 20-ton-gross-capacity jib crane.

Foreign-made equipment available to U.S. scrap processors included the Cosmo baler from France; the Liebherr R-942 hydraulic scrap handler, a 1,500-ton shear with precompression box by Lindemann KG GmbH, shears, presses, and shredders from Thyssen Henschel, and the Venti Oelde windsifter and deduster, all from the Federal Republic of Germany; shears, balers, and grabs from British McIntyre, Ltd., and the QUICK SORT analytical system by Lind System, Ltd., from the United Kingdom; and the Lollini MAX 300 mobile baling press from Italy.

Titan Engineering Corp. agreed to purchase the Stelco-Lurgi/Republic-National Lead DRI plant last operated in 1977 by Hecla Mining in Casa Grande, Ariz.

Pelletech, Inc., became the exclusive licensee for a special hydrothermal agglomeration process developed by the Michigan Technological University. The process produces DRI using saturated steam as heat, lime and silica as bonding agents, and carbon as a reducing agent. The company planned to use the process for the first time in its new $12.6 million plant in McKeesport, Pa., to be completed in 1982. The plant was expected to produce 60,000 tons per year of DRI, from mill scale, as a feed for foundry cupolas and electric furnaces.

Luria Bros. & Co., Cleveland, Ohio, and Commercial Metals Co., Dallas, Tex., started a venture in February 1981 to market up to 300,000 tons annually of DRI produced by Nordfero of the Federal Republic of Germany. However, a decrease of $20 to $25 per ton in the price of No. 1 heavy melting scrap temporarily stopped import plans. In late 1981 and January 1982, the price for sponge iron from one Canadian producer having an oversupply was $91.54 per short ton, although Sidbec-Dosco (Canada) had a published price of $105.23 per short ton. Georgetown Texas Steel Co., Beaumont, Tex., in September temporarily abandoned a plant to construct a 200,000-ton-per-year DRI plant using the new MIDREX ELECTROTHERMAL D-R (EDR) process because of high interest rates and general economic uncertainty. The EDR process uses coal as reductant in an electrically heated shaft furnace.

By November 1981, foreign pig iron producers controlled nearly half of the U.S. market for the product by underselling U.S. producers by at least $25 per ton.

TRANSPORTATION

Increased freight rates and a shortage of general-purpose gondola railcars prompted some steelmakers to receive an increasing tonnage of ferrous scrap by trucks and barges. At yearend 1981, Class I railroads owned 142,300, 75-ton-average-capacity gondola cars, down from 147,650 at the end of 1980. Class I railroads put 2,600 new units in service and retired 7,950 units during 1981. Smaller railroads, including switching and terminal companies, added 500 units, making their total 11,350.

Class II railroads added 3,000 units. Railgon Corp. added 3,800 units and reached its 4,000-unit goal in October after a 15-month, $175.6 million construction program. In July, Conrail suspended a program that would have constructed 4,700 units by 1982.

Scrap iron gondola traffic normally represents 5% of the carloadings in the United States.

PRICES

Based on 1981 Iron Age composite prices in dollars per long ton delivered in the Pittsburgh, Chicago, and Philadelphia districts, No. 1 heavy melting steel scrap averaged $91.53 compared with $91.35 in 1980. In March 1981, the price was $105.23 and decreased to $75.63 in November. In general, the quoted prices of many other grades of scrap in these three districts attained a maximum in early April and a minimum at the end of November.

As quoted by Iron Age, delivered prices in 1981 for two types of stainless steel scrap in the Pittsburgh and Chicago districts in dollars per long ton were as follows: Bundles and solids, $642.79 average; $710.00 maximum in January and February, and $480.00 minimum in December. Turnings averaged $529.13, reaching a maximum of $592.50 in January and a minimum of $380.00 in December.

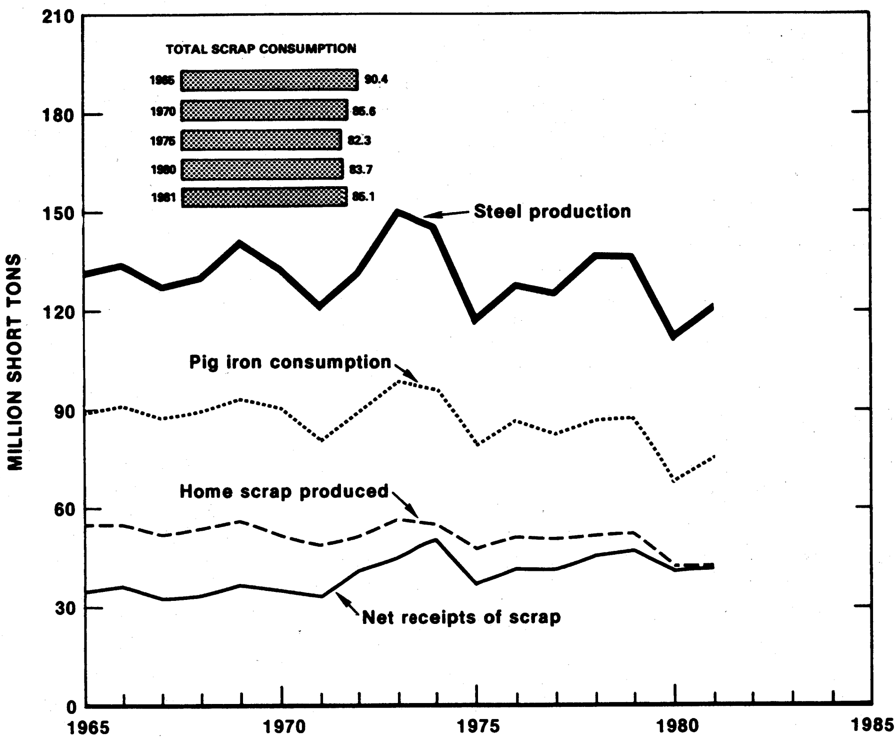

Figure 1.—Steel production (AISI), total iron and steel scrap consumption, pig iron consumption, home scrap production, and net scrap receipts.

FOREIGN TRADE

U.S. exports of ferrous, stainless, and alloy steel scrap to 64 countries in 1981 totaled 6,415,378 tons, valued at $638,644,000 or $99.55 average customs value per ton, $10.22 per ton less than in 1980. This tonnage was the smallest since 1977 when approximately 6 million tons were exported. Maximum exports of 693,679 tons in April 1981 decreased to 347,880 tons in July.

Exports of all types of ferrous scrap to 10 countries each receiving more than 100,000 tons totaled 5,963,290 tons, averaging $98.16 per ton, and ranging from $114.15 per ton for 896,453 tons to Mexico to $71.16 per ton for 737,244 tons to Canada. Collectively, the Republic of Korea, Japan, and Mexico received 3,327,960 tons, 51.9% of all exports, averaging $102.08 per ton. Twelve countries importing 10,000 to 100,000 tons of scrap from the United States received 396,592 tons averaging $100.40 per ton; 42 other countries received 55,496 tons averaging $240.87 per ton.

Of the total exports of scrap, 1,633,697 tons were shipped to Canada and Mexico through 12 customs districts, principally by surface transportation. Laredo, Tex., alone handled 646,136 tons. Scrap exports by water transportation totaled 4,781,681 tons. Of the total exports, 13 east coast districts accounted for 37.4%; six west coast districts reported 30.7%; while 11 districts on the Great Lakes and gulf coast handled 6.4%. Districts handling the largest tonnages in their respective areas were New York City, N.Y., with 938,917 tons; San Francisco, Calif., with 732,158 tons; Detroit, Mich., with 156,685 tons; and Tampa, Fla., with 115,345 tons.

In 1981, the Republic of Korea was the leading importer of U.S. scrap with 1,240,757 tons, compared with 1,190,750 tons to Japan.

The principal grades of scrap exported in 1981 were shredded steel, 1,923,233 tons at $93.40 average value per ton, and No. 1 heavy melting steel, 1,606,167 tons averaging $87.91 per ton.

Exports of stainless steel scrap totaled

63,545 tons, averaging $634.59 per ton. Japan received 29,466 tons at $642.52 per ton, and Spain received 14,472 tons at $617.64 per ton. Shipments to 23 other countries totaled 19,607 tons, averaging $635.17 per ton.

Exports of other ferrous alloy scrap totaled 98,341 tons averaging $227.90 per ton. Collectively, Taiwan, Japan, Canada, and Mexico received 93,429 tons at $221.58 per ton. Shipments to 18 other countries totaled 4,912 tons, averaging $348.14 per ton.

Spain purchased large tonnages of U.S. ferrous scrap because the United Kingdom, a prime supplier of scrap to Spain, had raised prices appreciably. Although it was a major producer of DRI, Mexico increased its dependence on U.S. scrap because of a high demand for steel by a rapidly growing petrochemical industry. Japan's smaller purchases of U.S. scrap were attributed to higher costs resulting from a weaker yen, a significant decrease in steel production, and the availability of Chinese scrap and pig iron.

Imports of iron and steel scrap not containing dutiable alloys totaled 535,653 tons averaging $98.95 per ton. Canada supplied 493,125 tons at $94.29 per ton; Mexico supplied 31,101 tons at $88.78 per ton; and 22 countries supplied 11,427 tons averaging $327.77 per ton.

Imports of iron or steel waste and scrap totaled 20,512 tons averaging $489.23 per ton. Canada furnished 18,085 tons at $428.15 per ton and 12 other countries supplied 2,427 tons at $944.39 per ton.

Imports of pig and cast iron free of dutiable alloy equaled 433,013 tons averaging $174.53 per ton. Imports in tons by countries and average values per ton were as follows: Canada, 234,979 tons averaging $195.71; Brazil, 138,950 tons at $140.95; the Republic of South Africa, 45,988 tons at $174.44; and 13,096 tons from six other countries at $151.07 per ton.

WORLD REVIEW

News items in various U.S. and foreign publications relating to foreign-produced DRI and pig iron show their impact on U.S. ferrous scrap exports and domestic pig iron producers. The domestic prices of DRI at $122.47 to $127.01 per short ton was about $20 more than the price per long ton of No. 1 bundles of ferrous scrap. Although the six DRI plants in the United States had an approximate 1.2-million-ton-per-year capacity, only two of the plants were in regular operation. Worldwide DRI capacity was about 30 million tons in 1980, from which about 8.0 million tons of commercial steelmaking grades were produced in 1981.

Shipbreaking was particularly active on small tonnage vessels in Pakistan and in Taiwan where vessels up to 100,000 lightweight tons could be broken in the Kaohsiung facility. Prices paid for ships scrapped in Pakistan and Taiwan ranged from $78 to $193 per lightweight ton. Plans were suggested to build or expand shipbreaking yards in Finland, Greece, Pakistan, and the United Arab Emirates. According to the International Association of Independent Tanker Owners, ships scrapped in 1981 included 41 very large cargo carriers. These vessels, totaling almost 10 million deadweight tons, comprised 4 tankers of 150,000 to 200,000 deadweight tons, 35 of 200,000 to 250,000 deadweight tons, and 2 over 250,000 deadweight tons.

Bangladesh.—A $180 million, 660,000-ton-per-year DRI plant was planned at Chittagong by a consortium comprising India's state-owned Metallurgical & Engineering Consultants and Austrian and Japanese companies.

Brazil.—Pig iron exports were expected to total 118,000 tons in August and September 1981. Taiwan was expected to take 49,000 tons; the United States, 30,000 tons; the Middle East, 15,000 tons; Argentina, 13,000 tons; and the European Communities (EC), 10,000 tons. However, Chinese pig iron reportedly replaced Brazilian material in the Japanese market.

SIDERBRAS of Brazil received governmental approval for the construction of a $35 million, 200,000-ton-per-year DRI plant that will use a solid fuel as reductant.

Burma.—A new 20,000-ton-per-year capacity Kinglor-Metor coal-based DRI plant was commissioned in September, and a contract for an identical unit was let by the Government to Danieli & C S.p.A., an Italian firm.

Canada.—A trend was developing whereby scrap processors and brokers exported less material to the United States and increased sales to expanding Canadian steel producers. Luria Bros. & Co., Inc., the largest U.S. scrap merchant, had a verbal agreement with Sidbec-Dosco, Ltd., of Canada, Montreal, Quebec, to market 100,000 to

150,000 tons of DRI in the United States in 1981. Lake Ontario Steel Co., Ltd. (Lasco), purchased 50% of the ferrous scrap operation of I. Waxman & Sons, Ltd., Hamilton, Ontario. Lasco, owned by Costeel International, Ltd., also in Whitby, owned four other scrapyards in Ontario to supply Lasco's 1-million-ton-per-year minimill with scrap.

China.—Japan increased imports of Chinese scrap. Some 4,175 tons were booked by individual customers in January alone. Kurimoto Ironworks, Japan, a leading producer of cast iron pipe, imported some 3,000 tons of Chinese scrap; nonintegrated steel producers also imported small tonnages from China.

China was expected to supply 650,000 tons or 68% of the pig iron to be imported by Japan in 1981. Most of the iron imported was of steelmaking quality although 60,000 to 70,000 tons brought in during the first 7 months of 1981 was foundry material. The Steel Authority of India, Ltd., contracted for 200,000 tons of pig iron from the China Metallurgical Import and Export Corp. at $95 per ton f.o.b., and Japanese buyers contracted for 200,000 tons of pig iron at $106 to $110 per ton. Some pig iron was sold to Japan through Hong Kong at $105 per ton, less than the $115 per ton charged for direct exports.

Colombia.—Design work was started on the state-owned Ferrominera 200,000- to 250,000-ton-per-year DRI plant estimated to require an $80 million investment. The plant will use iron ore pellets from Brazil, Venezuela, or Peru.

Egypt.—The Government and a NKK-led Japanese consortium agreed to operate the projected El Dikheila 800,000-ton-per-year DRI plant using Egyptian natural gas and iron ore from Brazil and Australia.

European Communities (EC).—The president of the ferrous division of the Bureau International de la Recuperation, representing 45 member countries, foresaw no EC restrictions on scrap exports or imports in any form. He believed that in the long run, sponge iron will have to compete pricewise with scrap, so long as it is available and on the market at a cheaper price. The EC dropped antidumping proceedings against imports of malleable cast iron from Brazil after that country's only producer and exporter, Fundicao Tupy SA, raised the price of its exports to EC. Low U.S. scrap prices encouraged increased flows of scrap to Italy and Spain to the detriment of EC exporters.

Germany, Federal Republic of.—Fried Krupp contracted with the Dravo Corp., Pittsburgh, Pa., to permit Dravo to sell and construct Krupp's coal-based Codir DRI plants in North and Central America and Australia. Hamburger Stahlwerke closed its Midrex DRI plant at yearend, and the plant was to be transferred to the Point Lisas site of the Iron & Steel Co. of Trinidad & Tobago (Iscott) to be used for a hot discharge-hot briquetting works fed by Iscott's own DRI modules.

A 60,000-ton-per-year DRI pilot plant passed its first trial in midyear at Badische Stahlwerke's Kehl works. The plant used a coal-reduction process developed jointly by Korf Stahl and Voest Alpine, the Austrian state-owned steel concern, a partner with Korf Engineering.

In early 1981, the world's first exclusively merchant direct reduction works was started by Norddeutsche Ferrowerke Nordfero in Emden to exploit the growing Eureopean DRI market. The plant is a joint effort of Nordfero, the Midrex owner Korf group, and the Norwegian iron ore miner and processor Sydvaranger. The new plant in August shipped 17,599 tons of DRI to Spain at a c.i.f. price of $137 per ton.

Viersener Metallhandel intalled a completely new process as a pilot project that was developed by Lindemann using an air system to separate residues from shredder scrap. Lindemann announced a new range of automobile shredders, claimed to be capable of reclaiming nearly 100% of the nonferrous metals without the need for shears or preshredders. Bankruptcy suits were filed by Metallhuttenwerke Lubeck GmbH, whose two Still coking batteries, with combined capacity of 440,000 tons per year, continued operation while awaiting a buyer.

Guam.—Short's Iron & Metal Co., Redding, Calif., started processing ferrous debris accumulated since World War II. About 90,000 tons of salable scrap was expected to be recovered from debris already collected by the Government.

India.—The Government in October proposed to import 200,000 tons of pig iron and 300,000 tons of DRI from Indonesia.

The 100% noncoking coal-based 30,000-ton-per-year DRI Paloncha plant was formally handed over to the national and state government-owned Sponge Iron India, Ltd., on June 5. Four DRI technology firms were competing for orders in India's coming DRI boom; in addition to Lurgi and Allis-Chalmers, Direct Reduction Corp. and

Krupp's Codir coal-based processes were involved. A proposed greenfield sponge iron plant at Maharashtra will use natural gas. The Indian Government's science and technology department studied the feasibility of a demonstration DRI plant based on technology from Sweden's Boliden. This plant's output would be used in domestic foundries. The Government's Metal Scrap Trade Corp. (MSTC) in August raised the price of integrated steelworks' home scrap by $18.30 per ton. This price increase was criticized by the Indian Foundry Association, whose members were the main market for this scrap. MSTC exempted from customs duty all categories of ferrous scrap used in electric arc furnaces. MSTC, in a joint venture called Ferro Scrap Nigam, Ltd., allowed a U.S. firm, Harsco Corp., Inc., a 40% holding interest. In 1981, India received 21,000 tons of pig iron from Pakistan.

Indonesia.—Indonesia's DRI-based Krakatau steelworks put into operation the third and fourth modules of its sponge iron plant in August and October, using Mexico's Hojalata y Lamina (HYL) technology. These two modules are rated at 1.1-million-ton-per-year capacity. The Krakatau plant shipped 13,000 tons of DRI to India in exchange for iron pellets. Indonesia PT Tosan received 33,000 tons of ferrous scrap from Australia.

Italy.—The increasing cost of energy and imported raw materials discouraged Danieli & C S.p.A. from continuing construction of the Kinglor-Metor two-module DRI plant at Cremona that was offered for sale and dismantled in April 1981. The pilot plant under construction at Piombino by the Italimpianti division of the Finsider group will be completed. Italimpianta was more interested in perfecting the technology process, called Flufer, because the firm was building a 130,000-ton-per-year plant scheduled to start operation in early 1982. Danieli indicated the direct cost per short ton of 92% metallized DRI in June 1980 as $108.94, distributed as iron ore, 52%; coal, 18%; natural gas, 17%; labor, 5%; electricity, 2%; consumables and spares, 2%; and retorts, 4%. At the same time, the cost of No. 1 heavy melting steel scrap, delivered at Acciarie Arvedi, was $101.00 per ton.

Japan.—In tests using HYL sponge by three major Japanese electric furnace operators on behalf of Nippon Direct Reduction Iron Development Co., it was shown that when using continuous charging of a 100-ton furnace the power consumption increased as the proportion of DRI was increased although the melting time was reduced. In two furnaces using batch charging, it was found that a higher ratio of DRI in the blend lowered the yield because of the tendency of the DRI to stick to the sides and bottom of the furnace.

Because of the general depressed production of the steel industry, nonintegrated steelmakers turned to low-priced pig iron and in the first 6 months of 1981 imported 200,000 tons from China. In the first 11 months of 1981, nonintegrated steel producers imported 140,000 tons of ferrous scrap from the U.S.S.R. and 53,000 tons from China.

In the first half of 1981, Japanese imports of ferrous scrap, in thousand tons, by country were as follows: United States, 744; Australia, 165; U.S.S.R., 62; United Kingdom, 42; Chile, 13; and China and Hong Kong, 7 each. Reportedly, Japanese imports of alloy steel scrap in the same time period totaled 36,200 tons of which the United States provided 15,400 tons, Hong Kong, 7,200 tons, and Taiwan, 6,000 tons.

Japanese ferrous scrap importers turned to the U.S. east coast because of large contracts placed on the U.S. west coast by South Korean buyers for available tonnages.

Libya.—A $300 million contract was signed April 5, 1981, for two MIDREX direct reduction modules for a steel mill complex at Misurata. Each 550,000-ton-per-year module will use natural gas as the reductant.

Malaysia.—The Government of the State of Sabah on May 19, 1981, signed a contract for a 600,000-ton-per-year Midrex Series module. The 92% metallized DRI will supply the steel industries of the Association of Southeast Asian Nations. Plant startup was scheduled for early 1984. On November 9, 1981, the Heavy Industries Corp. of Malaysia Berhad and Nippon Steel signed a letter of intent to construct a 600,000-ton-per-year DRI plant to be built in Trengganu. The Nippon process features high-pressure shaft furnace technology, the addition of soot to prevent the cohesion of solids in the high-temperature reducing zone, and hot briquetting of the product to prevent reoxidation.

Mexico.—The first commercially scaled HYL III continuous direct reduction plant for iron ore completed its first year of operation in May 1981, and was operating at a 330,690-short-ton-per-year rate. This plant can accommodate feeds comprising several kinds of iron ore pellets, combinations of pellets and lump ore, or 100% lump ore.

Netherlands.—On July 1, 1981, the Ministry of Economic Affairs removed the duty on exports of alloy scrap including stainless steel and chrome steel. However, any export of alloy scrap will remain subject to export licensing.

New Zealand.—Lurgi Chemie and Huttentechnik of the Federal Republic of Germany and Davy McKee of the United Kingdom completed a basic engineering study in early 1981 for the expansion of New Zealand Steel's plant by the addition of four new SL/RN kilns. The expansion plan was submitted to the New Zealand Government for approval.

Nigeria.—Work was completed on the first of two Midrex Series 600 DRI modules ordered by the Nigerian state-owned steelmaker Delta Steel Co., Ltd. The November startup awaited developments related to the company's oxide pellet plant that apparently awaited lime delivery from nearby Calabar.

Peru.—Fried. Krupp GmbH signed a contract with Siderperu on December 15, 1980, to supply a Codir 292,000-ton-per-year DRI plant at the Chimbote works. The project work was to be started after financing contracts were signed.

Philippines.—The ministeelworks of the National Steel Corp., Iligan City, Mindanao, contacted United States Steel Corp.'s subsidiary USS Engineers and Consultants to perform the engineering and act as consultants on the construction of a 1.2- to 1.4-million-ton-per-year DRI plant. Allis-Chalmers Corp. held exploratory talks with U.S. steelmaker Armco's Philippine subsidiary, Marsteel Corp., and with its own plant distributor, Engineering Equipment, Inc., on prospects for a private sector DRI works.

South Africa, Republic of.—The Direct Reduction Corp. of the United States in early 1981 won its first coal-based DRI order from the Republic of South Africa's Scaw Metals, Ltd. The plant will use a rotary kiln rated at 75,000 tons per year of product at 90% metallization.

Spain.—The pellet and DRI project of Presursa was approved by the Spanish cabinet in April. The investment of $255.6 million covers the construction of a 1.12-million-ton-per-year pellet plant at Fregenal de la Sieria using 3 million tons of ore from mines at Badajoz and Huelva, and a Midrex DRI plant in Huelva with a 774,000-ton-per-year capacity at 92% metallization. The DRI sponge plant will consume 248 million cubic meters of gas annually from wells near the Gulf of Cadiz.

Luria Bros. & Co., Inc., closed its Spanish subsidiary Luria Europe, Inc., and will in the future handle its Spanish scrap business through an exclusive agent, Mariano Detorres.

Sweden.—The Swedish special steelmaker AB Svenska Kullagerfabriken in February completed the first phase of its DRI plant using its Plasmared process. Energy consumption was kept within the expected level of about 2.1 gigacalories per ton of product at 90% metallization.

Thailand.—The Royal Thai Navy opposed the siting of a projected 2.1-million-ton-per-year DRI-based integrated steelworks at Ban Mab Cha Lud in Rayong Province because some of the navy's docks would have to be transferred to the steelworks.

U.S.S.R.—The scrap steel group is part of the steel industry and is responsible for the collection, processing, and sale of ferrous scrap in all parts of the Soviet Union. Deliveries are allocated to steelmakers based on their production plans. About half of the scrap consumed is supplied by the central agency; the balance is home production scrap.

United Kingdom.—On several occasions, the British Steel Corp. entirely suspended scrap purchases. Because of the closure of many steel plants and other heavy industrial plants, thousands of tons of good scrap was available for the cost of dismantling. In the third quarter of 1981, British steelmakers held 770,000 tons of scrap, a 6- to 8-week supply.

Many scrap consumers, particularly foundries, had monetary liquidity problems. Indecision among foundries ended Lazard Bros.' self-financing scheme to reduce by 25%, or 30,000 to 50,000 tons per year, the capacity of the United Kingdom's light to medium steel castings industry.

More than 30 members of the British Scrap Federation ceased trading or closed yards because of the reduced domestic demand, the decline in prices, rising freight rates, and world competition. R. Taylor & Sons (Scrap), Ltd., Bury, withdrew from the export market for an indefinite period. The major goal of scrap processors was to increase exports, which in 1981 nearly attained 3 million tons valued at $265 million. Scrap cargoes up to 25,000 tons could be handled at Barry, Cardiff, London, Newport, and Swansea.

A license to export ferrous alloy scrap was only possible if the exporter could show purchase refusals by six domestic consumers. Eisenlegierungem Handelgesellschaft GmbH established a new British firm called ELG Metals, Ltd., in Rotterdam, to trade in scrap stainless steel and scrap high-speed steel and cobalt and titanium and their alloys. Procor (UK), Ltd., was building 40 70-ton railcars to transport scrap.

Venezuela.—In 1981, Fior de Venezuela S.A. shipped 271,376 tons of briquetted DRI from its plant in Ciudad Guayana for $107.05 per ton. Eight shipments to the United States totaled 203,512 tons.

Zambia.—The Government sold as scrap the plant and equipment from the Tika steelworks that was 70% completed when abandoned.

TECHNOLOGY

Ford Motor Co., in its Rawsonville, Mich., powder-parts division, developed a new process for converting light, ductile scrap into iron powder. The scrap is made brittle by heat treatment before grinding.[6]

A study for the U.S. Environmental Protection Agency (EPA) Municipal Environmental Research Laboratory indicated that eight resource recovery facilities operating on municipal solid wastes did not provide the least cost mode of disposal and that increased ferrous recovery would not have resulted in cost break-even operations in any of the facilities.[7]

Electric furnace operators showed less interest in factory bundles of scrap because of electrode breakage problems. Instead, they preferred easier to handle and quickly charged No. 1 busheling, structural, plate, and shredded scrap and No. 1 heavy melting grades.[8]

In 1980, the Bureau of Mines issued a publication dealing with the availability of critical scrap metals containing chromium in the United States.[9]

National Steel Corp., at its Great Lakes steel plant, adopted the Kloeckner-Maximilianshuette process to modify an existing basic oxygen furnace (BOF) by installing tuyeres in the bottom of the vessel to permit the injection of oil with oxygen to preheat scrap. This was expected to increase the scrap charge from approximately 30% to 40% or 45%. Two additional BOF vessels were to be modified at the company's Granite City, Ill., plant by yearend 1981.[10]

A scrap metals research program begun in 1978 by the Bureau of Mines in cooperation with the National Association of Recycling Industries was extended until 1983. The $600,000-per-year program comprises four projects including the recovery of recyclable wastes from automobile shredding and a detinning process for steel cans.[11]

Based on 20 pilot heats using different amounts of scrap in each, Bureau of Mines metallurgists concluded that electric arc furnaces can produce acceptable grades of steel even when using charges containing more than 50% of scrap from municipal refuse processing facilities. The Midwest Research Institute, in a report to the EPA, indicated that the agency should reach a balance between acceptable levels of ambient air quality standards and maintaining the economic viability of the foundry industry.[12]

The Krupp Research Institute, Essen, developed and tested the Coal-Oxygen-Injection (COIN) process for preheating and melting scrap and sponge iron. The process includes the afterburning of carbon monoxide above the bath and the injection of a secondary fuel. The process can be used in BOF practice, thereby replacing the electric arc furnace for straight melting. In combination with a direct reduction process, the COIN process is suitable for producing steel from ore using coal fines and oxygen.[13]

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[1]Physical scientist, Division of Ferrous Metals.

[2]All quantities are in short tons unless otherwise noted.

[3]Swager, W. L., H. W. Lownie, Jr., and C. E. Mobley. Potential Effect of Ferrous Scrap Composition Changes on the Quality of Iron and Steel Castings. BuMines OFR 37-82, 1981, 226 pp.; available from National Technical Information Service, Springfield, VA 22161, PB 82-194184.

[4]American Metal Market. Hunter Sees Stainless Scrap Shortage. V. 89, No. 208, Oct. 27, 1981, p. 10.

[5]Bennett, K. W. Foundries Find the Recession Cramping Their Capacity. Iron Age, v. 225, No. 3, Jan. 22, 1982, pp. 37, 39, 45.

[6]American Metal Market. Process for Turning Machine Scrap Into Powder Being Developed by Ford. V. 89, No. 88, May 23, 1981, p. 4.

[7]Klingshirm, J. V., and O. W. Albrecht. Impediments to Energy and Materials Recovery for Municipal Solid Waste. EPA Project Summary. EPA-600/S2-81-1981, October 1981, 4 pp.

[8]Howard, H. P'gh Mart Seen Strengthening for Electric Furnace Grades. Am. Metal Market, v. 90, No. 244, Dec. 18, 1981, p. 9.

[9]Kusik, C. L., H. V. Makar, and M. R. Mounier. Availability of Critical Scrap Metals Containing Chromium in the United States. Wrought Stainless Steels and

Heat-Resisting Alloys. Bureau of Mines IC 8822, 1980, 51 pp.

[10]National Steel Corp. News. Oct. 23, 1979, p. 3.

[11]American Metal Market. BuMines' Scrap Program Extended Through 1983. V. 89, No. 36, July 16, 1981, p. 18.

[12]———. Refuse Scrap OK for Arc Furnaces. V. 90, No. 26, Feb. 8, 1982, p. 28.

[13]Hartwig, J., and D. Neuschutz. New Process Developments in Melting Scrap and Sponge Iron. Iron and Steel Eng., v. 59, No. 2, February 1982, pp. 36-42.

Table 2.—U.S. consumer receipts, production, consumption, shipments, and stocks of iron and steel scrap and pig iron in 1981, by grade

(Thousand short tons)

Grade	Receipts of scrap		Production of home scrap		Consumption of both purchased and home scrap (includes recirculating scrap)	Shipments of scrap	Ending stocks, Dec. 31
	From brokers, dealers, other outside sources	From other own-company plants	Recirculating scrap resulting from current operations	Obsolete scrap (includes ingot molds, stools, scrap from old equipment, buildings, etc.)			
MANUFACTURERS OF PIG IRON AND RAW STEEL AND CASTINGS[1]							
Carbon steel:							
Low-phosphorus plate and punchings	399	7	33	6	425	37	32
Cut structural and plate	550	139	632	--	1,385	11	93
No. 1 heavy melting steel	8,140	2,500	14,583	110	23,142	2,030	2,315
No. 2 heavy melting steel	2,043	215	922	2	3,167	101	423
No. 1 and electric-furnace bundles	5,845	439	2,606	(2)	8,629	151	1,075
No. 2 and all other bundles	1,646	80	78	--	2,071	15	246
Electric furnace 1 foot and under (not bundles)	45	(2)	(2)	(2)	49	--	7
Railroad rails	148	(2)	(2)	--	144	(2)	15
Turnings and borings	1,221	103	455	1	1,658	97	141
Slag scrap (Fe content 70%)	1,221	53	3,728	--	4,455	405	223
Shredded or fragmentized	2,643	621	31	--	3,297	7	259
No. 1 busheling	1,249	16	76	1	1,328	12	118
All other carbon steel scrap	2,328	328	9,501	20	11,205	761	689
Stainless steel scrap	406	39	467	14	872	34	102
Alloy steel (except stainless)	252	193	1,528	12	1,773	138	321
Ingot mold and stool scrap	351	608	977	1,613	2,516	762	664
Machinery and cupola cast iron	1	7	2	3	151	15	49
Cast iron borings	293	11	114	3	343	163	20
Motor blocks	4	--	--	--	3	--	1
Other iron scrap	588	62	586	10	934	349	266
Other mixed scrap	337	140	309	1	797	24	72
Total[3]	29,708	5,562	36,628	1,796	68,343	5,111	7,130
MANUFACTURERS OF STEEL CASTINGS[4]							
Carbon steel:							
Low-phosphorus plate and punchings	545	15	195	--	761	2	45
Cut structural and plate	193	13	22	--	224	1	16
No. 1 heavy melting steel	148	13	61	--	228	6	19
No. 2 heavy melting steel	64	--	10	--	76	(2)	6
No. 1 and electric-furnace bundles	35	1	2	--	37	--	1
No. 2 and all other bundles	10	1	1	--	12	--	(2)
Electric furnace 1 foot and under (not bundles)	79	--	24	--	98	1	6
Railroad rails	3	--	--	--	3	--	(2)
Turnings and borings	43	1	22	--	51	7	2
Slag scrap (Fe content 70%)	--	--	(2)	--	--	(2)	(2)
Shredded or fragmentized	47	--	--	--	47	--	3
No. 1 busheling	14	(2)	--	--	12	--	3
All other carbon steel scrap	389	13	259	2	654	1	36
Stainless steel scrap	12	1	24	--	36	(2)	5
Alloy steel (except stainless)	68	2	105	(2)	168	2	25
Ingot mold and stool scrap	2	--	(2)	--	2	1	1
Machinery and cupola cast iron	3	--	1	--	3	--	(2)
Cast iron borings	68	2	26	--	82	1	6
Motor blocks	(2)	--	--	--	(2)	--	(2)
Other iron scrap	57	1	49	(2)	101	5	11
Other mixed scrap	(2)	--	6	--	6	--	(2)
Total[3]	1,781	62	808	2	2,602	27	185

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 1981, 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							
Carbon steel:							
Low-phosphorus plate and punchings	702	95	80	(2)	863	9	54
Cut structural and plate	1,426	141	99	(2)	1,628	5	98
No. 1 heavy melting steel	113	38	65	--	182	36	11
No. 2 heavy melting steel	81	--	22	1	101	2	4
No. 1 and electric-furnace bundles	132	44	57	(2)	241	1	5
No. 2 and all other bundles	307	8	--	--	312	(2)	31
Electric furnace 1 foot and under (not bundles)	91	64	1	--	158	--	4
Railroad rails	131	--	(2)	(2)	125	(2)	18
Turnings and borings	481	61	18	(2)	565	23	48
Slag scrap (Fe content 70%)	13	--	(2)	--	15	(2)	7
Shredded or fragmentized	793	1	(2)	1	788	1	75
No. 1 busheling	173	18	14	--	208	18	7
All other carbon steel scrap	695	301	139	(2)	1,178	11	36
Stainless steel scrap	10	--	19	(2)	26	3	3
Alloy steel (except stainless)	21	(2)	5	1	24	4	10
Ingot mold and stool scrap	146	2	56	6	197	9	48
Machinery and cupola cast iron	945	135	456	1	1,577	6	100
Cast iron borings	679	154	177	1	1,003	34	38
Motor blocks	539	9	297	17	809	5	53
Other iron scrap	705	143	2,140	20	2,949	97	107
Other mixed scrap	356	521	323	7	1,204	6	48
Total[3]	8,541	1,735	3,969	57	14,152	271	804
TOTAL—ALL TYPES OF MANUFACTURERS[3]							
Carbon steel:[4]							
Low-phosphorus plate and punchings	1,645	117	309	6	2,049	49	132
Cut structural and plate	2,169	294	753	(2)	3,236	17	207
No. 1 heavy melting steel	8,401	2,552	14,710	110	23,552	2,072	2,346
No. 2 heavy melting steel	2,188	215	954	3	3,344	103	432
No. 1 and electric-furnace bundles	6,013	484	2,665	1	8,907	152	1,082
No. 2 and all other bundles	1,963	89	79	--	2,394	15	277
Electric furnace 1 foot and under (not bundles)	215	64	25	(2)	305	1	17
Railroad rails	282	(2)	(2)	(2)	272	(2)	33
Turnings and borings	1,744	165	495	2	2,275	127	192
Slag scrap (Fe content 70%)	1,234	53	3,729	--	4,469	405	230
Shredded or fragmentized	3,483	622	31	1	4,132	8	337
No. 1 busheling	1,436	34	91	1	1,548	30	127
All other carbon steel scrap	3,412	641	9,899	22	13,037	773	760
Stainless steel scrap	428	40	510	14	934	37	110
Alloy steel (except stainless)	341	195	1,638	13	1,965	144	355
Ingot mold and stool scrap	499	610	1,033	1,619	2,715	771	712
Machinery and cupola cast iron	949	142	458	4	1,732	21	149
Cast iron borings	1,040	167	317	4	1,428	198	64
Motor blocks	543	9	297	17	812	5	54
Other iron scrap	1,350	207	2,775	31	3,984	451	383
Other mixed scrap	693	660	638	8	2,007	30	120
Grand total[3]	40,030	7,359	41,405	1,855	85,097	5,408	8,118

[1]Includes only those castings made by companies producing raw steel.
[2]Less than 1/2 unit.
[3]Data may not add to totals shown because of independent rounding.
[4]Excludes companies that produce both raw steel and steel castings.

Table 3.—U.S. consumer receipts, production, consumption, shipments, and stocks of pig iron and direct-reduced iron in 1981

(Thousand short tons)

	Receipts	Production	Consumption	Shipments	Stocks, Dec. 31
MANUFACTURERS OF PIG IRON AND RAW STEEL AND CASTINGS					
Pig iron	2,276	73,755	73,011	3,955	786
MANUFACTURERS OF STEEL CASTINGS					
Pig iron	47	--	46	(1)	5
IRON FOUNDRIES AND MISCELLANEOUS USERS					
Pig iron	1,962	--	1,983	5	68
TOTAL—ALL TYPES OF MANUFACTURERS					
Pig iron	4,285	73,755	75,040	[2]3,959	859
Direct-reduced or prereduced iron	472	W	611	W	74

W Withheld to avoid disclosing company proprietary data.
[1]Less than 1/2 unit.
[2]Data do not add to total shown because of independent rounding.

Table 4.—Consumption of iron and steel scrap and pig iron in the United States in 1981, 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]	4,046	--	--	--	--	--	4,046	--
Basic oxygen process[3]	23,278	62,162	--	--	--	--	23,278	62,162
Open-hearth furnace	7,450	8,862	48	5	--	(4)	7,498	8,867
Electric furnace	32,467	260	2,430	40	4,745	283	39,642	583
Cupola furnace	37	175	114	(4)	8,961	511	9,113	685
Other (including air furnace)[5]	1,065	208	10	1	446	44	1,520	254
Direct castings[6]	--	1,344	--	--	--	1,145	--	2,489
Total	68,343	73,011	2,602	46	14,152	1,983	85,097	75,040

[1]Data may not add to totals shown because of independent rounding.
[2]Includes consumption in all 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]Includes vacuum melting furnaces and miscellaneous uses.
[6]Includes ingot molds and stools.

Table 5.—Proportion of iron and steel scrap and pig iron used in the United States in 1981, by type of furnace

(Percent)

Type of furnace	Scrap	Pig iron
Basic oxygen process	27.2	72.8
Open-hearth furnace	45.8	54.2
Electric furnace	98.6	1.4
Cupola furnace	93.0	7.0
Other (including air furnace)	85.7	14.3

Table 6.—Iron and steel scrap supply[1] available for consumption in 1981, 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, Vermont	1,461	107	1,169	25	2,762	182	2,580
Pennsylvania	5,565	2,422	9,111	566	17,665	1,936	15,729
Total[2]	7,026	2,530	10,281	591	20,427	2,118	18,310
North Central:							
Illinois	4,387	625	3,469	52	8,533	198	8,334
Indiana	2,436	143	8,204	469	11,251	975	10,276
Iowa, Kansas, Michigan, Minnesota, Missouri	5,355	1,559	2,731	48	9,693	149	9,545
Ohio	5,295	1,352	6,860	310	13,817	1,229	12,588
Wisconsin	708	10	523	([4])	1,242	21	1,221
Total[2]	18,181	3,689	21,788	878	44,536	2,572	41,964
South Atlantic:							
Delaware, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, West Virginia	4,413	243	2,916	183	7,754	189	7,565
South Central:							
Alabama, Arkansas, Kentucky, Louisiana, Mississippi, Oklahoma, Tennessee, Texas	7,095	603	4,102	111	11,911	343	11,568
Mountain and Pacific:							
Arizona, California, Colorado, Hawaii, Montana, Nevada, Oregon, Utah, Washington	3,315	294	2,319	92	6,020	187	5,833
Grand total[2]	40,030	7,359	41,405	1,855	90,649	5,408	85,241

[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.
[4]Less than 1/2 unit.

Table 7.—Consumption of iron and steel scrap and pig iron[1] in 1981, by region and State

(Thousand short tons)

Region and State	Pig iron and steel ingots and castings		Steel castings		Iron foundries and miscellaneous users		Total[2]	
	Scrap	Pig iron	Scrap	Pig iron	Scrap	Pig iron	Scrap	Pig iron
New England and Middle Atlantic:								
Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, Vermont	1,643	2,327	116	5	867	79	2,626	2,412
Pennsylvania	14,312	13,847	333	11	891	585	15,536	14,444
Total[2]	15,955	16,174	448	16	1,758	665	18,161	16,855
North Central:								
Illinois	6,999	5,101	328	(3)	1,052	331	8,379	5,432
Indiana	9,476	18,222	185	5	629	60	10,290	18,287
Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska	5,636	5,643	299	1	3,849	295	9,784	5,939
Ohio	9,684	11,478	206	13	2,504	390	12,394	11,880
Wisconsin	--	--	267	1	965	68	1,232	69
Total[2]	31,795	40,444	1,285	19	8,999	1,144	42,079	41,607
South Atlantic:								
Delaware, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, West Virginia	7,253	W	49	2	710	42	8,012	44
South Central:								
Alabama, Arkansas, Kentucky, Louisiana, Mississippi, Oklahoma, Tennessee, Texas	8,482	[4]12,155	461	4	2,158	109	11,101	12,268
Mountain and Pacific:								
Arizona, California, Colorado, Hawaii, Montana, Nevada, Oregon, Utah, Washington	4,856	4,238	359	5	529	23	5,744	4,266
Grand total[2]	68,343	73,011	2,602	46	14,152	1,983	85,097	75,040

W Withheld to avoid disclosing company proprietary data.
[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, 1981, 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, Vermont	199	21	17	59	2	297	256
Pennsylvania	1,540	42	161	345	40	2,127	225
Total[1]	1,739	63	177	403	42	2,425	481
North Central:							
Illinois	607	5	24	72	(2)	708	24
Indiana	618	5	14	305	2	943	25
Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska	355	5	1	69	16	446	21
Ohio	614	16	95	126	5	857	76
Wisconsin	12	1	(2)	9	(2)	23	5
Total[1]	2,207	32	135	581	23	2,977	151

See footnotes at end of table.

Table 8.—Consumer stocks of iron and steel scrap and pig iron, December 31, 1981, by region and State —Continued

(Thousand short tons)

Region and State	Carbon steel (excludes rerolling rails)	Stainless steel	Alloy steel (excludes stainless)	Cast iron (includes borings)	Other grades of scrap	Total scrap stocks[1]	Pig iron stocks
South Atlantic:							
Delaware, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, West Virginia	626	W	15	69	2	712	15
South Central:							
Alabama, Arkansas, Kentucky, Louisiana, Mississippi, Oklahoma, Tennessee, Texas	1,019	[3]14	19	192	20	1,264	183
Mountain and Pacific:							
Arizona, California, Colorado, Hawaii, Montana, Nevada, Oregon, Utah, Washington	580	1	9	116	33	740	29
Grand total[1]	6,171	110	355	1,362	120	8,118	859

W Withheld to avoid disclosing company proprietary data.
[1]Data may not add to totals shown because of independent rounding.
[2]Less than 1/2 unit.
[3]Includes South Atlantic region.

Table 9.—Average monthly price and composite price for No. 1 heavy melting scrap in 1981

(Per long ton)

Month	Chicago	Pittsburgh	Philadelphia	Composite price[1]
January	$95.50	$104.50	$95.75	$98.58
February	101.25	105.75	91.50	99.50
March	108.10	116.10	91.50	105.23
April	104.50	110.75	90.00	101.75
May	96.75	105.00	84.50	95.42
June	88.50	100.10	79.50	89.37
July	88.50	102.50	79.50	90.17
August	97.50	107.10	79.30	94.63
September	91.25	101.50	78.50	90.42
October	81.00	93.00	69.50	81.17
November	75.50	84.90	66.50	75.63
December	75.50	87.25	66.50	76.42
Average 1981	91.99	101.54	81.05	91.52
Average 1980[r]	87.05	95.00	92.00	91.35

[r]Revised.
[1]Composite price, Chicago, Pittsburgh, and Philadelphia.

Source: Iron Age, Jan. 4, 1982.

Table 10.—U.S. exports of iron and steel scrap, by country

(Thousand short tons and thousand dollars)

Country	1977		1978		1979		1980		1981	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Canada	522	23,847	795	41,698	861	60,275	790	57,507	737	52,463
Greece	300	17,192	340	25,079	500	52,395	545	57,484	271	25,452
Italy	208	18,441	657	54,522	1,186	124,361	892	101,865	34	2,407
Japan	1,036	61,927	3,190	238,979	2,922	305,509	2,838	308,784	1,191	117,724
Korea, Republic of	1,441	88,668	1,503	117,742	1,418	152,483	1,736	192,745	1,241	114,736
Mexico	322	22,555	450	35,808	814	85,098	1,134	137,273	896	102,329
Spain	784	46,909	744	53,038	1,400	127,592	1,163	114,837	434	34,570
Taiwan	435	35,647	394	41,126	634	70,004	990	125,716	374	59,874
Turkey	310	20,044	258	19,583	242	23,482	318	31,363	364	31,814
Other	496	45,811	708	70,662	1,077	141,207	762	98,367	874	97,274
Total[1]	5,854	381,041	9,039	698,237	11,054	1,142,406	11,168	1,225,941	6,415	638,644

[1]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	1977		1978 [1]		1979 [1]		1980 [1]		1981 [1]	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Exports:										
No. 1 heavy melting scrap	1,750	107,089	2,362	175,933	2,697	269,845	2,907	297,666	1,606	141,205
No. 2 heavy melting scrap	594	33,870	837	56,433	1,117	104,017	1,067	102,137	618	51,630
No. 1 bundles	103	2,442	148	11,231	145	14,455	119	11,542	41	3,476
No. 2 bundles	336	14,429	326	17,055	652	46,889	314	24,852	273	18,993
Stainless steel scrap	75	37,154	115	44,439	112	66,118	125	78,034	63	40,307
Shredded steel scrap	1,606	97,602	2,684	198,377	2,980	308,383	3,323	345,946	1,923	179,626
Borings, shovelings, turnings	476	17,916	750	33,163	889	59,467	769	50,381	486	24,757
Other steel scrap [2]	601	49,960	1,382	128,350	1,828	211,352	1,762	240,886	903	127,937
Iron scrap	314	20,579	434	33,258	632	61,879	783	74,497	501	50,714
Total [3]	5,854	381,041	9,039	698,237	11,054	1,142,406	11,168	1,225,941	6,415	638,644
Ships, boats, other vessels (for scrapping)	35	2,613	2	232	73	5,436	169	18,340	52	3,643
Rerolling material	321	31,691	50	5,528	70	10,222	86	12,768	57	10,831
Total [3]	6,211	415,345	9,090	703,996	11,197	1,158,064	11,423	1,257,049	6,524	653,118
Imports for consumption:										
Iron and steel scrap	614	40,501	794	50,220	760	70,804	582	61,192	556	62,126

[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 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

(Thousand short tons and thousand dollars)

Country	1977		1978[1]		1979[1]		1980[1]		1981[1]	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Korea, Republic of	99	9,371	--	--	2	172	4	538	--	--
Mexico	21	2,061	38	4,176	57	8,614	65	10,848	55	10,267
Pakistan	18	742	7	470	--	--	2	185	--	--
Thailand	133	14,078	--	--	--	--	--	--	--	--
Turkey	16	1,709	--	--	--	--	--	--	--	--
Other	34	3,730	6	882	11	1,436	14	1,197	2	564
Total[2]	321	31,691	50	5,528	70	10,222	86	12,768	57	10,831

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

Table 13.—U.S. imports for consumption of iron and steel scrap,[1] by country

Country	1980		1981	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Austria	18	$161	--	--
Belgium-Luxembourg	71	159	153	$8
Canada	499,271	51,935	511,209	52,600
Germany, Federal Republic of	125	322	939	140
Japan	24,827	943	1,114	2,628
Mexico	25,792	2,548	31,112	2,797
Netherlands	7,900	516	211	206
Panama	8,422	600	15	6
Sweden	7,787	1,266	2,336	676
United Kingdom	457	1,424	2,423	1,770
Other	6,843	1,318	6,653	1,295
Total	[2]581,512	61,192	556,165	62,126

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

Table 14.—Iron and steel scrap consumption, by continent and country[1]

(Thousand short tons)

Continent, country group, and country	1976	1977	1978	1979	1980
North America:					
Canada[2 3 4 5]	[r]7,131	7,683	8,622	9,145	9,395
United States[2 5]	[r]89,909	[r 6]92,138	[r 6]99,223	[6]98,901	[6]83,710
Latin America:[7]					
Argentina	1,657	1,892	1,523	1,775	[e]1,490
Brazil	4,644	5,044	5,800	[8]6,497	[8]7,119
Chile	186	227	177	[r e]200	[e]215
Colombia	229	250	183	[e]170	[e]190
Mexico	3,406	2,690	3,097	[r e]3,220	[e]3,230
Peru	185	184	150	[e]170	[e]185
Uruguay	34	55	57	[e]60	[e]55
Venezuela	499	583	602	[r e]550	[e]550
Central America, not further detailed	67	57	61	[e]60	[e]60
Europe:					
European Economic Community:					
Belgium[2]	4,032	3,728	4,182	4,467	4,065
Denmark[3 9 10]	[r]854	862	1,068	999	894
France[3 4 5]	8,964	8,282	9,018	8,941	8,748
Germany, Federal Republic of[5]	23,263	22,262	23,359	23,993	22,401
Ireland	75	60	[r]87	[11]93	[11]3
Italy[3]	16,362	16,629	17,897	[r]17,928	[11]19,825
Luxembourg	1,577	1,555	1,942	1,968	1,738
Netherlands	1,957	1,857	2,030	2,166	2,025

See footnotes at end of table.

Table 14.—Iron and steel scrap consumption, by continent and country[1] —Continued

(Thousand short tons)

Continent, country group, and country	1976	1977	1978	1979	1980
Europe —Continued					
European Economic Community —Continued					
United Kingdom	18,534	17,070	16,902	[r]16,761	10,248
European Free Trade Association:					
Austria	[r]1,992	1,789	1,926	2,013	[11]1,903
Finland	[3]634	898	[3]832	[3]819	[3]848
Norway[2 4 5]	593	[3]485	[r e]490	[r]607	[e]605
Portugal	219	396	[r]491	[e]520	[e]520
Sweden[2 3]	3,468	2,679	[r]2,872	[r]3,045	[e]2,730
Council for Mutual Economic Assistance:					
Bulgaria[e]	680	750	720	[r]805	860
Czechoslovakia[2 4 5]	8,088	8,216	8,173	8,438	[e]8,490
German Democratic Republic[2 3 4 5]	5,117	4,730	[r]5,040	[r]5,545	5,833
Hungary	2,420	2,467	2,566	2,595	2,528
Poland	10,352	11,083	12,518	11,597	11,817
Romania[e]	[r]3,605	3,890	4,080	[r]4,190	4,300
U.S.S.R.[e]	52,800	52,800	[r]54,450	[r]53,020	52,690
Other:					
Greece[e]	170	180	300	330	340
Spain	[3 4 5]7,759	[3 4 5]8,111	[3 4 5]8,726	[r]7,961	[11]9,195
Yugoslavia[3 4 5]	1,747	1,921	2,249	2,272	2,287
Africa: South Africa, Republic of[12]	[r]3,099	3,147	3,656	[e]3,800	[e]3,890
Asia:					
China[e]	7,000	7,000	8,000	8,000	8,000
India[e]	[r]4,080	[r]4,300	[r]4,400	[r]4,400	4,080
Japan	42,138	38,147	43,445	[r]50,292	[11]48,291
Korea, Republic of[e]	1,300	1,800	1,860	1,800	2,200
Taiwan[e 13]	400	550	600	760	700
Turkey[2 5]	[r]1,017	[14]1,279	[14]1,017	[e]1,100	[e]1,100
Oceania:					
Australia	2,697	2,105	[15]2,448	[r 16]2,639	[e]2,770
New Zealand	[e]165	[14]181	[e]182	[r 15]160	[e]160
Total	[r]345,105	[r]342,012	[r]367,021	[r]374,772	352,283

[e]Estimated. [r]Revised.

[1]Unless otherwise noted, figures represent reported actual consumption of iron and steel scrap utilized in the production of pig iron, ferroalloys, crude steel, foundry products, and rerolled steel, as well as in other unspecified uses by 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. 8, 1980, New York, 1981, 94 pp., which is the source of all data unless otherwise noted. (All estimates included are made by the U.S. Bureau of Mines.)

[2]Excludes scrap consumed by steel rerollers.

[3]Excludes scrap consumed in iron foundries.

[4]Excludes scrap consumed within the steel industry for purposes other than the manufacture of pig iron, ferroalloys, crude steel, foundry products, and rerolled steel.

[5]Excludes scrap consumed outside the steel industry.

[6]Source: U.S. Bureau of Mines.

[7]Source (except where individually noted as an estimate or another specific source): 1976-77—Instituto Latinoamericano del Fierro y el Acero. Statistical Yearbook of Steelmaking and Iron Ore Mining in Latin America, 1977. Santiago, 1979, 178 pp.; 1978—Instituto Latinamericano del Fierro y el Acero. Siderurgia Latinoamericano, No. 243, July 1980, p. 56. Source does not provide details on what is included; presumably figures represent total steel industry scrap consumption, excluding scrap used outside the steel industry.

[8]Source: Iron and Steel Statistics Bureau (United Kingdom). International Steel Statistics, Brazil 1980. London 1981, p. 4.

[9]Excludes scrap consumed by pig iron producers.

[10]Includes scrap used in production of steel castings in shipyards.

[11]Source: Organization for Economic Cooperation and Development. The Iron and Steel Industry in 1980. Paris 1982, p. 15.

[12]Source: Iron and Steel Statistics Bureau (United Kingdom). International Steel Statistics, South Africa. 1978, p. 4; 1979, p. 4.

[13]Excludes a substantial tonnage derived from shipbreaking possibly of the order of several million tons annually for electric furnace equipped steel mills.

[14]Source: Organization for Economic Cooperation and Development. The Iron and Steel Industry in 1978. Paris 1980, 40 pp.

[15]Source: Organization for Economic Cooperation and Development. The Iron and Steel Industry in 1979. Paris 1981, 32 pp.

[16]Source: Iron and Steel Statistics Bureau (United Kingdom). International Steel Statistics, Australia 1980. London 1981, p. 4.

Table 15.—Iron and steel scrap imports, by continent and country[1]

(Thousand short tons)

Continent, country group, and country	1976	1977	1978	1979	1980
North America:					
Canada	907	644	1,052	1,156	1,119
United States[2]	507	625	794	[r]761	582
Latin America:					
Argentina	[2]79	[2]177	[2]18	[e]22	[e]22
Brazil[2]	([3])	([3])	([3])	([3])	24
Chile	[2]17	[2]11	[2]8	[e]10	[e]10
Colombia	[2]10	[2]13	[2]23	[e]25	[e]25
Cuba	[4]86	[r][4]81	[4]92	[4]80	[e]80
Mexico	[2]577	[r][2]389	[r][2]531	[r][2]363	[e]385
Peru	[2]24	--	--	--	--
Venezuela[e]	66	66	55	50	60
Europe:					
European Economic Community:					
Belgium-Luxembourg	646	543	1,079	1,069	947
Denmark	8	14	290	313	239
France	302	316	434	465	503
Germany, Federal Republic of	1,703	1,569	1,705	1,769	1,658
Ireland	1	2	10	6	[5]9
Italy	6,914	6,421	7,238	7,596	8,168
Netherlands	177	126	182	136	[5]170
United Kingdom	765	110	47	49	28
European Free Trade Association:					
Austria	50	88	127	149	158
Finland	60	69	24	98	117
Norway	78	20	11	8	58
Portugal	32	105	731	161	[5]129
Sweden	151	36	130	143	[5]84
Switzerland	49	[r]64	96	197	151
Council for Mutual Economic Assistance:					
Bulgaria	([6])	([6])	([6])	[r][4]1	[e]1
Czechoslovakia	[r][4]37	[r][4]49	[4]54	[4]47	[e]50
German Democratic Republic	596	[r]546	602	780	[5]1,001
Hungary	10	2	3	[r]7	4
Poland	52	37	10	7	250
Romania	--	--	9	11	62
U.S.S.R.	[r][7]21	[r][7]20	[7]21	[7]22	[e]20
Other:					
Greece	88	103	218	254	263
Spain	2,930	2,197	2,811	3,805	4,835
Yugoslavia	377	451	443	292	437
Africa:					
Egypt	[2]41	[2]127	[2]46	[2]18	[e]20
Morocco	([3])	([3])	1	([3])	[e]([3])
South Africa, Republic of	[2]37	[2]33	[2]19	[2]9	[e]10
Asia:					
China[4]	52	[r]([3])	19	6	2
Hong Kong[2]	120	[r]100	139	116	103
India	[2]31	[r][2]82	[r][2]119	[e]130	[e]130
Indonesia[2]	32	52	89	33	43
Iran	[e]11	[e]11	NA	NA	NA
Japan	1,986	1,587	3,559	3,688	3,291
Korea, Republic of[2]	1,206	1,732	1,867	1,742	2,130
Malaysia	[2]3	[2]3	[e]3	[e]3	[e]3
Pakistan	152	[e]165	187	139	368
Philippines	[2]117	[2]68	[2]87	[2]105	[e]105
Singapore[2]	61	25	103	120	190
Taiwan	[2]327	[2]629	[2]686	[2]839	[e]800
Thailand[2]	304	489	884	678	373
Turkey	260	331	356	399	381
Oceania:					
Australia[2]	1	1	1	1	1
New Zealand[2]	([3])	18	19	1	69
Total	22,061	20,347	27,032	27,879	29,668

[e]Estimated. [r]Revised. NA Not available.

[1]Unless otherwise noted, source is United Nations Economic Commission for Europe. Annual Bulletin of Steel Statistics for Europe. V. 8, 1980. New York, 1981, 94 pp.

[2]Source: Official trade returns of subject country.

[3]Less than 1/2 unit.

[4]Partial figures, compiled from export statistics of trading partner countries.

[5]Source: United Nations Economic Commission for Europe. Quarterly Bulletin of Steel Statistics for Europe. V. 32, No. 3, 1981. New York, 1981, 66 pp.

[6]Revised to zero.

[7]Officially reported, but may be incomplete figure.

Table 16.—Iron and steel scrap exports, by continent and country[1]

(Thousand short tons)

Continent, country group, and country	1976	1977	1978	1979	1980
North America:					
Canada	1,117	768	963	1,139	865
United States[2 3]	[r]8,118	[r]6,175	[r]9,089	[r]11,124	11,254
Latin America:					
Mexico	[2]1	[2]2	([2 4])	[r 2]1	[e]1
Europe:					
European Economic Community:					
Belgium-Luxembourg	581	552	585	606	592
Denmark	128	63	89	100	110
France	3,772	3,702	4,038	3,887	3,651
Germany, Federal Republic of	2,863	2,735	3,048	[r]3,304	3,392
Ireland	9	9	60	79	[5]93
Italy	26	12	8	14	9
Netherlands	1,055	1,021	1,311	1,259	1,316
United Kingdom	660	1,034	1,725	1,475	3,092
European Free Trade Association:					
Austria	50	9	9	17	14
Finland	4	3	1	3	([4])
Norway	20	14	40	46	42
Portugal	3	4	11	6	[5]6
Sweden	10	83	86	19	[5]15
Switzerland	[r]78	68	97	110	71
Council for Mutual Economic Assistance:					
Bulgaria	[r]148	67	184	143	171
Czechoslovakia	58	89	126	137	109
German Democratic Republic	([4])	1	15	2	54
Hungary	41	78	46	41	34
Poland	101	1	[2]15	[2]12	[2]17
Romania[2]	[r]8	[r]2	3	1	([4])
U.S.S.R.	[2]2,025	[2]2,412	[2]1,849	[2]2,190	[6]1,620
Other:					
Greece	([4])	1	([4])	([4])	([4])
Iceland	4	2	--	4	3
Spain	([4])	([4])	1	([4])	1
Yugoslavia	22	46	87	52	50
Africa:					
Morocco[2]	55	21	50	98	39
South Africa, Republic of	3	3	8	2	[e]2
Asia:					
China	--	--	([4])	([4])	11
Hong Kong	195	250	315	412	302
India	[r]111	[r]60	[r]31	[r e]30	[e]30
Indonesia	([4])	--	7	--	1
Japan	224	233	181	166	175
Korea, Republic of	21	1	9	14	10
Malaysia	18	12	[e]10	[e]10	[e]10
Philippines	([4])	([4])	3	3	[e]3
Singapore	3	8	4	2	6
Taiwan	69	40	172	79	[e]80
Thailand	--	--	--	--	1
Oceania:					
Australia	769	713	755	63	[e]100
New Zealand	[r]2	[r]2	[r]2	[r]5	49
Total	22,372	20,296	25,033	26,655	27,401

[e]Estimated. [r]Revised.

[1]Unless otherwise noted, source is United Nations Economic Commission for Europe. Annual Bulletin of Steel Statistics for Europe. V. 8, 1980, New York, 1981, 94 pp.

[2]Source: Official trade returns of subject country.

[3]Includes rerolling material.

[4]Less than 1/2 unit.

[5]Source: United Nations Economic Commision for Europe. Quarterly Bulletin of Steel Statistics for Europe. V. 32, No. 3, 1981, New York, 1981, 66 pp.

[6]Partial figure; compiled from import statistics of trading partner countries.

Iron and Steel Slag

By Cynthia T. Collins[1]

Combined sales and use of iron and steel slag were down significantly for the second consecutive year, as shown in table 1. Average unit prices of all sales were up 7% in 1981. Major end uses for the various kinds of slag followed traditional patterns. However, in addition to the customary uses, there has been a growing interest by the cement industry in the use of blast-furnace slag for the manufacture of portland cement. In 1981, this was reflected in sales of small quantities of expanded slag for cement manufacture and in the construction by Atlantic Cement Co., Inc., of new facilities at Sparrows Point, Md., to produce granulated slag for cement.

DOMESTIC PRODUCTION

Production of iron and steel slag apparently increased in 1981, owing to a slight increase in production of both pig iron and steel. However, sales of all kinds of iron and steel slag were down in 1981 from the levels of 1980, reflecting the general decline in the construction industry, which uses much of the slag produced by iron and steel plants. Table 1 shows sales of iron and steel slag produced as reported to, or estimated by, the Bureau of Mines for those companies listed in table 3.

During 1981, Atlantic Cement Co., Inc., continued construction of its slag processing facilities at Sparrows Point, Md. From the "L" blast furnace of Bethlehem Steel Corp., Atlantic Cement will be able to produce more than 2,200 tons[2] per day of granulated slag, which will be used in the manufacture of cement.

The Lorain-Cuyahoga steel slag processing plant of United States Steel Corp. in Lorain, Ohio, was recognized for its outstanding production safety record. By the end of 1981, the plant had a record of more than 21 years without a lost-time accident in spite of the risks involved in handling extremely hot raw materials.

CONSUMPTION AND USES

Although consumption of iron and steel slag declined in 1981, uses of the several kinds of slag generally followed their traditional patterns. Air-cooled blast-furnace slag was used predominantly for road bases, railroad ballast, aggregates in concrete, and as fill material.

Granulated blast-furnace slag was used mostly for road bases, where its natural cementing properties impart the ability, on damp compaction, to slowly set into a hard, dense mass that minimizes settlement of pavements. Expanded blast-furnace slag was used chiefly in concrete products. Small quantities were used, also, in cement manufacture and as lightweight aggregate. The major uses of slag from steel furnaces were for road bases and fill.

PRICES

The most significant price change in 1981 resulted from an 11% decrease from that of 1980 in the average unit value of expanded blast-furnace slag. Unit values of all other kinds of slag increased from 5% to 15%, for an average overall increase of 7%.

FOREIGN TRADE

Granulated blast-furnace slag for use in the manufacture of hydraulic cements was imported from Japan and France in 1981. However, it is not possible to determine the quantities imported owing to the Tariff Schedule classification; slag imports are reported in a blanket category designated as "Mineral substances not provided for." Because of similar problems, it is not known whether any slag was exported in 1981. However, blast-furnace slag is known to be both exported and imported to and from Canada periodically in small quantities.

WORLD REVIEW

Data on production of slag in other countries were not available for 1981, nor were data on resources (new slag plus old stockpiles). However, resources and usage are known to be significant in such countries as France, the Federal Republic of Germany, Japan, and the United Kingdom, where there are large iron and steel industries. At Nippon Kokan's Kukuyama works in Japan, the world's first facility for recycling slag and waste heat from basic oxygen furnaces (BOF) was placed in operation in November 1981. The facility has the capacity to process 22,000 tons of BOF slag per month and to generate 200 tons of steam per day. The airblown BOF slag is an improved product now used in such construction materials as mortar reinforcement for walls.

In Raahe, Finland, Rautaruukki Oy and Ovato Oy, steel producers, and Oy Partek AB and Oy Lohja AB, cement producers, jointly established a new company, Kuonanjaloste Oy, to operate a slag-processing plant. The facility processes slag for use in the manufacture of fertilizer, mineral wool, and cement, and also ships unprocessed slag for road construction aggregate. The company intends eventually to be able to upgrade all of the blast-furnace slag produced in the country.

In Luxembourg, the Calumite Co. Europe S.A. constructed a plant at Esch-sur-Alzette to process their high-grade slag tradenamed "Calumite Slag"; the new plant has a planned annual capacity of 110,000 tons. The company closed its older processing facility at Neuss, Federal Republic of Germany, where a similar product was shipped to glass manufacturers in northern Europe. With the relocation, the company plans to expand its sales into southern Europe also.

TECHNOLOGY

Interest in the technology of slag cement processes has increased in the United States over the last several years. The technology is not new, and portland blast-furnace slag cement has been produced in Europe, Japan, and the Republic of South Africa for many years, and in the United States briefly during World War II. Interest in slag cement processes in this country increased when cement companies became faced with the cost of replacing or modernizing old, inefficient plants and escalation of kiln fuel costs. It is estimated that building a slag-processing facility would require one-half the per-ton capital of building a portland cement plant and would utilize only about one-fifth of the total unit energy requirement.[3]

The first U.S. facility to produce granulated slag for cement continued to be under construction in 1981 by Atlantic Cement at the Bethlehem Steel plant at Sparrows Point, Md. Molten slag from Bethlehem's large new "L" blast furnace flows directly to a high-pressure water granulator for quenching. A water-to-slag ratio of 10:1 results in granulated slag with a glass content of 95% to 98%. The granulated slag is pumped into filter beds for drainage and then trucked to the plant for drying, grinding, and storage. Atlantic Cement grinds the granulated slag separately from cement clinker, a method that allows greater control over product quality. Tests have shown that separate grinding of the granulated slag improves the rate of hydration reaction in cement over that of interground slag and clinker. The two products are stored in adjacent facilities at the company's distribution terminals and are later blended to customers' specifications.[4]

In addition to economic and environmental advantages to cement companies of constructing slag granulating and grinding facilities at blast furnaces, savings accrue to the steel companies as well. The rapid quenching of molten slag as it comes from the blast furnace eliminates the otherwise more costly methods of transporting the slag away from the furnace with its inherent dangers.[5]

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[1]Mineral specialist, Division of Ferrous Metals.
[2]Tons in this chapter refer to short tons of 2,000 pounds.
[3]Spellman, L. Use of Blast Furnace Slag as a Cementitious Component. Am. Min. Cong. J., v. 68, No. 4, April 1982, pp. 57-59.
[4]Burriss, C. Atlantic Moves Ahead Into Slag Cement. Rock Prod., v. 84, No. 6, June 1981, pp. 94-99.
[5]Work cited in footnote 3.

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Table 1.—Iron and steel slags sold or used in the United States[1]

(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
1977	22,753	61,270	1,488	3,579	1,475	6,414	25,716	71,262	6,668	10,850	32,384	82,112
1978	25,119	73,148	1,372	3,608	1,914	9,641	28,404	86,398	8,457	14,510	36,861	100,908
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

[1]Value based on selling price at plant.
[2]Data may not add to totals shown because of independent rounding.

Table 2.—Iron blast-furnace slags sold or used in the United States, by region and State[1]

(Thousand short tons and thousand dollars)

Region and State	1980				1981			
	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	3,519	10,245	W	W	2,642	9,202	W	W
Ohio	3,210	14,740	W	W	2,311	11,217	W	W
Total	6,729	24,985	7,590	29,678	4,953	20,419	5,495	23,637
Middle Atlantic:								
Pennsylvania	4,299	17,885	W	W	3,891	18,197	W	W
Maryland, New York, West Virginia	1,603	4,996	W	W	1,570	4,849	W	W
Total[2]	5,902	22,881	6,968	29,154	5,461	23,047	6,175	26,607
West: Colorado, Texas, Utah	2,446	8,751	2,446	8,751	2,356	9,016	2,356	9,016
South: Alabama and Kentucky	1,509	7,298	1,509	7,298	1,299	6,476	1,299	6,476
Pacific: California	528	1,398	528	1,398	391	1,205	391	1,205
Grand total[2]	17,113	65,313	19,041	76,279	14,461	60,164	15,717	66,941

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 and city	Company	Processing method of iron slag: Air-cooled	Processing method of iron slag: Expanded	Processing method of iron slag: Granulated	Steel slag	Sources of steel slag: Open hearth	Sources of steel slag: Basic oxygen process	Sources of steel slag: Electric
Alabama:								
Alabama City	Vulcan Materials Co	1	--	--	1	--	1	--
Birmingham	Jim Walter Resources, Inc	1	--	--	--	--	--	--
Fairfield	Vulcan Materials Co	1	--	--	1	--	1	--
Total		3	--	--	2	--	2	--
California: Fontana	Heckett Co	1	--	--	1	--	1	--
Colorado: Pueblo	Fountain Sand and Gravel Co	1	--	--	1	--	1	1
Delaware: Claymont	International Mill Service	--	--	--	1	--	--	1
Georgia: Atlanta	do	--	--	--	1	--	--	1
Illinois:								
Alton	do	--	--	--	1	--	--	1
Chicago	Illinois Slag & Ballast Co	1	--	--	1	--	1	--
Granite City	International Mill Service	--	--	--	1	--	1	--
Do	St. Louis Slag Products, Co., Inc	1	--	--	--	--	--	--
Peoria	International Mill Service	--	--	--	1	--	--	1
Total		2	--	--	4	--	2	2
Indiana:								
Burns Harbor	Levy Co., Inc	1	1	--	1	--	1	--
East Chicago	Vulcan Materials Co	1	--	--	--	--	--	--
Total		2	1	--	1	--	1	--
Kentucky: Ashland	Standard Slag Co	1	--	--	--	--	--	--
Maryland: Baltimore	Maryland Slag Co	1	1	--	--	--	--	--
Michigan:								
Detroit	Edward C. Levy Co	1	1	1	1	--	1	1
Ecorse	do	--	--	--	1	--	1	1
Trenton	do	1	--	--	1	--	1	--
Total		2	1	1	3	--	3	2
Minnesota: Newport	International Mill Service	--	--	--	1	--	--	1

New Jersey: Perth Amboy	do	--	--	--	1	--	--	1
New York: Buffalo	Buffalo Slag Co	1	1	--	--	--	--	--
Ohio:								
Canton	Heckett Co	--	--	--	1	--	--	1
Cleveland	Stein, Inc	--	--	--	1	--	1	1
Do	Standard Slag Co	1	--	--	1	1	--	--
Do	do	1	--	--	--	--	--	--
Hamilton	American Materials Corp	1	--	--	--	--	--	--
Lorain	Spang and Co	--	--	--	1	--	1	--
Do	United States Steel Corp	1	--	--	1	--	1	--
Lordstown	Standard Slag Co	--	--	1	--	--	--	--
Middletown	American Materials Corp	1	--	--	--	--	--	--
Do	McGraw Construction Co	--	--	--	1	1	1	--
Mingo Junction	International Mill Service	--	--	--	1	1	--	--
Do	Standard Slag Co	1	--	--	--	--	--	--
New Boston	do	1	--	--	--	--	--	--
Warren	Heckett Co	--	--	--	1	--	--	1
Do	Standard Slag Co	1	--	--	--	--	--	--
Youngstown	do	1	--	--	--	--	--	--
Total		9	--	1	8	3	4	3
Oklahoma: Sand Springs	International Mill Service	--	--	--	1	--	--	1
Pennsylvania:								
Belle Vernon	Duquesne Slag Products Co	1	--	--	--	--	--	--
Bethlehem	Bethlehem Mines Corp	1	--	--	--	--	--	--
Do	Sheridan Slag Co	--	1	--	--	--	--	--
Birdsboro	Birdsboro Slag Products	1	--	--	--	--	--	--
Burgettstown	Duquesne Slag Products Co	--	--	1	--	--	--	--
Butler	Spang and Co	--	--	--	1	--	--	1
Coatesville	International Mill Service	--	--	--	1	--	--	1
Dunbar	Vanderbilt Slag Co	--	--	1	--	--	--	--
Lebanon	Sheridan Slag Corp	1	--	--	--	--	--	--
McKees Rocks	Phillips Contracting	--	--	1	--	--	--	--
Midland	International Mill Service	1	--	--	1	1	--	1
Park Hill	Standard Slag Co	1	--	--	--	--	--	--
Penn Hills	United States Steel Corp	--	--	--	1	1	--	--

Table 3.—Locations and processing methods of iron slag and sources of steel slag —Continued

State and city	Company	Processing method of iron slag: Air-cooled	Processing method of iron slag: Expanded	Processing method of iron slag: Granu-lated	Steel slag	Sources of steel slag: Open hearth	Sources of steel slag: Basic oxygen process	Sources of steel slag: Electric
Pennsylvania —Continued								
Phoenixville	International Mill Service	--	--	--	1	1	--	--
Pittsburgh	Duquesne Slag Products Co	1	--	--	--	--	--	--
Pricedale	do	--	--	1	--	--	--	--
Riddlesburg	New Enterprise Stone & Lime Co., Inc	1	--	--	--	--	--	--
Steelton	Hempt Bros	1	--	--	--	--	--	--
West Aliquippa	Duquesne Slag Products Co	1	--	--	--	--	--	--
West Mifflin	do	1	--	--	1	1	1	--
Wheatland	Dunbar Slag Co	1	--	--	1	--	1	--
Total		12	1	4	7	4	2	3
South Carolina: Darlington	APAC-Carolina, Inc	--	--	--	1	--	--	1
Texas:								
Beaumont	International Mill Service	--	--	--	1	--	--	1
Houston	Houston Slag Materials Co	1	--	--	1	--	--	1
Lone Star	Gifford-Hill Co	1	--	--	--	--	--	--
Midlothian	International Mill Service	--	--	--	1	--	--	1
Total		2	--	--	3	--	--	3
Utah: Provo	United States Steel Corp	1	--	--	1	1	--	--
West Virginia:								
Weirton	International Mill Service	--	--	--	1	1	--	--
Do	Standard Slag Co	1	--	--	--	--	--	--
Total		1	--	--	1	1	--	--
Grand total		39	5	6	38	9	16	20

Table 4.—Shipments of iron and steel slag in the United States in 1981, by method of transportation

Method of transportation	Quantity (thousand short tons)	Percent of total
Truck	17,213	80
Rail	3,011	14
Waterway	603	3
Not transported (used at plant site)	660	3
Total	21,487	100

Table 5.—Air-cooled iron blast-furnace slag sold or used in the United States, by use[1]

(Thousand short tons and thousand dollars)

Use	1980		1981	
	Quantity	Value	Quantity	Value
Concrete aggregate	1,516	6,743	1,382	6,900
Concrete products	390	1,601	320	1,494
Cement manufacture	1	5	--	--
Asphaltic concrete aggregate	2,928	12,587	2,133	10,037
Road base	5,881	22,582	5,252	20,402
Fill	2,362	6,813	1,868	7,046
Railroad ballast	2,151	7,415	2,266	8,243
Mineral wool	680	3,354	604	3,055
Roofing, built-up and shingles	234	1,311	249	1,278
Sewage treatment	59	180	W	W
Glass manufacture	W	W	W	W
Other[2]	911	2,724	388	1,710
Total[3]	17,113	65,313	14,461	60,164

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 in the United States, by use[1]

(Thousand short tons and thousand dollars)

Use	1980				1981			
	Granulated		Expanded		Granulated		Expanded	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Lightweight concrete aggregate	--	--	369	3,420	--	--	W	W
Concrete products	--	--	527	3,203	--	--	408	2,537
Cement manufacture	--	--	--	--	--	--	W	W
Road base	644	2,149	--	--	W	W	--	--
Fill	--	--	--	--	W	W	W	W
Other[2]	128	789	260	1,405	456	1,823	392	2,416
Total	772	2,938	1,156	8,028	456	1,823	800	4,953

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Value based on selling price at plant.
[2]Includes miscellaneous uses indicated by symbol W.

Table 7.—Steel slag sold or used in the United States, by use[1]

(Thousand short tons and thousand dollars)

Use	1980		1981	
	Quantity	Value	Quantity	Value
Asphaltic concrete aggregate	662	2,259	649	2,386
Road base	3,231	7,499	2,151	5,949
Fill	1,251	3,552	1,617	5,238
Railroad ballast	644	1,990	678	1,977
Other[2]	371	970	676	1,945
Total[3]	6,158	16,270	5,770	17,494

[1]Excludes tonnage returned to furnace for charge material. Value based on selling price at plant.
[2]Includes ice control, soil conditioning, and miscellaneous uses.
[3]Data may not add to totals shown because of independent rounding.

Table 8.—Value per ton at the plant for iron and steel slags sold or used in the United States, by type

Year	Iron blast-furnace slag				Steel slag	Total slag
	Air-cooled	Granulated	Expanded	Total iron slag		
1977	$2.69	$2.41	$4.35	$2.77	$1.63	$2.54
1978	2.91	2.63	5.04	3.04	1.72	2.74
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

Table 9.—Average selling price and range of selling prices at the plant for iron and steel slags in the United States in 1981, by use

(Dollars per short ton)

Use	Iron blast-furnace slag						Steel slag	
	Air-cooled		Granulated		Expanded			
	Average	Range	Average	Range	Average	Range	Average	Range
Concrete aggregate	4.99	1.27-6.24	--	--	--	--	--	--
Lightweight concrete aggregate	--	--	--	--	W	W	--	--
Concrete products	4.66	2.48-6.24	--	--	6.22	4.94-8.80	--	--
Cement manufacture	--	--	--	--	W	W	--	--
Asphaltic concrete aggregate	4.70	2.76-6.35	--	--	--	--	3.67	1.70-8.25
Road base	3.88	1.50-6.24	3.63	3.44-3.64	--	--	2.76	.90-8.15
Fill	3.77	1.13-5.65	6.02	3.60-7.70	W	W	3.23	.93-7.75
Railroad ballast	3.63	2.75-7.73	--	--	--	--	2.91	1.24-7.59
Mineral wool	5.06	2.98-8.00	--	--	--	--	--	--
Roofing, built-up and shingles	5.14	2.80-9.00	--	--	--	--	--	--
Sewage treatment	W	W	--	--	--	--	--	--
Soil conditioning	--	--	--	--	--	--	W	W
Glass manufacture	W	W	--	--	--	--	--	--
Other	3.75	1.29-6.50	--	--	6.16	2.51-10.20	2.89	1.77-4.44

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

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 there has been no record in recent years of significant utilization of either dumortierite or topaz for this purpose in the United States.

Although published statistics are incomplete, it appears that the United States, India, and the Republic of South Africa are the leading world producers of kyanite-group minerals. It can be presumed that the U.S.S.R. and perhaps a few other industrialized nations also produce significant quantities of these materials.

U.S. kyanite output in 1981 was estimated to have shown a decrease compared with that of 1980. 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.

There has been a trend in recent years to replace lower duty refractories with higher duty, longer lasting refractories, such as those based on kyanite and mullite. As a result, the consumption of all refractories in the iron and steel, metallurgical, glass, etc., industries has decreased.

In steelmaking (which utilizes 75% of all refractories of all kinds), developments such as continuous casting have had a similar effect.[2] During 1980, 18% of U.S. steel was cast continuously, and this was expected to increase to 25% by 1982 and to 45% by 1988. By contrast, in Europe, 43% of the steel was processed by continuous casting in 1980, and in Japan, the figure was 65%.[3]

Legislation and Government Programs.—The allowable depletion rates for kyanite, established by the Tax Reform Act of 1969 and unchanged through 1981, were 22% for domestic production and 14% for foreign operations.

DOMESTIC PRODUCTION

Kyanite was produced in the United States in 1981 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 in 1981 was estimated to have shown a decrease compared with that of 1980. Kyanite production statistics for 1981 (and for all previous years since 1949) are withheld to avoid disclosing company proprietary data.

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 around 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 1981 was largely of the high-temperature sintered variety, and the four producers of this material were A. P. Green Refractories Co. at Philadelphia, Pa.; C-E Minerals, at Americus, Ga.; Didier Taylor Refractories Corp. at Greenup, Ky.; and Harbison-Walker Refractories Co. at Eufala, Ala. Electric furnace-fused mullite was produced by The Carborundum Co. at Niagara Falls, N.Y.

Table 1.—Synthetic mullite production in the United States

Year	Quantity (short tons)	Value (thousands)
1977	40,280	$5,283
1978	38,080	5,442
1979	40,660	6,675
1980	40,540	8,012
1981	42,000	9,050

CONSUMPTION AND USES

Conforming to established end use patterns, kyanite and related materials were consumed in 1981 mostly in the manufacture of high-alumina or mullite-class refractories and in lesser quantities as ingredients in some ceramic compositions. Domestic kyanite, already ground to minus 35 mesh as required by the flotation process used in its separation and recovery, was marketed either in the raw form or, after heat treatment, as mullite, which was sometimes further reduced in particle size before use. In the 35- to 48-mesh range, the mineral 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, for example, was used in body mixes for sanitary porcelains, wall tile, investment-casting molds, and miscellaneous special-purpose ceramics.

PRICES

Engineering and Mining Journal, December 1981, 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.

Price ranges quoted for kyanite-group materials in Ceramic Industry magazine, January 1982, follow:

	Per short ton
Andalusite	$180
Mullite, calcined kyanite	$150- 180
Mullite, calcined	59- 187
Mullite, fused	920-1,440

The December 1981 issue of Industrial Minerals (London) quoted kyanite-group prices approximately equivalent to the following (converted from pounds sterling per metric ton to dollars per short ton):

	Per short ton
Andalusite, Transvaal, 52% to 54% Al_2O_3, bulk, c.i.f. main European port	$127
Andalusite, Transvaal, 60% Al_2O_3, c.i.f. main European port	163
Sillimanite, South African, 70% Al_2O_3, bags, c.i.f. main European port	308

FOREIGN TRADE

Export data of kyanite and mullite-containing materials are no longer collected as a separate category by the Bureau of the Census. Data had been collected until 1977, and these export figures were published in this section in what was then table 2 (U.S. exports and imports for consumption of kyanite and related minerals). However, these census figures did not distinguish between synthetic mullite and materials that were in part mullite.

Import data for kyanite-group minerals have likewise not been collected as a separate category since 1977.

WORLD REVIEW

Belgium-Luxembourg.—Imports of kyanite-group minerals in 1979 amounted to 2,200 tons. Principal countries of origin and the share supplied were the United States, 42%, and the United Kingdom, 23%. In 1980, imports of kyanite-group minerals were 3,400 tons. Principal countries of origin and the quantities supplied were the United States, 41%; the Republic of South Africa, 21%; the United Kingdom, 18%; and Brazil, 10%.[4]

Bulgaria.—Kyanite deposits are represented by kyanite schists, forming seams and lenses of up to 160 feet in thickness but with an average of 16 to 20 feet in thickness. Kyanite content in the schists is about 25% and is associated with other minerals such as almandine-garnet, biotite, feldspar, etc. A combined processing flowsheet was said to have been developed that includes autogenous grinding, gravity separation on concentration tables, magnetic separation, etc. It is thought that kyanite concentrate will obtain a large industrial application in the next few years.[5]

India.—The Indian Government reiterated that it does not intend to permit export of refractory-grade minerals, such as kyanite and sillimanite. Export licenses have been granted for only those materials of nonrefractory grade after studying the conservation aspect and also the need to earn foreign exchange. It was also reported that the mineral development board had achieved substantial progress in the beneficiation of low-grade kyanite available in the Purulia and Singhbhum districts.[6]

Netherlands.—In 1979, imports of kyanite-group minerals were 1,600 tons. Principal countries of origin and the share supplied were said to be the Republic of South Africa, 72%, and the Federal Republic of Germany, 19%. In 1980, imports of kyanite-group minerals were 3,700 tons. Principal countries of origin and the percentage supplied were the Republic of South Africa, 57%; the Federal Republic of Germany, 24%; and Brazil, 9%.[7]

South Africa, Republic of.—Hudson Mining Co. was purchased by Rand London Corp. from Zimro (Pty.) Ltd. for $4.4 million. Hudson is the operator of the Republic of South Africa's largest andalusite mine at Annesley in the Northern Transvaal. Annual production capacity was around 65,000 tons, with actual output running about 44,000 tons per year.[8]

Tanzania.—The highly metamorphosed Archaean schists and gneisses in eastern Tanzania are found to have both kyanite and sillimanite as fairly common components, usually occurring as bands containing disseminations of the minerals within the rock body. Only a small amount of massive blue kyanite has been found. So far, there has never been any attempt to establish a conventional separation plant, and the commercial potential has remained untapped.[9]

United Kingdom.—Imports of kyanite-group minerals in 1980 were approximately 51,000 tons. Principal countries of origin and the share supplied were the Republic of South Africa, 57%; France, 24%; and the United States, 11%.[10]

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[1]Physical scientist, Division of Industrial Minerals.
[2]Industrial Minerals (London). Comment: Refractories—The Stakes Are High. No. 169, October 1981, p. 9.
[3]Brick and Clay Record. Executive Report. V. 178, No. 6, June 1981, p. 9.
[4]Industrial Minerals (London). Belgium-Luxembourg Industrial Minerals Trade Statistics, 1978-1980. No. 168, September 1981, p. 49.
[5]Stoev, S. The Industrial Minerals of Bulgaria. Ind. Miner. (London), No. 169, October 1981, p. 79.
[6]Industrial Minerals (London). No Export of Refractory Raw Materials. No. 165, June 1981, p. 12.
[7]———. Dutch Industrial Mineral Statistics, 1979 and 1980. No. 168, September 1981, p. 65.
[8]———. Rand Acquires Andalusite and Diamond Operations. No. 167, August 1981, p. 14.
[9]Jones, G. K. The Industrial Minerals of Tanzania. Ind. Miner. (London), No. 166, July 1981, p. 39.
[10]Industrial Minerals (London). United Kingdom Industrial Minerals Statistics. No. 162, March 1981, p. 45.

Table 2.—Kyanite, sillimanite, and related materials: World production, by country[1]

(Short tons)

Country[2] and commodity	1977	1978	1979	1980[p]	1981[e]
Australia: Sillimanite[3]	606	[r]626	626	729	730
Brazil: Kyanite[4]	[r]19	[r]1,954	1,929	[r e]1,930	2,000
France: Kyanite-andalusite	29,579	[r]35,904	[r e]33,000	[r e]33,000	33,000
India:					
Andalusite	427	248	--	--	--
Kyanite	46,433	34,058	44,874	51,282	52,900
Sillimanite	16,560	14,849	17,752	14,315	15,400
Korea, Republic of: Andalusite	127	67	66	90	80
South Africa, Republic of:					
Andalusite	124,645	123,503	147,905	216,622	[5]199,829
Sillimanite	17,036	10,516	21,577	17,851	[5]10,422
Spain: Andalusite	3,286	5,607	5,903	7,133	7,200
United States:					
Kyanite	W	W	W	W	W
Synthetic mullite	40,280	38,080	40,660	40,540	[5]42,000

[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. 31, 1982.

[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 revised to reflect output of marketable products; crude production (as reported in previous editions of this chapter) was as follows, in short tons: 1977—121; 1978—7,615; 1979—9,031; 1980—9,050 (estimated); 1981—9,300 (estimated).

[5]Reported figure.

Lead

By John A. Rathjen[1] and William D. Woodbury[2]

U.S. mine output of recoverable lead in 1981 dropped sharply owing to midyear strikes at the Missouri mines of the St. Joe Lead Co. and the Buick, Mo., lead complex owned by AMAX Lead Co. of Missouri and Homestake Lead Mining Co. Primary refinery production of lead in 1981 from domestic and foreign raw materials, including lead in antimonial lead, decreased slightly, as the shortfall in domestic mine production was partially offset by imports of raw materials. The principal countries supplying raw materials were Canada, Peru, Australia, and Honduras. Production of secondary lead dropped slightly owing to a shortage of scrap and low prices during the second half of the year.

Total stocks of refined and antimonial lead rose moderately in 1981, with an increase in producer stocks partially offset by a decrease in secondary and consumer inventories.

Table 1.—Salient lead statistics

(Metric tons unless otherwise specified)

	1977	1978	1979	1980	1981
United States:					
Production:					
Domestic ores, recoverable lead content	537,499	529,661	525,569	[r]550,366	445,535
Value thousands	$363,789	$393,516	$609,929	[r]$515,189	$358,821
Primary lead (refined):					
From domestic ores and base bullion	486,659	501,643	529,970	508,163	440,238
From foreign ores and base bullion	62,041	63,530	45,641	39,427	55,085
Antimonial lead (primary lead content)	2,987	2,914	2,596	851	3,008
Secondary lead (lead content)	757,592	769,236	801,368	675,578	641,105
Exports (lead content):					
Lead ore and concentrates	NA	54,231	32,902	27,615	33,043
Lead materials excluding scrap	8,931	8,225	10,646	164,458	23,320
Imports, general:					
Lead in ore and matte	66,533	52,985	39,998	44,095	58,545
Lead in base bullion	7,319	4,307	1,681	296	449
Lead in pigs, bars, and reclaimed scrap	243,164	226,926	198,344	88,995	107,185
Stocks Dec. 31 (lead content):					
At primary smelters and refineries	91,113	98,665	89,322	125,994	140,207
At consumers and secondary smelters	121,387	125,234	153,195	126,214	123,216
Consumption of metal, primary and secondary	1,435,473	1,432,744	1,358,335	1,070,303	1,167,101
Price: Common lead, average, cents per pound[1]	30.70	33.65	52.64	42.46	36.53
World:					
Production:					
Mine thousand metric tons	[r]3,345.3	[r]3,372.6	[r]3,400.5	[p]3,428.3	[e]3,352.6
Smelter[2] do	[r]3,189.9	[r]3,224.2	[r]3,299.2	[p]3,205.0	[e]3,159.0
Secondary smelter do	[r]1,949.8	[r]1,961.0	[r]2,070.4	[p]1,929.4	[e]1,822.0
Price: London, common lead, average, cents per pound	28.00	29.86	54.52	41.21	33.30

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available.
[1]Quotation on a nationwide, delivered basis.
[2]Primary metal production only. Includes secondary metal production where inseparably included in country total.

The U.S. monthly producer price continued a decline that began in 1980, reaching a yearly low of 30 cents per pound in February 1981. In mid-February, the price trend turned upward and rose steadily to an annual high of 44 cents per pound in August. Most of the increase was attributed to midyear labor problems in the Missouri lead belt. In August, when strike problems had been settled, the U.S. producer price began a steady decline, with the December monthly average price reduced to 31 cents per pound. The average price for lead in 1981 was 36.5 cents per pound compared with 42.5 cents per pound in 1980. London Metal Exchange (LME) quotations for lead essentially paralleled the U.S. price with the exception of a short period from mid-January to mid-February when the LME quotation was higher than the U.S. producer price. LME quotations began the year at 32 cents per pound and closed at 31 cents according to Metals Week.

World mine and smelter production decreased slightly in 1981, reflecting depressed market conditions and labor-management problems in the United States, Canada, and South America.

Legislation and Government Programs.—The International Lead and Zinc Study Group, at its 26th session in Geneva during October, estimated that world mine production in 1981 would be slightly lower than that of 1980 and that metal production and consumption would remain relatively unchanged from the 1980 totals. For 1982, increases in both mine and metal production were predicted along with a nominal growth in consumption.

The Federal Emergency Management Agency, which revised the national stockpile goal for lead in 1980 to 998,000 tons, did not initiate any futher modification, and the goal was unchanged through 1981. The stockpile inventory at yearend was 545,000 metric tons, indicating a continuing net shortage.

DOMESTIC PRODUCTION

MINE PRODUCTION

U.S. mine production of recoverable lead decreased 19% in 1981 from the 5-year high achieved in 1980. This was primarily the result of strikes at seven of the major producing mines in Missouri and was the lowest total in recent years. Eight lead mines in Missouri yielded 87% of total domestic production and, together with lead producing mines in Idaho and Colorado produced 99% of the total U.S. mine output.

The Buick Mine in Iron County, Mo., equally owned by AMAX Lead and Homestake Lead, continued as the largest single producing unit, milling 1.6 million tons of ore, down 16% from that of the previous year. Buick ore contributed 105,000 tons of lead in concentrates. Total reserves of the Buick Mine were estimated to be over 40 million tons at an average grade of 5.9% lead.

St. Joe Lead, the largest wholly owned domestic lead producer, was acquired by the Fluor Corp. on August 3, 1981. The company operated four lead mine and milling complexes in southeastern Missouri producing up to 1,000 tons per day of concentrates to feed its smelter at Herculaneum, Mo. The Viburnum trend properties operating during 1981 milled 3.4 million tons of ore averaging 4.6% lead, which generated 152,380 tons of lead in concentrates, a decrease of 29% from that of 1980. St. Joe Lead had proven domestic reserves of 58 million tons of ore containing 5.1% lead and was expected to have a daily production capability of 20,000 tons of ore in 1984 when the new Viburnum No. 35 is fully productive.

The Magmont Mine in Iron County, Mo., jointly owned by Cominco American, Inc., and Dresser Industries, Inc., produced slightly over 1 million tons of ore at an average grade of 7% lead, which yielded about 89,000 tons of lead concentrates. These concentrates were tolled by AMAX-Homestake Lead Tollers, at the Buick smelter in Boss, Mo. During 1981, the East ore body was brought into production and development of the new West ore body was 78% completed, which was expected to extend the mine life to about 1990.

Development continued at the new West Fork Mine of ASARCO Incorporated, 23 miles from its smelter at Glover, Mo. Shaft sinking and construction of the mill and surface facilities proceeded according to schedule. Full production will be about 3,450 tons per day of ore and 46,000 tons of lead in concentrates annually, which will triple Asarco's domestic lead mine capacity. The estimated development cost of West Fork was $77 million, and there were 15 million tons of measured reserves assaying 5.5% lead and 1.2% zinc.

Hecla Mining Co. reported that its Lucky Friday Mine, which was acquired through the acquisition of Day Mines, Inc., during 1981, produced 135,000 tons of ore at a grade of 8.4% lead. Overall production was down 21% from 1980 owing to a 9-week strike. The mine was connected with the Hunter Ranch property, formerly operated by Day Mines, Inc., and is now mined as one unit. A new shaft is being sunk that was planned to bottom 7,500 feet. Ultimate production will be increased 35% by the new shaft. The Star-Morning Unit, equally owned by The Bunker Hill Co. as of May 31, 1981, but operated by Hecla, produced 274,000 tons of ore at 5.0% lead, up 7% from that of 1980. Reserves at the Lucky Friday and Star-Morning mines were estimated to be 534,000 and 1,017,000 tons, respectively. Owing to the announced closure of the Bunker Hill smelter, new contracts were negotiated with Asarco to process lead concentrates from both units at East Helena, Mont. Prior to the Bunker Hill closing, all of the Star-Morning and 50% of the Lucky Friday lead concentrates were tolled at Kellogg, Idaho. Hecla produced 17,000 tons of lead in 1981 from these two mines, which did not include Bunker Hill's share from the Star-Morning property.

In August, Gulf Resources and Chemical Corp., the parent company of Bunker Hill announced the closing of the Bunker Hill Mine at Kellogg, Idaho, owing to excessive current and projected losses. Despite the phaseout and cessation of production late in the fourth quarter, the mine was the eighth largest domestic producer during 1981, producing approximately 14,500 tons of lead in concentrates. The Bunker Hill share of the Star-Morning production was approximately 6,000 tons of lead in concentrates.

SMELTER AND REFINERY PRODUCTION

Primary.—Domestic production of primary lead, including lead in antimonial lead from the five primary refineries in 1981, was 9% less than that in 1980. During the year, St. Joe Minerals Corp. licensed patents and technology for the production of wrought lead-calcium and lead-calcium-tin strip in the United Kingdom. The rolled lead strip alloy is used in maintenance-free batteries. The company also announced the discontinuation of its subsidiary, Formet Technology Corp., which had been researching new alloys with super plastic properties.

The St. Joe Lead smelter-refinery at Herculaneum, Mo., was the Nation's largest at 204,000 tons per year capacity. It produced 152,390 tons of lead metal in 1981, down 29% from that of the previous year, primarily because of a 12-week mine strike that deprived the smelter of raw feed material. The smelter processed concentrates from company mines in the Viburnum trend of southeastern Missouri.

At Boss, Mo., the AMAX-Homestake smelter-refinery produced 91,403 tons of lead metal from concentrates produced at their Buick Mine and the Magmont Mine in Iron County, Mo.

Asarco reported that its three smelters at East Helena, Mont., El Paso, Tex., and Glover, Mo., produced 169,825 tons of lead bullion in 1981. The El Paso and East Helena operations, which custom toll concentrates from domestic and foreign sources, ship bullion to Asarco's Omaha refinery where 89,720 tons of refined lead metal was produced. The Glover smelter-refinery complex produced 69,580 tons of lead metal from Missouri and Illinois ores. The company production of 159,300 tons of metal was 16% greater than that of 1980 but was only 60% of its total smelting capacity. Foreign sources of concentrates at East Helena and El Paso came primarily from Canada, Australia, Honduras, Mexico, and Peru. At East Helena, the completion of a $2.9 million, 425-foot concrete stack and fan on the baghouse, through which blast furnace emissions are filtered, will enable the plant to operate without the necessity of periodic curtailment for air-quality purposes. At Glover, a new 375-foot stack on the baghouse was completed along with a second blast furnace.

The Bunker Hill smelter-refinery produced an estimated 100,000 tons of lead metal in 1981 over 11 months, at which time operations were terminated. Reasons for the permanent closure cited by Gulf included projected losses for Bunker Hill in excess of $21 million in 1981 and no foreseeable near-term return to profitability. Raw material feed to the plant during 1981 came from Bolivia, Canada, Peru, and the United States.

At yearend, total domestic primary smelting-refining capacity for primary lead was 595,000 tons compared with 714,000 tons at the start, as a result of the announced Bunker Hill closure.

Secondary.—Production of lead from recycled materials continued to decline owing to a shortage of available scrap and reduced profit margins at secondary conversion plants.

A new 27,000-ton-per-year secondary lead smelter at St. Helens, Oreg., to be operated by the Bergsoe Metal Corp., was scheduled to come onstream in April 1982. Preliminary construction was completed and break-in procedures were initiated. Expansion at the Gould Inc. secondary smelter in Los Angeles, Calif., proceeded according to plan. It was expected that the new complex will produce about 54,000 tons of secondary lead per year beginning about August 1982.

CONSUMPTION AND USES

Domestic consumption of lead reversed its downward trend in 1981, increasing to 1.17 million tons, compared with 1.07 million tons in 1980. Declines in use for gasoline additives, solder, and casting metals were more than offset by increased demand for lead in the manufacture of lead-acid storage batteries, pigments, and ammunition. Starting-lighting-ignition (SLI) batteries, which are used primarily in the automotive industry, were the main contributors to increased consumption in 1981. Although production of new automobiles was reduced, there was strong demand for replacement SLI batteries. Shipments were about 7% above the 1980 total of 53.6 million units.

LEAD PIGMENTS

Consumption of pig lead in the manufacture of lead oxides and pigments in 1981 increased 27% from the 1980 total. The growth was attributed mainly to the upturn in use for storage battery oxides and chemicals required by the paint, ceramic, and plastic industries.

Prices.—The quoted price for lead chemicals in 1981 was based on the selling prices for pig lead in a given period; however, premium adjustments were made by the individual companies to reflect differences in manufacturing technique, freight considerations, quality requirements, and other factors. The average premium during 1980 for litharge was approximately 7.0 cents per pound above the U.S. price, and for red lead, about 9.0 cents per pound above the U.S. price.

Foreign Trade.—Imports of lead chemicals and pigments in 1981 increased about 17% above the 1980 receipts and reflected an increased demand in the replacement storage battery industry.

PRICES

The U.S. producer price for lead, which was declining at the beginning of the year, continued its downward trend to a Metals Week monthly published average of 30 cents per pound in February. During the last 2 weeks of February, Bunker Hill, Asarco, Cominco, and several of the larger secondary smelters increased their price quotations by 2 cents per pound. The reasons given for higher prices were a disparity in the world market where lead was being traded above the U.S. price, and a shortage of raw material in the secondary sector. This price increase initiated an upward trend that peaked at an average price of 44 cents per pound in August. The upward pressure on the pricing structure was accentuated by strikes at the Missouri lead mines of St. Joe Lead and a complete shutdown at the AMAX-Homestake lead complex. In September, following the resolution of labor problems in the Missouri lead belt, the U.S. producer price again fell into a decline which lasted through the balance of the year. The December average was published in Metals Week at 31 cents per pound. The annual average U.S. producer price for lead was 36.5 cents per pound in 1981, compared with 42.5 cents in 1980.

LME quotations during 1981 were not competitive with U.S. pricing. The average spread for the year on a 12-month weighted basis was about 3.6 cents per pound, and the cost of shipping, duty, handling, and inland freight was estimated to be above 6.0 cents. The average annual cash lead price on the LME was 33.3 cents per pound.

FOREIGN TRADE

In 1981, the United States was a net importer of about 15,000 tons of lead metal for consumption, in all forms excluding oxides, as compared with net exports of 197,000 tons in 1980. The change in trade balance was largely attributed to declines in exports of unwrought lead, lead alloys, and scrap because of depressed foreign markets. Because of labor problems at domestic primary smelters-refiners, there was a modest increase in exports of lead concentrates, while exports of wrought lead and lead alloys declined slightly. Canada and Mexico continued as the primary sources of imports. Honduras, Australia, and Peru also contributed to the domestic supply, exporting both metal and lead contained in concentrates, to the United States.

Tariff regulations in effect during 1981 are given in table 2, on a lead content basis.

Table 2.—U.S. import duties for lead materials, January 1, 1981

Item	TSUS No.	Most favored nation (MFN)	Least developed developing countries (LDDC)	Non-MFN
Ore	602.10	0.75 cent per pound	Free	1.5 cents per pound on lead content.
Lead bullion	[1]624.02	3.5% ad valorem	do	10.5% ad valorem.
Other unwrought	[1]624.03	[2]3.0% ad valorem	do	10% ad valorem.
Waste and scrap	[1]624.04	3.4% ad valorem	2.3% ad valorem	11.5% ad valorem.

[1]The minimum duty shall not be less than 1.0625 cents per pound of lead.
[2]Temporary reduction until July 1, 1983, unless rescinded.

WORLD REVIEW

Consumption of refined metal in the market economy countries dropped approximately 4.5% during 1981 to slightly under 3.8 million tons. Producer, consumer, and merchant stocks in these Nations remained essentially unchanged at 524,200 tons at yearend, according to International Lead and Zinc Study Group statistics.[3] The U.S. Bureau of Mines estimated total world refined production, excluding remelt scrap, remained essentially unchanged at 5.3 million tons, and total world mine production declined slightly.

Australia.—Mine production decreased and smelter and refinery production increased slightly. Estimated exports of bullion remained essentially the same. During 1981, one new mine with lead ore, the Que River project in Tasmania, was opened by Aberfoyle Ltd., owned 47% by Cominco. Primarily a silver and zinc project, the mine will also produce about 1,000 tons per month of lead, starting in 1982. No lead mine closings were announced during the year in Australia.

At Mount Isa Mines Holdings, Ltd. (MIM), Mount Isa Mine, the largest lead and silver mine in the world, work continued on development to expand lead production by 20% to 177,000 tons per year by 1983. During 1981, the mill modernization was completed. Asarco, which owned 49% of MIM Holdings, Ltd., announced intentions to reduce its holdings to 44% in order to give MIM greater flexibility in developing new resource projects under Australia's 50% domestic equity quidelines. Near Cobar, New South Wales, the Electrolytic Zinc Co. of Australasia Ltd. (EZ Industries) continued with development of the zinc-lead-silver Elura Mine, which was expected to start up in 1983 with a capacity of 40,000 tons per year of lead by 1985. In the Kimberley region in Western Australia near the Northern Territory, Aquitaine Proprietary Ltd. and MIM continued exploration and hydrogeochemical assessment of the Sorby Hills lead deposit. During 1982 and 1983, total mine capacity for lead in Australia was expected to increase by about 100,000 tons per year.

Bolivia.—Construction started during the year on the $165 million Karachipampa primary lead and silver smelter complex in the Potosí district. The plant will be jointly owned by Corporacion Minera de Bolivia and Empresa Nacional de Fundiciones and will use the Soviet KIVCET direct-reduction technology. The plant was expected to be operational in 1983, and production was expected to reach the level of 22,000 tons per year by 1984. At Quioma, Asarco, a 58% owner, completed a 50% expansion of its mine system to a capacity of 300 tons per day of ore and 6,000 tons per year of lead.

Canada.—Mine production of lead reached a 5-year high, primarily owing to Brunswick Mining and Smelting Corp. Ltd. completing the expansion of its No. 12 Mine near Bathurst, New Brunswick, early in the year and achieving full production of 10,000 tons per day of ore by April. The mine's lead capacity of 85,000 tons per year was second only to Cominco's Sullivan Mine, equivalent to 90,000 tons per year, at Kimberly, British Columbia. Also near Bathurst, Anaconda Canada Exploration Ltd. performed metallurgical testing to determine the feasibility of reopening its Caribou Mine. Two new producers in Nova Scotia, the Gays River Mine of Esso Resources Canada Ltd. and the Cape Breton Mine of Yava Mines Ltd. encountered major production problems during the year and temporarily ceased operations. Ore production at Cominco's Sullivan Mine in British Columbia was the highest since 1964 as ore grades improved by 0.5% and lead concentrate production was correspondingly higher. Conversion of the mine to a mechanized system progressed, and major improvements were made to the ventilation system. At Cominco's Polaris Mine on Little Cornwallis Island, Northwest Territory, the world's most northern mine, surface construction and underground contract development work was completed, and ore was first fed into the mill in November. The mill design capacity is 30,000 tons per year of lead in concentrates. When full production is achieved, Cominco will become the world's largest wholly integrated producer of lead and zinc.

Cadillac Explorations Ltd. of Calgary continued with development of the Prairie Creek Mine in the Nahanni mining district, Northwest Territory, and constructed a 900-ton-per-day mill. The average ore grade in proven reserves from 12 mineralized zones is 11.2%. The combined leases of Cadillac will yield mine production estimated at 25,000 tons per year lead in concentrates. Startup was scheduled for 1982.

In exploration during 1981, Cyprus Anvil Mining Corp. and Hudson Bay Oil and Gas Company Ltd. conducted a major program on the Cirque deposit in the Akie River district north of Williston Lake in north-central British Columbia. A diamond drilling program was completed that reportedly indicated a lead-zinc-silver district of potentially major proportions. Cyprus Anvil continued its Vangorda Plateau development program in the Yukon, completing a $71 million modification of its Anvil concentrator and starting a $240 million long-term development of the Vangorda and Grum opencast mines. These ores will be blended with those from the existing Faro Camp (presently 85,000 tons per year). In Newfoundland, Asarco continued with exploration and development of deeper and contiguous ore deposits of the Buchans Mine.

Italy.—Societa per Azioni Minero-Metallurgiche (SAMIM) closed its 30,000-ton-per-year primary smelter at San Gavino, Sardinia, but kept operating its 80,000-ton-per-year refinery and started construction of a new 80,000-ton-per-year smelter, scheduled for completion in 1985.

Mexico.—Although mine production was slightly higher than that of 1980, it was significantly below any level achieved in the previous 5 years. Smelter and refinery production rose moderately. Mexico Desarrollo Industrial Minero, S.A. (MEDIMSA), is a holding company owned 34% by Asarco, which owns the shares of the part of Industrial Minera Mexico, S.A. (IMMSA), that is engaged in the mining, milling, smelting and refining of nonferrous metals. In 1981, production of IMMSA's Santa Barbara and Santa Eulalia mines was reduced by strikes that lasted for 75 and 81 days, respectively. In March, MEDIMSA signed a $250 million loan agreement with a consortium of banks to finance the completion of several major expansion and construction projects. Three of those projects were completed for IMMSA in 1981. The Velardena Mine in Durango reached design capacity of 800 tons per day of ore in September; the Taxco Mine had an expansion from 2,400 tons per day of ore to 3,600 tons per day in July; and the Santa Barbara Mine in Chihuahua had an expansion from 2,600 tons per day to 5,300 tons per day by yearend. Development work also continued at IMMSA's Rosario project in Sinaloa. The new underground mine will have an estimated lead production capacity of 11,000 tons per year and is scheduled for startup in 1983. Comision de Fomento Minero, Frisco S.A. de C.V., and Placer Development Ltd. of Canada continued development of the Real de Angeles open pit mine in Zacatecas with an anticipated 1982 startup. This mine has an estimated capacity of 31,000 tons per year of lead in concentrates. By 1983, new mines and scheduled or ongoing expansions will add an estimated 55,000 tons per year to Mexican capacity for lead production. During 1981, the Cuale Mine was opened by Industrias Peñoles near Puerto Vallarta, Jalisco, which offset the closing of the company's mine at Reforma, Sinaloa.

Yugoslavia.—Expansion of three existing underground mines at Blagodat, Srebrenica, and Trepca, planned for completion by 1984, will provide additional capacities of 3,000, 4,000, and 9,000 tons per year of lead, respectively. A new open pit mine was under development at Vares by Energoinvest for startup in 1983, producing 4,000 tons per year of lead, and the new Topanica Mine near Kriva Planka in Macedonia came onstream. The Topanica Mine had reported reserves of 13.8 million tons of ore, sufficient for 20 years of mining.

TECHNOLOGY

During 1981, the Bureau of Mines Rolla Research Center developed an electrochemical system for recycling secondary lead materials that is energy efficient and less polluting than conventional pyrometallurgical smelting. Electrorefining of lead anodes made from scrap battery grid metal yielded cathode deposits of 99.99% lead at near 100% current efficiency. The scrap grid metal was cleaned in a ball mill containing $(NH_4)_2CO_3$ solution prior to melting to remove the adhering sludge and eliminate fumes that are normally generated during melting. The sludge was treated for recovery of lead during a second phase electrowinning operation. A hydrometallurgical treatment procedure was developed for recovery of the antimony, lead, and other values from slimes generated during electrorefining and for recycling the drosses generated in the melt prior to casting anodes. A report describing initial bench-scale work on the process was published in December,[4] and a patent was awarded in June.[5]

In a related development, the state-controlled Italian engineering company, Snamprogetti S.p.A., announced that it will license technology for its electrochemical technique that reclaims battery lead, known as the Ginatta process.[6] The process fundamentally involves cutting the bottoms off whole batteries and immersing them directly in an electrolyte where the lead values are dissolved prior to electrowinning.

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 are contained in quarterly issues of Lead Abstracts published by the Lead Development Association, London, England.

Progress reports of the projects supported by the International Lead and Zinc Research Organization, Inc. (ILZRO), are released annually in the ILZRO Research Digest.

[1]Mineral specialist, Division of Nonferrous Metals.
[2]Physical scientist, Division of Nonferrous Metals.
[3]International Lead and Zinc Study Group (London). Lead and Zinc Statistics. Monthly Bull., v. 22, No. 4, April 1982, pp. 15, 17.
[4]Cole, E. R., Jr., A. Y. Lee, and D. L. Paulson. Electrolytic Method for Recovery of Lead From Scrap Batteries. BuMines RI 8602, 1981, 19 pp.
[5]———. Electrowinning of Lead From H_2SiF_6 Solution. U.S. Pat. 4,272,340, June 9, 1981.
[6]American Metal Market. Snamprogetti To Market Non-Polluting Process To Recover Battery's Pure Lead. V. 89, No. 135, July 15, 1981, p. 8.

Table 3.—Mine production of recoverable lead in the United States, by State

(Metric tons)

State	1977	1978	1979	1980	1981
Arizona	288	416	354	r162	993
California	3	W	W	W	W
Colorado	20,860	15,151	7,554	10,272	11,431
Idaho	42,872	44,761	42,636	38,607	38,397
Maine	161	--	--	--	--
Missouri	453,824	461,762	472,054	497,170	389,721
Montana	96	132	258	295	194
Nevada	674	653	24	26	W
New York	2,520	990	458	876	968
Oregon	--	--	(1)	--	W
Tennessee	--	--	(1)	--	--
Utah	9,749	2,541	W	W	1,662
Virginia	1,998	1,803	1,596	1,563	1,607
Washington	1,090	W	(1)	W	--
Other	3,364	1,452	635	r1,395	562
Total	537,499	529,661	525,569	r550,366	445,535

rRevised. W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Less than 1/2 unit.

Table 4.—Production of lead and zinc in the United States in 1981, by State and class of ore from old tailings, etc., in terms of recoverable metal

(Metric tons)

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
Arizona	(1)	(1)	(1)	--	--	--	--	--	--
Colorado	--	--	--	--	--	--	(1)	(1)	W
Idaho	(1)	(1)	W	(1)	(1)	W	845,579	26,821	W
Missouri	7,729,301	389,721	52,904	--	--	--	--	--	--
Montana	549	21	4	--	--	--	--	--	--
New Jersey	--	--	--	89,037	--	16,198	--	--	--
New York	--	--	--	509,799	968	36,889	--	--	--
Pennsylvania	--	--	--	491,543	--	24,732	--	--	--
Tennessee	--	--	--	4,511,557	--	115,369	--	--	--
Utah	--	--	--	--	--	--	33,160	1,660	1,575
Virginia	--	--	--	398,291	1,607	9,731	--	--	--
Other[2]	7	4	--	11,431	--	149	11	3	43,260
Total	7,729,857	389,746	52,908	6,011,658	2,575	203,068	878,750	28,484	44,835
Percent of total lead-zinc	XX	87	17	XX	1	65	XX	6	14

State	Copper-lead, copper-zinc, and copper-lead-zinc ores			All other sources[3]			Total		
	Gross weight (dry basis)	Lead	Zinc	Gross weight (dry basis)	Lead	Zinc	Gross weight (dry basis)	Lead	Zinc
Arizona	--	--	--	[1]64,180,556	[1]993	[1]138	64,180,556	993	138
Colorado	--	--	--	[1]826,211	[1]11,431	W	826,211	11,431	W
Idaho	--	--	--	[1]869,640	[1]11,576	W	1,715,219	38,397	W
Missouri	--	--	--	--	--	--	7,729,301	389,721	52,904
Montana	--	--	--	559,064	173	21	559,613	194	25
New Jersey	--	--	--	--	--	--	89,037	--	16,198
New York	--	--	--	--	--	--	509,799	968	36,889
Pennsylvania	--	--	--	--	--	--	491,543	--	24,732
Tennessee	1,783,605	--	2,315	--	--	--	6,295,162	--	117,684
Utah	--	--	--	4,082	2	1	37,242	1,662	1,576
Virginia	--	--	--	--	--	--	398,291	1,607	9,731
Other[2]	--	--	--	2,398,598	555	9,132	2,410,047	562	52,541
Total	1,783,605	--	2,315	68,838,151	24,730	9,292	85,242,021	445,535	312,418
Percent of total lead-zinc	XX	--	1	XX	6	3	XX	100	100

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

[1]Lead ore, zinc ore, lead-zinc ore, copper-lead ore, and ore from "All other sources" combined to avoid disclosing company proprietary data.

[2]Includes Alaska, California, Illinois, Kentucky, Nevada, New Mexico, Oregon, and lead and zinc recovered from tailings not distinguishable as to State origin.

[3]Lead and zinc recovered from copper, gold, silver, and fluorspar ores and from mill tailings and miscellaneous cleanups.

Table 5.—Mine production of recoverable lead in the United States, by month

(Metric tons)

Month	1980	1981
January	51,432	42,647
February	50,278	40,893
March	49,838	43,396
April	48,904	26,741
May	49,893	27,846
June	46,101	17,403
July	43,409	31,825
August	41,541	38,236
September	[r]39,384	47,994
October	[r]48,553	47,499
November	[r]39,715	39,760
December	[r]41,318	41,295
Total	[r]550,366	445,535

[r]Revised.

Table 6.—Twenty-five leading lead-producing mines in the United States in 1981, 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	Milliken	Reynolds, Mo	Ozark Lead Co	Do.
3	Magmont	Iron, Mo	Cominco American, Inc	Do.
4	Fletcher	Reynolds,Mo	St. Joe Lead Co	Do.
5	Viburnum No. 29	Washington, Mo	do	Do.
6	Viburnum No. 28	Iron, Mo	do	Do.
7	Brushy Creek	Reynolds, Mo	do	Do.
8	Bunker Hill	Shoshone, Idaho	The Bunker Hill Co	Lead-zinc ore.
9	Star Unit	do	Helca Mining Co	Do.
10	Lucky Friday	do	do	Silver ore.
11	Indian Creek	Washington, Mo	St. Joe Lead Co	Lead ore.
12	Leadville Unit	Lake, Colo	ASARCO Incorporated	Lead-zinc ore.
13	Sunnyside	San Juan, Colo	Standard Metals Corp	Gold ore.
14	Ontario Project	Summit, Utah	Noranda Mines, Ltd	Lead-zinc ore.
15	Austinville and Ivanhoe	Wythe, Va	The New Jersey Zinc Co	Zinc ore.
16	Bulldog Mountain	Mineral, Colo	Homestake Mining Co	Silver ore.
17	Balmat	St. Lawrence, N.Y	St. Joe Lead Co	Zinc ore.
18	Sherman Tunnel	Lake, Colo	Helca Mining Co	Silver ore.
19	McCracken	Mohave, Ariz	Mindy Inc	Do.
20	Clayton	Custer, Idaho	Clayton Silver Mines	Do.
21	Inverness	Hardin, Ill	Inverness Mining Co	Fluorspar.
22	Camp Bird	Ouray, Colo	Federal Resources Co	Silver ore.
23	Silver Bell Unit	Pima, Ariz	ASARCO Incorporated	Copper ore.
24	Rosiclare	Hardin & Pope, Ill	Ozark Mahoning Co	Fluorspar.
25	Baker's Park	San Juan, Colo	Baker's Park Mining & Milling Co	Gold-silver ore.

Table 7.—Refined lead produced at primary refineries in the United States, by source material

(Metric tons)

	1977	1978	1979	1980	1981
Refined lead:[1]					
From primary sources:					
Domestic ores and base bullion	486,659	501,643	529,970	508,163	440,238
Foreign ores and base bullion	62,041	63,530	45,641	39,427	55,085
Total	548,700	565,173	575,611	547,590	495,323
From secondary sources	86	1,244	2,862	2,117	1,745
Grand total	548,786	566,417	578,473	549,707	497,068
Calculated value of primary refined lead (thousands)[2]	$371,371	$419,277	$668,004	$512,590	$398,908

[1]GSA metal is not included in refined lead production.
[2]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
1977	6,855	816	11.9	2,459	528	3,052	6,039
1978	5,006	710	14.2	2,384	530	1,382	4,296
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

Table 9.—Stocks and consumption of new and old lead scrap in the United States in 1981

(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
Smelters and refiners:						
Soft lead	1,988	27,538	--	27,925	27,925	1,601
Hard lead	1,684	19,562	--	19,831	19,831	1,415
Cable lead	4,704	2,280	--	4,806	4,806	2,178
Battery-lead plates	34,724	735,029	--	731,255	731,255	38,498
Mixed common babbitt	167	6,656	--	6,729	6,729	94
Solder and tinny lead	1,931	11,605	--	11,829	11,829	1,707
Type metals	1,908	13,795	--	14,041	14,041	1,662
Drosses and residues	12,484	83,900	84,799	--	84,799	11,585
Total	59,590	900,365	84,799	816,416	901,215	58,740
Foundries and other manufacturers:						
Soft lead	--	--	--	--	--	--
Hard lead	--	--	--	--	--	--
Cable lead	--	--	--	--	--	--
Battery-lead plates	--	--	--	--	--	--
Mixed common babbitt	43	2,803	--	2,775	2,775	71
Solder and tinny lead	--	--	--	--	--	--
Type metals	--	--	--	--	--	--
Drosses and residues	--	--	--	--	--	--
Total	43	2,803	--	2,775	2,775	71
All consumers:						
Soft lead	1,988	27,538	--	27,925	27,925	1,601
Hard lead	1,684	19,562	--	19,831	19,831	1,415
Cable lead	4,704	2,280	--	4,806	4,806	2,178
Battery-lead plates	34,724	735,029	--	731,255	731,255	38,498
Mixed common babbitt	210	9,459	--	9,504	9,504	165
Solder and tinny lead	1,931	11,605	--	11,829	11,829	1,707
Type metals	1,908	13,795	--	14,041	14,041	1,662
Drosses and residues	12,484	83,900	84,799	--	84,799	11,585
Grand total	59,633	903,168	84,799	819,191	903,990	58,811

Table 10. —Secondary metal recovered[1] from lead and tin scrap in the United States in 1981, by type of product

(Metric tons)

	Lead	Tin	Antimony	Other	Total
Refined pig lead	264,872	--	--	--	264,872
Remelt lead	17,282	--	--	--	17,282
Total	282,154	--	--	--	282,154
Refined pig tin	--	1,570	--	--	1,570
Remelt tin	--	18	--	--	18
Total	--	1,588	--	--	1,588
Lead and tin alloys:					
Antimonial lead	304,376	791	14,851	619	320,637
Common babbitt	6,112	200	837	5	7,154
Genuine babbitt	13	61	6	1	81
Solder	22,997	3,035	561	34	26,627
Type metals	9,521	576	1,727	6	11,830
Cable lead	1,193	--	11	--	1,204
Miscellaneous alloys	1,083	106	20	1	1,210
Total	345,295	4,769	18,013	666	368,743
Tin content of chemical products	--	265	--	--	265
Grand total	627,449	6,622	18,013	666	652,750

[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)

	1977	1978	1979	1980	1981
As metal:					
At primary plants	86	1,244	2,862	2,117	1,745
At other plants	303,063	281,340	349,359	313,061	280,409
Total	303,149	282,584	352,221	315,178	282,154
In antimonial lead:					
At primary plants	3,052	1,382	535	3	46
At other plants	380,335	408,528	378,295	306,683	304,330
Total	383,387	409,910	378,830	306,686	304,376
In other alloys	71,056	76,742	70,317	53,714	54,575
Grand total:					
Quantity	757,592	769,236	801,368	675,578	641,105
Value (thousands)[1]	$512,753	$570,662	$930,019	$632,397	$516,313

[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)

	1980	1981
KIND OF SCRAP		
New scrap:		
Lead-base	89,934	58,829
Copper-base	4,162	4,232
Tin-base	95	13
Total	94,191	63,074
Old scrap:		
Battery-lead plates	480,624	481,355
All other lead-base	87,966	81,762
Copper-base	12,796	14,913
Tin-base	1	1
Total	581,387	578,031
Grand total	675,578	641,105
FORM OF RECOVERY		
As soft lead:		
At primary plants	2,117	1,745
At other plants	313,061	280,409
Total	315,178	282,154
In antimonial lead[1]	306,686	304,376
In other lead alloys	41,531	40,061
In copper-base alloys	12,174	14,501
In tin-base alloys	9	13
Total	360,400	358,951
Grand total	675,578	641,105

[1]Includes 3 tons of lead recovered in antimonial lead from secondary sources at primary plants in 1980 and 46 tons in 1981.

Table 13.—Lead consumption in the United States, by product

(Metric tons)

SIC Code	Product	1980	1981
	Metal products:		
3482	Ammunition: Shot and bullets	48,662	49,514
	Bearing metals:		
35	Machinery except electrical	1,634	1,660
36	Electrical and electronic equipment	39	26
371	Motor vehicles and equipment	2,242	2,464
37	Other transportation equipment	3,893	2,772
	Total bearing metals	7,808	6,922
3351	Brass and bronze: Billets and ingots	13,981	13,306
36	Cable covering: Power and communication	13,408	12,072
15	Calking lead: Building construction	5,684	5,522
	Casting metals:		
36	Electrical machinery and equipment	776	993
371	Motor vehicles and equipment	1,267	1,247
37	Other transportation and equipment	12,380	12,634
3443	Nuclear radiation shielding	4,598	3,708
	Total casting metals	19,021	18,582
	Pipes, traps, and other extruded products:		
15	Building construction	7,734	8,509
3443	Storage tanks, process vessels, etc	863	320
	Total pipes, traps, and other extruded products	8,597	8,829
	Sheet lead:		
15	Building construction	12,943	12,283
3443	Storage tanks, process vessels, etc	6,853	938
3693	Medical radiation shielding	(1)	6,134
	Total sheet lead	19,796	19,355
	Solder:		
15	Building construction	4,507	6,167
341	Metal cans and shipping containers	10,268	7,749
367	Electronic components and accessories	8,232	5,606
36	Other electrical machinery and equipment	2,733	2,583
371	Motor vehicles and equipment	15,626	7,600
	Total solder	41,366	29,705
	Storage battery grids, post, etc.:		
36911	Storage batteries: SLI automotive	276,996	313,531
36912	Storage batteries: Industrial and traction	25,244	28,664
	Total storage battery grids, post, etc	302,240	342,195
	Storage battery oxides:		
36911	Storage batteries: SLI automotive	328,234	407,053
36912	Storage batteries: Industrial and traction	14,883	20,904
	Total storage battery oxides	343,117	427,957
371	Terne metal: Motor vehicles and equipment	2,861	3,971
27	Type metal: Printing and allied industries	8,997	7,838
34	Other metal products[2]	10,506	7,939
	Total metal products	846,044	953,707
	Pigments:		
285	Paints	20,736	16,316
32	Glass and ceramic products	45,361	44,339
28	Other pigments[3]	12,333	19,510
	Total pigments	78,430	80,165
2911	Chemicals: Petroleum refining	127,903	111,367
	Miscellaneous uses	17,926	21,862
	Grand total	1,070,303	1,167,101

[1]Included in "Storage tanks" 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	1980	1981
January	100,852	101,211
February	85,423	93,444
March	91,294	99,062
April	83,587	93,264
May	84,199	90,520
June	73,181	92,622
July	64,814	79,448
August	78,979	95,446
September	99,253	103,066
October	112,607	117,043
November	94,413	94,358
December	101,701	107,617
Total[2]	1,070,303	1,167,101

[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 in the United States in 1981, by State[1]

(Metric tons)

State	Refined soft lead	Lead in antimonial lead	Lead in alloys	Lead in copper-base scrap	Total
California	74,834	36,758	5,891	613	118,096
Colorado	608	269	15	--	892
Connecticut	8,223	13,994	--	325	22,542
District of Columbia	25	--	--	--	25
Florida	10,908	8,914	319	--	20,141
Georgia	53,343	21,791	2,392	12	77,538
Illinois	17,706	32,539	2,193	1,162	53,600
Indiana	101,017	18,966	6,962	513	127,458
Kansas	24,979	10,121	752	51	35,903
Kentucky	5,730	9,854	2	--	15,586
Maryland	339	823	170	--	1,332
Massachusetts	1,223	194	31	335	1,783
Michigan	7,766	9,752	238	6	17,762
Missouri	14,465	11,425	1,754	1,098	28,742
Nebraska	828	77	1,132	1,170	3,207
New Jersey	86,525	5,011	5,137	405	97,078
New York	23,242	4,772	4,951	588	33,553
Ohio	12,767	8,524	2,024	413	23,728
Pennsylvania	99,080	49,123	22,425	1,095	171,723
Rhode Island	3,384	61	10	--	3,455
Tennessee	1,530	12,955	55	96	14,636
Virginia and West Virginia	256	1,913	17	--	2,186
Washington	10,569	298	--	--	10,867
Wisconsin	5,927	8,674	48	154	14,803
Alabama and Mississippi	7,292	4,008	1,157	1,797	14,254
Arkansas and Oklahoma	2,105	1,204	--	--	3,309
Hawaii and Oregon	2,710	5,400	--	--	8,110
Iowa and Minnesota	13,456	14,875	105	--	28,436
Louisiana and Texas	122,814	24,606	1,523	--	148,943
Montana and Idaho	771	--	--	--	771
New Hampshire, Maine, Vermont, Delaware	10,038	13,573	--	119	23,730
North Carolina and South Carolina	22,737	19,258	3	--	41,998
Utah, Nevada, Arizona	--	--	914	--	914
Total	747,197	349,732	60,220	9,952	1,167,101

[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 1981, by class of product and type of material

(Metric tons)

Product	Soft lead	Lead in antimonial lead	Lead in alloys	Lead in copper-base scrap	Total
Metal products	83,206	54,781	35,616	9,952	183,555
Storage batteries	456,007	292,066	22,079	--	770,152
Pigments	80,165	--	--	--	80,165
Chemicals	111,367	--	--	--	111,367
Miscellaneous	16,452	2,885	2,525	--	21,862
Total	747,197	349,732	60,220	9,952	[1]1,167,101

[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	1980			1981		
	Production (metric tons)	Shipments		Production (metric tons)	Shipments	
		Metric tons	Value[2]		Metric tons	Value[2]
White lead, dry	1,111	1,056	$1,406,310	1,022	1,029	$1,297,317
Red lead	12,533	13,110	15,562,624	14,688	15,077	16,327,054
Litharge	41,412	47,060	47,419,465	46,891	47,141	35,342,133
Black oxide	361,130	--	--	444,625	--	--

[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, by source

(Metric tons)

Product	Lead in pigments from pig lead	
	1980	1981
White lead	889	818
Red lead	11,405	13,366
Litharge	38,514	43,608
Leady oxide	329,151	423,723
Total	379,959	481,515

[1]Excludes basic lead sulfate; withheld to avoid disclosing company proprietary data.

Table 19.—Distribution of red lead shipments, by industry

(Metric tons)

Industry	1977	1978	1979	1980	1981
Paints	5,914	5,993	5,300	3,241	3,172
Ceramics	--	--	--	2,597	2,307
Storage batteries	W	W	W	6,068	7,573
Other	11,870	13,234	12,846	995	2,025
Total	17,784	19,227	18,146	12,901	15,077

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

Table 20.—Distribution of litharge shipments, by industry

(Metric tons)

Industry	1977	1978	1979	1980	1981
Ceramics	27,161	33,865	37,620	36,560	34,732
Chrome pigments	--	--	--	3,015	4,247
Oil refining	W	W	W	170	227
Paints	2,455	3,200	3,038	3,362	3,765
Rubber	2,868	2,153	1,520	943	1,107
Other	78,789	62,887	58,792	784	3,063
Total	111,273	102,105	100,970	44,834	47,141

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

Table 21.—U.S. imports for consumption of lead pigments and compounds

Kind	1980		1981	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
White lead	116	$252	187	$344
Red lead	1,298	1,420	993	822
Litharge	9,414	9,195	11,026	8,812
Chrome yellow	1,214	3,050	1,204	2,919
Other lead pigments	35	164	297	487
Other lead compounds	857	1,144	1,479	1,849
Total	12,934	15,225	15,186	15,233

Table 22.—Stocks of lead at primary smelters and refineries in the United States, December 31

(Metric tons)

Stocks	1977	1978	1979	1980	1981
Refined pig lead	12,044	17,001	45,448	54,728	78,836
Lead in antimonial lead	1,945	556	646	122	666
Lead base bullion	5,312	5,818	5,683	5,398	4,872
Lead in ore and matte	71,812	75,290	37,545	65,746	55,833
Total	91,113	98,665	89,322	125,994	140,207

Table 23.—Stocks of lead at consumers and secondary smelters in the United States, December 31, by type of material

(Metric tons, lead content)

Year	Refined soft lead	Lead in antimonial lead	Lead in alloys	Lead in copper-base scrap	Total
1977	74,004	39,247	6,669	1,467	121,387
1978	72,065	44,417	7,564	1,188	125,234
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

Table 24.—Average monthly and annual quoted prices of lead[1]

(Cents per pound)

Month	1980 U.S. producer	1980 London Metal Exchange	1981 U.S. producer	1981 London Metal Exchange
January	49.88	50.66	33.79	31.95
February	49.56	52.93	30.42	31.24
March	49.22	50.72	35.06	33.06
April	44.02	43.88	37.52	34.38
May	36.00	35.49	36.41	31.58
June	34.19	33.44	37.97	32.30
July	35.60	36.74	40.99	35.55
August	40.96	38.65	43.89	37.34
September	42.26	40.01	40.32	34.61
October	45.00	39.50	37.05	32.47
November	43.81	36.89	33.88	30.18
December	38.97	33.68	31.07	30.56
Average	42.46	41.21	36.53	33.30

[1]Metals Week. Quotations for United States on a nationwide, delivered basis.

Table 25.—U.S. exports of lead, by country

Country	1980 Quantity (metric tons)	1980 Value (thousands)	1981 Quantity (metric tons)	1981 Value (thousands)
Ore and concentrates:				
Belgium-Luxembourg	437	$416	291	$343
Brazil	--	--	4,983	2,875
Bulgaria	--	--	7,808	5,010
Canada	24,840	9,051	15,420	8,554
Dominican Republic	--	--	69	21
Finland	--	--	799	690
Germany, Federal Republic of	--	--	2,450	1,056
Japan	522	276	--	--
Mexico	812	352	776	232
Netherlands	752	817	18	6
Philippines	--	--	19	17
Spain	--	--	328	112
Taiwan	169	108	--	--
United Kingdom	38	41	49	31
Other	45	57	33	11
Total	27,615	11,118	33,043	18,958
Unwrought lead and lead alloys:				
Argentina	397	322	2	2
Australia	15	26	8	9
Austria	--	--	64	82
Belgium-Luxembourg	30,175	34,092	4,316	2,832
Canada	2,910	3,028	2,996	2,597
Chile	160	149	2	14
Colombia	14	39	--	--
Costa Rica	7	12	4	7
Denmark	79	76	--	--
Dominican Republic	1	2	31	65
Ecuador	42	88	62	59
Egypt	4	21	30	126
El Salvador	1	7	2	9
France	1,000	749	12	14
Germany, Federal Republic of	1,386	1,647	65	37
Haiti	2	1	21	30
Honduras	21	22	10	34
Hong Kong	16	18	1	2
India	1,429	1,015	([1])	2
Indonesia	130	109	--	--
Israel	14	32	22	28
Italy	2,890	2,780	13	17
Japan	2,667	2,502	876	1,088
Korea, Republic of	2,051	1,838	1,478	972
Kuwait	--	--	23	41
Mexico	1,033	1,671	234	390
Mozambique	208	183	--	--
Netherlands	93,124	88,118	4,037	4,138
Netherlands Antilles	15	12	25	29
Nicaragua	1	27	28	32
Panama	([1])	1	150	107
Philippines	94	104	159	168
Saudi Arabia	75	189	81	156

See footnotes at end of table.

Table 25.—U.S. exports of lead, by country —Continued

Country	1980 Quantity (metric tons)	1980 Value (thousands)	1981 Quantity (metric tons)	1981 Value (thousands)
Unwrought lead and lead alloys —Continued				
Singapore	--	--	132	$104
South Africa, Republic of	--	--	163	171
Spain	87	$149	27	218
Switzerland	1,004	850	--	--
Taiwan	1,746	1,649	174	134
Thailand	656	620	238	180
Trinidad	--	--	106	125
Turkey	529	583	--	--
United Arab Emirates	5,414	4,502	11	34
United Kingdom	6,716	6,009	856	652
Venezuela	270	357	282	698
Zambia	--	--	27	27
Other	117	151	36	97
Total	156,500	153,750	16,804	15,527
Wrought lead and lead alloys:				
Argentina	3	4	--	--
Australia	17	31	20	23
Bahrain	21	29	--	--
Belgium-Luxembourg	1,531	790	1,740	587
Brazil	6	14	10	25
Canada	818	1,087	2,746	2,889
Chile	16	39	--	--
Colombia	3	6	2	4
Costa Rica	4	10	([1])	2
Dominican Republic	19	38	7	46
Ecuador	7	25	--	--
Finland	3	6	--	--
France	9	3	7	14
Germany, Federal Republic of	83	92	43	59
Guatemala	9	32	--	--
Honduras	7	26	([1])	1
Hong Kong	3	9	31	146
India	32	142	77	263
Israel	3	5	16	111
Italy	4	88	2	2
Japan	195	214	143	266
Korea, Republic of	37	24	30	24
Mexico	925	3,262	1,375	4,988
Netherlands	3,023	3,056	15	18
Netherlands Antilles	5	7	21	46
Panama	6	10	13	27
Philippines	7	25	42	162
Saudi Arabia	79	215	42	94
Singapore	9	57	2	6
South Africa, Republic of	([1])	2	2	9
Spain	112	384	20	80
Sweden	2	18	--	--
Taiwan	30	351	20	335
United Kingdom	836	740	9	41
Venezuela	13	30	50	101
Other	81	214	31	100
Total	7,958	11,085	6,516	10,469
Scrap:				
Argentina	606	296	([1])	2
Austria	16	12	--	--
Belgium-Luxembourg	495	369	768	240
Brazil	1,118	538	1,771	748
Canada	28,643	10,552	18,477	6,027
Denmark	5,561	2,855	1,187	583
Egypt	1,066	740	--	--
France	348	362	17	3
German Democratic Republic	1,810	933	--	--
Germany, Federal Republic of	9,255	5,814	3,268	1,336
Hong Kong	--	--	102	31
India	172	109	1,147	533
Ireland	165	127	32	152
Italy	3,621	3,047	17	24
Jamaica	49	17	--	--
Japan	6,316	3,918	1,819	963
Korea, Republic of	9,924	4,550	1,991	617
Kuwait	249	164	--	--
Mexico	8,143	2,519	10,847	2,591

See footnotes at end of table.

Table 25.—U.S. exports of lead, by country —Continued

Country	1980 Quantity (metric tons)	1980 Value (thousands)	1981 Quantity (metric tons)	1981 Value (thousands)
Scrap —Continued				
Mozambique	--	--	199	$175
Netherlands	6,626	$5,499	2,784	1,489
Norway	--	--	47	53
Philippines	139	75	36	40
Saudi Arabia	459	278	--	--
South Africa, Republic of	945	724	3,764	1,709
Spain	77	122	45	49
Sweden	108	64	147	50
Taiwan	15,033	6,068	8,732	2,996
Thailand	252	111	--	--
Turkey	699	339	--	--
Trust Territory of the Pacific Islands	54	18	--	--
United Kingdom	16,280	11,250	2,040	1,844
Venezuela	1,300	654	98	70
Other	122	97	84	63
Total	119,651	62,221	59,419	22,388
Grand total	311,724	238,174	115,782	67,342

[1]Less than 1/2 unit.

Table 26.—U.S. exports of lead, by year

Year	Blocks, pigs, anodes, etc.: Unwrought Quantity (metric tons)	Unwrought Value (thousands)	Unwrought alloys Quantity (metric tons)	Unwrought alloys Value (thousands)	Wrought lead and lead alloys: Sheets, plates, rods, other forms Quantity (metric tons)	Sheets, plates, rods, other forms Value (thousands)	Foil, powder, flakes Quantity (metric tons)	Foil, powder, flakes Value (thousands)	Scrap Quantity (metric tons)	Scrap Value (thousands)
1979	6,585	$8,383	795	$1,466	2,349	$3,456	917	$624	119,748	$53,514
1980	147,356	143,458	9,144	10,292	7,522	10,507	436	578	119,651	62,221
1981	14,484	12,591	2,320	2,936	5,966	9,719	550	750	59,419	22,388

Table 27.—U.S. imports[1] of lead, by country

Country	1979 Quantity (metric tons)	1979 Value (thousands)	1980 Quantity (metric tons)	1980 Value (thousands)	1981 Quantity (metric tons)	1981 Value (thousands)
Ore, flue dust, and residues, n.s.p.f. (lead content):						
Argentina	152	$160	61	$56	3,932	$3,023
Australia	1,923	1,828	2,971	2,309	2,160	1,228
Bolivia	--	--	571	477	--	--
Canada	12,762	10,954	8,520	6,901	23,500	17,149
Chile	--	--	2,236	1,927	2,084	1,719
Colombia	136	145	211	154	122	64
Honduras	10,923	11,619	3,974	3,943	11,617	9,271
Mexico	1,646	1,606	781	665	961	864
Peru	12,444	11,287	17,980	13,169	14,149	8,397
South Africa, Republic of	--	--	6,790	5,514	--	--
Other	12	10	--	--	20	14
Total	39,998	37,609	44,095	35,115	58,545	41,729
Base bullion (lead content):						
Canada	1,654	1,654	247	219	59	58
Denmark	27	36	--	--	--	--
Mexico	--	--	27	30	--	--
Peru	--	--	--	--	390	278
Other	([2])	1	22	260	([2])	4
Total	1,681	1,691	296	509	449	340

See footnotes at end of table.

Table 27.—U.S. imports[1] of lead, by country —Continued

Country	1979 Quantity (metric tons)	1979 Value (thousands)	1980 Quantity (metric tons)	1980 Value (thousands)	1981 Quantity (metric tons)	1981 Value (thousands)
Pigs and bars (lead content):						
Argentina	--	--	--	--	300	$220
Australia	17,275	$18,597	11,338	$12,365	10,893	8,023
Belgium-Luxembourg	1,981	11,026	846	5,567	286	1,666
Canada	71,342	79,512	34,929	31,649	50,849	39,298
Denmark	521	726	619	591	354	341
France	2,000	2,041	--	--	--	--
Germany, Federal Republic of	574	5,529	446	4,342	1,433	8,899
Mexico	73,643	76,488	28,636	27,987	33,723	25,183
Namibia	3,913	4,231	--	--	--	--
Netherlands	--	--	56	590	--	--
Peru	17,903	19,387	3,298	2,974	2,907	2,146
South Africa, Republic of	1,299	1,260	--	--	--	--
Spain	--	--	1,036	1,313	--	--
United Kingdom	801	1,979	468	1,085	989	2,269
Other	410	535	61	45	186	499
Total	191,662	221,311	81,733	88,508	101,920	88,544
Reclaimed scrap, etc. (lead content):						
Australia	2,676	2,349	4,747	3,458	2,605	1,611
Bahamas	18	3	26	7	83	12
Barbados	3	2	--	--	22	5
Canada	2,661	2,720	1,639	1,570	1,792	1,394
Chile	--	--	--	--	87	28
Dominican Republic	56	39	86	32	--	--
Guatemala	102	62	8	5	77	29
Haiti	5	12	13	3	--	--
Jamaica	48	7	--	--	3	1
Mexico	896	652	551	405	456	344
Panama	19	16	18	8	--	--
Spain	36	157	108	637	92	380
United Kingdom	17	16	--	--	--	--
Other	145	94	66	20	48	27
Total	6,682	6,129	7,262	6,145	5,265	3,831
Grand total	240,023	266,740	133,386	130,277	166,179	134,444

[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.

Table 28.—U.S. imports for consumption of lead, by country

Country	1979 Quantity (metric tons)	1979 Value (thousands)	1980 Quantity (metric tons)	1980 Value (thousands)	1981 Quantity (metric tons)	1981 Value (thousands)
Ore, flue dust, and residues, n.s.p.f. (lead content):						
Argentina	152	$160	61	$56	3,932	$3,023
Australia	5,780	1,831	365	322	648	457
Bolivia	--	--	571	477	--	--
Canada	7,866	4,822	2,985	2,873	1,913	1,353
Chile	--	--	2,236	1,927	2,084	1,719
Colombia	136	145	211	154	122	64
Honduras	15,048	12,814	3,973	3,943	11,617	9,271
Mexico	1,646	1,606	781	665	961	864
Peru	13,761	11,638	18,141	13,292	5,909	3,431
South Africa, Republic of	--	--	291	218	--	--
Other	12	10	--	--	20	14
Total	44,401	33,026	29,615	23,927	27,206	20,196
Base bullion (lead content):						
Canada	1,654	1,654	247	219	59	58
Denmark	27	36	--	--	--	--
Mexico	--	--	27	30	--	--
Peru	--	--	--	--	390	278
Other	([1])	1	22	260	([1])	4
Total	1,681	1,691	296	509	449	340

See footnotes at end of table.

Table 28.—U.S. imports for consumption of lead, by country —Continued

Country	1979 Quantity (metric tons)	1979 Value (thousands)	1980 Quantity (metric tons)	1980 Value (thousands)	1981 Quantity (metric tons)	1981 Value (thousands)
Pigs and bars (lead content):						
Argentina	--	--	--	--	300	$220
Australia	8,163	$6,737	10,884	$11,464	9,080	6,505
Belgium-Luxembourg	1,981	11,026	846	5,567	286	1,666
Canada	71,342	79,512	34,929	31,649	50,849	39,298
Denmark	521	726	619	591	354	341
France	2,000	2,041	--	--	--	--
Germany, Federal Republic of	574	5,529	446	4,342	1,433	8,899
Mexico	73,643	76,488	28,657	28,009	33,723	25,183
Namibia	3,913	4,231	--	--	--	--
Netherlands	--	--	56	590	--	--
Peru	17,903	19,387	3,298	2,974	2,907	2,146
South Africa, Republic of	1,299	1,260	--	--	--	--
Spain	--	--	1,036	1,313	--	--
United Kingdom	801	1,979	468	1,085	989	2,269
Other	410	535	61	45	187	499
Total	182,550	209,451	81,300	87,629	100,108	87,026
Reclaimed scrap, etc. (lead content):						
Australia	(1)	2	353	218	--	--
Bahamas	18	3	26	7	83	12
Canada	2,661	2,720	1,639	1,570	1,792	1,394
Chile	--	--	--	--	87	28
Dominican Republic	56	39	86	32	--	--
Guatemala	102	62	8	5	77	29
Jamaica	48	7	--	--	4	1
Mexico	896	652	551	405	456	344
Panama	19	16	18	8	--	--
Spain	36	157	108	637	92	380
United Kingdom	17	16	--	--	--	--
Other	153	108	79	23	70	32
Total	4,006	3,782	2,868	2,905	2,661	2,220
Sheets, pipe, shot:						
Canada	201	305	280	544	203	343
Germany, Federal Republic of	1	8	57	119	51	85
Italy	--	--	--	--	20	33
Mexico	--	--	588	647	177	164
United Kingdom	3	4	8	36	4	17
Other	10	11	17	162	19	84
Total	215	328	950	1,508	474	726
Grand total	232,853	248,278	115,029	116,478	130,898	110,508

[1]Less than 1/2 unit.

Table 29.—U.S. imports for consumption of lead, by class

(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
1978	62	25,220	4	2,930	225	169,866	1	2,116
1979	44	33,026	2	1,691	183	209,451	(1)	328
1980	30	23,927	(1)	509	81	87,629	(1)	888
1981	27	20,196	(1)	340	100	87,026	(1)	564

Year	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	
1978	3	2,086	1	806	(1)	64	203,088
1979	4	3,207	(1)	575	(1)	288	248,566
1980	2	2,144	1	761	1	620	116,478
1981	2	1,568	1	652	(1)	162	110,508

[1]Less than 1/2 unit.

Table 30.—U.S. imports for consumption of miscellaneous products containing lead[1]

Year	Gross weight (metric tons)	Lead content (metric tons)	Value (thousands)
1979	362	107	$3,565
1980	968	388	11,144
1981	1,090	520	7,813

[1]Babbitt metal, solder, white metal, and other lead-containing combinations.

Table 31.—Lead: World mine production, by continent and country[1]

(Thousand metric tons)

Continent and country[2]	1977	1978	1979	1980[p]	1981[e]
North America:					
Canada	281.0	319.8	310.7	296.7	332.1
Guatemala	.1	[e].1	[e].1	.1	.1
Honduras	20.6	21.8	16.4	15.1	14.0
Mexico[3]	163.5	170.6	173.5	145.5	157.4
Nicaragua	1.0	.4	--	--	--
United States[4]	537.5	529.7	525.6	550.4	445.5
South America:					
Argentina	33.6	30.3	31.7	34.0	32.0
Bolivia	[r]18.9	18.0	15.4	17.7	16.7
Brazil	24.0	31.2	27.9	27.5	29.6
Chile	[r].1	.4	.3	.5	.5
Colombia	[r].2	.1	.2	.2	.1
Ecuador	.2	.2	.2	.2	.2
Peru[5]	[r]175.7	182.7	174.0	189.1	186.7
Europe:					
Austria	4.3	4.6	4.5	4.3	4.2
Bulgaria	117.0	117.0	116.0	116.0	116.0
Czechoslovakia	4.3	4.0	4.0	3.3	3.4
Finland	.6	.8	1.0	1.1	1.6
France	31.5	32.5	29.5	28.8	19.0
Germany, Federal Republic of	[r]30.5	23.2	25.2	23.1	21.6
Greece	16.4	[r]20.3	21.7	20.5	21.0
Greenland	28.8	30.6	31.9	34.3	30.0
Hungary	[r]1.2	[r]1.1	1.0	1.1	1.0
Ireland	41.0	47.8	71.0	59.0	29.9
Italy	31.5	[r]30.5	28.1	22.9	20.6
Norway	3.3	3.6	3.6	3.3	3.6
Poland	63.0	63.9	61.9	60.0	50.4
Romania	35.0	33.3	33.3	33.5	33.5
Spain	65.5	71.3	72.3	87.1	83.0
Sweden	88.1	81.9	81.6	72.2	84.1
U.S.S.R.[e]	405.0	410.0	410.0	410.0	410.0
United Kingdom	[r]7.7	4.6	4.7	2.4	2.4
Yugoslavia	130.0	[r]129.4	129.8	121.4	120.0
Africa:					
Algeria	.9	1.8	2.3	2.4	2.6
Congo (Brazzaville)	2.4	4.2	[r e]3.5	[r e]3.5	3.5
Morocco	93.4	100.2	115.7	115.4	125.0
Namibia	41.2	38.6	46.0	47.7	59.1
Nigeria	.1	.1	.1	.1	1.0
South Africa, Republic of	--	--	--	86.1	98.9
Tunisia	10.2	8.0	10.0	8.3	8.0
Zambia	13.5	15.8	17.6	14.0	14.0
Asia:					
Burma	[r]8.3	[r]9.9	14.5	14.2	15.6
China	135.0	145.0	155.0	155.0	155.0
India	12.7	12.8	16.0	12.7	15.3
Iran	40.0	[e]30.0	[e]15.0	15.0	10.0
Japan[6]	54.8	56.5	46.9	44.7	44.9
Korea, North[e]	110.0	105.0	100.0	100.0	100.0
Korea, Republic of	16.6	16.1	11.1	11.4	11.4
Philippines	3.7	1.4	1.9	1.8	1.6

See footnotes at end of table.

Table 31.—Lead: World mine production, by continent and country[1] —Continued

(Thousand metric tons)

Continent and country[2]	1977	1978	1979	1980[p]	1981[e]
Asia —Continued					
Thailand	.5	1.7	8.7	10.6	17.0
Turkey	8.7	9.5	7.5	6.7	7.2
Oceania: Australia[7]	432.2	400.3	421.6	397.4	392.3
Total	[r]3,345.3	[r]3,372.6	3,400.5	3,428.3	3,352.6

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through June 16, 1982.
[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]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).
[4]Recoverable.
[5]Recoverable metal content of lead in concentrates for export plus lead content of domestic smelter products (refined lead, antimonial lead, and bismuth-lead bars).
[6]Content of concentrates.
[7]Content by analysis.

Table 32.—Lead: World smelter production, by continent and country[1]

(Thousand metric tons)

Continent and country	1977	1978	1979	1980[p]	1981[e]
North America:					
Canada:					
Primary (refined)	187.5	194.1	183.8	162.5	[2]168.5
Secondary (refined)[3]	53.1	[r]51.8	68.6	72.1	[2]69.7
Total	240.6	[r]245.9	252.4	234.6	[2]238.2
Guatemala, primary	.1	.1	.1	.1	.1
Mexico:					
Primary	153.9	166.1	173.0	145.0	156.7
Secondary (refined)[3]	62.3	49.3	50.0	50.0	50.0
Total	216.2	215.4	223.0	195.0	206.7
United States:					
Primary (refined)	548.7	565.2	575.6	547.6	[2]495.3
Secondary (refined)[3]	757.6	769.2	801.4	675.6	[2]641.1
Total	1,306.3	1,334.4	1,377.0	1,223.2	[2]1,136.4
South America:					
Argentina:					
Primary (refined)	[r]38.0	[r]19.7	32.0	26.7	30.0
Secondary	([4])	([4])	([4])	--	--
Total	[r]38.0	[r]19.7	32.0	26.7	30.0
Brazil:					
Primary (refined)	48.3	47.2	55.1	44.5	34.7
Secondary (refined)[3]	29.0	33.2	43.0	40.4	31.1
Total	77.3	80.4	98.1	84.9	65.8
Peru, primary (refined)	79.2	[r]74.3	85.1	82.0	[2]79.2
Venezuela, secondary	([4])	([4])	([4])	--	--
Europe:					
Austria:					
Primary	6.3	5.8	6.0	5.4	5.3
Secondary	10.5	9.3	10.8	11.5	11.5
Total	16.8	15.1	16.8	16.9	16.8
Belgium:					
Primary[e 5]	31.6	44.7	33.7	51.7	43.8
Secondary[3]	42.0	30.0	27.0	30.0	28.1
Total	73.6	74.7	60.7	81.7	71.9

See footnotes at end of table.

Table 32.—Lead: World smelter production, by continent and country[1] —Continued

(Thousand metric tons)

Continent and country	1977	1978	1979	1980[p]	1981[e]
Europe —Continued					
Bulgaria:					
Primary (refined)	112.0	115.0	115.0	115.0	115.0
Secondary (refined)[3]	8.0	5.0	4.0	4.0	4.0
Total	120.0	120.0	119.0	119.0	119.0
Czechoslovakia, primary and secondary	([4])	([4])	([4])	--	--
France:					
Primary	[r]126.1	[3]125.9	[3]129.1	[3]126.0	126.0
Secondary	[3]18.3	[3]25.5	[3]30.8	[3]35.7	34.0
Total	[r]144.4	[r]151.4	159.9	161.7	160.0
German Democratic Republic, secondary (refined)[e 3]	37.0	38.0	40.0	40.0	40.0
Germany, Federal Republic of:					
Primary	[r]182.9	[r]189.9	194.8	191.1	190.8
Secondary (refined)[3]	[r]190.6	[r]179.1	178.5	159.2	168.0
Total	[r]373.5	[r]369.0	373.3	350.3	358.8
Greece:					
Primary (refined)	[r]14.5	[r]15.6	15.6	21.1	21.0
Secondary	([4])	([4])	([4])	--	--
Total	[r]14.5	[r]15.6	15.6	21.1	21.0
Hungary, secondary	([4])	([4])	([4])	--	--
Italy:					
Primary	[r]34.2	[r]31.1	26.8	42.1	38.0
Secondary (refined)[3]	83.5	85.1	101.0	91.6	92.0
Total	117.7	116.2	127.8	133.7	130.0
Netherlands:					
Primary[e]	3.3	.5	6.8	6.0	5.5
Secondary	([4])	([4])	([4])	--	--
Total	[r]3.3	.5	6.8	6.0	5.5
Norway, secondary	([4])	([4])	([4])	--	--
Poland:					
Primary (refined)[e]	63.4	61.7	59.2	56.0	48.0
Secondary (refined)[e 3]	22.0	25.0	25.0	26.0	21.0
Total[e]	85.4	86.7	84.2	82.0	[2]69.0
Portugal:					
Primary	[r].1	.1	--	--	--
Secondary	([4])	([4])	([4])	--	--
Total	[r].1	.1	([4])	--	--
Romania:					
Primary (refined)	34.7	34.0	35.0	35.0	35.0
Secondary	([4])	([4])	([4])	--	--
Total	34.7	34.0	35.0	35.0	35.0
Spain:					
Primary[e 5]	89.2	[r]83.4	87.2	84.3	80.2
Secondary (refined)[e 3]	29.4	38.8	39.8	39.7	37.8
Total	118.6	122.2	127.0	124.0	118.0
Sweden:					
Primary	[r]23.7	[r]26.9	22.6	20.3	27.6
Secondary	([4])	([4])	([4])	--	--
Total	[r]23.7	[r]26.9	22.6	20.3	27.6

See footnotes at end of table.

Table 32.—Lead: World smelter production, by continent and country[1] —Continued

(Thousand metric tons)

Continent and country	1977	1978	1979	1980[p]	1981[e]
Europe —Continued					
U.S.S.R.:					
Primary (refined)[e]	405.0	410.0	410.0	410.0	410.0
Secondary (refined)[e 3]	205.0	210.0	215.0	215.0	220.0
Total[e]	610.0	620.0	625.0	625.0	630.0
United Kingdom:					
Primary	35.0	30.4	32.3	30.0	26.5
Secondary (refined)[3]	211.4	223.0	244.2	211.4	198.0
Total	246.4	253.4	276.5	241.4	224.5
Yugoslavia:					
Primary	111.7	100.3	92.0	91.0	49.0
Secondary	33.3	40.1	41.6	42.0	40.0
Total	145.0	140.4	133.6	133.0	89.0
Africa:					
Morocco:					
Primary (refined)	33.1	28.5	35.3	40.3	40.0
Secondary	(4)	(4)	(4)	--	--
Total	33.1	28.5	35.3	40.3	40.0
Namibia, primary	42.7	39.5	41.7	42.7	48.5
South Africa, Republic of, secondary[3]	r24.0	23.6	23.3	35.4	25.4
Tunisia:					
Primary (refined)	19.2	16.1	16.2	19.2	20.0
Secondary	(4)	(4)	(4)	--	--
Total	19.2	16.1	16.2	19.2	20.0
Zambia, primary (refined)	13.1	12.9	12.8	10.0	10.0
Asia:					
Burma:					
Primary[e]	r4.8	r5.0	6.2	6.0	7.5
Secondary[e]	(4)	(4)	(4)	--	--
Total[e]	r4.8	r5.0	6.2	6.0	7.5
China:					
Primary (refined)[e]	135.0	140.0	150.0	150.0	150.0
Secondary (refined)[e 2]	15.0	20.0	20.0	20.0	20.0
Total[e]	150.0	160.0	170.0	170.0	170.0
India:					
Primary (refined)	7.6	10.1	9.8	14.9	14.3
Secondary	(4)	(4)	(4)	--	--
Total	7.6	10.1	9.8	14.9	14.3
Japan:					
Primary	187.4	188.9	187.8	185.8	230.0
Secondary (refined)[3]	117.8	105.0	106.4	129.8	90.3
Total	r305.2	293.9	294.2	315.6	320.3
Korea, North:					
Primary (refined)[e]	r70.0	r75.0	70.0	70.0	70.0
Secondary[e]	(4)	(4)	(4)	--	--
Total[e]	r70.0	r75.0	70.0	70.0	70.0
Korea, Republic of, primary (refined)	6.7	7.2	7.6	5.5	9.3
Taiwan, secondary	(4)	(4)	(4)	--	--
Thailand, secondary	(4)	(4)	(4)	--	--
Turkey, primary	r3.0	3.0	5.9	6.5	6.0

See footnotes at end of table.

Table 32.—Lead: World smelter production, by continent and country[1] —Continued

(Thousand metric tons)

Continent and country	1977	1978	1979	1980[p]	1981[e]
Oceania:					
Australia, primary:					
Bullion for export	156.4	152.0	169.5	160.2	159.5
Refined	181.5	204.0	215.6	200.5	207.7
Total	337.9	356.0	385.1	360.7	367.2
Grand total	[r]5,139.7	[r]5,185.2	5,369.6	5,134.4	4,981.0
Of which:					
Primary	[r]3,189.9	[r]3,224.2	3,299.2	3,205.0	3,159.0
Secondary	[r]1,949.8	[r]1,961.0	2,070.4	1,929.4	1,822.0

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

[1]Table includes data available through June 16, 1982. 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 3.) For those countries for 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, refined lead output has been reported, noted parenthetically, because it is believed that the difference between crude (or smelter) output and refined output is negligible.

[2]Reported figure.

[3]A significant 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 an overly large figure.

[4]Revised to zero; material previously included is regarded as being merely re-refined. (Now entered in refined lead world production table.)

[5]Data not reported, derived from reported primary refined lead output minus imports of lead bullion plus exports of lead bullion and checked against sum of lead content of domestically produced ores plus lead content of imported ores (estimated) minus lead content of exported ores (estimated).

Table 33.—Lead: World refined production, by continent and country[1]

(Thousand metric tons)

Continent and country	1977	1978	1979	1980[p]	1981[e]
North America:					
Canada:					
Primary	187.5	194.1	183.9	162.5	[2]168.5
Secondary	53.1	51.8	68.5	72.1	[2]69.7
Total	240.6	245.9	252.4	234.6	[2]238.2
Jamaica, secondary[e]	1.5	2.0	2.0	2.0	1.0
Mexico:					
Primary	143.7	159.3	167.1	140.3	150.5
Secondary	62.3	49.3	50.0	50.0	50.0
Total	206.0	208.6	217.1	190.3	200.5
Trinidad and Tobago, secondary[e]	1.5	2.0	2.0	2.0	2.0
United States:					
Primary	548.7	565.2	575.6	547.6	[2]495.3
Secondary	757.6	769.2	801.4	675.6	[2]641.1
Total	1,306.3	1,334.4	1,377.0	1,223.2	[2]1,136.4
South America:					
Argentina:					
Primary	[r]38.0	[r]19.7	32.0	26.7	30.0
Secondary[e]	[r]7.0	[r]10.0	15.0	12.0	9.0
Total	[r]45.0	[r]29.7	47.0	38.7	39.0
Brazil:					
Primary	48.3	47.3	55.1	44.5	34.7
Secondary	29.0	33.2	43.0	40.4	31.1
Total	77.3	80.5	98.1	84.9	65.8
Colombia, secondary[e]	1.5	[r]2.0	2.5	3.0	3.0

See footnotes at end of table.

Table 33.—Lead: World refined production, by continent and country[1] —Continued

(Thousand metric tons)

Continent and country	1977	1978	1979	1980[p]	1981[e]
South America —Continued					
Peru:					
Primary	79.2	[r]74.2	85.1	82.0	[2]79.2
Secondary[e]	5.0	5.0	5.0	5.0	5.0
Total	84.2	79.2	90.1	87.0	84.2
Venezuela, secondary[e]	8.0	9.0	10.0	10.0	10.0
Europe:					
Austria:					
Primary	8.4	7.1	5.2	5.5	6.0
Secondary	10.7	10.5	17.7	12.4	12.5
Total	19.1	17.6	22.9	17.9	18.5
Belgium:					
Primary	62.1	74.2	65.2	75.9	71.9
Secondary	42.0	30.0	27.0	30.0	30.0
Total	104.1	104.2	92.2	[2]105.9	101.9
Bulgaria:					
Primary	112.0	115.0	115.0	115.0	115.0
Secondary	8.0	5.0	4.0	4.0	4.0
Total	120.0	120.0	119.0	119.0	119.0
Czechoslovakia, secondary	19.0	19.0	19.0	20.0	20.0
Denmark, secondary	24.2	26.2	29.8	24.5	26.5
Finland, secondary	3.0	3.0	3.0	3.2	3.6
France:					
Primary	[2]184.1	[2]208.5	[2]219.7	[2]218.8	210.0
Secondary	80.2	82.3	90.6	92.0	90.0
Total	264.3	290.8	310.3	310.8	300.0
German Democratic Republic, secondary[e]	37.0	38.0	40.0	40.0	40.0
Germany, Federal Republic of:					
Primary	[r]182.9	189.9	194.8	191.1	190.8
Secondary	[r]190.6	179.1	178.5	159.2	168.0
Total	373.5	369.0	373.3	350.3	358.8
Greece:					
Primary	[r]14.5	[r]15.6	15.6	21.1	21.0
Secondary	[r]4.2	[r]5.6	6.0	4.0	4.0
Total	[r]18.7	[r]21.2	21.6	25.1	25.0
Hungary, secondary	.2	[r].1	.1	.1	.1
Ireland, secondary[e]	5.0	2.1	5.0	7.0	6.8
Italy:					
Primary	34.2	31.1	26.8	42.0	38.0
Secondary	83.5	85.1	101.0	91.6	92.0
Total	117.7	116.2	127.8	133.6	130.0
Netherlands:					
Primary	21.1	18.2	16.4	13.9	9.5
Secondary	12.7	13.7	14.7	13.9	16.0
Total	33.8	31.9	31.1	27.8	25.5
Norway, secondary	.9	[r].9	.4	.4	--
Poland:					
Primary	63.4	61.7	59.2	58.0	47.0
Secondary	22.0	25.0	25.0	24.0	22.0
Total	85.4	86.7	84.2	82.0	[2]69.0
Portugal:					
Primary	[r].1	[r].1	--	--	--
Secondary	.4	.2	([3])	1.0	.9
Total	[r].5	[r].3	([3])	1.0	.9

See footnotes at end of table.

Table 33.—Lead: World refined production, by continent and country[1] —Continued

(Thousand metric tons)

Continent and country	1977	1978	1979	1980[p]	1981[e]
Europe —Continued					
Romania:					
Primary[e]	34.7	34.0	30.9	34.9	35.0
Secondary[e]	7.0	8.8	10.0	6.0	6.0
Total	41.7	42.8	40.9	40.9	41.0
Spain:					
Primary	89.2	83.4	87.2	83.3	77.0
Secondary	29.4	38.8	39.8	37.4	39.6
Total	118.6	122.2	127.0	120.7	116.6
Sweden:					
Primary	23.8	26.9	22.7	20.3	17.6
Secondary	17.4	18.1	18.9	22.0	10.0
Total	41.2	45.0	41.6	42.3	27.6
Switzerland, secondary[e]	5.0	5.0	5.0	7.0	7.2
U.S.S.R.:					
Primary[e]	405.0	410.0	410.0	410.0	410.0
Secondary[e]	205.0	210.0	215.0	215.0	220.0
Total[e]	610.0	620.0	625.0	625.0	630.0
United Kingdom:					
Primary	139.7	122.8	124.1	113.4	135.4
Secondary	211.4	223.0	244.2	211.4	198.0
Total	351.1	345.8	368.3	324.8	333.4
Yugoslavia:					
Primary	111.6	[r]100.3	92.0	84.7	70.4
Secondary	[r]18.2	[r]16.4	19.0	17.0	16.0
Total	[r]129.8	116.7	111.0	101.7	[2]86.4
Africa:					
Morocco:					
Primary	33.1	28.5	35.2	40.3	40.0
Secondary	1.5	1.5	1.5	2.1	2.1
Total	34.6	30.0	36.7	42.4	42.1
Namibia, primary	42.7	39.5	41.7	42.7	48.5
Nigeria, secondary[e]	--	--	1.5	2.0	2.0
South Africa, Republic of, secondary	[r]24.0	23.6	23.3	35.4	25.4
Tunisia:					
Primary	19.2	16.1	16.2	19.2	20.0
Secondary[e]	.5	.5	.6	.6	.6
Total	19.7	16.6	16.8	19.8	20.6
Zambia, primary	13.1	12.9	12.8	[2]10.0	10.0
Asia:					
Burma:					
Primary[e]	4.3	5.1	6.0	5.7	7.3
Secondary[e]	.5	.2	.2	.2	.2
Total[e]	4.8	5.3	6.2	5.9	7.5
China:					
Primary[e]	135.0	140.0	150.0	150.0	150.0
Secondary[e]	15.0	20.0	20.0	20.0	20.0
Total[e]	150.0	160.0	170.0	170.0	170.0
Cyprus, secondary[e]	2.5	2.5	2.5	2.5	2.5
India:					
Primary	7.6	10.1	9.8	14.9	14.3
Secondary	12.4	10.9	10.8	10.7	11.1
Total	20.0	21.0	20.6	25.6	25.4
Iran, secondary[e]	.3	--	--	--	--

See footnotes at end of table.

Table 33.—Lead: World refined production, by continent and country[1] —Continued

(Thousand metric tons)

Continent and country	1977	1978	1979	1980[p]	1981[e]
Asia —Continued					
Japan:					
Primary	[r]169.9	186.1	176.3	175.1	226.3
Secondary	117.8	105.0	106.4	129.8	90.3
Total	[r]287.7	291.1	282.7	304.9	316.6
Korea, North:					
Primary[e]	65.0	70.0	65.0	65.0	65.0
Secondary[e]	5.0	5.0	5.0	5.0	5.0
Total	70.0	75.0	70.0	70.0	70.0
Korea, Republic of:					
Primary	6.7	7.2	7.6	[2]5.5	9.3
Secondary[e]	.3	1.0	5.8	1.3	7.2
Total[e]	7.0	8.2	13.4	6.8	16.5
Malaysia, secondary[e]	2.0	2.0	2.1	2.3	.5
Pakistan, secondary[e]	1.5	1.5	1.5	1.5	1.5
Philippines, secondary	[r]3.4	[r]3.5	1.9	4.8	4.8
Taiwan, secondary[e]	10.8	14.0	20.0	16.8	17.0
Thailand, secondary	1.1	1.1	.8	1.7	1.8
Turkey:					
Primary	2.0	2.0	4.9	5.0	5.0
Secondary	1.0	1.0	1.0	1.0	1.0
Total	3.0	3.0	5.9	6.0	6.0
Oceania:					
Australia:					
Primary	181.5	204.0	215.6	200.5	207.7
Secondary	36.5	35.1	42.0	32.6	32.5
Total	218.0	239.1	257.6	[2]233.1	240.2
New Zealand, secondary[e]	[r]8.0	[r]10.0	10.0	12.0	12.0
Grand total	[r]5,419.9	[r]5,497.9	5,694.7	5,422.9	5,308.8
Of which:					
Primary	[r]3,212.3	[r]3,280.1	3,324.7	3,225.4	3,216.2
Secondary	[r]2,207.6	[r]2,217.8	2,370.0	2,197.5	2,092.6

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

[1]Table includes data available through June 16, 1982. 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, particularly new scrap, unless otherwise noted.

[2]Reported figure.

[3]Less than 1/2 unit.

Lime

By J. W. Pressler[1]

Lime output in 1981, including that for Puerto Rico, was 18.9 million tons, a decrease of 1% compared with that of 1980, and the lowest since 1968. Total value was $888 million, a 5% increase compared with that of 1980.

In 1981, output of chemical and industrial lime remained virtually the same, but refractory lime decreased 12%, agricultural lime decreased 6%, and construction lime decreased 2% from 1980 levels.

Table 1.—Salient lime statistics in the United States[1]

(Thousand short tons, unless otherwise specified)

	1977	1978	1979	1980	1981
Number of plants	161	155	154	153	150
Sold or used by producers:					
Quicklime	16,281	16,845	17,553	15,972	16,142
Hydrated lime	2,698	2,582	2,599	2,544	2,279
Dead-burned dolomite	968	1,016	793	494	435
Total	19,947	20,443	20,945	19,010	18,856
Value[2] thousands	$666,472	$749,667	$862,459	$842,922	$884,197
Average value per ton	$33.41	$36.67	$41.18	$44.34	$46.89
Lime sold	14,202	15,062	15,423	13,809	14,271
Lime used	5,745	5,381	5,522	5,201	4,585
Exports[3]	33	45	45	42	28
Imports for consumption[3]	423	610	640	480	504

[1]Excludes regenerated lime. Excludes Puerto Rico.
[2]Selling value, f.o.b. plant, excluding cost of containers.
[3]U.S. Bureau of the Census.

DOMESTIC PRODUCTION

Lime producers sold or used 18.9 million tons in 1981, compared with 19.0 million tons in 1980. Commercial sales of lime increased 3% in 1981 to 14.3 million tons. Captive lime used by producers continued its long-term decline with a 9% reduction in 1981 to 4.6 million tons. This was a 37% decrease from the record year of 1971.

In 1981, output of quicklime increased 1% to 16.6 million tons. Production of hydrated lime decreased 10% to 2.3 million tons. Output of dead-burned dolomite decreased 12%, 82% below the 1956 record level of 2.4 million tons.

In 1981, five States—Ohio, Missouri, Pennsylvania, Texas, and Alabama—accounted for 47% of the total output. Compared with that of 1980, production increased 8% in Alabama and 4% in Missouri, but decreased 8% in Texas, 4% in Pennsylvania, and 1% in Ohio.

Table 2.—Lime sold or used by producers in the United States, by State[1]

(Thousand short tons and thousand dollars, unless otherwise specified)

State	1980					1981				
	Plants	Hydrated	Quicklime	Total[2]	Value	Plants	Hydrated	Quicklime	Total[2]	Value
Alabama	5	131	997	1,128	53,685	5	124	1,095	1,219	59,454
Arizona	6	--	514	514	23,904	6	--	538	538	29,913
Arkansas	3	W	W	175	7,785	3	W	W	149	8,102
California	12	W	W	554	29,444	12	W	W	472	26,834
Colorado, Nevada, Wyoming	13	79	390	469	20,878	13	67	382	449	19,921
Connecticut	1	11	8	19	1,352	1	11	5	16	1,190
Florida	3	W	W	195	12,434	3	W	W	191	11,343
Hawaii, Idaho, Oregon, Washington	8	28	432	461	24,899	8	27	409	436	23,658
Illinois and Indiana	5	75	1,625	1,699	69,332	5	58	1,854	1,912	83,257
Iowa, Kansas, Nebraska, North Dakota, South Dakota	9	57	316	373	12,954	9	53	306	359	14,021
Kentucky, New York, Tennessee, West Virginia	9	54	2,309	2,363	99,152	8	64	2,280	2,344	100,752
Louisiana, New Mexico, Oklahoma	5	144	294	438	23,411	5	118	266	384	22,314
Maryland	1	5	8	12	497	1	4	5	9	441
Massachusetts	2	15	165	180	10,806	2	14	156	170	10,793
Michigan	8	--	836	836	36,750	8	W	W	807	36,800
Minnesota	4	--	162	162	3,562	4	--	155	155	3,818
Mississippi	1	--	31	31	707	--	--	--	--	--
Missouri	3	W	W	1,667	63,733	3	W	W	1,738	73,427
Montana	3	--	223	223	9,001	3	--	194	194	7,621
Ohio	15	130	2,656	2,786	122,817	15	119	2,648	2,767	127,751
Pennsylvania	10	409	1,360	1,768	84,291	10	335	1,355	1,690	85,418
Puerto Rico	1	25	2	27	4,131	1	32	2	34	3,884
Texas	11	667	848	1,515	67,075	10	573	819	1,393	67,158
Utah	4	W	W	259	13,293	4	W	W	333	16,679
Virginia	7	105	719	824	33,872	7	100	704	804	35,984
Wisconsin	5	103	254	357	17,287	5	98	229	326	17,548
Other[3]	(4)	539	2,311	(4)	(4)	(4)	513	3,177	(4)	(4)
Total[2]	154	2,579	16,458	19,037	847,053	151	2,311	16,579	18,890	888,081

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.

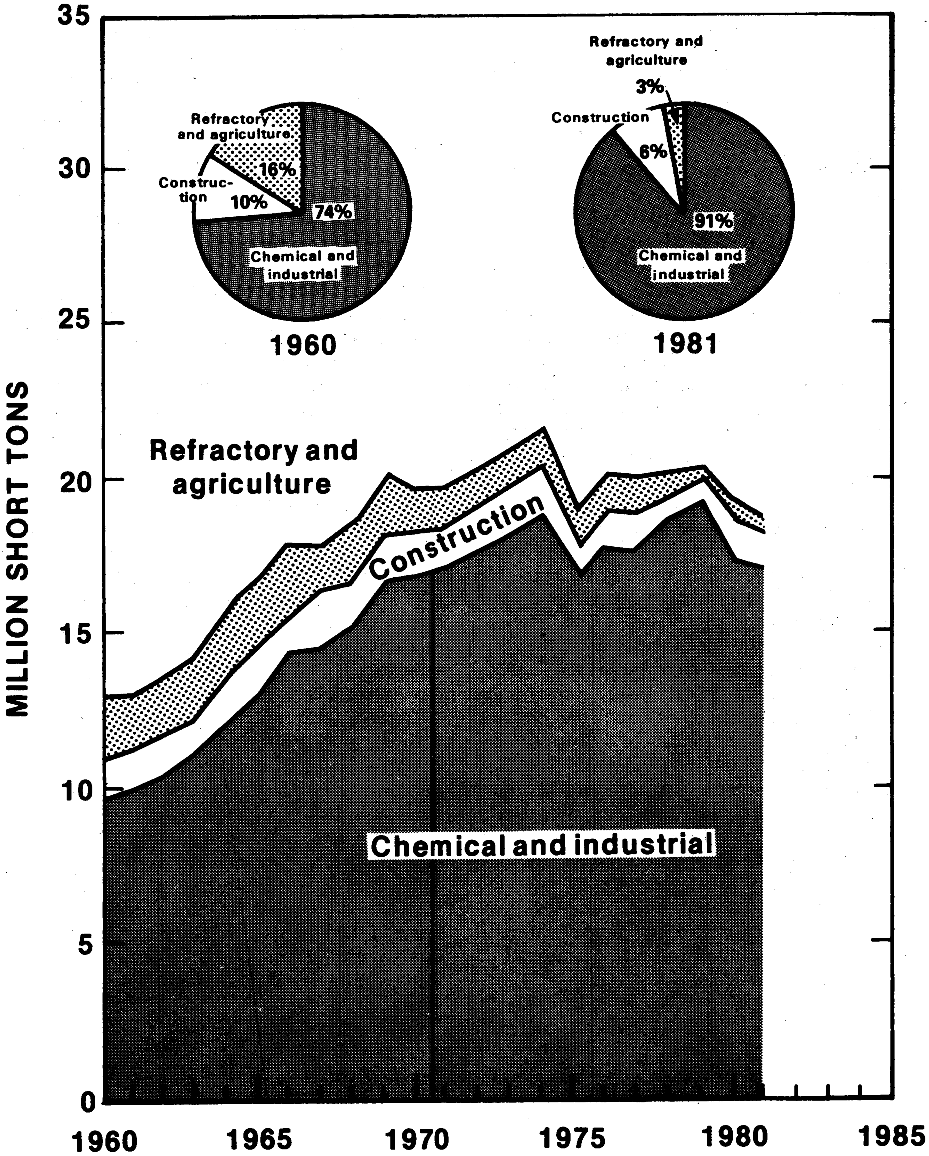

Figure 1.—Trends in major uses of lime.

Leading producing companies in 1981 were Marblehead Lime Co. with two plants in Illinois and one each in Indiana, Michigan, Pennsylvania, and Utah; Dravo Corp. with one plant each in Alabama, Kentucky, Louisiana, and Texas; Mississippi Lime Co. in Missouri; the Martin Marietta Corp. Chemical Div. in Alabama and Ohio; Bethlehem Steel Corp. with two plants in Pennsylvania and one in New York; Genstar Cement & Lime Co. with two plants in California, two in Nevada, and one each in Arizona, Utah, and Virginia; Allied Chemical Corp. in New York; Allied Products Co. with two plants in Alabama; Black River Lime Co. in Kentucky; United States Gypsum Co. with one plant each in Louisiana, Ohio, and Texas. These 10 companies, operating 30 plants, accounted for 48% of the total 1981 lime production.

In 1981, the seven largest lime plants, each producing more than 400,000 tons, accounted for 27% of the total lime output. Thirty-one plants produced more than 200,000 tons each and accounted for 61% of the total.

Leading individual plants in 1981 were Mississippi Lime's Ste. Genevieve plant, Dravo's Maysville plant, Marblehead's Buffington plant, Allied Chemical's Syracuse plant, and Black River Lime's Carntown plant.

A total of 483 lime kilns were operational during 1981: 244 vertical kilns, 186 rotary kilns, 25 pot kilns (primitive vertical), 16 Calcimatic traveling-hearth kilns, 6 fluidized-bed kilns, 4 Ellernan kilns, 1 Maerz two-shaft vertical kiln, and 1 traveling-grate rotary kiln. Hydrators for the production of hydrated lime totaled 120 during 1981; 22 were of the batch type, and 98 were of the continuous type.

In 1981, the number of lime plants in the United States and Puerto Rico decreased by 3 to 151, and the average output per plant was 125,100 tons per year, a 1% increase when compared with that of 1980.

New Plants and Expansions.—Marblehead Lime Co. of Chicago, Ill., a subsidiary of General Dynamics Corp., placed into operation in 1981 the world's largest lime-producing kiln, which added 350,000 tons per year to current capacity and replaced 140,000 tons per year of outdated capacity. The Fuller 15-foot-diameter by 17-foot-diameter by 14-1/2-foot-diameter by 485-foot-long rotary kiln is driven by two 500-horsepower direct-current motors controlled by variable-speed drives. Marblehead Lime continued to be the largest U.S. producer of lime in 1981.[2]

Continental Lime Co., a subsidiary of Steel Brothers Canada, Ltd., placed its new 500-ton-per-day lime plant near Delta, Utah, into operation in early 1981. Fired by Utah coal, the plant produced a high-calcium lime, used for copper ore concentration, gold mining, water purification, and for removal of sulfur dioxide from utility plant stack gases. Energy consumption was 5 million British thermal units (Btu) per ton of quicklime produced.[3]

Continental Lime purchased the Tacoma lime plant of Domtar Gypsum America, Inc., in January 1981. The plant supplied lime for the Pacific Northwest and obtained its limestone from Domtar's Texada Island quarry in British Columbia.[4] Continental Lime was also constructing a 500-ton-per-day lime plant near Townsend, Mont., which was expected to be onstream by yearend 1982.[5]

Rockwell Lime Co. of Manitowoc, Wis., tripled its plant capacity in 1981 by the addition of a second kiln measuring 8 feet in diameter by 220 feet in length, a new hydrator, and a new baghouse. The new kiln was rated at 300 tons per day, and increased the total plant capacity to 450 tons per day of quicklime and 275 tons per day of hydrate.[6]

Three Canadian companies were active in U.S. lime operations: Domtar Chemicals Group's Lime Div. operated its Bellefonte, Pa., plant; Steetley Industries, Ltd., through its U.S. subsidiary, Steetley Resources Inc., operated the Gibsonburg, Ohio, dolomitic lime plant and also continued part-time operation of its dolomitic quicklime plant located at Woodville, Ohio; and Steel Bros. Canada Ltd., through its U.S. subsidiary, Continental Lime, Inc., operated its two lime plants in Delta, Utah, and Tacoma, Wash.

Table 3.—Lime sold or used by producers in the United States, by size of plant[1]

Size of plant	1980 Plants	1980 Quantity (thousand short tons)	1980 Percent of total	1981 Plants	1981 Quantity (thousand short tons)	1981 Percent of total
Less than 10,000 tons	9	57	(2)	12	77	(2)
10,000 to 25,000 tons	29	461	2	26	420	2
25,000 to 50,000 tons	30	1,026	5	25	837	4
50,000 to 100,000 tons	25	1,810	10	27	1,925	10
100,000 to 200,000 tons	26	3,644	19	28	4,057	21
200,000 to 400,000 tons	28	7,192	38	26	6,590	35
More than 400,000 tons	7	4,847	25	7	4,983	26
Total[3]	154	19,037	100	151	18,890	100

[1]Excludes regenerated lime. Includes Puerto Rico.
[2]Less than 1/2 unit.
[3]Data may not add to totals shown because of independent rounding.

CONSUMPTION AND USES

Lime was consumed in every State. Leading consuming States in 1981 were Pennsylvania, Ohio, Indiana, Texas, and Michigan, each of which consumed more than 1 million tons. These five States accounted for 48% of the total lime consumed.

Lime consumption in the steel industry increased 9% in 1981 to 7.8 million tons and equaled 42% of all lime consumed in the United States. Low housing and building starts during 1981 caused a 12% decrease in the sales of mason's and finishing lime. Environmental uses of lime continued to appreciate rapidly. Lime consumption in flue gas desulfurization processes and effluent water cleanup increased 22% during 1981.

Leading quicklime-consuming States in 1981 were Pennsylvania, Ohio, Indiana, and Michigan, each of which consumed more than 1 million tons. These four States accounted for 43% of the total quicklime consumed.

Leading hydrate-consuming States in 1981 were Texas, Pennsylvania, Ohio, Louisiana, and Illinois, each of which consumed more than 100,000 tons. These five States accounted for 51% of the total hydrate consumed.

Lime sold by producers in 1981 was utilized for chemical and industrial uses, 89%; construction, 8%; refractories, 2%; and agriculture, 1%. Captive lime used by producers was 24% of the total, compared with 27% in 1980. Captive lime was used mainly in basic oxygen furnace (BOF) steel, 28%; sugar, 19%; alkalies, 18%; and copper ore concentration, 6%.

Leading individual lime uses in 1981 were for BOF steel, water purification, sulfur removal from stack gases, paper and pulp, sugar refining, and electric steel, which together accounted for 62% of the total consumption.

Of the main chemical and industrial uses in 1981, lime for BOF was produced principally in Ohio, 25%; Indiana and Illinois combined, 29%; and Pennsylvania, 10%. Lime for water purification was produced mainly in Missouri; with Alabama, Texas, and Pennsylvania contributing 11%, 9%, and 8% of the totals,respectively. Lime used for sulfur removal from stack gases was principally produced in Kentucky. Lime used for paper and pulp, excluding regenerated lime, was produced mainly in Alabama, 28%; Virginia, 18%; and Texas, 13%. Lime for sugar refining was produced mainly in California, 20%; Minnesota, 16%; and Idaho, 11%. Lime used for electric steel was produced mainly in Pennsylvania, 23%; and in Ohio and Texas, 17% each.

Mason's lime was produced at 29 plants in 16 States, including Puerto Rico; leading States, with three plants each, were Pennsylvania, 23%; Virginia, 15%; and Wisconsin, 12%. Finishing lime was produced in 7 States at 10 plants; the leading State was Ohio with 2 plants.

The use of lime in agriculture decreased 6% in its long-term decline to 74,000 tons in 1981, compared with 79,000 tons in 1980. Compared with its high of 250,000 tons per year in 1956, it has become of small significance. In 1981, 29 million tons of the less-reactive, pulverized limestone was sold, a decrease of 9% compared with that of 1980.

Table 4.—Destination of shipments of lime sold or used by producers in the United States, by State[1]

(Thousand short tons)

State	1980			1981		
	Quicklime	Hydrated lime	Total[2]	Quicklime	Hydrated lime	Total[2]
Alabama	483	46	530	587	54	642
Alaska	W	W	1	W	W	1
Arizona	366	23	389	347	18	365
Arkansas	176	27	203	149	27	176
California	724	94	819	647	82	729
Colorado	242	15	257	249	14	264
Connecticut	33	16	49	16	13	29
Delaware	39	5	43	36	6	41
District of Columbia	W	W	1	W	W	9
Florida	386	53	439	427	58	485
Georgia	186	39	225	179	27	206
Hawaii	2	5	6	1	7	8
Idaho	116	4	119	120	4	124
Illinois	777	117	893	740	117	857
Indiana	1,629	70	1,699	1,843	48	1,891
Iowa	67	19	86	100	17	117
Kansas	87	18	105	74	15	89
Kentucky	443	17	460	453	23	476
Louisiana	192	161	353	182	127	309
Maine	36	1	37	31	(3)	32
Maryland	373	23	396	365	23	388
Massachusetts	57	16	73	84	17	101
Michigan	1,333	22	1,355	1,303	24	1,327
Minnesota	254	16	271	237	15	251
Mississippi	118	29	147	111	44	155
Missouri	155	104	259	146	63	209
Montana	241	9	250	238	7	245
Nebraska	120	6	126	94	5	99
Nevada	43	9	52	52	7	59
New Hampshire	W	W	1	W	W	2
New Jersey	88	52	140	103	44	147
New Mexico	105	13	118	114	28	142
New York	1,024	54	1,077	748	48	796
North Carolina	163	30	193	141	24	166
North Dakota	110	7	117	87	6	93
Ohio	1,798	161	1,959	1,930	150	2,080
Oklahoma	102	16	118	100	20	119
Oregon	137	11	148	89	10	99
Pennsylvania	2,067	239	2,306	2,086	206	2,292
Rhode Island	5	3	8	4	3	7
South Carolina	109	19	128	120	21	141
South Dakota	31	17	49	7	15	22
Tennessee	156	71	227	159	65	224
Texas	862	673	1,535	890	577	1,466
Utah	153	12	166	175	12	187
Vermont	W	W	1	W	W	3
Virginia	132	76	208	137	72	209
Washington	262	16	277	248	14	262
West Virginia	290	37	327	426	26	453
Wisconsin	108	52	160	118	51	169
Wyoming	35	14	48	53	12	65
Other[4]	4	14	18	14	27	26
Total United States[2]	16,414	2,551	18,965	16,561	2,293	18,855
Exports:						
Canada	20	10	31	12	7	19
Mexico	20	--	20	3	--	3
Other countries	4	17	22	2	10	13
Total exports[2]	44	28	72	18	17	35
Grand total[2]	16,458	2,579	19,037	16,579	2,311	18,890

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 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	1980 Sold	1980 Used	1980 Total[2]	1980 Value	1981 Sold	1981 Used	1981 Total[2]	1981 Value
Agriculture	79	--	79	3,727	74	--	74	3,595
Construction:								
Road stabilization	554	--	554	26,845	528	--	528	28,500
Soil stabilization	170	--	170	8,226	230	--	230	12,384
Mason's lime	288	40	328	15,916	185	32	217	11,695
Finishing lime	99	--	99	4,777	159	--	159	8,556
Other	16	27	44	2,111	17	27	43	2,343
Total[2]	1,126	68	1,194	57,872	1,118	59	1,176	63,478
Chemical and industrial:								
Steel, BOF	4,409	1,441	5,850	256,469	4,806	1,300	6,107	282,974
Water purification	1,487	9	1,496	65,603	1,422	5	1,427	66,119
Steel, electric	755	34	789	34,556	1,071	147	1,218	56,453
Paper and pulp	1,039	116	1,156	50,658	1,079	110	1,189	55,117
Sugar refining	58	909	967	42,414	54	888	941	43,618
Sulfur removal	743	--	743	32,566	908	--	908	42,090
Sewage treatment	848	12	860	37,705	849	7	855	39,640
Alkalies	6	1,167	1,173	51,407	3	836	839	38,886
Copper ore concentration	340	318	658	28,859	376	278	654	30,301
Magnesia from seawater or brine	W	W	648	28,414	W	W	562	26,029
Steel, open-hearth	564	38	602	26,407	493	55	547	25,365
Aluminum and bauxite	160	114	275	12,036	163	103	266	12,309
Calcium carbide	121	63	185	8,103	178	70	248	11,491
Acid water, mine or plant	419	70	490	21,467	233	--	233	10,799
Glass	180	--	180	7,910	167	--	167	7,734
Magnesium metal	W	W	187	8,193	11	155	167	7,723
Precipitated calcium carbonate	65	47	112	4,905	64	41	105	4,866
Petrochemicals	99	--	99	4,327	93	--	93	4,334
Ore concentration, other	18	--	18	773	63	--	63	2,904
Metallurgy, other	31	4	35	1,518	45	--	45	2,102
Petroleum refining	59	--	59	2,567	44	--	44	2,029
Oil well drilling	39	--	39	1,689	38	--	38	1,744
Food products, animal or human	37	--	37	1,602	37	--	37	1,714
Oil and grease	32	--	32	1,395	37	--	37	1,707
Tanning	28	--	28	1,243	18	--	18	854
Wire drawing	13	--	13	581	17	--	17	786
Gelatin	--	--	--	--	6	--	6	263
Fertilizer	5	--	5	209	5	--	5	225
Brick, sand-lime	6	--	6	262	4	--	4	185
Calcium silicate	--	--	--	--	3	--	3	143
Paint	2	--	2	102	3	--	3	121
Insecticides	3	--	3	152	1	--	1	25
Other[3]	645	714	523	23,053	465	452	357	16,569
Total[2]	12,211	5,059	17,269	757,145	12,757	4,447	17,204	797,220
Refractory dolomite	420	75	494	28,308	356	79	435	23,789
Grand total[2]	13,836	5,201	19,037	847,053	14,305	4,585	18,890	888,081

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 chrome, coke and gas, explosives, manganese, rubber, silica brick, other, and uses indicated by symbol W.

PRICES

The average value of lime sold or used by producers in 1981 was $47.01 per ton, an increase of 6% over the 1980 price of $44.50 and an increase of 170% over the 1973 price of $17.42. Values ranged from $43.34 for chemical and industrial lime to $53.96 for construction lime, $54.69 for refractory dolomite, and $48.36 for lime used in agriculture.

Values for quicklime sold ranged from $46.46 for chemical lime to $46.86 for construction lime, $35.15 for lime used in agriculture, and $54.88 for dead-burned dolomite, and averaged $46.68, an increase of 5% over the 1980 average value.

Values for hydrated lime sold ranged from $56.39 for construction lime to $51.28 for chemical lime and $58.58 for lime used in agriculture, and averaged $53.55, an increase of 8% over the 1980 average value.

FOREIGN TRADE

Exports of lime in 1981 decreased 32% to 28,400 tons, 59% below the 1968 record. Of the total exports, Canada received 56%; Mexico, 17%; Trinidad, 7%; and Guyana, 6%. The remaining 14% went to 37 countries, with order of tons shipped as follows: The Bahamas, Bermuda, Panama, Saudi Arabia, the Philippines, the Netherlands, Venezuela, Brazil, the Windward Islands, Australia, New Zealand, Israel, Colombia, Peru, Nigeria, the Netherlands Antilles, Kuwait, Chile, the Republic of South Africa, Sweden, and Japan.

Imports of lime have grown at an average rate of over 14% during the last 10 years. Imports from Canada (98%) and Mexico (2%) were 504,000 tons, an increase of 3% compared with that of 1980. Net import reliance, expressed as a percentage of apparent consumption, was 2%.

Table 6.—U.S. exports of lime

	Quantity (short tons)	Value (thousands)
1978	44,794	$3,082
1979	45,421	3,827
1980	41,843	3,990
1981	28,429	3,996

Table 7.—U.S. imports for consumption of lime

	Hydrated lime		Other lime		Total[1]	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1978	62,290	$2,491	547,830	$16,663	610,120	$19,154
1979	85,169	3,450	554,332	19,165	639,500	22,614
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

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

WORLD REVIEW

Lime is produced all over the world, mainly in the heavily industrialized nations. Large quantities of lime are produced in many countries of the world in small, primitive pot and vertical kilns. The quicklime is used in the manufacture of mortar and plaster for use in the construction of homes and buildings. Production statistics are not reported, and estimates can only be made that the quantities are substantial. Source materials are adequate. The United States, with 15% of the total, ranked second in world production in 1981, following the U.S.S.R.

Belgium.—Production of lime in Belgium was 3.55 million tons in 1981, the same as in 1980. The pattern of lime exports from Belgium tended to negate the recessionary influences, with about 22% of production exported to the Netherlands, 17% to Luxembourg, and a smaller percentage going to France. The largest producer of lime in Belgium was the Lhoist Group through three operating subsidiaries. In 1980, lime in Belgium was used principally for steel, 71%; construction, including ceilings, roads, and calcium silicate bricks, 18%; chemicals, 6%; and other, 5%.[7]

Canada.—Canadian production of lime in 1981 was 2.3 million tons, virtually the same as in 1980. In spite of the downturn in the steel and mining industries, environmental uses of lime had increased growth rates in water and sewage treatment and in the removal of SO_2 from smelter stack gases and thermal powerplant emissions. In 1980, 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, five were captive plants, of which three were in the sugar industry, one was in the steel industry, and one was in magnesium, calcium, and strontium production.[8]

Steel Brothers Canada Ltd. started up the second kiln at their Pavilion Lake, British Columbia, plant, and Domlim Inc. started production of their new oil-fired Kennedy Van Saun vertical kiln at St. Adolphe de Dunville, Quebec. Most of Domlim's product was to be used for the chemical and pulp industries and for other metallurgical uses.

Steetley Industries' Dundas plant in Ontario accounted for 85% to 95% of Canadian production of calcined dolomite for the steel industry and refractory use. It was also the country's only producer of dead-burned dolomite.[9]

Denmark.—Danish lime production in 1981 was 151,000 tons, a decrease of 19% compared with that of 1980. A/S Faxe Kalkbrud of Copenhagen was the sole producer with plants at Hedelhusene, Boesdal, and Fakse near Rodvig on the island of Zealand, and at Arhus. At both of the Zealand island plants, high-calcium coral limestone was the feedstock. Faxe Kalkbrud markets included construction products, steel, paper and pulp, water purification, and sewage treatment.[10]

Finland.—The production of lime in Finland in 1981 was 208,000 tons, a 4% decrease compared with that of 1980. Most of the commerical market was supplied by Oy Partek AB from its two plants at Pargas and Lappeenranta. Two other small companies had plants at Tytyri and Ruokajarvi. The Finnish steel producer, Rautaruukki Oy, produced about 150,000 tons of burnt lime for its own consumption in steelmaking. Other principal markets included pulp and paper, metallurgy, water purification, building materials, and sugar refining.[11]

France.—Production of lime in France in 1981 was 4 million tons, an 8% decrease compared with that of 1980. This was principally caused by the recession in the French steel industry, which accounted for about 60% of total lime consumption. The Lhoist Group of Belgium accounted for about 1.7 million tons of French capacity through its subsidiaries, which operated at Rety, Boran, and Dugny in the north of France. Lime was produced in 34 different locations spread throughout France, 14 of which had less than 22,000 tons per year of capacity each. Use patterns included steel, 60%; nonferrous metallurgy, road stabilization, and agriculture, 6% each; and other, 22%.[12]

Germany, Federal Republic of.—The Federal Republic of Germany was the leading European producer of burnt lime with production of 9.4 million tons in 1981. The largest producer was Rheinische Kalksteinwerke GmbH with a total capacity of 2.9 million short tons from 14 kilns, followed by Rheinische-Westfalische Walkwerke AG with burning capacity of 2.2 million tons from 1 rotary kiln and 25 to 30 shaft kilns including some Maerz kilns, and by Fels-Werke Peine-Salzgitter GmbH with a capacity of 600,000 tons. In the Federal Republic of Germany, 35% of the lime was consumed in the iron and steel industry with an average consumption of 136 pounds of lime per ton of crude steel. Other important uses included building materials, 22%; building industry, 15%; and agriculture, 7%.[13]

Rheinische Kalksteinwerke reported a drop in sales volume for its lime products of 18% to 1.7 million tons in 1980, caused principally by the recession in the iron and steel and building industries. The company's associate, Dolomitwerke GmbH Wülfrath reported its sales of refractory products held up well for the same period, decreasing by only 2.3%.[14]

Libya.—The new shaft lime kiln of the Libyan Cement Co. was placed onstream in July 1981 at Benghazi, Libya, as a turnkey project of KHD Humboldt Wedag AG. In 1981, Libya operated three lime production lines with a total output of 220,000 tons per year of white hydrated lime at plants in Benghazi and Souk el Khamis.[15]

Netherlands.—CV Nekami Kalk at Gouda was the only company actively producing burnt lime products in the Netherlands. The company was merged in 1981 with SA Carrieres et Foursa Chaux de la Meuse to form a company called SES. Importing high-quality lime from Belgium, SES marketed a variety of products. CV Nekami Kalk, through its subsidiary BV Nekami-Gouda, produced about 100,000 tons per year of hydrated lime and other derived products using imported lime.[16]

Norway.—In 1981, the principal producers of burnt lime in Norway were Hylla Kalkvert, a subsidiary of Franzefoss in the Verdal area near Trondheim, with production of 51,000 tons per year; Mjoendalen Kalkfabrik at Aasen, with a production of 8,000 tons per year used for water purification; and A/S Norsk Jernverk, the leading Norwegian steel producer, with a captive burnt lime plant producing 53,000 tons per year used in the production of iron and steel.[17]

Sweden.—Since 1974, the annual production of burnt lime in Sweden had gradually declined from 1 million tons per year to an estimated level of 785,000 tons per year in 1981. In 1980, 40% of the production was consumed by the iron and steel industry. Of the commercial lime produced, 45% was sold to the steel industry, 25% was for the pulp and chemical industries, 15% was used in the manufacture of building materials, and the remaining 15% was sold for water treatment and other minor uses. Cementa AB was the sole Swedish cement producer, and in addition, produced burnt lime at its Limhamn and Koping plants, with production of 100,000 tons and 200,000 tons per year, respectively. The Limhamn plant has a unique method of quicklime production in which siliceous limestone is burned, followed by air classification to produce two salable products—flint and burnt lime. The other major Swedish producer of commercial lime was Stabruken AB, which operated two plants, one at Boda off the southeast coast of Sweden with a capacity of 94,000 short tons per year, and the other at Raettviks in central Sweden with a capacity of 190,000 short tons per year.[18]

Switzerland.—Swiss production of lime increased slightly to about 90,000 short tons in 1981. Two companies accounted for virtually all of Swiss production—Kalkfabrik Netstal AB, with one plant at Netstal, and Cementfabrik Holderbank, with three plants at Lausanne, Unterterzen, and Zurich. Most of Holderbank's production was used in the construction industry.[19]

United Kingdom.—The production of quicklime and hydrated lime increased 1% in 1981 to a level of 3.3 million tons. A decrease was prevented principally because of the recovery of the iron and steel industry from a prolonged strike in 1980. In the United Kingdom there were five large producers of burnt lime that supplied the commercial market as well as their own needs—Imperial Chemical Industries, Ltd. (ICI), Tilling Construction Services, Amey Roadstone Corp., Steetley Minerals Ltd., and Peakstone Ltd. Four smaller companies produced hydrated lime, and three other companies produced burnt lime for their own requirements in the iron and steel industry, sugar refining, and in the production of calcium-silicate bricks.

The largest producer of lime in the United Kingdom was the Mond division of ICI with 13 kilns at Tunstead with a total capacity of 860,000 tons per year and 2 kilns at Hindlow with a total capacity of 240,000 tons per year. Industrial uses for burnt lime in the United Kingdom in 1979 were iron and steel, 44%; chemicals, 38%; building, 4%; and other, 14%.[20]

Venezuela.—A quicklime and hydrated lime plant with a capacity of 550,000 tons per year of quicklime, including 190,000 tons per year of hydrated lime, was installed as an integral part of the only Venezuelan integrated steel-production facility, the state-owned enterprise Siderúrgica del Orinoca (SIDOR). Energy consumption was 4.7 million Btu per ton of quicklime. SIDOR required quicklime partly as a flux for the electric furnace operations, and to a larger extent, as hydrated lime as a binding agent in iron ore pelletizing operations.[21]

Western Europe.—Owing to the diverse uses of burnt lime in the chemical and manufacturing industries, almost every country in Western Europe was a producer of burnt lime, largely for domestic consumption, but with considerable international trade, especially with the members of the European Communities. The most significant factor affecting the production was the economic recession, which had caused a severe reduction in the high-volume consumption of lime in the iron and steel, construction, and chemical industries. This was especially apparent in the United Kingdom steel industry, which created excess burning capacity that could not be absorbed by other market outlets.[22]

Table 8.—Quicklime and hydrated lime, including dead-burned dolomite: World production, by country[1]

(Thousand short tons)

Country[2]	1977	1978	1979	1980[p]	1981[e]
North America:					
Canada	2,094	2,242	2,242	2,274	2,270
Costa Rica[e]	7	8	10	8	8
Dominican Republic	23	[e]28	42	44	45
Guatemala	50	49	45	39	35
Jamaica	159	173	225	175	175
Mexico	[e]4,575	[e]4,900	5,047	4,800	5,100
Nicaragua[e]	40	41	40	44	35
United States, including Puerto Rico (sold or used by producers)	19,987	20,484	20,983	19,037	[3]18,890
South America:					
Brazil[e]	4,960	[r]5,100	5,200	5,300	5,500
Chile[e]	680	680	700	700	660
Colombia[e]	1,430	1,430	1,430	1,430	1,430
Paraguay	59	42	36	61	65

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]	1977	1978	1979	1980^{p}	1981^{e}
South America —Continued					
Peru	([4])	([4])	([4])	([4])	40
Uruguay	77	94	89	22	55
Venezuela	NA	NA	NA	220	440
Europe:					
Austria	1,068	1,120	1,127	1,213	1,215
Belgium	^{r}2,782	^{r}3,846	3,697	3,554	3,550
Bulgaria	1,901	1,964	2,059	2,061	1,915
Czechoslovakia	3,300	3,393	3,272	3,327	3,300
Denmark	191	179	195	187	151
Finland	259	214	220	217	208
France	$^{r\,e}$4,925	$^{r\,e}$5,071	4,266	^{e}4,409	4,056
German Democratic Republic	3,711	3,795	3,825	3,749	3,750
Germany, Federal Republic of	9,667	9,910	10,174	9,921	9,420
Hungary	819	816	82	769	770
Ireland	88	101	80	35	35
Italy	2,421	2,360	2,315	^{e}2,315	2,156
Malta	35	31	33	34	35
Norway	113	139	^{e}143	143	145
Poland[5]	9,521	10,070	8,435	8,267	7,440
Portugal	250	286	288	300	290
Romania	3,798	4,031	4,221	4,203	4,200
Spain^{e}	440	390	440	500	500
Sweden[6]	847	825	854	^{e}882	785
Switzerland	73	75	77	83	90
United Kingdom	3,574	3,470	3,649	3,285	3,310
U.S.S.R.^{e}	26,000	26,000	26,500	27,000	27,560
Yugoslavia	2,256	2,265	2,647	^{e}2,756	2,980
Africa:					
Algeria^{e}	44	55	90	100	100
Burundi	1	([4])	([4])	([4])	([4])
Egypt^{e}	^{r}110	^{r}110	100	97	100
Kenya	86	^{e}55	30	29	30
Libya	330	243	248	255	250
Mauritius	8	9	^{e}9	8	8
Mozambique^{e}	110	^{r}11	11	11	10
South Africa, Republic of (sales)	1,658	2,067	1,897	2,407	2,380
Tanzania^{e}	2	^{r}6	7	7	7
Tunisia	373	471	474	583	515
Uganda^{e}	22	28	31	17	15
Zaire	111	^{e}110	^{e}110	110	110
Zambia	^{e}280	^{e}280	280	201	194
Asia:					
Cyprus	31	17	^{e}20	15	15
India^{e}	200	220	450	440	440
Iran^{e}	1,100	1,000	550	550	550
Israel	112	137	137	137	140
Japan	9,945	9,985	10,613	10,307	9,380
Jordan	3	3	4	^{e}4	4
Korea, Republic of	66	^{e}66	66	231	220
Kuwait	22	4	^{e}13	13	13
Lebanon	179	111	130	130	67
Mongolia	$^{r\,e}$55	40	51	55	55
Philippines	31	37	59	96	100
Saudi Arabia^{e}	22	33	165	165	200
Taiwan	^{r}196	211	195	219	160
United Arab Emirates	NA	NA	NA	44	44
Oceania:					
Australia[7]	^{r}945	981	963	992	1,000
Fiji Islands	2	1	1	2	2
New Zealand^{e}	190	175	190	190	190
Total	^{r}128,444	^{r}132,088	131,582	130,779	128,908

^{e}Estimated. ^{p}Preliminary. ^{r}Revised. NA Not available.
[1]Table includes data available through June 16, 1982.
[2]Lime is produced in many other countries besides those listed. Argentina, China, Iraq, Pakistan, Syria, and Turkey are among the more important countries for which official data are unavailable.
[3]Reported figure.
[4]Less than 1/2 unit.
[5]Excludes output by small producers.
[6]Series reflects total production, not sales as stated in previous editions of this chapter.
[7]Data are for years ending June 30 of that stated.

TECHNOLOGY

In the previous 20 years, there had been substantial changes in lime kiln design and technology, including the flexibility of fuels used. There had been a gradual progression from using simple vertical shaft kilns to rotary kilns, rotary hearth kilns, and twin-shaft regenerative kilns for higher quality burnt lime and lower energy consumption. The choice of the kiln system depends on properties of the raw material and the use specifications of the consumer. Simple vertical kilns were highly energy efficient but produced a lower quality lime; also, the minus 2-inch material had to be screened out of the feed material. Rotary kilns could accept any practical size feed but had higher energy consumption, although the new preheater and short section adaptations could enhance energy efficiency. In the later 1960's, British Steel Corp. initiated the use of the calcimatic rotary hearth kiln for the production of low sulfur quicklime. These kilns met the strict specifications for quicklime as well as being more energy efficient. Other advantages were lower capital investment, flexibility of operations, use of small-size feed, and production of a consistently high-reactive lime.

One of the most important breakthroughs in kiln technology was the development of the multishaft regenerative kiln, which produced soft-burned lime ideal for steelmaking, along with low fuel consumption. The kiln operation depended upon the alternate firing of two or three shafts, while the other shafts used waste gas for preheating of the stone. Combustion fuel and air was transferred from one shaft to the other at short intervals, while cooling air was introduced at the bottom of both shafts, which continuously discharged quicklime.[23]

Three Maerz shaft lime kilns were installed by British Steel Corp. at their Shapfell works—two double-shaft kilns with capacities of 330 short tons per day and one triple-shaft kiln, fired by liquid propane gas. The kilns were commissioned in March 1975 and, with the exception of a 2-month period of lining repair, had been in continuous operation since that time. Energy consumption averaged 2.7 million Btu per short ton of quicklime.[24]

Advantages and disadvantages of various calcining devices were discussed with relationship to limestone feed properties, required product quality, and intended use. The choice of long rotary kilns, short kilns with limestone preheaters, vertical shaft kilns, and flash calcining systems must all be carefully considered when evaluating production equipment.[25]

A patented process has been developed that converts many liquid hazardous wastes to a stable form. Waste sludges undergo an exothermic reaction when mixed with quicklime, which quickly converts the organic waste to an inert powder, thereby facilitating onsite treatment, with final disposal of the product as a construction material or landfill.[26]

The Alzada pelletizing plant in the State of Colima, Mexico, processed the beneficiated magnetite, 67% iron, from the El Encino Mine. After vacuum filtering, 0.9% to 1.2% of hydrated lime was added to the filter cake, which was then passed through a Pekay mixer and distributed to four pelletizing disks. After induration, the pellets satisfactorily withstood the 800-mile trip by rail to the steelworks.[27]

A Kennedy Van Saun low-pressure-drop preheater-precalciner, a hydraulic coupling, and prior feed stone washing had cut fuel consumption at the Austin White Lime Co.'s plant in McNeil, Tex. It was estimated that annual savings during the 1980-81 period amounted to $55,000 per year.[28]

A circular limestone preheater, operated much like the retangular lime preheater, can reduce energy consumption and produce high-quality lime with energy consumption of 4.5 to 5.5 million Btu per ton of quicklime produced. The unit development was designed for system capacities up to 1,000 tons per day.[29]

An oil-fired, parallel-flow Kennedy Van Saun MCV kiln system was producing 400 tons per day of quicklime, with a fuel consumption of 3.5 million Btu per short ton. This regenerative heat recoupment system at the Domlim, Inc., plant at Lime Ridge, Quebec, Canada, was producing high-reactive lime in a computer-controlled operation.[30]

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Lithium

By John E. Ferrell[1] and James P. Searls[1]

In 1981, the United States continued as both the world's largest producer and consumer of lithium minerals and chemicals. The United States was self-sufficient in this commodity and was the world's largest exporter. Domestic production advanced slightly in 1981. Imports remained minor in 1981. U.S. exports were estimated to have risen slightly while apparent consumption increased approximately 7%.

Known world supply advanced slightly as production increased in the United States. Production in the rest of the world did not increase significantly. World consumption was estimated to have increased slightly to 7,700 short tons of contained lithium. Aluminum potlines continued to be the world's largest end use for lithium. The aluminum industry used 33% of the lithium chemicals consumed in the United States, while glass, ceramics, and lubricants accounted for another 40%.

The United States and the U.S.S.R. are the world's primary lithium producers. The United States continued to supply about three-fourths of demand in nonproducing countries; the remainder was supplied by the U.S.S.R. and China as chemicals and by Zimbabwe as mineral concentrate. Brazil, Portugal, and Argentina produce primarily for internal consumption. The Federal Republic of Germany and Japan are large importers of lithium chemicals, primarily lithium carbonate, which they use or convert for resale to their export markets.

Table 1.—Salient lithium statistics

(Short tons of contained lithium)

	1977	1978	1979	1980	1981
United States:					
Production[1]	W	W	W	W	W
Yearend producers' stocks[1]	W	W	W	W	W
Imports[1]	10	10	50	90	150
Shipments of Government stockpile surplus[2]	253	5	--	--	--
Supply[1 3]	6,900	6,300	6,300	6,200	6,700
Supply[e 2 4]	5,900	5,400	5,600	5,500	5,800
Exports[e 2]	1,800	2,000	2,400	2,500	2,600
Apparent consumption[e 2]	4,100	3,400	3,200	3,000	3,200
Rest of world: Production[e 1]	2,000	2,000	2,250	2,250	2,250

[e]Estimated. 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.—No lithium hydroxide monohydrate was sold from the General Services Administration (GSA) excess stock in 1981. GSA reports that it has 11,500 short tons (1,898 short tons of contained lithium) of virgin material and 28,500 short tons (4,703 short tons of contained lithium) of depleted material (depleted of lithium 6) that may contain 8 to 9 parts per million of mercury. This material was excess from a nuclear weapons program.

Public Law 96-386, October 1980, could encourage the consumption of lithium in the future. This law provides for an accelerated program of magnetic fusion energy technologies research and development. Fusion energy, as presently planned, would use lithium in large amounts to convert the fusion energy to heat energy for electricity production.

DOMESTIC PRODUCTION

There were two lithium producers in the United States in 1981. Foote Mineral Co., 92% 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. Production and sales data reported to the Bureau of Mines are withheld to avoid disclosing company proprietary data.

Foote Mineral reported[2] production of 14,420 tons of Li_2CO_3 equivalent (2,710 tons of contained lithium) in 1981; 7,500 tons (1,410 tons of contained lithium) from the North Carolina plant and 6,920 tons (1,300 tons of contained lithium) from the Nevada plant. Foote Mineral raised the North Carolina plant capacity rating from 7,000 to 9,000 tons per year of Li_2CO_3 equivalent during late 1980. Lithco reported[3] production of 14,454 tons of Li_2CO_3 equivalent (2,717 tons of contained lithium) from its North Carolina plant. Lithco also reported that, in 1981, 39% of its sales were to foreign customers. Annual mill capacity rating at the Lithco North Carolina plant was raised from 15,000 tons of Li_2CO_3 equivalent (2,820 tons of contained lithium) to 18,000 tons of Li_2CO_3 equivalent (3,384 tons of contained lithium) during 1981.

CONSUMPTION AND USES

Some mineral concentrate, possibly as much as 10%, was used directly by the ceramics industry, but most concentrate was converted to lithium chemicals and metal. The Bureau of Mines estimates a 15% loss in conversion from ore to lithium carbonate. Lithium chemicals are used by the aluminum, air-conditioning, ceramics, grease, specialty glasses, synthetic rubber, thermoplastic, and primary battery industries.

Apparent domestic consumption of all lithium-containing products was estimated to have increased about 7% in 1981. Foote Mineral reported that increased sales of lithium products were primarily attributable to increased use of lithium in the domestic aluminum industry.[4] In addition, it reported that inventories of lithium products decreased in 1981 as sales exceeded production levels. Both domestic producers reported that no single customer accounted for more than 10% of sales. Lithco reported that no single industry accounted for more than 30% of its sales. Lithium battery systems continued to be one of the fastest growing markets for lithium products and technology.

PRICES

Domestic midyear prices of lithium materials increased by an average of about 17%, as indicated in table 2, probably owing to increased energy and raw material costs.

Table 2.—Domestic midyear producers' prices of lithium and lithium compounds

(Dollars per pound)

	1980	1981
Lithium bromide, 54% brine: 2,268-pound lots, delivered in drums	3.31	3.68
Lithium carbonate, technical: Truckload lots, delivered	1.205	1.41
Lithium chloride, anhydrous, technical: Truckload lots, delivered	1.93	2.19
Lithium fluoride	3.90	4.50
Lithium hydroxide monohydrate: Truckload lots, delivered	1.60	1.84
Lithium metal ingot: 1,000-pound lots, f.o.b	17.15	20.65
Lithium sulfate, anhydrous	2.12	2.64
N-butyllithium in n-hexane (15%): 3,000-pound lots, delivered	11.30	12.75

FOREIGN TRADE

U.S. exports of lithium chemicals (shown in tables 3 and 4) and metal are not completely reported in available Bureau of the Census trade statistics. However, a review of 1981 trade data, when compared with that of 1980, indicates a slight increase in exports for lithium compounds, except for lithium hydroxide, which decreased moderately.

Table 3.—U.S. exports of lithium compounds, by country

(Gross weight)

Country	1980		1981	
	Quantity (pounds)	Value (dollars)	Quantity (pounds)	Value (dollars)
Argentina	--	--	159,323	214,263
Australia	248,932	615,709	305,909	504,391
Belgium	177,147	234,916	38,245	78,840
Brazil	--	--	127,658	217,660
Canada	2,071,414	2,664,753	4,586,122	5,985,699
China	--	--	32,659	20,000
Colombia	--	--	20,000	38,958
Germany, Federal Republic of	8,446,484	8,998,095	8,473,063	9,671,592
India	235,089	316,147	20,476	42,469
Italy	--	--	22,291	193,839
Israel	--	--	35,482	87,939
Japan	3,947,845	4,227,497	5,475,111	6,954,660
Korea, Republic of	106,920	132,011	196,430	271,315
Mexico	409,537	802,078	437,343	975,566
Netherlands	193,031	206,510	65,233	138,648
South Africa, Republic of	327,777	316,767	230,857	259,514
Spain	264,124	489,290	89,776	105,260
Taiwan	--	--	141,876	169,303
United Kingdom	391,397	448,120	414,095	536,661
Venezuela	3,220,641	3,622,307	1,956,541	2,649,502
Other	526,456	1,010,076	117,016	298,750
Total	20,566,794	24,084,276	22,945,506	29,414,829

Source: U.S. Department of Commerce, Bureau of the Census.

Table 4.—U.S. exports of lithium hydroxide, by country

(Gross weight)

Country	1980 Quantity (pounds)	1980 Value (dollars)	1981 Quantity (pounds)	1981 Value (dollars)
Argentina	89,646	140,781	67,000	113,797
Australia	248,913	346,077	126,700	198,752
Belgium	249,200	345,024	220,000	365,200
Brazil	517,018	655,982	940,814	1,470,091
Canada	285,665	441,063	114,250	200,317
Chile	--	--	119,565	185,397
Colombia	--	--	44,700	77,328
Egypt	77,074	115,945	--	--
France	187,046	299,377	201,424	353,081
Germany, Federal Republic of	1,573,400	2,170,239	709,150	1,058,352
India	353,400	465,113	154,840	230,098
Indonesia	--	--	30,000	53,479
Israel	--	--	75,100	123,394
Italy	90,468	144,452	11,000	19,075
Japan	852,391	1,255,327	1,061,318	1,835,684
Kenya	66,112	98,155	57,228	92,885
Mexico	389,411	602,432	128,376	217,087
Philippines	151,967	233,703	23,256	40,116
Singapore	--	--	69,274	108,473
South Africa, Republic of	271,600	382,765	151,200	267,660
Spain	184,200	263,840	123,200	191,096
Sweden	64,920	93,776	31,220	44,166
United Kingdom	511,456	787,823	478,032	701,795
Venezuela	105,600	143,896	856,549	1,196,092
Other	411,231	614,673	245,450	398,132
Total	6,680,718	9,600,443	6,039,646	9,541,547

Source: U.S. Department of Commerce, Bureau of the Census.

Table 5.—U.S. imports for consumption of lithium-bearing materials, by commodity and country

Commodity and country	1980 Gross weight (pounds)	1980 Value (thousand dollars) Customs	1980 Value (thousand dollars) C.I.F.	1981 Gross weight (pounds)	1981 Value (thousand dollars) Customs	1981 Value (thousand dollars) C.I.F.
Lithium ores:						
Netherlands	45,680	1	1	--	--	--
South Africa, Republic of	7,739,844	459	576	[e]8,000,000	NA	NA
Total	7,785,524	460	577	[e]8,000,000	NA	NA
Lithium compounds:						
Bahamas	72	1	2	--	--	--
Belgium	44,092	48	50	--	--	--
Canada	500	(1)	1	7,900	9	9
China	32,805	32	38	501,496	524	600
Denmark	--	--	--	7	1	1
France	30,003	1,477	1,496	13,989	1,020	1,031
Germany, Federal Republic of	13,617	249	254	36,297	121	125
Japan	37	17	17	162	64	65
Switzerland	2,205	1	1	595	1	1
United Kingdom	268	16	17	213	13	13
Total	123,599	1,841	1,876	560,659	1,753	1,845
Lithium salts:						
Denmark	48	2	2	--	--	--
Germany, Federal Republic of	10	5	5	--	--	--
Total	58	7	7	--	--	--
Lithium metal:						
Germany, Federal Republic of	--	--	--	11	1	1
Japan	--	--	--	6	--	--
Total	--	--	--	17	1	1

[e]Estimated. NA Not available.
[1]Less than 1/2 unit.

Source: U.S. Department of Commerce, Bureau of the Census.

WORLD REVIEW

Argentina and Bolivia.—Both countries are exploring salars for lithium content. These brine deposits are located near the Salar de Atacama in northern Chile.

Australia.—Greenbush Tin NL announced a significant lithium find in association with tin, tantalum, and columbium southeast of Perth in Western Australia. The reported 4.7 million tons of reserves with a cutoff grade at 1.5% Li_2O might contain 56,000 metric tons of contained lithium.

Chile.—Sociedad Chilena de Litio, Ltda. (SCL), a limited partnership of Foote Mineral and Corporacíon de Fomento de la Produccíon (CORFO), announced approval of construction wells and solar evaporation ponds at the Salar de Atacama as well as a lithium carbonate production plant to be built near Antofagasta on the northern coast. CORFO is a Chilean state-owned corporation. Construction cost estimates are now at $61 million with production commencing in 1984.[5] Annual plant capacity should be 14 million pounds of lithium carbonate. SCL has a 30-year concession, renewable for 5-year intervals thereafter. During the initial 30 years, SCL can only produce up to 200,000 metric tons of lithium equivalent.[6] Total Salar de Atacama reserves are estimated to contain 1.3 million tons of lithium equivalent.

CORFO has continued efforts to further develop the Salar de Atacama by offering the potash and boric acid parts of the brine to other developers. The Chileans are also exploring the Salar de Pedernales, which may also contain lithium, potash, and boric acid.

Israel.—The Dead Sea Works of Beer-Sheba, Israel, has developed a possible method for extracting lithium from the Dead Sea.[7] The method involves precipitation as lithium aluminate followed by solvent extraction to separate the lithium from the aluminum. The total amount of lithium equivalent estimated in the Dead Sea is 2.7 million tons. A preliminary economic analysis using this extraction method indicates a production cost of $30 per kilogram of lithium metal compared with the current selling price, which is also $30 per kilogram.

Japan.—On a contained-lithium basis, Japanese imports of lithium materials increased approximately 55% compared with that of the previous year. The United States captured 79% of the Japanese market, and the U.S.S.R. and China captured 16% and 4%, respectively. Japanese imports for 1981 included 3,660 short tons of lithium carbonate and 695 short tons of lithium hydroxide.

Zimbabwe.—Future lithium production in Zimbabwe appears closely tied to the country's political stability and development. Since Zimbabwe's independence on April 18, 1980, official Government policy toward mining has been friendly with encouragement both for exploration and increased production at existing mines.

Bikita Minerals Ltd. is potentially one of the world's major lithium producers. Bikita pegmatite reportedly has lithium minerals with the following approximate lithia percentages: Petalite, 4.5%; eucryptite, 8%; bikitatite, 6%; spodumene, 7.5%; lepidolite, 4.1%; and amblygonite, 10%.[8] The lithium content of Bikita reserves has been estimated to be 125,000 short tons of contained lithium with an ore grade average of 1.4% lithium. The Bikita Al Hayat quarry extracts 11,000 short tons of ore for processing each month. The grinding plant currently has a capacity to handle about 2,050 short tons per month.

Of the lithium minerals, the Bikita principal product is ground petalite, which contains 4.1% lithia. About 12% of Bikita sales are typically spodumene in the form of a fine-grained concentrate. It has also been reported that Bikita has a stockpile of some 900,000 short tons of petalite with an average grade of 1.44% contained lithium.

Table 6.—Lithium minerals: World production, by country[1]

(Short tons)

Country[2] and minerals produced	1977	1978	1979	1980[p]	1981[e]
Argentina (minerals not specified)	454	885	117	88	99
Brazil:					
Amblygonite	539	[r]475	206	201	220
Lepidolite	638	[r]55	64	56	220
Petalite	1,133	2,200	1,655	2,741	2,755
Spodumene	[r]123	976	--	108	110
China, (minerals not specified)[e 3]	11,000	11,000	11,000	15,000	15,000
Namibia (minerals not specified)[4]	2,809	NA	NA	NA	NA
Portugal, lepidolite	1,300	1,300	1,100	1,100	990
Rwanda, amblygonite[e]	33	31	31	33	28
U.S.S.R. (minerals not specified)[e 3]	55,000	55,000	55,000	61,000	61,000
United States (minerals not specified)	W	W	W	W	W
Zimbabwe (minerals not specified)	8,874	18,395	14,547	23,182	23,000

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available. W Withheld to avoid disclosing company proprietary data.

[1]Table includes data available through Apr. 28, 1982.

[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]Output has not been officially reported since 1966, but presumably production has continued because a number of countries record imports from the Republic of South Africa, which no longer produces lithium minerals. Data given represent imports by the United States. The countries of the European Community and Spain reported imports as originating in the Republic of South Africa, but the reader is cautioned that a portion of this material may have been mined in Zimbabwe. In 1966, actual output from Namibia totaled 1,739 short tons including amblygonite—30, lepidolite—365, and petalite—1,344.

TECHNOLOGY

The Bureau of Mines Salt Lake City Research Center continued its efforts to extract lithium from hectorite clays available in the McDermot Caldera on the Nevada-Oregon border. Research in 1981 on lithium extraction by lime-gypsum roasting included determining the effect of carbon monoxide on conventional lime-gypsum roasting and investigating the use of sulfur dioxide and sulfur trioxide as sulfating agents. Research indicated that the presence of carbon monoxide depresses conversion of lithium silicates in the clay into water-soluble lithium sulfates. Research on one method for extracting lithium from low-grade clays—selective chlorination—was completed. Using this method, mixtures of clay and limestone are chlorinated at 750° C with hydrochloric acid vapors. Lithium is recovered from the calcines by leaching with water and precipitating lithium carbonate from the leach liquor with sodium carbonate.

The Bureau of Mines Reno Research Center continued studying the recovery of lithium, among other metals, from the brines of the Imperial Valley, Calif., geothermal wells. The superheated brine would be brought to the surface in large volumes for steam-electric power generation. If the lithium recovery process is economical, with a reasonable lithium recovery rate, there is a potential for significant amounts of lithium production.

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[1]Physical scientist, Division of Industrial Minerals.

[2]See company 10-K reports for 1981 filed with the Securities and Exchange Commission, Washington, D.C.

[3]Work cited in footnote 2.

[4]Work cited in footnote 2.

[5]Engineering and Mining Journal. Chile Will Exploit Atacama Salar Mineral Wealth. V. 182, No. 7, July 1981, p. 43.

[6]Work cited in footnote 5.

[7]Epstein, J. A., E. M. Feist, J. Zmora, and Y. Marcus. Extraction of Lithium From the Dead Sea. Hydrometallurgy, No. 6, 1981, pp. 269-275.

[8]Clarke, G. M. Zimbabwe's Industrial Minerals—Optimism for the Future. Ind. Miner. (London), No. 172, January 1982, pp. 19-61.

Magnesium

By Benjamin Petkof[1]

Domestic primary magnesium metal production declined from that of 1980. Secondary metal recovery continued to move upward. Magnesium consumption continued the decline that commenced in 1979. Total metal exports declined in both quantity and value; however, all classes of imports increased in quantity and value. The quoted metal price advanced in 1981. World primary metal production declined.

Table 1.—Salient magnesium statistics

(Short tons unless otherwise specified)

	1977	1978	1979	1980	1981
United States:					
Production:					
Primary magnesium[1]	125,958	149,463	162,464	r169,477	142,887
Secondary magnesium	32,694	36,228	37,222	40,461	46,256
Exports	28,061	41,807	54,280	56,761	34,855
Imports for consumption	5,964	6,668	4,754	3,757	6,897
Consumption	103,576	108,958	108,844	95,788	91,461
Price per pound	$0.96-$0.99	$0.99-$1.01	$1.01-$1.09	$1.07-$1.25	$1.25-$1.34
World: Primary production	283,554	r317,730	r338,850	p349,953	e328,117

eEstimated. pPreliminary. rRevised.

[1]Derived from data reported by the International Magnesium Association and the Canadian Department of Mines and Natural Resources. Figures are the difference between total North American production reported by the International Magnesium Association and Canadian production reported by the Canadian Department of Mines and Natural Resources.

DOMESTIC PRODUCTION

Domestic primary ingot production declined from that of 1980 and followed the downward trend of the economy in 1981. Three companies produced about 143,000 short tons of magnesium: The Dow Chemical Co. (Freeport, Tex.), AMAX Specialty Metals Corp. (Rowley, Utah), and Northwest Alloys, Inc. (Addy, Wash.). The first two companies produced magnesium metal from magnesium chloride obtained from natural brine by the electrolytic method. Northwest Alloys used the silicothermic process.

The American Magnesium Co., which terminated production in December 1980, had no activity in 1981 and was not expected to resume production in the future.

Secondary magnesium continued to provide a significant portion of the domestic supply of magnesium metal.

Table 2.—Magnesium recovered from scrap processed in the United States, by kind of scrap and form of recovery

(Short tons)

	1977	1978	1979	1980	1981
KIND OF SCRAP					
New scrap:					
Magnesium-base	3,363	4,634	5,025	5,929	2,833
Aluminum-base	16,807	17,501	18,315	16,978	19,240
Total	20,170	22,135	23,340	22,907	22,073
Old scrap:					
Magnesium-base	5,255	5,522	4,778	5,275	5,593
Aluminum-base	7,269	8,571	9,104	12,279	18,590
Total	12,524	14,093	13,882	17,554	24,183
Grand total	32,694	36,228	37,222	40,461	46,256
FORM OF RECOVERY					
Magnesium alloy ingot[1]	3,785	4,272	3,739	4,205	4,230
Magnesium alloy castings (gross weight)	859	956	790	836	806
Magnesium alloy shapes	932	1,909	2,176	3,144	13
Aluminum alloys	25,211	27,301	28,857	29,612	38,755
Zinc and other alloys	21	19	13	13	9
Chemical and other dissipative uses	43	48	47	9	55
Cathodic protection	1,843	1,723	1,600	2,642	2,388
Total	32,694	36,228	37,222	40,461	46,256

[1]Includes secondary magnesium content of both secondary and primary alloy ingot.

CONSUMPTION AND USES

Total U.S. magnesium metal consumption declined for the second consecutive year. Magnesium metal was used to fabricate structural products that included cast and wrought items and was used for sacrificial uses where advantage was taken of the metal's alloying and chemical properties. The metal's useful structural properties, such as low specific gravity, good machinability, hot formability, and high strength-to-weight ratio, resulted in almost one-fifth of the 1981 consumption being used in aircraft, automotive, and other types of transportation equipment; material-handling equipment; and the manufacture of such items as power tools. Almost three-fifths was used for alloying with other metals. The remainder was used for other sacrificial purposes such as cathodic protection, modular iron production, chemicals, and reducing agents for metals such as titanium, zirconium, uranium, and beryllium.

Table 3.—Consumption of primary magnesium in the United States, by use

(Short tons)

Use	1977	1978	1979	1980	1981
For structural products:					
Castings:					
Die	5,011	5,575	5,182	3,190	2,812
Permanent mold	1,048	1,012	1,069	922	917
Sand	1,142	1,064	1,209	1,735	1,222
Wrought products:					
Extrusions	(1)	6,301	6,420	6,855	5,786
Sheet and plate	(1)	4,375	4,925	4,704	4,547
Other (includes forgings)	12,632	399	217	61	43
Total	19,833	18,726	19,022	17,467	15,327

See footnotes at end of table.

Table 3.—Consumption of primary magnesium in the United States, by use —Continued

(Short tons)

Use	1977	1978	1979	1980	1981
For distributive or sacrificial purposes:					
Alloys:					
Aluminum	56,086	58,798	60,549	54,490	50,518
Copper	10	12	9	6	5
Zinc	23	21	15	11	9
Other	8	8	8	7	7
Cathodic protection (anodes)	4,083	6,600	6,769	3,930	6,449
Chemicals	9,941	9,192	9,044	6,278	5,315
Nodular iron	7,297	7,956	4,335	4,176	3,755
Scavenger and deoxidizer	([1])	([1])	([1])	([1])	([1])
Reducing agent for titanium, zirconium, hafnium, uranium, and beryllium	5,235	6,230	7,435	7,957	9,071
Other including powder	1,060	1,415	1,658	1,466	1,005
Total	83,743	90,232	89,822	78,321	76,134
Grand total	103,576	108,958	108,844	95,788	91,461

[1]Included with "Other."

STOCKS

Consumer stocks of primary magnesium and alloy ingot were 11,367 tons and 756 tons, respectively, at the end of 1981. Yearend stocks for magnesium categories declined from those at yearend 1980. New and old magnesium scrap stocks are shown in table 4.

Table 4.—Stocks and consumption of new and old magnesium scrap in the United States

(Short tons)

	Stocks, Jan. 1	Receipts	Consumption			Stocks, Dec. 31
			New scrap	Old scrap	Total	
1980:						
Cast scrap	1,077	6,815	680	5,797	6,477	1,415
Solid wrought scrap[1]	233	791	864	--	864	160
Total	1,310	7,606	1,544	5,797	7,341	1,575
1981:						
Cast scrap	1,415	6,986	796	6,146	6,942	1,459
Solid wrought scrap[1]	160	833	965	--	965	28
Total	1,575	7,819	1,761	6,146	7,907	1,487

[1]Includes borings, turnings, drosses, etc.

PRICES

At the beginning of 1981, the price of magnesium metal and magnesium diecasting alloy was \$1.25 and \$1.21 per pound, respectively. On June 1, 1981, the price of magnesium metal increased to \$1.34 per pound. The price of diecasting alloy was unchanged. There were no price changes during the second half of the year.

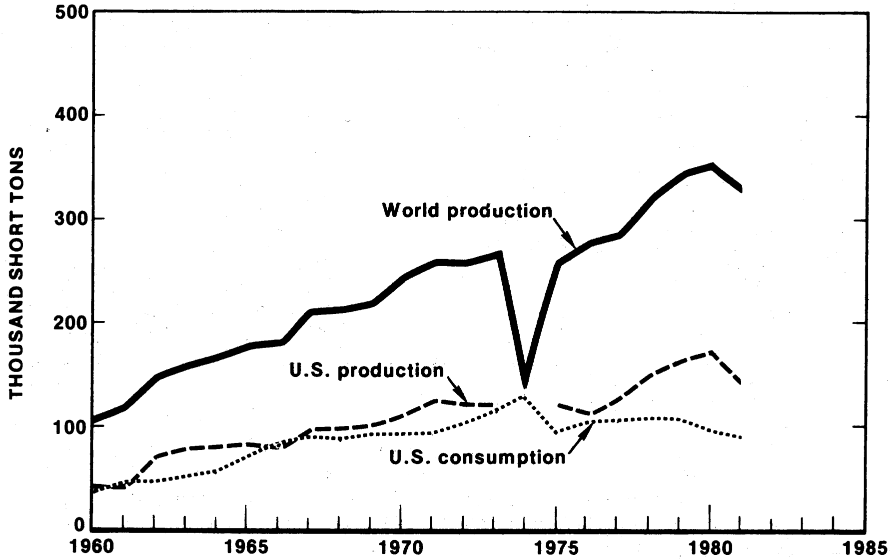

Figure 1.—U.S. and world production and U.S. consumption of primary magnesium.

FOREIGN TRADE

Total 1981 U.S. magnesium exports declined sharply from those of 1980 in both quantity and value. Large quantities of metal were exported to industrialized nations, especially those producing aluminum.

Imports of all classes of magnesium increased significantly from those of 1980, suggesting the possibility of decreased magnesium demand in the rest of the world during 1981.

The United States retained its status as a net exporter of magnesium.

Table 5.—U.S. exports and imports for consumption of magnesium

Year	EXPORTS					
	Waste and scrap		Metals and alloys in crude form		Semifabricated forms n.e.c.	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1979	688	$794	47,456	$90,788	6,136	$22,246
1980	250	587	49,584	104,086	6,927	23,033
1981	261	689	32,910	81,116	1,684	9,048

Year	IMPORTS							
	Waste and scrap		Metal		Alloys (magnesium content)		Powder, sheets, tubing, ribbons, wire, other forms (magnesium content)	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1979	2,757	$2,958	1,460	$3,127	412	$1,767	125	$1,190
1980	2,384	2,806	940	2,242	344	1,770	89	1,443
1981	3,225	3,338	2,897	6,844	625	2,652	150	4,804

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)
1980						
Argentina	6	$24	407	$898	37	$160
Australia	--	--	1,600	3,341	401	2,481
Austria	--	--	46	117	218	545
Belgium-Luxembourg	--	--	--	--	401	1,112
Brazil	--	--	10,124	21,709	1	10
Canada	17	34	3,391	7,639	272	1,339
China	--	--	5,123	8,688	--	--
Colombia	--	--	33	102	12	46
France	--	--	42	115	105	504
Germany, Federal Republic of	12	25	2,156	5,079	1,338	3,380
Ghana	--	--	1,423	2,874	--	--
Hong Kong	--	--	10	11	41	138
India	--	--	517	1,089	67	183
Israel	--	--	41	215	222	1,033
Italy	--	--	226	895	267	886
Japan	7	34	9,334	18,871	641	2,163
Korea, Republic of	38	85	73	174	161	431
Mexico	10	54	2,792	6,288	288	1,323
Netherlands	20	43	10,221	20,342	1,263	2,892
New Zealand	--	--	74	155	6	54
Norway	--	--	199	451	1	17
South Africa, Republic of	2	25	737	2,473	210	619
Spain	--	--	49	139	51	190
Sweden	--	--	115	293	33	208
Taiwan	12	24	11	19	18	58
United Kingdom	1	2	265	658	202	1,144
Venezuela	2	4	109	252	36	234
Other	123	233	466	1,199	635	1,883
Total	250	587	49,584	104,086	6,927	23,033
1981						
Argentina	39	167	390	908	6	35
Australia	--	--	1,379	3,113	232	1,239
Austria	--	--	336	857	5	69
Belgium-Luxembourg	--	--	129	328	9	73
Brazil	--	--	2,892	6,540	8	44
Cameroon	--	--	35	83	--	--
Canada	73	162	3,943	9,819	186	883
China	--	--	--	--	--	--
Colombia	--	--	59	187	25	98
France	1	2	143	364	43	566
Germany, Federal Republic of	--	--	1,247	3,225	44	362
Ghana	--	--	--	--	1	3
Hong Kong	--	--	10	25	--	--
India	--	--	154	381	8	17
Israel	--	--	68	380	66	443
Italy	--	--	139	517	53	571
Japan	25	70	7,982	18,310	71	450
Korea, Republic of	--	--	266	669	3	36
Mexico	65	162	2,204	5,338	400	1,775
Netherlands	20	41	9,210	24,146	(1)	1
New Zealand	--	--	74	181	1	20
Norway	--	--	68	448	1	17
Romania	--	--	547	1,389	--	--
Saudi Arabia	37	81	233	481	53	177
Singapore	--	--	11	20	--	--
South Africa, Republic of	--	--	440	1,066	67	261
Spain	--	--	84	238	19	188
Sweden	--	--	1	12	5	55
Taiwan	--	--	159	376	14	102
United Kingdom	--	--	345	884	88	705
Venezuela	--	--	92	160	27	55
Other	1	4	270	671	249	803
Total	261	689	32,910	81,116	1,684	9,048

[1]Less than 1/2 unit.

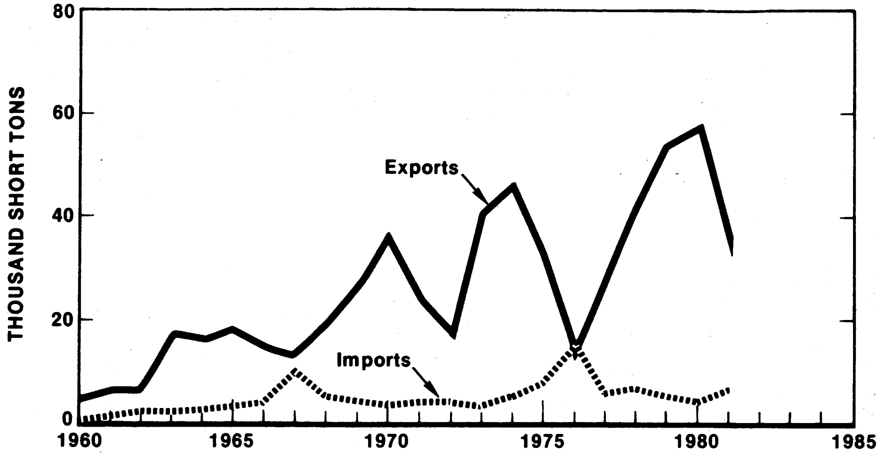

Figure 2.—U.S. imports and exports of magnesium.

WORLD REVIEW

Primary world magnesium production has increased steadily since 1975 but declined in 1981 because of reduced world demand. Despite its reduced production in 1981, the United States remained the world's largest magnesium producer and was followed by the U.S.S.R. and Norway. Other producing countries are identified in table 7.

Available data on the world recovery of secondary magnesium appear in table 8. In 1981, the United States and Japan were the major known producers of secondary magnesium.

Table 7.—Magnesium: World primary production, by country[1]

(Short tons)

Country	1977	1978	1979	1980[p]	1981[e]
Canada	8,414	9,159	9,937	10,199	[2]9,673
China[e]	5,500	6,600	6,600	7,700	7,700
France	9,570	9,370	9,968	10,282	9,600
India	(3)	(3)	(3)	--	--
Italy	9,663	[r]10,668	9,653	8,693	8,500
Japan	10,379	[r]12,304	12,531	10,199	[2]6,247
Norway	42,070	[r]43,166	48,697	48,943	52,910
U.S.S.R.[e]	72,000	77,000	79,000	83,000	86,000
United States[4]	125,958	149,463	162,464	169,477	[2]142,887
Yugoslavia	--	(5)	(5)	1,100	4,600
Total	283,554	[r]317,730	338,850	349,593	328,117

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through May 21, 1982.
[2]Reported figure.
[3]Data deleted; information now available indicates that Indian production reported in previous editions as primary is actually secondary.
[4]Derived figure; U.S. production is not officially reported by the Bureau of Mines in order to avoid disclosing company proprietary data; figures reported represent the difference between total North American production reported by the International Magnesium Association and Canadian production reported by the Canadian Department of Mines and Natural Resources.
[5]Revised to zero.

Table 8.—Magnesium: World secondary production, by country[1]

(Short tons)

Country	1977	1978	1979	1980[p]	1981[e]
Germany, Federal Republic of	660	[e]660	[e]660	[e]660	660
India	118	25	31	32	16
Japan	8,360	12,057	18,058	23,800	[2]31,345
United Kingdom	3,000	3,000	3,000	[e]3,000	3,000
United States	32,694	36,228	37,222	40,461	46,256

[e]Estimated. [p]Preliminary.

[1]Table summarizes available information on world secondary magnesium production, but has not been totaled because of the omission of other producers for which data are not available and for which no reliable basis for estimations are available. Most notable among omitted secondary producers (and probably the only one of significance) is the U.S.S.R. Table includes data available through May 21, 1982.

[2]Reported figure.

TECHNOLOGY

A series of papers were published describing various aspects of the magnesium industry. Subjects such as supply and demand, use of magnesium in the aluminum industry, steel desulfurization with magnesium, magnesium pressure diecasting, energy storage with magnesium, and others were discussed.[2]

[1]Physical scientist, Division of Nonferrous Metals.

[2]International Magnesium Association. Proc. From the 38th Ann. World Conf. on Magnesium, Houston, Tex., May 10-13, 1981, 58 pp.

Magnesium Compounds

By Benjamin Petkof[1]

The United States was a major world producer of magnesium compounds in 1981. Most of these compounds were derived as synthetic magnesia from natural brines. Almost all of the classes of magnesium compounds shipped and used declined in quantity and value from those of the previous year. Total exports of magnesia and magnesite declined in quantity and value from those of 1980. Total imports of magnesite increased from those of 1980. World production of magnesite declined from that of 1980. The U.S.S.R., China, North Korea, Austria, and Greece were major world magnesite producers.

Table 1.—Salient magnesium compound statistics

(Thousand short tons and thousand dollars)

	1977	1978	1979	1980	1981
United States:					
Caustic-calcined and specified magnesias:[1]					
Shipments by producers:					
Quantity	129	156	164	157	160
Value	$29,574	$43,008	$50,047	$51,282	$58,420
Exports: Value[2]	$6,336	$7,741	$16,433	$17,692	$14,559
Imports for consumption: Value[2]	$566	$793	$1,169	$2,122	$2,177
Refractory magnesia:					
Sold and used by producers:					
Quantity	690	796	847	[r]731	616
Value	$94,799	$125,082	$125,289	[r]$162,697	$146,903
Exports: Value	$16,477	$10,617	$8,183	$13,279	$4,727
Imports: Value	$12,332	$14,421	$13,546	$16,672	$22,990
Dead-burned dolomite:					
Sold and used by producers:					
Quantity	968	1,016	793	494	435
Value	$37,992	$45,881	$41,676	$28,308	$23,789
World: Crude magnesite production: Quantity	[r]10,979	[r]11,278	11,869	[p]12,489	[e]12,272

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available.
[1]Excludes caustic-calcined magnesia used in production of refractory magnesia.
[2]Caustic-calcined magnesia only.

DOMESTIC PRODUCTION

Synthetic magnesia, derived from natural brine solutions such as seawater, lakes, and wells, was the primary source of domestically produced magnesium compounds. Most firms that produced magnesia also produced other magnesium compounds. Magnesium compounds were also produced from natural magnesite in Nevada. Olivine was produced in North Carolina and Washington and comminuted to various grades for consumption by the foundry, steel, and refractory industries. Current domestic magnesium compound producers are shown in table 2.

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, Nev	150,000
Lake brines:		
Great Salt Lake Minerals & Chemicals Corp	Ogden, Utah	100,000
Kaiser Aluminum & Chemical Corp	Wendover, Utah	50,000
Well brines:		
The Dow Chemical Co	Ludington, Mich	300,000
Do	Midland, Mich	75,000
Martin Marietta Chemicals	Manistee, Mich	350,000
Morton Chemical Co	do	5,000
Seawater:		
Barcroft Co	Lewes, Del	5,000
Basic Magnesia, Inc	Port St. Joe, Fla	100,000
The Dow Chemical Co	Freeport, Tex	75,000
Harbison-Walker Refractories Co	Cape May, N.J	100,000
Kaiser Aluminum & Chemical Corp	Moss Landing, Calif	150,000
Merck & Co., Inc	South San Francisco, Calif	15,000
Western Magnesium Corp	Chula Vista, Calif	5,000
Total		1,480,000

CONSUMPTION AND USES

The total quantity and value of all classes of magnesium compounds shipped and used declined from those of 1980, except for caustic-calcined and specified magnesias, which increased. The manufacture of refractory products was the major end use for magnesia. Chemical processing and pharmaceutical industries provided a strong demand for caustic-calcined and specified magnesias. Caustic-calcined and specified magnesias were used to prepare animal feeds, fertilizers, construction materials, chemicals, electrical heating rods, fluxes, petroleum additives, rayon, and uranium.

Table 3.—Magnesium compounds shipped and used in the United States

	1980		1981	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Caustic-calcined[1] and specified (USP and technical) magnesias	157,303	$51,282	160,067	$58,420
Refractory magnesia	r730,505	r162,697	615,661	146,903
Magnesium hydroxide (100% $Mg(OH)_2$)[1]	493,326	50,791	415,009	47,922
Magnesium sulfate (anhydrous and hydrous)	42,878	11,280	33,246	8,120
Precipitated magnesium carbonate[1]	5,144	1,456	4,002	900

rRevised.
[1]Excludes material produced as an intermediate step in the manufacture of other magnesium compounds.

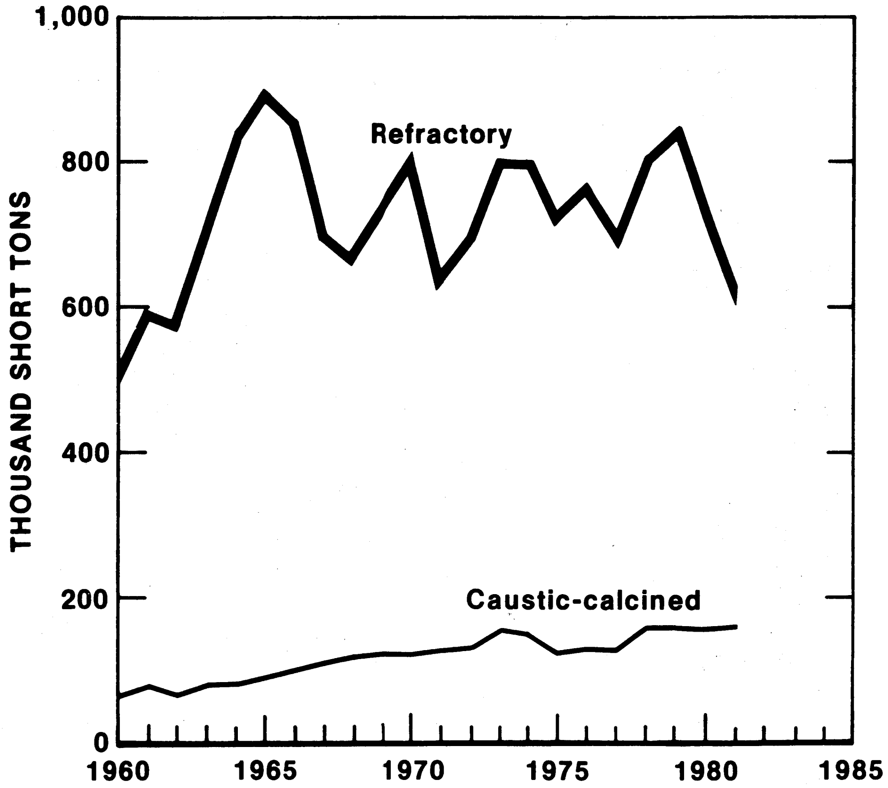

Figure 1.—Consumption and shipments of magnesia in the United States.

Table 4.—Domestic shipments of caustic-calcined and specified magnesias, by use

(Short tons)

Use	1979	1980	1981
Agriculture, nutrition, and pharmaceuticals:			
Animal feed	W	W	W
Fertilizer	W	W	W
Medicinals and pharmaceuticals	701	598	W
Sugar and candy	W	W	W
Winemaking	--	W	W
Total	701	598	W
Construction materials:			
Insulation and wallboard	W	W	W
Oxychloride and oxysulfate cement	W	W	W
Total	W	W	W
Chemical processing, manufacturing, and metallurgical:			
Chemical	9,660	23,632	19,330
Electrical heating rods			
Flux	37,071	26,012	
Petroleum additive			57,581
Pulp and paper			
	28,081	29,406	
Rayon			
Rubber	14,209	13,688	
Stack-gas scrubbing			W
Uranium processing	6,513	4,322	
Water treatment			
Total	95,534	97,060	76,911
Unspecified	67,359	59,645	83,156
Grand total	163,594	157,303	160,067

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

PRICES

At yearend, the Chemical Marketing Reporter published the following price quotations for magnesium compounds: Magnesia, natural, technical, heavy, 85% and 90% (bulk, carlot and truckload, f.o.b. Nevada), $184 and $210 per ton, respectively; magnesium chloride, hydrous, 99%, flake (bags, carlot, works), $290 per ton; magnesia, technical, neoprene-grade, light (bags, carlot and truckload, works), $55 per ton; magnesium carbonate, technical (bags, carlot and truckload, works, freight-equalized), $0.52 to $0.54 per pound; magnesium hydroxide, NF, powder (drums, carlot and truckload, works, freight-equalized), $0.54 to $0.58 per pound; magnesium sulfate, technical (bags, mixed carlot, 10,000-pound minimum, works), $0.121 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 1980 in both quantity and value. Over four-fifths of total exports were shipped to Canada, Australia, Venezuela, and Argentina.

Total imports of crude and processed magnesite were greater than those of 1980 but remained under 100,000 tons in quantity and were valued at over $25 million. Additional magnesium compounds valued at about $6.2 million were also imported.

Table 5.—U.S. exports of magnesite and magnesia, by country

Destination	Magnesite and magnesia, dead-burned				Magnesite, n.e.c., including crude caustic-calcined, lump or ground			
	1980		1981		1980		1981	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Argentina	65	$15	--	--	6,368	$2,204	1,354	$527
Australia	212	112	240	$58	530	464	3,220	1,391
Belgium-Luxembourg	170	38	18	4	291	217	679	493
Brazil	459	132	--	--	89	69	495	352
Canada	48,163	11,093	17,080	3,903	35,240	9,962	24,238	7,423
Colombia	1,389	161	1,042	132	146	114	141	133
Costa Rica	10	3	--	--	112	25	1	2
Ecuador	--	--	44	10	31	17	28	34
Finland	--	--	53	58	199	186	10	15
France	102	34	128	41	312	287	202	195
Germany, Federal Republic of	3,411	1,118	46	14	444	347	611	366
Italy	6	2	--	--	515	445	317	274
Japan	24	25	31	7	69	34	30	31
Korea, Republic of	--	--	--	--	37	25	104	70
Mexico	251	56	518	118	73	50	828	761
Netherlands	183	54	390	88	190	158	110	100
New Zealand	191	43	--	--	168	133	203	222
Peru	--	--	--	--	41	28	15	22
Philippines	2	1	--	--	111	94	23	10
Singapore	--	--	--	--	15	15	38	42
South Africa, Republic of	142	100	92	21	237	156	138	122
Spain	--	--	--	--	153	120	151	96
Sweden	254	80	--	--	200	161	191	169
Taiwan	17	27	--	--	238	158	110	63
United Kingdom	171	81	239	65	394	291	508	396
Venezuela	783	93	231	52	5,238	1,718	2,764	1,062
Other	33	11	774	156	r262	r214	174	188
Total	56,038	13,279	20,926	4,727	51,703	17,692	36,683	14,559

rRevised.

Table 6.—U.S. imports for consumption of crude and processed magnesite, by country

Country	1980		1981	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Lump or ground caustic-calcined magnesia:[1]				
Australia	556	$121	--	--
China	--	--	2,467	$133
Germany, Federal Republic of	--	--	5	1
Greece	7,619	1,419	8,744	1,917
India	1,782	212	74	12
Japan	--	--	375	21
Netherlands	203	67	40	11
Romania	--	--	24	8
Spain	1,635	162	--	--
Turkey	551	125	25	5
United Kingdom	60	16	311	69
Total	12,406	2,122	12,065	2,177
Dead-burned and grain magnesia and periclase:				
Not containing lime or not over 4% lime:				
Austria	--	--	41	17
Brazil	463	221	8,587	1,363
Canada	83	6	25	14
China	--	--	22	11
France	1	7	(2)	1
Greece	9,211	2,019	8,818	2,361
Ireland	49,731	11,505	38,411	12,417
Japan	10,887	2,914	19,568	6,645
Mexico	--	--	537	161
Total	70,376	16,672	76,009	22,990

See footnotes at end of table.

Table 6.—U.S. imports for consumption of crude and processed magnesite, by country —Continued

Country	1980 Quantity (short tons)	1980 Value (thousands)	1981 Quantity (short tons)	1981 Value (thousands)
Dead-burned and grain magnesia and periclase —Continued				
Containing over 4% lime:				
Austria	--	--	3	$1
Canada	2,288	$143	535	59
Germany, Federal Republic of	55	15	233	57
Ireland	--	--	5	(2)
Japan	--	--	25	7
Total	2,343	158	801	124
Total dead-burned and grain magnesia and periclase	72,719	16,830	76,810	23,114

[1]In addition, crude magnesite was imported as follows: 1980—Canada, 2 short tons ($343); the United Kingdom, 40 short tons ($17,337); Greece, 3 short tons ($1,683); and Australia, 1 short ton ($366). 1981—Canada, 162 short tons ($7); Brazil, 8,819 short tons ($1,500); Ireland, 2,425 short tons ($671); the Federal Republic of Germany, 785 short tons ($55); India, 64 short tons ($1); and Japan, 11 short tons (2).
[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)
1979	3,216	$1,772	95	$187	26	$15	164	$73	25,950	$1,530	6,988	$2,042
1980	1,468	1,871	117	211	61	20	355	93	30,031	1,674	4,092	2,038
1981	1,537	2,419	212	362	40	20	592	161	30,233	1,852	2,768	1,427

[1]In addition, magnesium carbonate, not precipitated, was imported as follows: 1979—32 short tons ($24,942); 1980—41 short tons ($36,357); and 1981—119 short tons ($97).
[2]Not specifically provided for; includes magnesium silicofluoride or fluosilicate and calcined magnesium.

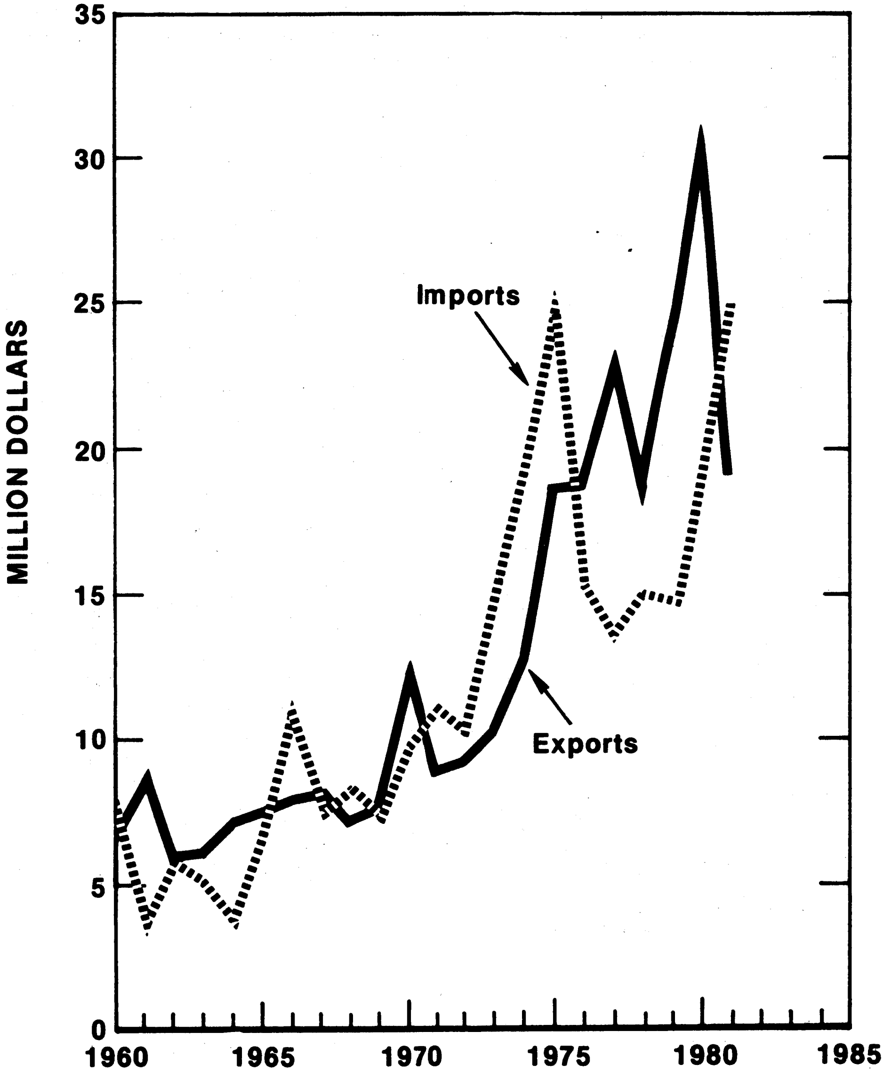

Figure 2.—Value of U.S. exports and imports of magnesia.

WORLD REVIEW

World production of natural magnesite and synthetic magnesia met industrial and other demands for refractory and caustic-calcined and specified magnesias. Most nations derived their magnesia from magnesium minerals, but countries such as the United States, Ireland, and Israel recovered magnesia from natural brines.

Zimbabwe.—Gatooma Magnesite, Ltd., a subsidiary of the Republic of South Africa's Cullinan Refractories Ltd. and Vereeniging Refractories Ltd., produced magnesite from an underground deposit at Barton Farm near the village of Gatooma, southwest of the capital, Salisbury. Most of Gatooma Magnesite's output was 95% magnesite and was consumed by Cullinan Refractories and Vereeniging Refractories for the production of magnesia-based refractory brick in the Republic of South Africa. G and W Industrial Minerals used small quantities of Gatooma Magnesite's magnesite to produce caustic-calcined magnesia that was used by Sable Chemical Industries Ltd. for the production of fertilizers.

Table 8.—Magnesite: World production, by country[1]

(Short tons)

Country	1977	1978	1979	1980[p]	1981[e]
North America:					
Canada[e]	41,000	39,000	58,000	65,000	66,000
Mexico	73,193	83,814	89,971	[r][e]88,000	88,000
United States	W	W	W	W	W
South America:					
Brazil[2]	226,766	[r]239,499	292,186	348,166	386,000
Colombia	1,951	1,543	1,744	1,744	1,800
Europe:					
Austria	1,105,662	1,082,821	1,216,563	1,453,017	1,430,000
Czechoslovakia	728,627	725,320	720,911	734,139	728,000
Greece	[r]1,415,757	[r]1,497,824	1,166,477	1,286,394	1,025,000
Poland	27,999	[r]26,125	22,046	21,605	21,000
Spain	464,338	337,911	420,936	557,253	550,000
U.S.S.R.[e]	2,040,000	2,090,000	2,150,000	2,200,000	2,290,000
Yugoslavia	380,297	367,069	322,977	399,036	[3]330,693
Africa:					
Kenya	3,941	[r][e]4,400	[e]4,400	1	10
South Africa, Republic of	54,255	41,234	71,910	66,111	[3]62,343
Zimbabwe	59,750	[r]72,483	93,140	86,219	77,000
Asia:					
China	1,700,000	2,000,000	2,200,000	2,200,000	2,200,000
India	443,136	456,539	424,020	[3]408,486	440,000
Iran[4]	5,500	5,500	5,500	4,400	4,400
Korea, North[e]	1,615,000	1,720,000	2,010,000	2,040,000	2,040,000
Pakistan	1,727	2,945	3,029	858	780
Turkey	568,971	459,885	[e]562,000	[r][e]493,000	495,000
Oceania:					
Australia	20,426	23,534	32,299	34,715	34,720
New Zealand	[r]661	[r]926	[r][e]940	[e]960	960
Total	[r]10,978,957	[r]11,278,372	11,869,049	12,489,104	[5]12,272,000

[e]Estimated. [p]Preliminary. [r]Revised. W Withheld to avoid disclosing company proprietary data.
[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. 26, 1982.
[2]Series reflects output of marketable concentrates. Production of crude ore was as follows: 1977—530,381 (revised); 1978—451,877 (revised); 1979—651,583; 1980—803,268; and 1981—880,000 (estimated).
[3]Reported figure.
[4]Year beginning Mar. 21 of that stated.
[5]Detail does not add to total because of estimates.

TECHNOLOGY

A high carbon-magnesia refractory composition was introduced into basic oxygen steelmaking primarily for the use in the high-wear trunnion areas of the furnace. The use of this refractory composition resulted in increased refractory lining life and lowered gunning maintenance for the vessel.[2]

Two recent papers described the planning and technology of magnesium oxide from the brine operation at Veendam, Groningen Province, Netherlands.[3]

A bibliography was published describing research relating to magnesium oxide ceramics and refractories. Research was cited on sintering, structure, mechanical properties, strength, degradation, phase studies, additives, and uses of magnesium ceramics and refractories.[4]

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[1]Physical scientist, Division of Nonferrous Metals.
[2]Nacamu, R. L., and S. J. LaLama. High Carbon-Magnesia Refractories in Basic Oxygen Steelmaking. Iron Steelmaker, v. 8, No. 5, May 1981, pp. 21-25.
[3]Pettifer, L. The Industrial Minerals of the Netherlands. Ind. Miner. (London), No. 168, September 1981, pp. 53-55.
Van Den Assen, L. Planning for New Industrial Minerals Projects—Magnesium Oxide From Brine in the Netherlands. Ind. Miner. (London), No. 172, January 1982, pp. 35-43.
[4]U.S. Department of Commerce, National Technical Information Service. Magnesium Oxide Ceramics and Refractories, 1978—March 1981. Springfield, Va., PB 81-805863, April 1981, 81 pp.

Manganese

By Thomas S. Jones[1]

There was neither production nor shipment of manganese ore containing 35% or more manganese in the United States in 1981. Lower grade manganiferous ores were produced and shipped in Minnesota, New Mexico, and South Carolina. Imports of ferromanganese, silicomanganese, and manganese metal all increased compared with those of 1980; imports of ore decreased. In 1981, considerably more manganese was imported as ferromanganese than as ore; also, more than twice as much manganese was imported as manganese ferroalloys and metal combined than as ore. Compared with industry performance in 1980, domestic production advanced only slightly for ferromanganese and declined for both silicomanganese and manganese metal. The changes from 1980 to 1981 in consumption of manganese ore, ferroalloys, and metal were a mixture of small increases and decreases. These changes did not keep pace with a 7% increase in raw steel production. Takeover of domestic manganese ferroalloy facilities by foreign interests was virtually completed with the mid-1981 sale of plants belonging to Union Carbide Corp.'s Metals Div. to a Norwegian consortium headed by Elkem AS. The General Services Administration continued to make deliveries of ore from Government stockpile excesses at a relatively low rate.

Table 1.—Salient manganese statistics in the United States

(Short tons)

	1977	1978	1979	1980	1981
Manganese ore (35% or more Mn):					
Imports, general	930,947	547,820	499,782	697,516	639,141
Consumption	1,358,811	1,281,479	1,372,190	1,070,775	1,076,631
Manganiferous ore (5% to 35% Mn):					
Production (shipments)	215,893	312,124	240,696	173,887	175,760
Ferromanganese:					
Production	334,134	272,530	317,102	189,472	192,690
Exports	6,051	9,433	25,344	11,686	14,925
Imports for consumption	534,423	680,399	821,213	605,703	671,178
Consumption	886,299	985,623	976,482	789,076	820,921

Legislation and Government Programs.—In announcing in March the Government's first purchase program for strategic and critical materials in over 20 years, the Federal Emergency Management Agency identified manganese dioxide as 1 of 11 mineral-based materials to be given priority consideration for acquisitions for the National Defense Stockpile. However, no action was taken in 1981 on manganese dioxide.

Sales of Government manganese stockpile excesses consisted of 9,617 short tons[2] of stockpile-grade and 16,074 tons of nonstockpile-grade natural battery ore and 7,952 tons of nonstockpile-grade metallurgical ore.

Government stockpile physical inventories of manganese items declined at about the same rate as in 1980. The most significant change during 1981 was for stockpile-grade metallurgical ore, which decreased 271,693 tons to 2,742,079 tons. Other changes in yearend inventories were a small decrease in nonstockpile-grade metallurgical ore to 960,942 tons, a slight increase (evidently through inventory reclassification) in stockpile-grade natural battery ore to 209,020 tons, and a decrease in nonstockpile-grade natural battery ore to 33,761 tons. Inventories remained unchanged for other items as follows, in tons: Synthetic manganese dioxide, 3,011; chemical ore, 221,045; high-carbon ferromanganese, 599,978; medium-carbon ferromanganese, 28,920; silicomanganese, 23,574; and electrolytic metal, 14,172. Yearend physical inventories included approximately 330,000 tons of stockpile-grade metallurgical ore and 24,000 tons of stockpile-grade natural battery ore that had been sold but not yet shipped.

The National Oceanic and Atmospheric Administration, U.S. Department of Commerce, issued deep seabed mining regulations for exploration licenses effective October 15, 1981, in implementing its licensing responsibilities under the Deep Seabed Hard Mineral Resources Act of 1980. Under these regulations, licenses for seabed exploration will be for a 10-year period, renewable for up to an additional 5 years.[3] In accordance with the act, a commercial recovery permit will also have to be obtained before mining can commence, and this can be no earlier than January 1, 1988.

DOMESTIC PRODUCTION

No manganese ore, concentrate, or nodules, containing 35% or more manganese, was produced or shipped in the United States. Ferruginous manganese ores or concentrates containing 10% to 35% manganese were produced and shipped in New Mexico and in the Cuyuna 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, S.C., by brick manufacturers or contractors for use in coloring brick. This latter material reported in table 2 ranged in manganese content from 5% to 15%, but averaged less than 10%.

Table 2.—Manganese and manganiferous ore shipped[1] in the United States, by type and State

(Short tons)

Type and State	1980 Gross weight	1980 Manganese content	1981 Gross weight	1981 Manganese content
Manganese ore (35% or more Mn, natural)	--	--	--	--
Manganiferous ore:				
Ferruginous manganese ore (10% to 35% Mn, natural):				
Minnesota	119,029	16,712	139,571	20,712
New Mexico	35,198	4,069	12,741	1,453
Total	154,227	20,781	152,312	22,165
Manganiferous iron ore (5% to 10% Mn, natural):				
South Carolina[2]	19,660	1,875	23,448	2,160
Total manganiferous ore	173,887	22,656	175,760	24,325
Value of manganese and manganiferous ore	$2,443,753	XX	$2,889,669	XX

XX Not applicable.
[1]Shipments are used as the measure of manganese 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. Besides direct-shipping ore, they include, without duplication, concentrate and nodules made from domestic ores.
[2]Miscellaneous ore.

CONSUMPTION, USES, AND STOCKS

In the production of raw steel (ingots, continuous- or pressure-cast blooms, billets, slabs, etc., and including steel castings), consumption of manganese as ferroalloys, metal, and direct-charged ore, as reported to the Bureau of Mines by consumers, totaled 12.0 pounds per ton of raw steel produced. On the basis of contained manganese, the makeup of the 12.0-pound total was ferromanganese, 10.3; silicomanganese, 1.5; spiegeleisen, negligible; metal, 0.2; and manganese ore containing 35% or more manganese, negligible. The comparable 1980 total, on the same basis, was 12.6 pounds with ferromanganese at 10.8, silicomanganese at 1.6, spiegeleisen negligible, metal at 0.2, and ore none. In addition to the aforementioned consumption of manganese in 1981, there was consumed per ton of raw steel produced approximately 1.0 pound of manganese contained in manganese ore used in making pig iron or equivalent hot metal, the same as in 1980. In 1979, the comparable figure was 1.4 pounds.

Table 3.—Consumption and industry stocks of manganese ore[1] in the United States

(Short tons)

	Consumption 1980	Consumption 1981	Stocks, Dec. 31, 1981
By use:			
Manganese alloys and metal	727,530	744,832	547,811
Pig iron and steel	131,516	147,812	151,186
Dry cells, chemicals and miscellaneous	211,729	183,987	337,210
Total	1,070,775	1,076,631	1,036,207
By origin:			
Domestic	60,701	79,432	19,865
Foreign	1,010,074	997,199	1,016,342
Total	1,070,775	1,076,631	1,036,207

[1]Containing 35% or more manganese (natural).

Table 4.—Consumption, by end use, and industry stocks of manganese ferroalloys and metal in the United States in 1981

(Short tons, gross weight)

End use	Ferromanganese: High carbon	Ferromanganese: Medium and low carbon	Silicomanganese	Spiegeleisen	Manganese metal[1]
Steel:					
Carbon	515,992	105,098	95,034	53	6,458
Stainless and heat-resisting	11,223	1,082	4,707	--	2,770
Full alloy	88,092	16,795	31,470	--	1,254
High-strength low-alloy	46,443	13,943	10,055	--	1,101
Electric	164	65	321	--	78
Tool	385	79	66	--	122
Unspecified	697	176	1,019	--	6
Total steel	662,996	137,238	142,672	53	11,789
Cast irons	15,575	1,121	9,450	--	2
Superalloys	286	W	W	--	135
Alloys (excluding alloy steels and superalloys)	1,688	414	2,725	56	11,359
Miscellaneous and unspecified	722	881	894	--	495
Total consumption	681,267	139,654	155,741	109	23,780
Stocks, Dec. 31:					
Consumer	137,489	17,561	13,386	W	3,587
Producer	15,317	31,212	42,927	W	4,506
Total stocks	152,806	48,773	56,313	45	8,093

W Withheld to avoid disclosing company proprietary data; included with "Miscellaneous and unspecified" where applicable.
[1]Virtually all electrolytic.

Table 5.—Ferromanganese and silicomanganese produced in the United States and manganese ore[1] consumed in their manufacture

Year	Production: Ferromanganese: Gross weight (short tons)	Ferromanganese: Manganese content: Percent	Ferromanganese: Manganese content: Short tons	Silicomanganese (gross weight, short tons)	Manganese ore[1] consumed (gross weight, short tons): Foreign[2]	Domestic[2]	Per ton of ferromanganese and silicomanganese made[3]
1977	334,134	78.8	263,136	120,000	889,296	35,769	1.9
1978	272,530	80.6	219,707	142,000	740,906	90,660	1.9
1979	317,102	80.2	254,389	165,000	785,664	125,130	1.8
1980	189,472	79.7	150,982	188,000	691,250	34,877	1.9
1981	192,690	80.0	154,156	173,000	684,857	57,722	2.0

[1]Containing 35% or more manganese (natural).
[2]Includes ore used in producing silicomanganese and metal.
[3]Ratio of ore consumed to ferromanganese produced if silicomanganese is considered a special grade of ferromanganese. Includes ore used in producing silicomanganese.

Nearly all manganese ferroalloy plants in the United States came under control of foreign interests when sale of portions of Union Carbide Corp.'s Metals Div. to a Norwegian consortium was completed in midyear. The sale included production facilities at Alloy, W. Va., and Marietta, Ohio. Following the sale, ownership of the Alloy and Marietta plants was 49% by Elkem Metals Co.—a wholly owned subsidiary of Elkem AS of Norway—and 51% by a number of other Norwegian interests combined. It was reported that operations would be by Elkem Metals, with headquarters in Pittsburgh, Pa., and ore requirements would be satisfied through purchases by Elkem AS, the parent company. Earlier in the year, Union Carbide announced that in 1981 it would close its Portland, Oreg., plant, which had been a producer of both high-carbon ferromanganese and silicomanganese.

Electrolytic Manganese Metal.—All of the manganese metal produced domestically and virtually all of that imported was electrolytic metal. Virtually all of the metal consumed was electrolytic metal; 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. The metal that was used to make manganese-aluminum additives is included in table 4 under the "Alloys (excluding alloy steels and superalloys)" category. These additives are not knowingly included in the table, since it is desired to report consumption at the metal rather than at the additive level of the usage cycle.

Production of electrolytic manganese metal declined by nearly 10% to 24,222 tons. Production was by four companies at three plants: Foote Mineral Co., New Johnsonville, Tenn.; Kerr-McGee Chemical Corp., Hamilton (Aberdeen), Miss.; and by Union Carbide Corp. and then Elkem Metals Co. at Marietta, Ohio.

Foote announced in October 1981 a program to modernize by mid-1982 its New Johnsonville plant, thereby improving competitiveness of its metal production. Because of excess inventories, the plant was temporarily closed in December. Included in the modernization program was provision for later converting part of the metal plant to production of electrolytic manganese dioxide without necessitating a reduction in the company's metal production level.

In the early part of 1981, KBI Div. of Cabot Corp. opened a new plant in Henderson County in northwestern Kentucky for production of aluminum master alloys, some of which would be aluminum-manganese alloys made by using manganese metal.

Ferromanganese.—Domestic production was by six companies at six locations; no blast furnaces were used. Electric furnaces were used to produce ferromanganese for shipment by five companies at five plants: Autlan Manganese Corp., Theodore (Mobile), Ala.; Roane Ltd., Rockwood, Tenn.; SKW Alloys, Inc., Calvert City, Ky.; Union Carbide Corp., Marietta, Ohio, and Portland, Oreg.; and Elkem Metals Co., Marietta, Ohio. Fused-salt electrolysis was used by Chemetals Corp. at Kingwood, W. Va., to make low- and medium-carbon ferromanganese sold under the trade name of Massive Manganese. Shipments of ferromanganese from U.S. furnaces declined to 188,000 tons compared with 194,000 tons in 1980. Shipments in 1979 and 1978 were 330,000 tons and 318,000 tons, respectively.

The ferromanganese production reported in the various tables is net production; that is, the quantity of ferromanganese produced for shipment outside the producing ferroalloy facility. It does not include the remelt material; that is, the fines, offgrade, or other ferromanganese output of the furnace that was fed back to the furnace or lost in the plant, and which is included in gross production data reported by the furnace operator.

Silicomanganese.—Domestic production of silicomanganese decreased by 8% to 173,000 tons. Production in 1979 and 1978 was 165,000 tons and 142,000 tons, respectively. This is net production produced for shipment and does not include silicomanganese produced for use in the same plant as an intermediate for the production of medium- or low-carbon ferromanganese. Shipments of silicomanganese from U.S. furnaces totaled 173,000 tons in 1981, compared with 162,000 tons in 1980. Six companies used six plants to produce silicomanganese for shipment in 1981: Autlan Manganese Corp., Theodore (Mobile), Ala.; Globe Metallurgical Div., Interlake Inc., Beverly, Ohio; Roane Ltd., Rockwood, Tenn.; SKW Alloys, Inc., Calvert City, Ky.; Union Carbide Corp., Marietta, Ohio, and Portland, Oreg.; and Elkem Metals Co., Marietta, Ohio. End-use consumption of silicomanganese—that is, consumption outside the ferroalloy plants—was 19.0% that of ferromanganese in 1981, compared with 19.7% in 1980 and 17.6% in 1979.

Spiegeleisen.—There was no domestic production of spiegeleisen and negligible reported consumption.

Pig Iron.—A total of 336,000 tons of manganese-bearing ores containing 5% or more manganese (natural) was consumed in the production of pig iron or its equivalent hot metal. Domestic sources supplied 186,000 tons, of which 168,000 was manganiferous iron ore containing 5% to 10% manganese, 17,000 tons was ferruginous manganese ore containing 10% to 35% manganese, and 1,000 tons was manganese ore containing more than 35% manganese. Foreign sources supplied 150,000 tons, of which 2,000 tons was ferruginous manganese ore containing 10% to 35% manganese and 148,000 tons was manganese ore containing more than 35% manganese.

Battery and Miscellaneous Industries.—The ore reported in table 3 includes that consumed in making synthetic manganese dioxide by both electrolytic and chemical means, but it does not include consumption of synthetic dioxide. Although some synthetic dioxide is used for chemical purposes, most of it is used in the manufacture of dry-cell batteries, particularly for the manganese-alkaline type, for premium or heavy-duty Leclanché (manganese dioxide-ammonium chloride-zinc) cells, and for blending with natural ore in the ordinary Leclanché cells.

The domestic ore and much of the foreign ore used for chemical and miscellaneous purposes did not meet national stockpile specification P-81-R for chemical-grade ore.

Two companies announced plans to commence future production of synthetic manganese dioxide. Chemetals began installation of facilities for making chemical manganese dioxide at its Baltimore, Md., plant, to become operational in the latter part of 1982. Annual capacity for dioxide was to be 6,600 tons initially, with provision for expanding rapidly to twice that amount. Foote Mineral announced plans to construct a pilot plant for production of electrolytic manganese dioxide at its New Johnsonville, Tenn., facility. The pilot plant was to be built by the third quarter of 1982 and then to be operated for 6 months. Subsequent production was to be achieved by converting part of the metal plant at New Johnsonville so as to give an annual capacity for dioxide of 6,200 tons.

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, buyer's needs, and availability of ores having the specifications desired. Trade journal quotations reflect the paper's evaluation of the market.

Contract prices for 1981 delivery of metallurgical ore to the United States were not set until contracts were made, after lengthy negotiations, between foreign buyers and producers that called for only a slight price increase. A representative average 1981 price for metallurgical ore containing 48% manganese was $1.72 per long ton unit, c.i.f. U.S. ports, only marginally greater than that of $1.70 for 1980.

Manganese Alloys.—Slight upward price pressure was evident, although not for domestically produced standard high-carbon ferromanganese with a minimum manganese content of 78%. Two producers' list prices continued to be quoted throughout the year for this item—$490 and $530 per long ton of alloy, f.o.b. shipping point—reportedly with discounting. The price of imported high-carbon ferromanganese of the same manganese content was increased minimally at midyear, from a range of $390 to $425 to $400 to $430 per long ton of alloy, f.o.b. Pittsburgh or Chicago warehouse. Prices were advanced for both imported and domestic silicomanganese, that for the imported alloy by 5% towards the beginning of 1981 and that for the domestic alloy by 8% about the middle of the year. After the increases, imported silicomanganese was listed at 21.5 to 22 cents and domestic silicomanganese at 26.5 cents, both per pound of alloy f.o.b. either warehouse or producer.

Manganese Metal.—The domestic producer price for standard and comparable grades of electrolytic manganese metal was unchanged at 70 cents per pound for bulk shipments, f.o.b. producer plant.

FOREIGN TRADE

Ferromanganese exports were 14,925 tons valued at $12,477,137 in 1981, compared with 11,686 tons valued at $7,656,934 in 1980. Principal 1981 recipients were Canada, 13,309 tons, and Mexico, 1,056 tons. Silicomanganese exports in 1981 totaled 3,941 tons with a value of $2,171,783, compared with 6,489 tons valued at $3,468,192 in 1980. Canada, with 3,768 tons, was the principal recipient in 1981. Exports classified as "manganese and manganese alloys, wrought or unwrought, and waste and scrap" were, at 2,523 tons with a value of $3,979,619, much reduced from those in 1980, in which year the corresponding totals were 12,320 tons and $11,459,925. Material in this classification was reported as exported to 34 countries in 1981, of which the leading recipients were Sweden, 672 tons; Canada, 603 tons; the Netherlands, 251 tons; Japan, 156 tons; and Mexico, 124 tons. This classification included electrolytic manganese metal and such nonferrous manganese alloys as manganese-copper, but not ferromanganese or silicomanganese.

Exports of ore and concentrate containing 5% or more manganese were 65,064 tons with a value of $5,132,190, compared with 52,537 tons valued at $6,328,371 in 1980. Practically all of the 1981 exports consisted of shipments to Canada, 31,798 tons; Mexico, 28,735 tons; and Guatemala, 3,748 tons. Much of the tonnage to Canada and Mexico is believed to have been metallurgical ore obtained from excess Government stocks, whereas most of that exported elsewhere appears to have been imported manganese dioxide ore that may or may not have been ground, blended, or otherwise classified in the United States.

Imports of manganese ore declined overall by 8% and by nearly 70% for those from Australia. Distribution of supply was the Republic of South Africa, 36%; Gabon, 28%; Brazil, 12%; Australia, 10%; Mexico, 10%; and Morocco, 4%. The average grade of imported manganese ore remained at the 1980 average of 47%, which was a drop from the 1979 average of 49%. Imports of manganiferous ore (more than 10% but less than 35% manganese) were 6,090 tons averaging 27% manganese, all from Mexico.

The trend of growing imports of manganese ferroalloys and metal resumed, imports of ferromanganese increasing by 11%, silicomanganese by 72%, and metal by 5%. The Republic of South Africa was the leading supplier of ferromanganese, virtually the only source of manganese metal imports, and was second only to Brazil as a supplier of silicomanganese. For both ferromanganese and silicomanganese, about 90% of imports were received from the Republic of South Africa plus four other leading source countries: France, Canada, Mexico, and Portugal for ferromanganese; Brazil, Norway, Yugoslavia, and Australia for silicomanganese.

Silicomanganese imports for consumption totaled 129,005 tons containing 84,900 tons of manganese in 1981, and 74,975 tons containing 49,158 tons in 1980. Sources and gross weight tonnages in 1981 were reported as follows: Brazil, 38,942; the Republic of

South Africa, 25,557; Norway, 17,307; Yugoslavia, 16,306; Australia, 13,675; France, 6,284; the United Kingdom, 3,124; Venezuela, 2,756; Italy, 2,298; Mexico, 1,378; Lithuania, 770; Canada, 499; and Portugal, 110.

Imports for consumption classified as unwrought manganese metal were 8,331 tons, as follows: The Republic of South Africa, 8,245; Japan, 67; the United Kingdom, 18; and the Federal Republic of Germany, 2. An additional 12 tons of manganese metal waste and scrap of low unit value were imported, all from Canada except a negligible quantity from the United Kingdom.

Manganese dioxide imports for consumption rose to 16,310 tons compared with 11,512 tons in 1980. Over 16,000 tons of the 1981 total was apparently battery-grade synthetic dioxide: 11,836 tons from Japan; 2,018 tons from Belgium; 1,954 tons from Greece; 397 tons from Ireland; and 20 tons from China. Manganese sulfate imports were of variable unit value totaling 70 tons, of which 47 tons were from the Federal Republic of Germany, 22 tons from the Netherlands, and less than one-half ton each from Mexico and Sweden.

Tariffs.—The respective rates of duty for manganese and manganiferous ore, metal, and the principal manganese ferroalloys are given in table 8. Duties in 1981 were the same as in 1980.

Table 6.—U.S. imports[1] of manganese ore (35% or more Mn), by country

Country	1980			1981		
	Gross weight (short tons)	Mn content (short tons)	Value (thousands)	Gross weight (short tons)	Mn content (short tons)	Value (thousands)
Australia	205,388	106,043	$14,467	[2]65,762	[2]34,259	[2]$5,028
Brazil	69,670	33,648	3,663	76,252	38,909	6,291
Gabon	159,959	79,858	13,610	179,528	90,629	13,582
Mexico	43,707	[3]18,568	2,216	64,982	25,813	4,504
Morocco	[4]9,821	[4]5,260	[4]1,161	[2]25,407	[2] [3]13,594	[2]2,717
South Africa, Republic of	208,970	86,373	11,296	227,211	97,536	10,522
Total[5]	697,516	329,750	46,413	639,141	300,740	42,643

[1]Quantities for general imports and imports for consumption were identical.
[2]After adjustment of data for shipment originally declared as from Australia but subsequently identified as having been from Morocco.
[3]Includes Bureau of Mines conversion of part of reported data (from apparent MnO_2 content to Mn content).
[4]Data include 4,559 tons gross weight, 2,416 contained weight (calculated by Bureau of Mines from reported 3,830 tons apparent MnO_2 content), with a value of $535,000 reported as manganiferous ore. Morocco doesn't produce or export manganiferous ore.
[5]Data may not add to totals shown because of independent rounding.

Table 7.—U.S. imports for consumption of ferromanganese, by country

Country	1980			1981		
	Gross weight (short tons)	Mn content (short tons)	Value (thousands)	Gross weight (short tons)	Mn content (short tons)	Value (thousands)
Australia	20,206	15,674	$5,976	6,471	5,099	$2,168
Belgium-Luxembourg	5,427	4,311	1,920	--	--	--
Brazil	12,566	9,553	3,884	12,401	9,425	3,676
Canada	17,148	13,514	4,872	62,422	48,793	21,169
China	--	--	--	5	4	3
France	218,214	170,189	78,410	189,498	148,139	65,729
Germany, Federal Republic of	25	21	21	39	33	33
Japan	15,220	12,174	8,784	4,949	4,002	2,948
Korea, Republic of	--	--	--	21	16	6
Mexico	41,967	32,949	13,598	45,654	35,786	18,325
Norway	22,265	17,528	9,858	5,109	4,069	2,420
Portugal	12,049	9,398	3,443	32,858	25,630	10,109
South Africa, Republic of	224,118	174,894	73,176	274,482	212,047	87,118
Spain	11,923	9,639	5,880	9,508	7,662	5,005
Taiwan	276	201	110	--	--	--
United Kingdom	--	--	--	14,257	10,659	3,565
Yugoslavia	4,299	3,353	1,432	13,503	10,465	4,343
Total[1]	605,703	473,399	211,365	671,178	521,827	226,618

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

Table 8.—U.S. import duties

Tariff item	TSUS number	Most favored nation (MFN) Jan. 1, 1981	Most favored nation (MFN) Jan. 1, 1987	Non-MFN Jan. 1, 1981
Ore and concentrate	601.27	Free	Free	1 cent per pound Mn.
Metal	632.30	14% ad valorem	14% ad valorem	20% ad valorem.
Ferromanganese:				
High-carbon	606.30	0.3 cent per pound Mn.[1]	1.5% ad valorem	10.5% ad valorem.
Medium-carbon	606.28	0.46 cent per pound Mn.[1]	1.4% ad valorem	6.5% ad valorem.
Low-carbon	606.26	0.3 cent per pound Mn plus 2% ad valorem.[1]	2.3% ad valorem	22% ad valorem.
Silicomanganese	606.44	0.46 cent per pound Mn plus 3.5% ad valorem.[1]	3.9% ad valorem	23% ad valorem.

[1]Free from certain countries under Generalized System of Preferences.

WORLD REVIEW

Australia.—Manganese ore production declined about 30% to 1,554,000 tons from the 1980 peak of 2,162,000 tons. Virtually all production was by Groote Eylandt Mining Co. Pty. Ltd. (Gemco), whose mining and processing operations on Groote Eylandt in the Gulf of Carpentaria, Northern Territory, were reviewed.[4] Gemco's production capacity was increased to approximately 2,600,000 tons per year by installation of a plant for beneficiating fines that previously were discarded. Market conditions caused plans for further expansion to be deferred and mine operations to be cut back by yearend to a third of capacity. Gemco's exports were lower to all major markets; in tons, shipments were to Japan, 493,000; Europe, 289,000; the Republic of Korea, 141,000; and the United States, 70,000; for a total of 993,000. Shipments for domestic consumption decreased to a lesser extent, to 525,000 tons. Production of metallurgical-grade ore in the Peak Hill area of Western Australia was 1,318 tons in 1981 and 1,866 tons in 1980.

Brazil.—Exports of manganese ore products from the Serra do Navio, Amapa Territory, operations of Industria e Comercio de Minerios S.A. totaled 925,000 tons, nearly a one-third decrease from 1980 shipments. The largest portion of 1981 exports, 642,000 tons, went to Europe via Porto de Santana on the Amazon River. Destinations of the remainder were Asia, 136,000 tons; North America, 117,000 tons; and South America other than Brazil, 30,000 tons.[5]

Manganese deposits were among those in northern Brazil identified as having high potential for future production. Upwards of 60 million tons of high-grade ore have been projected to be minable by open pit methods from the Azul, Buritirama, and Sereno deposits in the Serra dos Carajas mining district, Pará State. The Azul deposits were the largest of the three and the most favorably situated with respect to projected future infrastructure.

Gabon.—Manganese ore production totaled 1,640,000 tons at an average manganese content of 51%, of which 1,500,000 tons was metallurgical ore and 140,000 tons was battery-grade (battery and chemical) ore (83% MnO_2). Exports shipped by Cie. Minière de l'Ogooué S.A. (COMILOG) out of Pointe Noire in the Congo decreased by about 30% to 1,710,000 tons, of which 1,545,000 tons was metallurgical ore and 165,000 tons was battery-grade ore.[6] The Government of Gabon announced that it would increase its share in COMILOG to 25% from 11%. Of the other shareholders, all foreign, the United States Steel Corp. had the largest interest. During 1981, United States Steel's ownership of COMILOG decreased from 44% to 41%. The contribution of manganese ore to Gabon's total export earnings had dropped to 6% in 1980 from 7% in 1979. Manganese ore was exported in 1980 to as many as 20 countries, of which, on a value basis, France and Norway received the largest amounts.

Ghana.—Exports of manganese ore by Ghana National Manganese Corp., which have been declining at about a 15% annual rate for the last few years, fell to 217,000 tons in 1981. Production from the Nsuta Mine was shipped through the Port of Takoradi to five West European countries (Belgium, Ireland, the Netherlands, Norway, and Spain) and to Japan.[7]

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

(Short tons, gross weight)

Country[2]	Percent Mn[e]	1977	1978	1979	1980[p]	1981[e]
North America: Mexico[3]	35+	536,409	576,692	543,068	492,874	[4]637,500
South America:						
Bolivia[3] [5]	28-54	9,464	1,364	11,574	4,960	--
Brazil[6]	38-50	1,670,741	[r]2,113,261	2,490,483	2,601,452	2,090,000
Chile	33-40	19,843	25,621	27,524	30,535	29,800
Europe:						
Bulgaria	30-	44,100	44,100	46,300	54,000	55,100
Greece	48-50	[r]10,573	7,727	6,283	6,123	6,060
Hungary[7]	30-33	132,000	126,000	91,000	97,000	91,000
Italy	22+	10,267	10,738	10,783	10,103	[4]9,913
U.S.S.R.[8]	35	9,470,000	9,984,000	11,292,000	10,748,000	10,360,000
Yugoslavia	30+	27,282	30,203	33,235	[e]33,000	27,600
Africa:						
Egypt	28+	4,225	191	--	--	--
Gabon	50-53	2,039,857	[r]1,885,414	2,535,417	2,366,386	[4]1,639,700
Ghana	30-50	321,417	347,864	300,005	278,279	248,000
Morocco	50-53	125,164	139,112	149,583	144,750	[4]120,863
South Africa, Republic of	30-48+	5,564,411	4,758,721	5,712,615	6,278,125	[4]5,555,000
Sudan	48	504	496	500	400	441
Zaire	30-57	42,216	--	--	18,283	11,000
Asia:						
China[e] [9]	20+	[r]1,250,000	1,400,000	1,650,000	1,750,000	1,760,000
India[10]	10-54	2,055,865	1,784,503	1,934,641	1,813,692	1,650,000
Indonesia	47-56	[r]6,587	6,492	6,514	4,739	4,950
Iran[11]	33+	44,100	33,100	[e]22,050	--	--
Japan	24-28	139,063	114,802	96,925	87,721	96,130
Korea, Republic of	23-40	732	823	39	89	83
Pakistan	35-	58	317	121	205	28
Philippines	35-45	22,706	4,311	4,155	2,818	2,200
Thailand	46-50	84,836	79,599	38,984	59,866	12,000
Turkey	35-46	21,275	[e]22,000	20,750	45,500	24,250
Oceania:						
Australia	37-53	1,531,113	1,376,699	1,871,722	2,161,630	[4]1,553,600
Vanuatu (formerly New Hebrides)	40-44	25,397	22,853	11,623	--	--
Total	XX	[r]25,210,205	[r]24,897,003	28,907,894	29,090,530	25,985,218

[e]Estimated. [p]Preliminary. [r]Revised. XX Not applicable.

[1]Table includes data available through June 30, 1982.

[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 short tons: Argentina (16% to 22% Mn) 1977—90,814, 1978—20,389, 1979—11,233, 1980—6,775 (revised), 1981—3,417; Czechoslovakia (about 17% Mn) 1977—1,003, 1978 through 1981—an estimated 1,000 in each year; Malaysia (grade unspecified but apparently a manganiferous ferruginous ore) 1977—50,040, 1978—47,092, 1979—34,839, 1980—4,413, 1981—nil; Romania (about 22% Mn) an estimated 90,000 in each year; the Republic of South Africa (15% to 30% Mn, in addition to material listed in table) 1977—266,930, 1978—105,490, 1979—nil, 1980—nil, 1981—nil.

[3]Estimated on the basis of reported contained manganese.

[4]Reported figure.

[5]Exports.

[6]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.

[7]Concentrate. Crude ore tonnages (18% to 26% Mn) as previously reported were 1977—177,072 (revised), 1978—172,160, 1979—114,260 (revised), 1980—148,230, 1981—148,800 (estimated).

[8]Reported in Soviet sources. Grade represents the annual averages obtained from reported metal contents of the gross weights shown.

[9]Includes manganiferous ore.

[10]Much of India's production grades below 35% Mn; recent details on output by grade are not available.

[11]Reported as if data are for calendar years, but may actually represent output for Iranian calendar years beginning Mar. 21 of the year stated.

India.—Exports of manganese ore of various grades rose, according to preliminary figures, to a total of 777,000 tons in 1981, as compared with 720,000 tons in 1980. Japan's share of ore exports continued to be the largest, although it decreased to about two-thirds of the total in 1981, compared with three-fourths in 1980. Exports to East Europe were up significantly, with Romania and Bulgaria the chief recipients. Domestic ore requirements were projected to double by 1990. As part of the effort to meet growth in internal demand, Manganese Ore India Ltd. was expanding its exploration activities to include search in Orissa State for high-grade, low-phosphorus ore that could be blended with already known quantities of lower grade ore.

A new ferromanganese plant was brought into production at Tumsar by Uniferro International, a subsidiary of Universal Ferro & Allied Chemicals, Bombay. This new capacity, rated at 72,000 annual tons of ferromanganese additional to that of the existing plant at Tumsar, has increased the concentration of ferromanganese production facilities in Maharashtra State. In line with the Government's relaxation of restrictions on ferromanganese exports, the new plant was export oriented. Phibro Corp. of the United States provided a production loan and had about a 40% share in the plant's equity.

Italy.—Through Samim Ocean, a U.S. subsidiary of Ente Nazionale Idrocarburi, the Italian Government moved towards involvement in ocean mining by becoming a participant in Ocean Mining Associates (OMA). OMA, long interested in developing plans to recover manganese nodules from the depths of the Pacific Ocean, had been a partnership between two U.S. firms—United States Steel Corp. and Sun Co.—and Belgium's Union Minière S.A. The Government was also involved in the study of possible deep-sea mining in Italian territorial waters, especially of a deposit of volcanic nodules in waters northwest of Sicily. These nodules reportedly had much higher manganese content than Pacific Ocean nodules.

Japan.—Completion of expansion of annual production capacity for electrolytic (synthetic) manganese dioxide to 27,500 tons at its Takehara plant was extended to mid-1982 by Mitsui Mining & Smelting Co., Ltd.

Norway.—The manganese ferroalloy plant at Sauda that had belonged to Union Carbide was acquired at midyear by a Norwegian consortium led by Elkem AS, and Elkem's ownership of Sauda Smelteverk AS became 91%.

South Africa, Republic of.—Exploration work in or near the Kalahari Field revealed possible additions to the already large manganese reserves of that field. South African Manganese Amcor Ltd. reported having intersected potential ore zones on a property north of its Wessels Mine and on its Rissik property next to its Mamatwan Mine. At the Mamatwan Mine, rich ore with as much as 50% manganese and as much as 70% manganese dioxide was found. On the farm Olive Wood, about 10 miles west of Hotazel, General Mining Union Corp. Ltd. drilled into substantial quantities of ore, some with over 50% manganese, at depths of 3,300 to 4,600 feet. On the adjacent farm Olive Pan, South Africa Iron and Steel Industrial Corp. Ltd. also drilled into high-grade ore.

On the basis of provisional figures, overall production of manganese ore in 1981 was 5,555,000 tons, a 12% decrease from the 1980 total. Of the 1981 total, approximately 5,180,000 (tons) was metallurgical ore, of which 2,678,000 contained 30% to 40% manganese, 745,000 contained 40% to 45% manganese, 1,351,000 contained 45% to 48% manganese, and 406,000 contained over 48% manganese. The remaining 376,000 was chemical ore, of which 327,000 contained less than 35% manganese dioxide, 49,000 contained 35% to 65% manganese dioxide, and 250 contained 65% to 75% manganese dioxide.

U.S.S.R.—Ore production was down somewhat in 1981. However, production capacities were being increased through mine developments at the two large producing centers of the Nikopol' Basin in the Ukraine and the Chiatura Basin in Georgia. In the Ukraine, capacity of the Ordzhonikidze complex in the Nikopol' Basin was enlarged. Across the Dnieper River to the southeast, initial development of the Bol'she-Tokmak carbonate ore deposit was scheduled for 1981-85.

TECHNOLOGY

Under contract to the Bureau of Mines, the National Materials Advisory Board of the National Academy of Sciences independently evaluated present land-based manganese reserves and resources of the world. This study was carried out by a panel that also reviewed geology of the deposits, manganese extraction and metallurgical processing, and implications of consumers' dependence on a limited number of manganese suppliers.[8]

The industrial aspects of manganese were addressed in two other reviews. One reviewed the currently used metallurgical manganese ores and the technology for processing them into ferroalloys and metal.[9] The other reviewed the chemical properties of manganese compounds and the methods for manufacturing such commercially significant compounds as manganese dioxide and potassium permanganate.[10]

The Bureau of Mines reported laboratory development of a hydrometallurgical extraction system applicable to manganese-bearing Pacific Ocean nodules. Employing sulfur dioxide as leachant, this selective leaching process rapidly solubilized metal values in mixed hydrous oxide ores at room temperature and ambient pressure. By this procedure, in excess of 90% of the manganese, nickel, and cobalt contents were extracted and copper was rejected to the residue to a comparable degree. Success of the method depended on suitable choice of a parameter—ratio of number of moles of SO_2 in the leaching solution to weight of nodules being leached—and reduction of ore particle size to at least less than 100 mesh.[11]

A laboratory study of leaching with dilute acids showed that high-phosphorus manganese ore from central India could be dephosphorized as effectively with hydrochloric acid as with either nitric or sulfuric acid. For India, hydrochloric acid was indicated to be the least costly of the three acids. These studies delineated processing conditions whereby phosphorus contents of about 0.25% to 0.50% in ore samples from Madhya Pradesh and Maharashtra could be lowered to below 0.10%. It was demonstrated that powdery, dephosphorized ore could be pelletized by a heat-hardening treatment conducted at about 1,100° C.[12]

The manganese oxygen refining (MOR) process developed by the Metals Div. of Union Carbide for production of medium-carbon ferromanganese was described. In this process, as taught in the underlying 1967 patent, high-carbon ferromanganese is top-blown with oxygen to a carbon level of 1.0% to 1.5%, in a fashion similar to steelmaking in a basic oxygen furnace. Advantages claimed for the MOR process over conventional silicothermic reduction methods for making medium-carbon ferromanganese included lower energy usage and costs. Beginning in 1976, the MOR process was used in full-scale production facilities at manganese ferroalloy plants operated by Union Carbide in the United States and Norway, and since 1977 has displaced silicothermic methods at Union Carbide plants in the United States. Under a technology purchase agreement with Union Carbide, Cía. Minera Autlán has placed a MOR production facility in operation at its Tamos plant in Mexico.[13]

Burden movement in submerged-arc ferromanganese furnaces was mathematically modeled. The model was tested in trials conducted on large commercial furnaces in which samples of irradiated manganese ore were inserted into the furnace and radioactivity of tap samples was measured. The model, which applied only to behavior of the liquid metal phase during smelting, was judged valid and of possible use for improving process control.[14]

In another investigation of factors involved in ferromanganese smelting, conditions inside a model submerged-arc furnace were explored by shutting off the power and digging out the furnace after it had cooled. Conclusions reached from examination of the furnace interior, especially those dealing with positioning of the taphole and the electrodes, were used to improve continuity of operation for large commercial furnaces.[15]

The unusual electrical and mechanical design features of the rectangular, six-electrode ferromanganese furnace at Nikopol' in the U.S.S.R. were discussed. It was noted that this type of furnace might be used to conduct a duplex smelting operation whereby ferromanganese acceptably low in phosphorus could be produced from typical Soviet ore relatively high in phosphorus.[16]

Mechanical properties of samples of Hadfield steel containing about 1.1% carbon and 11% manganese were investigated in an ongoing experimental study. The results were interpreted as indicating that rapid work hardening in this type of steel was caused mainly by dynamic strain aging stemming from the behavior of certain carbon atoms during deformation. It was inferred that wear resistance of Hadfield steel could be improved by increasing carbon content and simultaneously adding an appropriate substitutional solute.[17]

The reason why higher manganese contents improve corrosion resistance of aluminum-manganese alloys was studied in the laboratory for commercial compositions containing iron as typical impurity. It was found that increasing the manganese content of the alloy increased the amount of manganese in solid solution in the matrix, up to a limit, and also increased the manganese-to-iron ratio of intermetallic phases. Both of these compositional effects worked towards reducing the electrochemical potential difference between matrix and intermetallics, and thereby decreased overall corrosion.[18]

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[1]Physical scientist, Division of Ferrous Metals.

[2]Unless otherwise stated, the unit of weight used in this chapter is the short ton of 2,000 pounds.

[3]National Oceanic and Atmospheric Administration. Deep Seabed Mining Regulations for Exploration Licenses. Federal Register, v. 46, No. 178, Sept. 15, 1981, pp. 45,890-45,920.

[4]Mining Magazine. Groote Eylandt. V. 144, March 1981, pp. 216-225.

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[6]———. V. 71, No. 13, Mar. 27, 1982, p. 19.

[7]———. V. 71, No. 7, Feb. 13, 1982, p. 5.

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Mercury

By Linda C. Carrico[1]

U.S. mine production of mercury decreased 9% in 1981. Production was reported by three mines—one in California and two in Nevada. Secondary supplies also declined, owing primarily to the decrease in the General Services Administration (GSA) monthly sales.

Mercury consumption increased slightly in 1981. The largest increase appeared in the instruments and related products category owing mainly to an increase in dental care applications. Mine producers stocks increased 6% while consumer and dealer stocks decreased 29%.

New York dealer and London prices showed similar patterns, increasing moderately in 1981, owing partly to restriction of sales and decline in output by some foreign producers.

Imports for consumption increased dramatically over the low level of 1980, with Spain, Yugoslavia, and Japan the principal suppliers.

GSA continued through October its monthly auctions of surplus secondary mercury from the U.S. Department of Energy (DOE). Starting in November, GSA held its first in a series of auctions of surplus primary mercury held in the national defense stockpile.

World mine production increased for the second consecutive year with the reopening of one mine in Italy and the reported opening of a new mine in the U.S.S.R.

Table 1.—Salient mercury statistics

	1977	1978	1979	1980	1981
United States:					
Producing mines	5	2	3	4	3
Production flasks	28,244	24,163	29,519	30,657	27,904
Value thousands	$3,833	$3,705	$8,299	$11,939	$11,549
Exports flasks	852	NA	NA	NA	NA
Reexports do	101	NA	NA	NA	NA
Imports:					
For consumption do	28,750	41,693	26,448	9,416	12,408
General do	28,750	42,874	28,818	11,564	13,024
Stocks, Dec. 31 do	34,178	38,749	27,582	33,069	27,339
Consumption do	61,259	59,393	62,205	58,983	59,244
Price: New York, average per flask	$135.71	$153.32	$281.10	$389.45	$413.89
World:					
Production flasks	190,736	181,434	174,735	p203,925	e206,604
Price: London, average per flask	$140.70	$131.57	$291.73	$398.07	$417.52

eEstimated. pPreliminary. NA Not available.

Legislation and Government Programs.—Since 1965, surplus secondary mercury, obtained from DOE and other Government agencies, has been sold at monthly auctions to industry through GSA; in 1981, GSA sold 7,000 flasks.[2] In October, the agency suspended the longstanding series of monthly auctions.

On August 13, the President signed Public Law 97-35,[3] the Omnibus Budget Reconciliation Act of 1981, which authorized disposal of 50,000 flasks of primary mercury and 710,253 pounds of mercuric oxide held in the national defense stockpile. GSA announced in early November plans to auction 1,500 flasks per month of primary mercury. At yearend, 191,391 flasks of primary mercury were held in the national defense stockpile.

Mercury was one of 42 hazardous chemicals and petroleum products covered by Public Law 96-510,[4] the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, commonly known as "the superfund." As provided by that law, mercury sold by the manufacturer, producer, or importer was taxed starting April 1, 1981. The money goes into a hazardous substance response fund intended to cover the costs of cleaning up hazardous chemical waste sites and spills. The tax will terminate on September 30, 1985.

In 1978, the Environmental Protection Agency (EPA) proposed plans to implement the Toxic Substances Control Act of 1976. Mercury had not been included in the list of toxic substances by yearend 1981, but the metal was being evaluated by EPA to determine if there is a need for its regulation.

DOMESTIC PRODUCTION

Mercury mine production in the United States decreased in 1981. Three mines were in operation, the Carlin gold mine and the McDermitt mercury mine, both located in Nevada, and the Knoxville Mine, located in California. Despite the higher prices in 1981, most small mines remained closed. Of the total output, Nevada supplied 27,819 flasks and California supplied 85 flasks.

It was reported that exploration work was underway at the McDermitt Mine in Nevada in an effort to open another section of its open pit.

Secondary mercury production in 1981 decreased, due primarily to the dramatic decline in GSA sales. Major sources of secondary mercury besides GSA material were batteries, dental amalgams, sludges, and industrial and control instruments.

Table 2.—Mercury produced in the United States

Year and State	Producing mines	Flasks	Value[1] (thousands)
1980:			
California and Nevada	4	30,657	$11,939
1981:			
California and Nevada	3	27,904	11,549

[1]Value calculated at average New York price.

Table 3.—Mercury ore treated and mercury produced in the United States[1]

Year	Ore treated (short tons)	Mercury produced: Flasks	Mercury produced: Pounds per ton of ore
1977	216,577	28,244	9.9
1978	256,197	24,144	7.2
1979	242,564	29,499	9.2
1980	356,043	30,623	6.5
1981	262,380	27,888	8.1

[1]Excludes mercury produced from old surface ores, dumps, and placers, and as a byproduct.

Table 4.—Production of secondary mercury in the United States

(Flasks)

Year	Industrial production	GSA releases	Total
1977	5,566	1,000	6,566
1978	3,560	5,702	9,262
1979	4,287	11,300	15,587
1980	6,793	10,013	16,806
1981	4,244	7,000	11,244

CONSUMPTION AND USES

Industrial consumption of mercury in 1981 increased slightly. The largest increase appeared in the instruments and related products category (table 6) due partly to an increase in dental care applications.

Pennwalt Corp. announced plans to close its Calvert City, Ky., chlorine and caustic soda plant in the spring of 1982. Pennwalt has made arrangements to sell the plant's mercury stocks and the mercury used in the production process, totaling about 4,000 flasks.

Table 5.—Mercury consumed in the United States, by use

(Flasks)

Use	1977	1978	1979	1980	1981
Agriculture[1]	584	W	W	W	79
Amalgamation	W	--	--	--	--
Catalysts	1,545	W	548	265	815
Dental preparations	1,230	512	793	[r]1,041	1,866
Electrical apparatus	29,180	([2])	([2])	([2])	([2])
Electrolytic preparation of chlorine and caustic soda	10,744	11,166	12,180	9,470	7,323
General laboratory use	406	420	410	363	328
Industrial and control instruments	5,221	([2])	([2])	([2])	([2])
Paint, mildew proofing	8,365	8,956	9,979	8,621	7,049
Pharmaceuticals	W	W	W	--	--
Other[3]	2,589	([2])	([2])	([2])	([2])
Total known uses	59,864	59,393	62,205	58,983	59,244
Total unknown uses	1,395	--	--	--	--
Grand total	61,259	59,393	62,205	58,983	59,244

[r]Revised. W Withheld to avoid disclosing company proprietary data; included in "Other."
[1]Includes fungicides and bactericides for industrial purposes.
[2]See table 6 of this chapter and those of previous years for SIC end use data.
[3]Includes mercury used for installation and expansion of chlorine and caustic soda plants.

Table 6.—Mercury consumed in the United States in 1981

(Flasks)

Use	Primary	Redistilled	Secondary	Total
Chemicals and allied products:				
Chlorine and caustic soda preparation	7,323	--	W	7,323
Pigments	W	--	--	W
Catalysts	W	W	--	815
Laboratory uses	149	157	22	328
Plastic materials and synthetic (processing and resins)	W	--	--	W
Pharmaceuticals	--	--	--	--
Paint	7,049	--	--	7,049
Agricultural chemicals	79	--	--	79
Chemicals and allied products, n.e.c	W	W	--	W
Electrical and electronic instruments:				
Electrical lighting	W	W	--	1,043
Wiring devices and switches	W	688	W	2,641
Batteries	20,675	W	W	29,441
Other electrical and electronic equipment	W	W	--	W
Instruments and related products:				
Measuring and control devices	W	1,880	W	5,671
Dental equipment and supplies	514	1,099	W	1,613
Other instruments and related products	W	W	W	253
Other	8,161	9,362	2,086	2,988
Total known uses	43,950	13,186	2,108	59,244

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

Table 7.—Stocks of mercury, December 31

(Flasks)

Year	Producer (mine)	Consumer and dealer	Total
1977	11,275	22,903	34,178
1978	16,600	22,149	38,749
1979	9,181	18,401	27,582
1980	11,095	21,974	33,069
1981	11,783	15,556	27,339

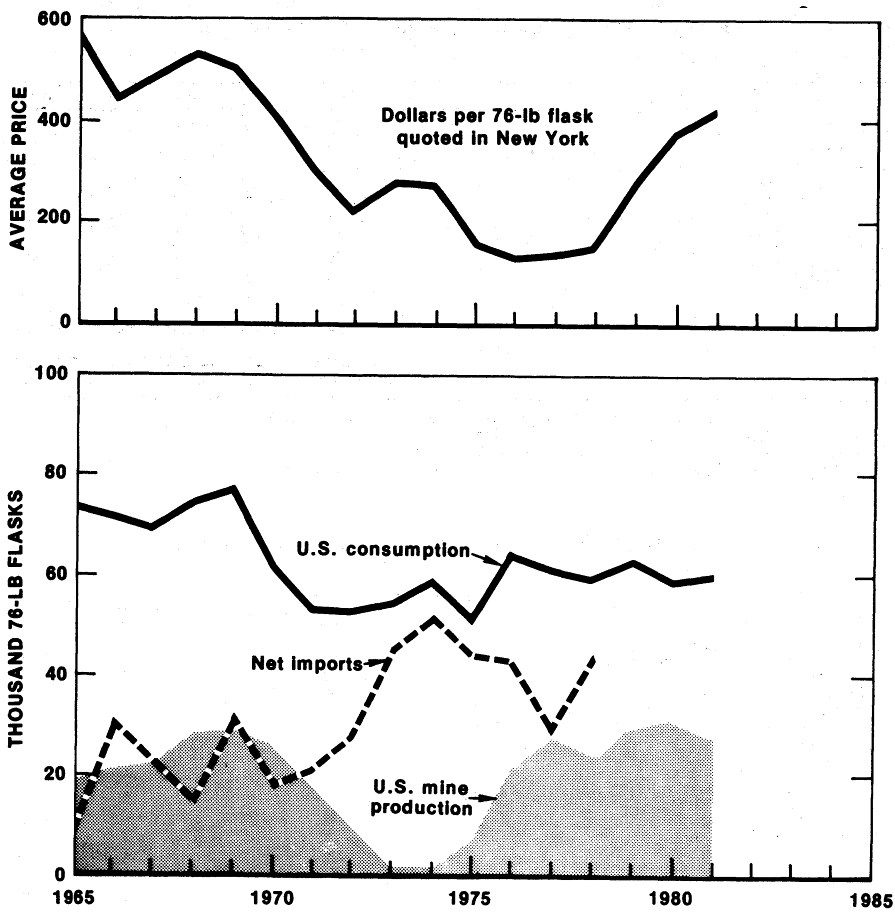

Figure 1.—Trends in production, consumption, net imports, and price of mercury, in the United States.

PRICES

The 1981 average New York dealer price for primary mercury was $413.89 per flask, compared with $389.45 per flask in 1980. At the beginning of 1981, the New York price of mercury was $355 to $360 per flask, compared with $408 to $418 per flask at yearend. The London prices showed a similar pattern during 1981. The annual average London price was $417.52 per flask in 1981, compared with $398.07 per flask in 1980. At the beginning of 1981, the London price was $360 to $370 per flask, compared with $416 to $422 per flask at yearend.

Table 8.—Average monthly prices of mercury at New York and London

(Per flask)

	1980		1981	
	New York[1]	London[2]	New York[1]	London[2]
January	$378.64	$390.06	$364.52	$368.06
February	390.00	393.33	381.39	389.00
March	393.81	396.56	409.77	413.61
April	402.05	404.39	417.96	421.88
May	389.52	394.17	413.75	426.67
June	381.43	386.88	419.32	430.00
July	389.32	399.33	433.17	429.33
August	387.62	408.11	441.67	430.56
September	394.05	415.00	430.52	430.06
October	404.77	414.72	426.14	427.78
November	398.53	399.31	418.22	422.38
December	363.64	374.94	410.18	420.95
Average	389.45	398.07	413.89	417.52

[1]Metals Week, New York.
[2]Metal Bulletin, London; reported in terms of U.S. dollars.

FOREIGN TRADE

Data on mercury exports were last reported in 1977.

Imports for consumption increased 32% in 1981, with Spain supplying 40% of the total, followed by Yugoslavia, 23%, and Japan, 19%. Imports from Yugoslavia were 2,901 flasks, the first sign of trade to the United States since 1977 when its Idria Mine closed because of depressed prices.

The average unit value of imports for the year was $403.37 per flask, compared with $301.72 per flask in 1980.

The U.S. rate of duty on mercury metal imports from "most favored nation" countries in 1981 was 11.3 cents per pound ($8.59 per flask). The statutory rate of 25 cents per pound ($19 per flask) applied to other countries.

Table 9.—U.S. imports for consumption[1] of mercury, by country

Country	1979		1980		1981	
	Flasks	Value (thousands)	Flasks	Value (thousands)	Flasks	Value (thousands)
Algeria	100	$34	--	--	--	--
Canada	3,943	783	843	$197	112	$78
China	--	--	204	61	801	308
Denmark	--	--	--	--	500	201
Dominican Republic	611	129	200	73	129	54
France	470	127	--	--	(2)	(2)
Germany, Federal Republic of	--	--	15	24	--	--
Italy	4,429	675	--	--	--	--
Japan	7,960	1,755	3,813	1,260	2,372	925
Mexico	403	60	989	206	104	29
Netherlands	25	4	--	--	--	--
Spain	8,507	1,640	3,352	1,020	4,989	2,021
Turkey	--	--	--	--	500	197
Yugoslavia	--	--	--	--	2,901	1,192
Total	26,448	5,207	9,416	2,841	12,408	5,005

[1]General imports: 1979—28,818 ($5,659,206), China 1,400 ($182,674), Italy 5,369 ($926,522), Japan 8,611 ($1,919,543), and Spain 8,356 ($1,621,083); 1980—11,564 ($3,618,781), China 200 ($60,635), Japan 5,464 ($1,840,377), and Spain 3,853 ($1,218,025); 1981—13,024 ($5,259,480), Japan 2,317 ($898,675), and Spain 6,160 ($2,503,566).
[2]Less than 1/2 unit.

WORLD REVIEW

World mine production of mercury increased for the second consecutive year due primarily to rising prices and the opening of mines. Although prices have increased in the past 3 years, mining operations in Canada and Yugoslavia remained closed in 1981. The international association of mercury producers, Assimer, met periodically in 1981 to review the mercury market.

Italy.—Italy's nonferrous metals agency, Societa per Azioni Minero Metallurgiche, reported the reopening of the Monte Amiata mercury mine, which had closed in 1976 because of low prices. The mine came onstream around May with planned production of about 5,000 flasks annually, all of which will be used domestically.

Spain.—Minas de Almáden Arrayanes was investigating a new mercury mine at La Cuevas. Studies in 1980 concluded that the mine could be profitable; if current studies confirm that conclusion, the mine could come onstream around 1986 or 1987.

U.S.S.R.—According to reports, a new mercury mine, Glubokaya, came onstream in early 1981. The mine is the first stage of a mining complex in Kirgiziya, U.S.S.R., which should meet the ore requirement of the Khaydarkan mercury complex.

Yugoslavia.—The Idria mercury mine in Slovenia was closed in 1977 because of depressed prices and declining grade of ore. It was reported that the Yugoslavian Government plans to reopen the mine in 1983. One factor favoring the reopening was the discovery of a new mineral vein, close to the surface, containing an estimated 163,000 flasks of mercury. It was reported that production would run about 8,700 flasks annually, with 20% used domestically.

Table 10.—Mercury: World production, by country[1]

(Flasks)

Country	1977	1978	1979	1980[p]	1981[e]
Algeria	30,429	30,603	14,736	24,425	25,000
Australia	1	--	--	--	--
Chile	20	--	--	--	--
China[e]	20,000	20,000	20,000	20,000	20,000
Czechoslovakia	5,309	5,686	4,960	4,612	4,600
Dominican Republic	495	500	500	[e]500	500
Finland	630	1,145	1,347	2,170	2,000
Germany, Federal Republic of	2,872	2,437	2,639	1,624	1,200
Italy	406	87	--	96	4,000
Mexico	9,660	2,205	1,973	4,206	4,000
Spain	26,851	29,588	33,275	49,198	50,000
Turkey	4,686	5,020	4,786	4,437	4,400
U.S.S.R.[e]	58,000	60,000	61,000	62,000	63,000
United States	28,244	24,163	29,519	30,657	[2]27,904
Yugoslavia	3,133	--	--	--	--
Total	190,736	181,434	174,735	203,925	206,604

[e]Estimated. [p]Preliminary.
[1]Table includes data available through Apr. 14, 1982.
[2]Reported figure.

TECHNOLOGY

The Bureau of Mines Albany Research Center, Albany, Oreg., reported the modification of an atomic absorption spectrophotometer to rapidly determine trace levels of mercury. For the past 2 years, this cold-vapor mercury analysis system was successfully used at the Albany Research Center.[5] A cold-vapor atomic absorption system for the determination of volatile mercury in stack gases of a municipal solid-waste incinerator was described by the Institute for Nuclear Sciences located in Belgium.[6]

The use of sulfides to precipitate mercury from water has been instrumental in reducing mercury losses to the environment.

However, a study published in 1981 concluded that sulfide treatment does not effect adequate removal of elemental mercury, although it is excellent for removing ionic mercury species from industrial wastewaters.[7]

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[1]Mineral specialist, Division of Nonferrous Metals.

[2]Flask, as used throughout this chapter, refers to the 76-pound flask.

[3]U.S. Congress. Omnibus Budget Reconciliation Act of 1981. Public Law 97-35, Aug. 13, 1981, 95 Stat. 357.

[4]———. Comprehensive Environmental Response, Compensation, and Liability Act of 1980. Public Law 96-510, Dec. 11, 1980, 94 Stat. 2767.

[5]Perry, J. A., R. F. Farrell, and A. J. Mackie. Modification of a Commercial Atomic Absorption Spectrophotometer for Cold-Vapor Determination of Mercury. BuMines RI 8573, 1981, 11 pp.

[6]Dumarey, R., R. Heindryckx, and R. Dams. Determination of Mercury Emissions From a Municipal Incinerator. Environ. Sci. Technol., v. 15, No. 2, February 1981, pp. 206-209.

[7]Findlay, D. M., and R. A. McLean. Removal of Elemental Mercury From Wastewaters Using Polysulfides. Environ. Sci. Technol., v. 15, No. 11, November 1981, pp. 1388-1390.

Mica

By Wilton Johnson[1]

In 1981, a total of 133,000 tons[2] of scrap and flake mica was reported produced in the United States, an increase of 15% from the 1980 production. Output of ground mica, sold or used, was 117,000 tons, a 5.4% increase from that of the previous year.

Consumption of mica block increased by 6.4% to 166,000 pounds. Mica film consumption decreased by 25% to 3,000 pounds. Consumption of mica splittings remained unchanged from that of 1980 at 4.4 million pounds.

Exports of unmanufactured mica decreased 21% to 11,000 tons, and imports of all forms of mica increased 8% to 13,000 tons.

Legislation and Government Programs.—The total Government stockpile inventory of natural sheet mica was reduced to 27.4 million pounds by December 31, 1981. Sales of sheet mica by the General Services Administration during 1981 totaled 277,000 pounds, all muscovite splittings. There were no sales of block or film mica.

Table 1.—Salient mica statistics

	1977	1978	1979	1980	1981
United States:					
Production (sold or used by producing companies):					
Sheet mica ---- thousand pounds--	1	(1)	1	NA	NA
Value ---- thousands--	(1)	(1)	(1)	NA	NA
Scrap and flake mica ---- thousand short tons--	2129	2139	2134	r116	133
Value ---- thousands--	2$7,039	2$7,916	2$7,708	r$6,262	$8,212
Ground mica ---- thousand short tons--	2122	2124	2122	r111	117
Value ---- thousands--	2$11,906	2$12,979	2$14,522	r$14,112	$16,373
Consumption:					
Block ---- thousand pounds--	439	239	277	r156	166
Value ---- thousands--	$952	$1,328	$1,841	r$1,886	$1,533
Film ---- thousand pounds--	9	8	5	4	3
Value ---- thousands--	$38	$34	$25	$18	$13
Splittings ---- thousand pounds--	4,144	5,537	4,877	4,383	4,386
Value ---- thousands--	$2,718	$3,031	$3,248	$3,101	$3,064
Exports ---- thousand short tons--	10	9	12	14	11
Imports ---- do----	4	7	10	12	13
World: Production ---- thousand pounds--	r748,612	r801,142	r786,965	p730,840	e772,976

eEstimated. pPreliminary. rRevised. NA Not available.
1Less than 1/2 unit.
2Data have been revised to exclude low-quality sericite.

Table 2.—Stockpile status, December 31, 1981[1]

(Thousand pounds)

Material	Goal	Total inventory	Available for disposal	Sales 1980-81
Stockpile grade:				
Block:				
Muscovite, Stained and better	6,200	5,006	--	--
Phlogopite	210	17	--	--
Film: Muscovite, 1st and 2d qualities	90	1,274	--	--
Splittings:				
Muscovite	12,630	19,035	5,773	277
Phlogopite	930	2,029	772	--

[1]In addition to the data shown, the stockpile contains the following: Material with goals (nonstockpile grade) includes 206,740 pounds muscovite block, Stained and better; 640 pounds muscovite film, 1st and 2d qualities; and 114,027 pounds phlogopite block.

DOMESTIC PRODUCTION

Scrap and Flake Mica.—U.S. production of scrap (flake) mica[3] in 1981 was 133,000 tons valued at $8,212,000. North Carolina was again the major producing State with 92,000 tons or 69% of the total. The remaining 31% was produced in Connecticut, Georgia, New Mexico, Pennsylvania, South Carolina, and South Dakota. Most of the scrap (flake) mica includes mica recovered from mica and high-quality sericite schist and mica that is a byproduct of kaolin, feldspar, and lithium beneficiation. The five leading producers in 1981 were Deneen Mica Co., Micaville, N.C.; Harris Mining Co., Spruce Pine, N.C.; Mineral Industrial Commodities of America, Inc. (M.I.C.A.), Santa Fe, N. Mex.; Lithium Corp. of America, Inc., Gastonia, N.C.; and Kings Mountain Mica Corp., Kershaw, S.C.

Ground Mica.—Production (sold or used) of ground mica, from scrap and flake mica, increased in 1981 by 5.4% to 117,000 tons. Dry-ground mica, which represented 91% of the total ground mica production, increased by 7%, and wet-ground mica production increased by 10%. The total value of ground mica production increased by 16% to $16,373,000.

During 1981, 15 companies operated 16 plants producing ground scrap (flake) mica including high-quality sericite; of these, 12 produced dry-ground, 2 produced wet-ground, and 1 produced both wet- and dry-ground material. Leading ground mica producers were the same as those for scrap and flake mica, except for Lithium Corp. of America, Inc., which did not produce ground mica.

In 1981, production of low-quality sericite, primarily for use in brick manufacturing, was 28,000 tons valued at $82,300. Approximately 28,000 tons of ground sericite valued at $167,700 was produced from this crude sericite.

Table 3.—Scrap and flake mica sold or used by producers in the United States[1]

Year and State	Quantity (thousand short tons)	Value (thousands)
1977	129	$7,039
1978	139	7,916
1979	134	7,708
1980	r116	r6,262
1981:		
North Carolina	92	6,398
Other States[2]	42	1,814
1981 total	[3]133	8,212

rRevised.

[1]Includes finely divided mica recovered from mica and high-quality sericite schist, and mica that is a byproduct of feldspar, kaolin, and lithium beneficiation. 1977-79 data have been revised to exclude low-quality sericite.

[2]Includes Connecticut, Georgia, New Mexico, Pennsylvania, South Carolina, and South Dakota.

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

Table 4.—Ground mica sold or used by producers in the United States, by method of grinding[1]

(Thousand short tons and thousand dollars)

Year	Dry-ground		Wet-ground		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
1977	107	8,233	15	3,673	122	11,906
1978	110	9,039	14	3,940	124	12,979
1979	108	10,193	14	4,329	122	14,522
1980	100	r10,797	10	r3,315	r 2 111	r14,112
1981	107	12,692	11	3,681	2 117	16,373

rRevised.
[1]Domestic and some imported scrap. 1977-79 data have been revised to exclude low-quality sericite.
[2]Data do not add to total shown because of independent rounding.

CONSUMPTION AND USES

Sheet Mica.—Consumption of muscovite block (ruby and nonruby) totaled 154,700 pounds, an increase of 8% from that of 1980. Of the total muscovite block fabricated, 83% went into electronic uses (66% for vacuum tubes and 17% for capacitors and other uses); the remaining 17% went into nonelectronic uses, including gauge glass and diaphragms.

In 1981, Stained-quality muscovite block was in greatest demand and accounted for 76% of consumption, followed by Lower-than-Stained quality, 21%, and Good-Stained or better, 3%. Consumption by increasing size (grade) was: Smaller than No. 6, 14%; No. 6, 30%; No. 5 1/2, 23%; No. 5, 19%; and larger than No. 4, 14% of the total.

Mica film consumption, first and second quality, decreased 30% from that of 1980 to 2,800 pounds. This decline could be attributed to a continued increase in fabrication overseas, and substitution by other materials. First-quality film represented about 46% of the total amount fabricated, and second-quality film accounted for the remainder.

Muscovite block and film was consumed by eight companies in seven States; two plants in North Carolina, one in Massachusetts, and one each in New Jersey, New York, Ohio, Pennsylvania, and Virginia. New York, Pennsylvania, and Virginia companies consumed 80% of the total block and film used for fabrication in 1981.

Phlogopite block fabrication totaled 10,800 pounds, a decrease of 19% from the 1980 total. This amount was consumed by six companies in five States.

Consumption of mica splittings in 1981 remained unchanged from that of 1980 at 4.4 million pounds. Of the total amount consumed, 97% was muscovite splittings from India and the remainder phlogopite splittings from Madagascar. The mica 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. In 1981, total production, sold or used, of built-up mica decreased by 5.8% from that of 1980. Molding plate and segment plate represented the major end uses; each accounted for 34% of the total, followed by tape, 13%.

Ground Mica.—In 1981, a total of 117,000 tons of ground mica was sold or used by U.S. producers, an increase of 5.4% over 1980 production. The major end uses were joint cement (44%) and paint (15%). Miscellaneous end uses, including ground mica used in oil well drilling muds, roofing, and rubber, represented 41% of the total.

Table 5.—Fabrication of muscovite ruby and nonruby block and film mica and phlogopite block mica in the United States in 1981, by quality and end-product use

(Pounds)

Variety, form, and quality	Electronic uses				Nonelectronic uses			Grand total[1]
	Capacitors	Tubes	Other	Total	Gauge glass and diaphragms	Other	Total	
Muscovite:								
Block:								
Good Stained or better	300	300	100	700	3,000	700	3,700	4,400
Stained	--	96,800	17,600	114,400	400	3,300	3,700	118,000
Lower than Stained[2]	--	4,600	8,900	13,500	--	18,800	18,800	32,300
Total[1]	300	101,700	26,600	128,600	3,400	22,800	26,200	154,700
Film:								
1st quality	1,300	--	--	1,300	--	--	--	1,300
2d quality	1,500	--	--	1,500	--	--	--	1,500
Total	2,800	--	--	2,800	--	--	--	2,800
Block and film:								
Good Stained or better[3]	3,100	300	100	3,500	3,000	700	3,700	7,200
Stained[4]	--	96,800	17,600	114,400	400	3,300	3,700	118,000
Lower than Stained	--	4,600	8,900	13,500	--	18,800	18,800	32,300
Total[1]	3,100	101,700	26,600	131,400	3,400	22,800	26,200	157,500
Phlogopite: Block (all qualities)	--	--	300	300	--	10,500	10,500	10,800

[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 1981, by quality and grade

(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	2,400	700	200	500	--	3,700
Stained	8,100	28,200	30,700	42,900	3,900	113,700
Lower than Stained	5,600	500	4,000	1,400	14,500	25,900
Total[2]	16,000	29,400	34,900	44,800	18,300	143,300
Nonruby:						
Good Stained or better	500	200	--	--	--	700
Stained	3,100	300	400	600	--	4,300
Lower than Stained	2,800	--	--	700	3,000	6,500
Total[2]	6,300	500	400	1,300	3,000	11,400
Total block (ruby and nonruby)[2]	22,300	29,800	35,200	46,000	21,300	154,700
Film:						
Ruby:						
1st quality	--	300	200	200	--	700
2d quality	100	400	600	200	--	1,300
Total	100	700	800	400	--	2,000
Nonruby:						
1st quality	--	--	300	300	--	600
2d quality	--	--	200	--	--	200
Total	--	--	500	300	--	800
Total film (ruby and nonruby)[2]	100	700	1,400	700	--	2,800

[1]Figures for block mica include all smaller 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	
	Quantity	Value	Quantity	Value	Quantity	Value
Consumption:						
1977	3,979	2,525	165	193	4,144	2,718
1978	5,371	2,837	166	194	5,537	3,031
1979	4,714	2,745	163	503	4,877	3,248
1980	4,216	2,543	167	557	4,383	[1]3,101
1981	4,268	2,601	117	463	[1]4,386	3,064
Stocks on Dec. 31:						
1977	3,130	NA	68	NA	3,198	NA
1978	2,695	NA	76	NA	2,771	NA
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

NA Not available.
[1]Data do not add to total 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	1980		1981	
	Quantity	Value	Quantity	Value
Molding plate	1,351	3,554	1,318	3,696
Segment plate	1,309	3,818	1,329	4,208
Heater plate	116	402	110	437
Flexible (cold)	328	1,314	289	1,247
Tape	719	3,406	512	2,420
Other	299	1,453	325	1,600
Total[2]	4,122	13,946	3,882	13,607

[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	1980		1981	
	Quantity	Value	Quantity	Value
Roofing	W	W	W	W
Rubber	[r]3	[r]646	W	W
Paint	[r]17	[r]1,935	18	2,262
Joint cement	50	[r]5,762	52	6,774
Other[1]	41	[r]5,769	47	7,337
Total	[r]111	[r]14,112	117	16,373

[r]Revised. W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes mica used for agricultural products, molded electric insulation, plastics, wallpaper (1980), welding rods, well drilling mud, textile and decorative coatings, and uses indicated by symbol W.

STOCKS

Reported yearend consumer stocks of sheet mica in 1981 were 3.0 million pounds. Mica splittings represented 90% and mica block represented 10%.

PRICES

Average reported values of muscovite sheet mica in 1981, based on consumption data, were block, $9.34 per pound; film, $4.56 per pound; and splittings, $0.61 per pound. The average values of phlogopite sheet mica for 1981 were $7.79 per pound for block and $3.95 per pound for splittings. Compared with 1980 average reported values, muscovite block decreased 26%, muscovite film increased 1%, and muscovite splittings increased 2%. Compared with that of 1980, the average value of phlogopite block and splittings increased 40% and 18%, respectively.

The average value of scrap (flake) mica, including high-quality sericite, was $61.74 per ton. The average value per ton for North Carolina scrap (flake) mica, predominantly a flotation product, was $69.54.

The averages of reported prices for ground mica are shown in table 10.

Table 10.—Averages of reported prices for dry- and wet-ground mica sold or used by U.S. producers in 1981

(Dollars per short ton)

Wet-ground	349
Dry-ground	119
End uses:	
Roofing	W
Rubber	W
Paint	127
Joint cement	129
Other[1]	156

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

[1]Includes mica used for agricultural products, molded electrical insulation, plastics, welding rods, well drilling mud, textile and decorative coatings, miscellaneous, and uses indicated by symbol W.

FOREIGN TRADE

Unmanufactured mica exports included block, film, splittings, and waste; sometimes small quantities of ground mica were also included in this category. These exports totaled 3,943 tons valued at $1.35 million in 1981. Japan was again the leading country of destination receiving 1,326 tons valued at $575,000.

Exports of ground mica totaled 6,977 tons valued at $2.1 million. Canada was the leading country of destination receiving 2,638 tons valued at $511,000.

The total value of stamped or built-up mica exports was $7 million, with Canada the leading country of destination accounting for 38% of the total value shipped.

Imports of all classes of mica in 1981 rose 7.5% to 25.9 million pounds. The increase was caused by additional imports of unmanufactured mica waste from China, the Federal Republic of Germany, and India. Tables 11-13 list in detail U.S. mica imports and exports, by kind and country.

Table 11.—U.S. exports of mica and manufactures of mica in 1981, by country

Country	Mica, unmanufactured, including block, film, splittings, and waste[1]		Mica, ground or pulverized		Mica, cut or stamped, built-up mica
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Value (thousands)
Angola	11	$2	145	$66	--
Australia	241	68	43	16	$189
Brazil	4	1	--	--	578
Canada	314	89	2,638	511	2,658
Egypt	26	5	177	85	--
France	18	5	745	156	60
Germany, Federal Republic of	143	40	231	45	31
India	--	--	--	--	231
Italy	10	3	310	125	807
Japan	1,326	575	168	87	105
Mexico	332	94	213	57	626
Netherlands	--	--	288	107	31
Nigeria	57	12	--	--	--
Peru	53	20	165	55	39
Singapore	31	17	206	100	1
South Africa, Republic of	--	--	21	5	205
Spain	82	44	301	61	346
United Arab Emirates	--	--	52	27	2
United Kingdom	661	205	29	17	514
Venezuela	193	41	796	357	9
Other[2]	441	131	449	208	568
Total	3,943	1,352	6,977	2,085	7,000

[1]Some shipments of ground mica are included in this category.

[2]Includes Argentina, Austria, the Bahamas, Barbados, Belgium, Belize, Bolivia, Cayman Islands, Chile, China, Colombia, Costa Rica, the Dominican Republic, Ecuador, El Salvador, Finland, Gabon, Ghana, Haiti, Honduras, Ireland, Israel, the Ivory Coast, Jamaica, the Republic of Korea, Kuwait, Malaysia, Morocco, New Zealand, Pakistan, Panama, the Philippines, Portugal, Saudi Arabia, Sudan, Sweden, Switzerland, Taiwan, Thailand, Trinidad and Tobago, and Tunisia.

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

UNMANUFACTURED

Country	Waste and scrap: Phlogopite: Quantity (pounds)	Waste and scrap: Phlogopite: Value (thousands)	Waste and scrap: Other: Quantity (pounds)	Waste and scrap: Other: Value (thousands)	Block mica: Quantity (pounds)	Block mica: Value (thousands)	Other: Muscovite: Quantity (pounds)	Other: Muscovite: Value (thousands)	Other: Other, n.e.c.: Quantity (pounds)	Other: Other, n.e.c.: Value (thousands)
1979	--	--	176,368	$9	243,480	$752	--	--	6,365,888	$846
1980	72,570	$7	--	--	70,591	477	--	--	7,568,423	1,128
1981:										
Belgium	--	--	--	--	--	--	--	--	806	2
Brazil	--	--	--	--	4,516	34	--	--	461,966	167
Canada	--	--	--	--	--	--	--	--	162,136	19
France	--	--	--	--	3,418	24	--	--	114,198	69
India	--	--	--	--	22,278	88	--	--	7,336,609	1,065
United Kingdom	352	23	--	--	1,555	15	--	--	614	31
Other	--	--	--	--	29	11	--	--	23,938	21
Total	352	23	--	--	31,796	172	--	--	8,100,267	1,374

MANUFACTURED

Country	Splittings: Quantity (pounds)	Splittings: Value (thousands)	Not cut or stamped, not over 0.006 inch in thickness: Quantity (pounds)	Not cut or stamped, not over 0.006 inch in thickness: Value (thousands)	Cut or stamped: Not over 0.006 inch in thickness: Quantity (pounds)	Cut or stamped: Not over 0.006 inch in thickness: Value (thousands)	Cut or stamped: Over 0.006 inch in thickness: Quantity (pounds)	Cut or stamped: Over 0.006 inch in thickness: Value (thousands)
1979	3,977,205	$1,547	921	$2	96,717	$1,047	109,725	$416
1980	4,223,989	1,660	13,825	40	102,785	1,277	103,331	700
1981:								
Canada	--	--	1,610	1	--	--	2,623	16
France	3,306	66	--	--	12,142	28	--	--
Germany, Federal Republic of	--	--	121,430	10	391	5	--	--
India	2,413,174	1,006	882,143	69	60,242	838	58,921	355
Switzerland	--	--	--	--	425	1	--	--
United Kingdom	530	12	9	1	886	40	41	4
Other	662	31	3,096	5	1,038	68	91,263	353
Total	2,417,672	1,115	1,008,288	86	75,124	980	152,848	728

Country	Mica plates and built-up mica: Quantity (pounds)	Mica plates and built-up mica: Value (thousands)	Ground or pulverized: Quantity (short tons)	Ground or pulverized: Value (thousands)	Articles not especially provided for of mica: Quantity (pounds)	Articles not especially provided for of mica: Value (thousands)
1979	558,957	$1,349	4,533	$743	10,901	$122
1980	615,443	1,413	5,673	1,065	9,145	95
1981:						
Belgium	256,156	516	--	--	--	--
Canada	1,375	10	6,462	1,317	1,502	11
France	639	1	--	--	17,505	25
India	105,944	262	110	16	17,415	332
Japan	20,120	85	([1])	1	783	10
Korea, Republic of	10,835	43	--	--	--	--
United Kingdom	--	--	111	55	223	10
Other	--	--	1	--	3,995	46
Total	395,069	917	6,684	1,389	41,423	434

[1]Less than 1/2 unit.

Table 13.—Summation of U.S. mica trade data

	EXPORTS					
	Unmanufactured[1]		Ground or pulverized		Manufactured, cut or stamped, built-up	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1977	[2]9,101	[2]$3,557	NA	NA	506	$3,267
1978	3,414	2,051	5,848	$1,204	NA	4,697
1979	5,827	1,673	5,846	1,374	NA	5,224
1980	6,275	1,953	8,187	2,247	NA	7,665
1981	3,943	1,352	6,977	2,085	NA	7,000

	IMPORTS							
	Uncut sheet[3] and punch		Scrap		Ground or pulverized		Manufactured, cut or stamped, built-up	
	Quantity (thousand pounds)	Value (thousands)	Quantity (thousand pounds)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (thousand pounds)	Value (thousands)
1977	4,328	$1,680	2,348	$112	146	$29	827	$2,652
1978	8,855	2,629	1,221	59	1,728	263	969	3,096
1979	10,587	3,147	176	9	4,533	743	776	2,929
1980	11,877	3,305	73	7	5,673	1,065	831	3,487
1981	11,558	2,747	352	23	6,684	1,389	664	3,059

NA Not available.
[1]Includes block, film, splittings, and waste. Sometimes shipments of ground mica are placed in this category.
[2]Includes ground mica.
[3]The "Other" classification included in this category often contains scrap mica shipments.

WORLD REVIEW

World production of all forms of mica increased 6% to 773 million pounds in 1981. India led the world in production of sheet mica. The United States remained the leader for production of scrap (flake) mica.

India.—The Government's Mica Trading Corp. announced plans to establish two new micronized mica production units and a wet-ground mica powder unit. When in full production, these plants should add substantially to India's export earnings of fabricated mica.[4]

Price negotiations between India and the U.S.S.R. intensified in 1981. The U.S.S.R. is traditionally India's largest buyer of mica. The outlook for India mica exports brightened with successful trade agreements signed with the U.S.S.R. and Czechoslovakia during 1981.[5]

U.S.S.R.—The estimated output of mica remained at about 50,000 short tons, still inadequate to meet domestic demand. Strategic-grade mica continued to be imported from India.

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

(Thousand pounds)

Country[2]	1977	1978	1979	1980[p]	1981[e]
Argentina:					
Sheet	666	785	1,896	481	423
Waste, scrap, etc.	4,057	5,018	2,513	1,358	1,609
Brazil[3]	4,310	[r]10,033	8,979	8,818	9,921
Colombia[e]	(4)	--	--	--	--
Egypt	190	[r e]190	--	--	--
France[e]	15,400	16,100	15,400	15,400	15,000
India:					
Exports:					
Block	2,423	3,208	1,366	1,323	1,102
Film and disk	278	271	353	441	441
Splittings	7,595	9,229	10,891	11,023	11,023
Scrap	21,954	[e]21,800	27,470	27,558	28,660

See footnotes at end of table.

Table 14.—Mica: World production, by country[1] —Continued

(Thousand pounds)

Country[2]	1977	1978	1979	1980[p]	1981[e]
India —Continued					
Exports —Continued					
Powder	16,546	[e]18,100	21,054	22,046	19,842
Manufactured	1,036	882	838	882	1,100
Domestic consumption, all forms[e]	24,691	25,100	25,600	26,000	26,500
Total	74,523	78,590	87,572	89,273	88,668
Korea, Republic of (sericite)	22,339	37,309	22,057	22,773	22,046
Madagascar (phlogopite):					
Block	NA	NA	134	185	187
Sheet and splittings	3,303	3,452	2,438	3,631	3,638
Scrap	NA	NA	NA	NA	NA
Mexico	1,700	884	536	[e]880	880
Mozambique (including scrap)	[e] [2]1,764	[e] [2]1,984	553	[e]440	440
Norway (including scrap)[5]	6,213	[r]5,925	6,426	6,393	6,400
Peru	[r]330	[r]220	[e]110	[e]130	130
South Africa, Republic of:					
Sheet	([6])	([6])	([6])	([6])	([6])
Scrap	6,927	5,604	7,974	11,125	5,330
Spain	6,468	7,374	11,395	10,650	11,020
Sri Lanka (scrap)	[e]220	309	814	320	440
Sudan	[e]880	2,200	4,409	[e]3,300	2,200
Tanzania (sheet)	15	13	13	22	24
U.S.S.R. (all grades)[e]	97,000	99,000	101,000	101,000	104,000
United States:					
Sheet[e]	1	([6])	1	NA	NA
Scrap and flake[7]	[r]258,000	[r]278,000	268,000	232,000	[8]266,000
Ground mica	[r]244,000	[r]248,000	244,000	222,000	[8]234,000
Yugoslavia	306	152	745	661	620
Grand total	[r]748,612	[r]801,142	786,965	730,840	772,976

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available.
[1]Table includes data available through May 12, 1982.
[2]In addition to the countries listed, China, Namibia, Pakistan, Romania, Sweden, and Zimbabwe are known to produce mica, but available information is inadequate to make reliable estimates of output levels.
[3]Exports.
[4]Revised to zero.
[5]Official Norwegian sources indicate that actual mica output is "not available for publication," but one or two mines evidently were in operation during 1977-81.
[6]Less than 1/2 unit.
[7]Excludes U.S. production of low-quality sericite.
[8]Reported figure.

TECHNOLOGY

The Bureau of Mines announced the results of research to concentrate coarse, liberated mica particles by the pneumatic process. A Bureau-designed system of crushers, screens, and zigzag air classifiers was used to concentrate mica ores from Arizona, North Carolina, and South Dakota and waste tailings from Alabama, Georgia, and South Dakota. Results demonstrated that plus 65-mesh size mica can be effectively recovered by the pneumatic method and that this method can also be used to recover up to 78% of the mica that was originally contained in the samples. The pneumatic beneficiation process may prove to be most advantageous in areas with limited water resources.[6]

The Bureau also announced results of research to determine the effectiveness of crushing techniques for pneumatic concentration of mica. Three types of crushers were investigated, a roll crusher, a jaw crusher, and a hammer mill. The hammer mill proved to be the most effective, producing four concentrates with recoveries of at least 70%.[7]

[1]Mineral specialist, Division of Industrial Minerals.
[2]Short tons are used throughout unless otherwise stated.
[3]Production of high-quality sericite is included in the totals; however, figures for low-quality sericite, used principally for brick manufacturing, are not included.
[4]Industrial Minerals (London). No. 170, November 1981, pp. 12-13.
[5]———. No. 171, December 1981, p. 13.
[6]Jordan, C. E., G. V. Sullivan, and B. E. Davis. Pneumatic Concentration of Mica. BuMines RI 8457, 1980, 24 pp.
[7]Smith, C. W., C. E. Jordan, and G. V. Sullivan. Crushing Techniques for Pneumatic Concentration of Mica. BuMines RI 8601, 1982, 16 pp.

Molybdenum

By James A. O'Donnell[1]

Domestic and foreign molybdenum markets were imbalanced throughout most of 1981. Worldwide mine production exceeded demand, while consumer stocks were kept at a minimum. U.S. mine output of molybdenum decreased to a level of 139.9 million pounds, 7% below that of 1980, and represented 58% of world production. Reported end-use consumption of molybdenum in raw materials and apparent domestic demand declined 6% and 3%, respectively, compared with the same figures for 1980. World demand for molybdenum fell by an estimated 5% to 10%, resulting in smaller quantities of molybdenum being exported from the United States and domestic producer stocks of molybdenum concentrate and products increasing by about 175%. Confronted with large stock inventories, domestic producers reduced price listings several times during the year. World market prices were considerably below that of the U.S. producer listings for most of the year. Despite a lack of global economic stability, several companies completed new molybdenum mine projects and expansion programs.

Legislation and Government Programs.—The U.S. Government stockpile, maintained by the General Services Administration, no longer contains molybdenum materials. The stockpile goal of zero for molybdenum was reaffirmed by the Federal Emergency Management Agency in 1980.

The Alaska National Interest Lands Conservation Act (Public Law 96-487) was signed into law on December 2, 1980. A section of this law permits additional exploratory and development work by U.S. Borax & Chemical Corp. on its Quartz Hill molybdenum deposit located in the Tongass National Forest of southeastern Alaska.

Table 1.—Salient molybdenum statistics

(Thousand pounds of contained molybdenum and thousand dollars)

	1977	1978	1979	1980	1981
United States:					
Concentrate:					
Production	122,408	131,843	143,967	150,686	139,900
Shipments	124,974	130,694	143,504	149,311	118,916
Value	$450,421	$607,950	[1]$871,068	$1,344,181	$945,541
Consumption	91,041	96,375	103,152	108,206	80,725
Imports for consumption	1,976	2,705	2,329	1,825	1,988
Stocks, Dec. 31: Mine and plant	9,161	8,980	9,520	18,101	35,548
Primary products:					
Production	90,520	96,052	101,753	106,284	76,840
Shipments	100,626	105,920	109,419	95,391	64,368
Consumption	54,557	61,091	60,388	53,265	50,189
Stocks, Dec. 31: Producers	10,141	7,996	8,502	27,007	44,961
World: Production	r209,707	r220,712	229,423	p241,745	e240,387

eEstimated. pPreliminary. rRevised.

[1]For 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

In 1981, domestic mine production of molybdenum decreased for the first time in 5 years to a total of 139.9 million pounds. The country's three primary molybdenum mines (Climax, Henderson, and Questa) provided about 66% of the year's total U.S. output. The balance of domestic production was supplied as a byproduct or coproduct of copper mining. Tungsten and tin were reclaimed as byproducts at the Climax molybdenum mine in Colorado. In addition, small quantities of rhenium were reclaimed in the roasting of molybdenite concentrate from certain domestic copper ores.

AMAX Inc.'s Climax and Henderson Mines, located in Colorado, remained two of the world's largest primary molybdenum mines, together producing over 90 million pounds of molybdenum in 1981. This quantity represented nearly 64% of U.S. output and 41% of total world production. Ore reserves at the two mines indicate that production levels of 100 million pounds of molybdenum per year could be sustained for the remainder of this century. Output at Molycorp Inc.'s Questa Mine in New Mexico remained small because lower grade deposits were being worked by surface mining methods. As a result, Molycorp moved ahead with the development of its adjacent Goat Hill underground mine, which is scheduled to be operational in 1983.

Molybdenum produced in association with domestic copper mining was recovered at 17 mines operated by 10 companies. Byproduct molybdenum from copper operations accounted for over 34% of total U.S. output and increased approximately 4 million pounds from that of the previous year. Duval Corp. (a subsidiary of Pennzoil Co.) and Kennecott Corp. remained the leading producers of molybdenum from copper mining operations. Other domestic mining firms that recovered molybdenum from copper ore were Anamax Mining Co., ASARCO Incorporated, Cities Service Co., Cyprus Mines Corp. of Amoco Minerals Co., Eisenhower Mining Co. (a partnership of Anamax and Asarco), Inspiration Consolidated Copper Co., Magma Copper Co. (a subsidiary of Newmont Mining Corp.), and Phelps Dodge Corp. Duval's Sierrita Mine in Arizona and Kennecott's Bingham Mine were again in 1981 the copper mines producing the largest quantity of byproduct molybdenum in the United States.

During the second half of 1981, domestic producers attempted to correct oversupply conditions by reducing production, closing mines, and canceling new project development.

In September, AMAX announced that fourth quarter molybdenum production from its Climax and Henderson Mines in Colorado would be decreased by 10%. Then in December, AMAX announced further production cutbacks for the two western mines in 1982 that amounted to approximately 25% to 30%. Also in December, Duval closed its Sierrita, Esperanza, and Mineral Park molybdenum-copper mines in Arizona for a period of 3 months, beginning December 14.

In December, AMAX notified the Colville Confederated Tribe that it was withdrawing from a cooperative mining venture for the development of molybdenum-copper ore deposits located at Mount Tolman on the Colville Indian Reservation in the State of Washington. Reserves of the Mount Tolman deposit were estimated to be 900 million tons of ore, grading 0.10% molybdenum disulfide. Several months earlier, AMAX had postponed development of the Mount Emmons molybdenum project in Colorado for at least 2 years. Mount Emmons ore reserves were estimated at 155 million tons, with an average grade of about 0.19% molybdenum disulfide.

Despite a worldwide surplus of molybdenum stocks in 1981, some producers moved ahead on new mining and processing projects.

Near the end of 1981, U.S. Borax was in the final stage of exploration and beginning development of its Quartz Hill molybdenum project in southeast Alaska. Reserves of the mine were estimated at 1.5 billion tons averaging 0.13% molybdenum disulfide. Development of the Quartz Hill deposit is scheduled to begin in 1984 and production to begin in 1987. Annual output of the mine was expected to be 40 million pounds of molybdenum concentrate. By yearend, the company had made no decision relative to the construction of roasting facilities near the mine site.

The Anaconda Minerals Co. (formerly Anaconda Copper Co.) began production during the fourth quarter of 1981 at its new Tonopah open pit molybdenum mine near Tonopah, Nev. The mine produced 598,000 pounds of molybdenum concentrate in 1981 and is expected to produce 8 to 13 million pounds of concentrate in 1982.

In November, Asarco completed the expansion of the molybdenum recovery plant at its Mission copper mine. The plant modification will increase molybdenum concentrate production by approximately 25%. Molybdenum production of the mine in 1981 was 537,000 pounds.

Cyprus Mines continued to develop the Thompson Creek molybdenum mine and nearby concentrator in central Idaho. Ore reserves of the Thompson Creek Mine were estimated at 193 million tons, with an average grade of 0.18% molybdenum disulfide. Mine production is scheduled to begin in 1983 and, when in full operation, produce 18 to 20 million pounds of molybdenum concentrate annually.

Table 2.—Production, shipments, and stocks of molybdenum products in the United States

(Thousand pounds of contained molybdenum)

	Molybdic oxides[1] 1980	Molybdic oxides[1] 1981	Metal powder 1980	Metal powder 1981	Ammonium molybdate 1980	Ammonium molybdate 1981
Received from other producers	6,453	5,767	180	45	1,643	1,144
Gross production during year	115,523	86,507	6,093	4,062	3,845	3,273
Used to make other products listed here	30,969	26,864	1,189	548	1,878	1,558
Net production	84,554	59,645	4,904	3,513	1,967	1,715
Shipments	73,759	49,044	4,785	3,603	3,101	2,689
Producer stocks, Dec. 31	22,825	38,999	560	507	944	1,075
	Sodium molybdate		**Other[2]**		**Total**	
Received from other producers	27	23	14	262	8,317	7,241
Gross production during year	1,142	96	13,793	11,886	140,396	105,824
Used to make other products listed here	([3])	([3])	76	14	34,112	28,984
Net production	1,142	96	13,717	11,871	106,284	76,840
Shipments	1,179	131	12,567	8,901	95,391	64,368
Producer stocks, Dec. 31	48	27	2,630	4,353	27,007	44,961

[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 80.7 million pounds, about 25% below that of 1980. The remainder of the mine production of concentrate, containing about 59.2 million pounds of molybdenum, was either exported for conversion, added to producer inventories, 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 3% from that of 1980 to 59.1 million pounds of molybdenum. The decline in apparent demand was the second since 1975 and reflected the depressed economic conditions existing in 1981. Likewise, total reported end-use consumption of molybdenum in raw materials decreased about 6% from that of 1980. Molybdenum consumed in oxide form (technical-grade, purified, and briquets) accounted for about 72% of total reported consumption; in ferromolybdenum and calcium molybdate, 15%; and in other forms, 13%.

Molybdenum reported as consumed in the production of steel accounted for over 71% of total consumption in 1981. Approximately 18% 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 comprised the final 11% of total consumption. Most end-use areas exhibited a decline in molybdenum consumption when compared with that of 1980. Molybdenum used in the production of steel increased 2%, while the production of cast irons decreased by 6%. Molybdenum use in superalloys and in mill products made of powder fell by nearly 38%. Molybdenum consumption in the ca lyst area increased about 2%; other nonmetallurgical uses were less than those of 1980.

Table 3.—U.S. consumption of molybdenum, by end use and form

(Thousand pounds of contained molybdenum)

End use	Molybdic oxides	Ferromolybdenum[1]	Ammonium and sodium molybdate	Other molybdenum materials[2]	Total
1980					
Steel:					
Carbon	2,390	133	--	31	2,554
Stainless and heat resisting	6,582	1,156	--	140	7,878
Full alloy	17,340	2,123	--	35	19,498
High-strength, low-alloy	1,357	311	--	9	1,677
Tool	2,641	559	--	36	3,236
Cast irons	476	2,460	--	132	3,068
Superalloys	1,906	446	--	2,174	4,526
Alloys (excludes steels and superalloys):					
Welding and alloy hard-facing rods and materials	--	305	--	47	352
Other alloys[3]	215	324	--	185	724
Mill products made from metal powder	--	--	--	4,222	4,222
Chemical and ceramic uses:					
Pigments	397	--	268	--	665
Catalysts	2,585	--	W	77	2,662
Other	12	--	17	1,033	1,062
Miscellaneous and unspecified	179	137	483	342	1,141
Total	36,080	7,954	768	8,463	53,265
1981					
Steel:					
Carbon	1,145	128	--	12	1,285
Stainless and heat resisting	5,595	796	--	134	6,525
Full alloy	20,843	2,192	--	44	23,079
High-strength, low-alloy	1,521	624	--	66	2,211
Tool	2,099	400	--	49	2,548
Cast irons	457	2,257	--	177	2,891
Superalloys	923	236	--	1,191	2,350
Alloys (excludes steels and superalloys):					
Welding and alloy hard-facing rods and materials	--	331	--	12	343
Other alloys[3]	228	218	--	140	586
Mill products made from metal powder	--	--	--	3,035	3,035
Chemical and ceramic uses:					
Pigments	W	--	332	--	332
Catalysts	2,648	--	W	72	2,720
Other	8	--	--	829	837
Miscellaneous and unspecified	673	101	505	168	1,447
Total	36,140	7,283	837	5,929	50,189

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.

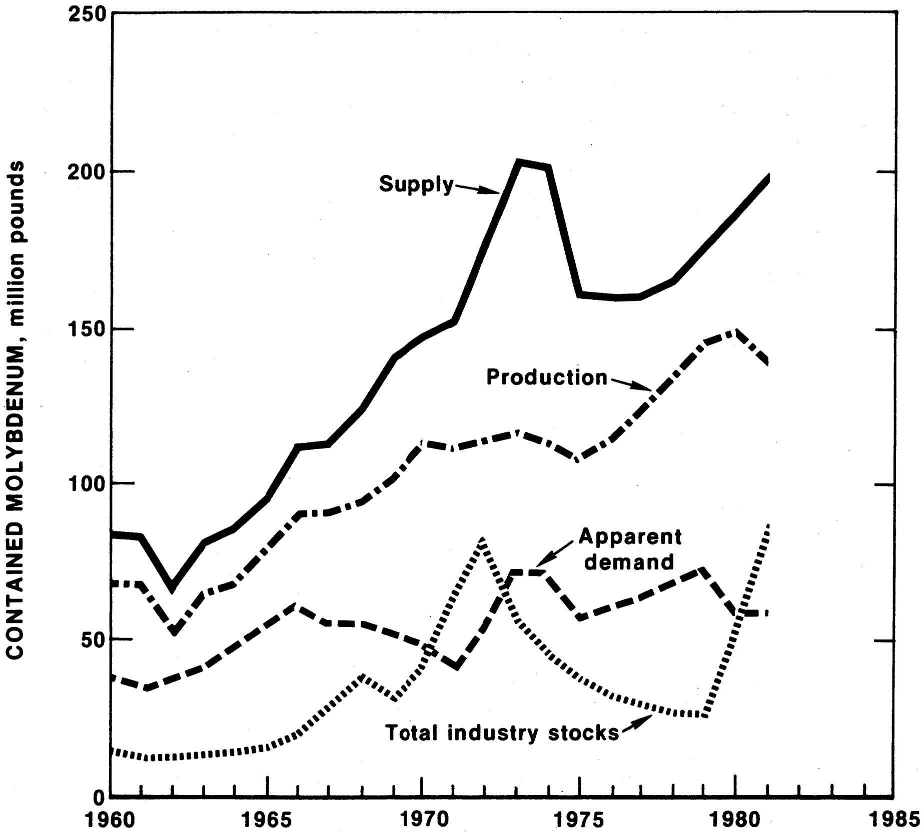

Figure 1.—Apparent demand, supply, production, and total industry stocks of molybdenum in the United States.

STOCKS

With the continued decline in consumption and lower exports, inventories of domestic molybdenum producers rose sharply during 1981. Inventories of industrial stocks were at their highest levels since 1972. Total industry stocks (including both producers' and consumers') increased by almost 64% to 86.3 million pounds of contained molybdenum during 1981. Inventories of molybdenum in concentrate at mine locations registered an advance from 18.1 to 35.5 million pounds, moving up steadily throughout most of the year. Producers' stocks of molybdenum in consumer products (oxide, ferromolybdenum, molybdate, metal powders, and other types) increased from 27 million pounds at the beginning of the year to 45 million pounds by yearend. Compared with monthly molybdenum shipments, yearend producer stocks of these materials totaled almost a 12-month supply. Domestic consumers held inventories of about 6 to 7 million pounds throughout most of 1981, 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	1977	1978	1979	1980	1981
Concentrate: Mine and plant	9,161	8,980	9,520	18,101	35,548
Producers:					
Molybdic oxides[1]	6,914	5,275	6,172	22,825	38,999
Metal powder	327	300	270	560	507
Ammonium molybdate	640	495	381	944	1,075
Sodium molybdate	97	47	58	48	27
Other[2]	2,163	1,879	1,621	2,630	4,353
Total	10,141	7,996	8,502	27,007	44,961
Consumers:					
Molybdic oxides[1]	5,761	5,893	5,102	3,816	3,217
Ferromolybdenum[3]	1,940	1,864	1,872	1,507	914
Ammonium and sodium molybdate	338	444	325	280	167
Other[4]	1,421	1,824	1,761	1,813	1,467
Total	9,460	10,025	9,060	7,416	5,765
Grand total	28,762	27,001	27,082	52,524	86,274

[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 economic downturn in 1981 greatly affected domestic molybdenum markets. Producers and dealers, under pressure from weak demand accompanied by excess stocks, lowered product prices several times during the year.

In the first quarter, U.S. producers, including Duval Sales Corp., Climax Molybdenum Co., Molycorp, and Kennecott Minerals Co., reduced domestic molybdenum prices by $0.35, listing technical-grade molybdic oxide at $9.35 and ferromolybdenum at $10.25 (all prices per pound of contained molybdenum). Two Canadian firms—Noranda Mines Ltd. and Placer Development, Ltd.—decreased export prices for canned oxide by $0.60 to $9.60 and ferromolybdenum by $0.67 to $10.85.

Midway into the year, Duval Sales decreased domestic quotes on molybdenum products by $1.10, pricing canned molybdic oxide at $8.25 and ferromolybdenum at $9.15. Climax Molybdenum lowered its market postings by $0.85 to $8.50 for canned oxide and $9.50 for ferromolybdenum. Kennecott Minerals matched Climax's price actions.

During the fourth quarter, two Canadian producers—Noranda Mines and Placer Development—lowered their export prices for molybdic oxide by $1.60 to $7 and ferromolybdenum by $1.65 to $8.10. Also, Corporación del Cobre de Chile (CODELCO) decreased its export prices of molybdic oxide by $1.38 to $6.87. Duval Sales reduced domestic pricing of canned molybdic oxide and ferromolybdenum by $1.40 to $6.85 and $6.91 and $7.75, respectively. Climax Molybdenum notified consumers that it would continue to list published prices of canned oxide at $8.50 and ferromolybdenum at $9.40, but in actual sales transactions it would price products competitively.

Domestic producers also lowered molybdenum export prices during 1981. The differential between export and domestic oxide quotes narrowed during the year from $0.50 ($10.20 versus $9.70) to $0.15 ($7 versus $6.85) and similarly for ferromolybdenum, from $0.92 ($11.52 versus $10.60) to $0.35 ($8.10 versus $7.75). Major foreign producers generally listed molybdenum prices at levels approaching that of U.S. producers' export quotes. Over the year, dealers and traders reduced molybdenum oxide export quotes from a range level of $7.10 to $8.40 in the first quarter to a level of $3.45 to $5.15 in the fourth quarter.

Yearend published prices for products, per pound of contained molybdenum, are shown in table 5.

Table 5.—Major domestic producer price listings for molybdenum

	1980	1981
Producer quotes:		
Concentrate-export	$5.80-$9.20	$3.35-$7.90
Oxide-domestic	9.00- 9.70	6.85- 8.50
Oxide-export	9.75-10.20	5.51- 8.75
Ferromolybdenum-domestic	10.60	7.75- 9.40
Ferromolybdenum-export	11.52	8.10- 9.90
Dealer quotes:		
Oxide-domestic	9.75-10.20	3.45- 5.15

FOREIGN TRADE

Exports.—Exports of molybdenum in concentrate and oxide dropped to 51.4 million pounds, nearly 25% under that of the previous year. Molybdenum exports were about 37% of domestic mine production and in terms of calculable molybdenum content, 98% of total exports. Approximately 85% of exported concentrate and oxides were shipped to Austria, the United Kingdom, the Netherlands, Japan, Belgium-Luxembourg, and the Federal Republic of Germany. Exports of other molybdenum materials were almost negligible and varied slightly from that of 1980. The calculated molybdenum content of all exports decreased from 70.4 million pounds in 1980 to 52.4 million pounds in 1981. Because of both the lower quantity of exports and lower unit price, the total value of exports fell sharply from $854 million in 1980 to $477 million in 1981.

Imports.—Approximately 7.4 million pounds of molybdenum in various forms was imported into the United States during 1981, an increase of 25% compared with that of 1980. This quantity represented 3% of total U.S. supply and 12% of apparent demand for 1981. Total value of all forms of molybdenum imported decreased by 26%, from $70 million in 1980 to $52 million in 1981. In terms of both value and quantity, the major forms of molybdenum 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 in 1980 and 1981.

Table 6.—Molybdenum reported by producers as shipments for export from the United States

(Thousand pounds of contained molybdenum)

	1980	1981
Molybdenite concentrate	35,026	37,328
Molybdic oxide	33,167	19,072
All other primary products	2,390	932

Table 7.—U.S. exports of molybdenum ore and concentrates (including roasted concentrates), by country

(Thousand pounds of contained molybdenum and thousand dollars)

Country	1979		1980		1981	
	Quantity	Value	Quantity	Value	Quantity	Value
Austria	--	--	2,034	20,407	2,723	21,793
Belgium-Luxembourg	14,834	117,879	11,412	129,004	2,518	24,069
Brazil	439	4,667	445	4,762	115	1,052
Canada	600	4,798	314	2,593	369	2,204
Chile	430	3,691	312	2,055	2,315	7,691
France	([1])	7	901	8,430	408	3,381
Germany, Federal Republic of	6,733	87,212	9,077	94,824	5,080	30,374
Japan	12,369	111,509	12,654	134,099	7,958	73,567
Mexico	865	10,231	624	5,471	863	5,969
Netherlands	27,938	226,700	24,642	252,911	22,027	189,116
Sweden	2,049	23,207	2,601	27,536	1,840	13,556
Switzerland	317	4,019	83	1,215	81	395
U.S.S.R	3,463	41,098	277	2,802	1,080	9,547
United Kingdom	1,398	16,187	2,003	20,974	3,501	20,047
Other	807	7,677	838	8,348	472	4,055
Total	72,242	658,882	68,217	715,431	51,350	406,816

[1]Less than 1/2 unit.

Table 8.—U.S. exports of molybdenum products

(Thousand pounds, gross weight, and thousand dollars)

Product and country	1980 Quantity	1980 Value	1981 Quantity	1981 Value
Ferromolybdenum:[1]				
Australia	426	3,178	208	1,223
Canada	118	867	99	561
Colombia	4	33	--	--
Japan	161	1,268	14	93
Malaysia	31	42	3	20
Mexico	20	149	--	--
Netherlands	403	4,652	--	--
Philippines	102	793	39	442
Poland	114	1,600	--	--
South Africa, Republic of	366	4,450	14	104
Other	15	72	78	540
Total	1,760	17,104	455	2,983
Metal and alloys in crude form and scrap:				
Belgium	10	98	8	53
Canada	16	190	24	269
France	5	55	7	61
Germany, Federal Republic of	172	899	1,604	4,248
India	8	104	5	56
Japan	159	1,845	138	1,317
Mexico	16	164	83	370
Netherlands	15	163	12	82
Spain	5	47	5	43
Sweden	18	198	342	1,935
United Kingdom	176	996	50	223
Other	14	111	363	1,106
Total	614	4,870	2,641	9,763
Wire:				
Argentina	10	151	4	97
Australia	19	380	4	76
Austria	8	183	(2)	11
Bahamas	19	27	125	137
Belgium-Luxembourg	6	199	(2)	1
Brazil	39	827	14	373
Canada	51	1,060	27	485
France	66	2,008	4	136
Germany, Federal Republic of	167	3,807	98	1,700
India	4	99	5	81
Ireland	9	88	--	--
Italy	60	1,305	83	1,954
Japan	138	2,766	76	1,514
Mexico	6	323	19	488
Netherlands	11	484	9	501
Singapore	12	311	(2)	62
South Africa, Republic of	11	235	1	21
Spain	19	450	16	337
Sweden	21	565	12	284
United Kingdom	14	332	15	216
Other	15	384	31	556
Total	705	15,984	543	9,030
Powder:				
Argentina	3	49	--	--
Australia	(2)	4	(2)	9
Belgium-Luxembourg	60	423	--	--
Canada	14	87	18	138
France	5	85	13	167
Germany, Federal Republic of	66	708	4	33
Italy	6	52	3	48
Japan	109	592	48	275
Mexico	--	--	29	181
Netherlands	21	117	3	20
Sweden	7	77	8	81
Taiwan	80	1,043	83	1,382
United Kingdom	40	734	48	345
Other	14	132	13	141
Total	425	4,103	270	2,820

See footnotes at end of table.

Table 8.—U.S. exports of molybdenum products —Continued

(Thousand pounds, gross weight, and thousand dollars)

Product and country	1980 Quantity	1980 Value	1981 Quantity	1981 Value
Semifabricated forms, n.e.c.:				
Australia	1	27	4	81
Austria	51	501	--	--
Belgium-Luxembourg	11	213	(2)	1
Brazil	16	412	20	625
Canada	23	638	24	517
France	19	843	8	283
Germany, Federal Republic of	63	1,799	36	767
Japan	46	674	16	236
Mexico	1	46	6	178
Netherlands	16	879	3	192
Philippines	3	44	2	41
Singapore	(2)	17	(2)	5
South Africa, Republic of	14	249	9	643
United Kingdom	21	673	21	559
Other	21	456	16	640
Total	306	7,471	165	4,768
Molybdenum compounds:				
Argentina	--	--	4	11
Australia	135	907	9	14
Belgium-Luxembourg	578	4,261	382	1,110
Brazil	63	486	22	118
Canada	382	2,548	499	3,328
German Democratic Republic	386	5,449	--	--
Germany, Federal Republic of	1,075	13,162	112	777
Japan	5,256	43,997	4,765	28,768
Mexico	83	450	81	414
Netherlands	811	6,477	577	1,879
Sweden	127	712	(2)	2
Switzerland	180	2,284	4	61
Taiwan	127	706	7	39
United Kingdom	603	4,276	233	985
Other	348	3,588	633	3,180
Total	10,154	89,303	7,328	40,686

[1]Ferromolybdenum contains about 60% to 65% molybdenum.
[2]Less than 1/2 unit.

Table 9.—U.S. imports for consumption of molybdenum products

(Thousand pounds and thousand dollars)

TSUS No.	Material	1980 Gross weight	1980 Contained molybdenum	1980 Value	1981 Gross weight	1981 Contained molybdenum	1981 Value
601.33	Ore and concentrate	4,520	1,825	10,475	4,959	1,988	9,911
603.40	Material in chief value molybdenum	3,264	1,953	18,701	5,085	1,651	9,574
606.31	Ferromolybdenum	45	29	243	1,175	918	6,353
628.70	Waste and scrap	373	NA	7,246	NA	296	2,674
628.72	Unwrought	NA	163	2,637	NA	153	2,893
628.74	Wrought	137	NA	4,031	93	NA	2,557
417.28	Ammonium molybdate	3,140	1,805	23,307	3,866	2,217	15,387
419.60	Molybdenum compounds	185	115	1,520	206	152	1,056
421.10	Sodium molybdate	50	23	568	31	13	114
423.88	Mixtures of inorganic compounds, chief value molybdenum	(1)	(1)	2	3	1	15
473.18	Molybdenum orange	1,056	NA	1,637	1,058	NA	1,480
	Total	12,770	5,913	70,367	16,476	7,389	52,014

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

Table 10.—U.S. import duties on molybdenum articles

TSUS No.	Article	Most Favored Nation (MFN)		Non-MFN
		Jan. 1, 1982	Jan. 1, 1987	Jan. 1, 1982
601.33	Ore and concentrate	11.3 cents per pound	9 cents per pound	35 cents per pound.
603.40	Material in chief value molybdenum.	9 cents per pound plus 2.7% ad valorem.	6 cents per pound plus 1.9% ad valorem.	50 cents per pound plus 15% ad valorem.
606.31	Ferromolybdenum	10 cents per pound plus 3% ad valorem.	4.5% ad valorem	31.5% ad valorem.
	Molybdenum:			
628.70	Waste and scrap	9.4% ad valorem[1]	6% ad valorem	50% ad valorem.[1]
628.72	Unwrought	9 cents per pound plus 2.7% ad valorem.	6.3 cents per pound plus 1.9% ad valorem.	50 cents per pound plus 15% ad valorem.
628.74	Wrought	11% ad valorem	6.6% ad valorem	60% ad valorem.
	Molybdenum chemicals:			
417.28	Ammonium molybdate	5.7% 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.	3.9% ad valorem	3.2% ad valorem	20.5% ad valorem.
420.22	Potassium molybdate	3.6% ad valorem	3% ad valorem	23% ad valorem.
421.10	Sodium molybdate	4.8% ad valorem	3.7% ad valorem	25.5% ad valorem.
423.88	Mixtures of inorganic compounds, chief value molybdenum.	3.4% ad valorem	2.8% ad valorem	18% ad valorem.
473.18	Molybdenum orange	5% ad valorem	5% ad valorem	25% ad valorem.

[1]Duty on waste and scrap temporarily suspended.

WORLD REVIEW

World mine production of molybdenum was 240.4 million pounds, less than 1% below that of 1980. Over 95% 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 second year in succession supply exceeded demand. As world molybdenum consumption continued to decline in 1981, production remained steady, resulting in a sharp increase in producer stocks. Four new mines came into production during 1981, with three additional mines scheduled for operation in the next several years.

Canada.—Molybdenum production increased by about 4% in 1981 to an estimated 35.5 million pounds, owing mainly to the addition of two new Canadian mines, plus the expansions of two other mines.

AMAX of Canada, Ltd., reopened its open pit mine and mill near Kitsault, British Columbia. Between May and December of 1981, AMAX produced approximately 3.8 million pounds of molybdenum concentrate. Unfortunately, most of this production did not meet the company's concentrate quality specifications. By yearend, mill processing problems were reportedly corrected and commercial production was expected to begin in January 1982. When fully operational, the Kitsault Mine will be able to produce 9 to 10 million pounds of molybdenum per year.

In midyear, Teck Corp. Ltd. brought onstream the second mill circuit at its Highmont copper-molybdenum mine in British Columbia. Highmont's two-line circuit was expected to raise production capacity to an annual rate of nearly 4.5 million pounds.

Lornex Mining Corp. Ltd. expanded its Lornex molybdenum mining and milling operations in British Columbia. As a result of this major program, production was expected to increase by over 50% to 6.8 million pounds per year.

Placer Development Ltd. expanded the flotation circuit and roasting plant at its Endako Mine in British Columbia. However, reports indicated that Placer had lowered its molybdenum production by almost 30% in 1981.

By yearend, Noranda Mines had almost completed mill expansion at its Boss Mountain molybdenum mine in British Columbia. Milling capacity was expanded from 1,800 to 3,000 tons per day. Over the next several years, Boss Mountain molybdenum production capacity will reportedly be increased to approximately 2.9 million pounds per year from the current 2-million-pound level.

Chile.—Molybdenum production in Chile increased slightly from that of 1980. CODELCO was the sole producer of molybdenum from its four divisions, Chuquicamata, El Teniente, El Salvador, and Andina. To be able to maintain the production capacity of its four divisions, considering the decrease in the ore grade of its deposits, CODELCO is going ahead with plans to expand their extraction capacity. Of these expansions, the one at Chuquicamata will contribute the most toward maintaining production capacity. The changes at Chuquicamata include additional drilling capacity, more loading and transportation equipment, replacement of the primary crusher, and increased capacity of the concentrator. New technology is planned to upgrade several areas of the process. Working conditions will be improved by expansions in housing and industrial and community services.

China.—During the past few years, two large molybdenum deposits have been found in the Provinces of Hunan and Hebei. Reserves have not yet been verified, because prospecting work is still in progress.

Japan.—New molybdenum ore reserves have been discovered by Sumitomo Metal Mining Co. at the abandoned Hirase molybdenum mine. Located in central Japan, initial reserves are estimated at 150,000 metric tons averaging 1.4% to 1.5% molybdenum. Exploratory work will continue for another year to determine the size and quality of the deposit. The Hirase Mine had been in operation from 1951 to 1974 and produced about 100 metric tons of molybdenum per year.

The Government of Japan approved a stockpile program that includes molybdenum. The Special Metal Stockpile Association planned to start the program in April 1982. The money for the program was expected to be secured from private banks with 66% of the interest being paid by the Government.

Korea, Republic of.—A large molybdenite deposit was discovered in late 1980. The deposit, which is located in the Pangdong Area of Yongwol County, Kangwou Province, is estimated to contain about 80 million metric tons of low-grade 0.41% molybdenite. At present time, there are no plans to develop the ore body.

Peru.—Southern Peru Copper Corp. (SPCC) was the major producer of molybdenum in Peru during 1981—from its two mines, Toquepala and Cuajone. Production declined about 7% from that of 1980 and was attributed to low prices and to work interruption created by a 45-day strike at the two mines.

A feasibility study was conducted to evaluate the planned expansion of Toquepala's Mine and mill operations. This expansion was directed toward the extension of the mine's life expectancy from 12 to 30 years. The study concluded that the expansion would be uneconomical under present Peruvian mining laws. Other alternatives are being considered by the company. A change in legislative and tax laws could induce SPCC to go ahead with the expansion plans.

A new nitrogen unit installed at the Cuajone molybdenum recovery plant during January 1981 to replace air with nitrogen gas in the flotation process has reportedly decreased operation costs by producing sizable savings in reagent consumption.

Table 11.—Molybdenum: World mine production, by country[1]

(Thousand pounds contained molybdenum)

Country[2]	1977	1978	1979	1980[p]	1981[e]
Bulgaria[e]	330	330	330	330	330
Canada (shipments)	36,526	[r]30,739	24,634	26,211	[3]31,160
Chile	[r]24,112	29,092	29,895	30,133	33,300
China[e]	3,300	4,400	4,400	4,400	4,400
Japan	401	271	258	209	175
Korea, Republic of	223	485	417	661	[3]692
Mexico	2	24	105	225	770
Peru	[r]1,005	1,607	2,606	5,860	5,485
Philippines	--	121	311	130	175
U.S.S.R.[e]	21,400	21,800	22,500	22,900	24,000
United States	122,408	131,843	143,967	150,686	[3]139,900
Total	[r]209,707	[r]220,712	229,423	241,745	240,387

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through Apr. 7, 1982.
[2]In addition to the countries listed, Mongolia, Niger, North Korea, Romania, Turkey, and Yugoslavia are believed to produce molybdenum, but output is not reported quantitatively, and available general information is inadequate to make reliable estimates of output levels.
[3]Reported figure.

TECHNOLOGY

Molybdenum research in 1981 was directed mostly toward metallurgical and chemical applications. Faced with potential supply problems associated with mineral imports, various research and development programs focused on materials substitution of strategic minerals, including chromium and manganese, in various molybdenum steels.

A new 0.2% Mo steel for electric-resistance-welded pipe for L-80 and N-80 petroleum applications was produced commercially late in 1981 and is expected to capture a portion of a market that has traditionally depended on molybdenum-free C-Mn steel.[2]

Two steels for heavy wellhead components were identified. One is the 2 1/4 Cr-1 Mo steel modified with 0.9% Ni and 1.2% Mo; the other is a 1% Cr steel alloyed with similar amounts of manganese and nickel, but also alloyed with 0.03% Cb and with molybdenum ranging from 0.75% to 1.35%.[3]

Research on corrosion inhibitors for automotive cooling systems has demonstrated molybdate additions to be critical to satisfactory performance in systems containing aluminum along with iron, copper, and solders—combinations encountered in the new lightweight engines. In 1981, Toyota began to use molybdates in a portion of their production. Molybdates are nontoxic alternatives to nitrites in water-base metalworking fluids, and partial substitution of sodium molybdates for organic inhibitors significantly improves rust protection.[4]

Justification for molybdenum levels above the traditional 1% in steels for elevated temperature service was documented as a result of 1981 research. Low-carbon 12 Cr-Mo steels and modifications with 1.5% Mo and 1% W exhibit excellent creep resistance.[5]

Research aimed at replacing Cr-Mo carburizing steels with lower price Mn-Cr steels slowed. Lower prices and greater availability of molybdenum, aided by technical progress, prompted producers and users to stay with molybdenum technology. Research in 1981 revealed the deterioration of properties in Mn-Cr steels when phosphorus and nitrogen levels approach the higher levels encountered in normal commercial production; Cr-Mo steels are insensitive.[6]

In the high-hardenability carburizing steels used in heavy gearing and oil well drill bits, those with higher levels of chromium and molybdenum can be annealed for machining much more readily than those with higher levels of manganese and nickel.[7]

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[1]Commodity specialist, Division of Ferrous Metals.

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Nickel

By Scott F. Sibley[1]

The nickel market experienced further weakening in 1981, as domestic consumption declined about 7% compared with that of 1980. Stainless steel and corrosion-resistant alloy producers and electroplaters continued to operate well below capacity. Reduction in demand occurred in nearly all end-use areas in line with the recessionary conditions in the economy. A similar situation existed in Europe and Japan. Continuing high interest rates throughout the year dampened consumption in the capital goods sector on which nickel depends. Producer inventories in the United States increased above 200 million pounds, partly owing to the dropoff in demand. Producers worldwide operated on the average at about 60% of capacity. In summary, the nickel market was characterized by producer shutdowns and cutbacks worldwide, depressed demand, collapsing prices, and general oversupply conditions.

Major consumption occurred in stainless and alloy steel, 46%; nonferrous alloys, 34%; and electroplating, 15%. Cathode nickel prices, listed by several major producers, were lowered on or about November 25 from $3.45 to $3.20 per pound during a period of very low demand.

Table 1.—Salient nickel statistics

(Short tons unless otherwise specified)

	1977	1978	1979	1980	1981
United States:					
Mine production[1]	14,347	13,509	15,065	14,653	12,099
Plant production:					
Domestic ores	12,897	11,298	11,691	11,225	10,305
Imported materials	25,000	26,000	32,500	33,000	38,500
Secondary[2]	12,449	12,304	13,201	11,338	NA
Exports (gross weight)	39,412	36,293	50,810	56,675	46,778
Imports for consumption	194,770	234,352	177,205	r189,188	200,348
Consumption (primary)	155,260	180,723	196,293	156,299	144,748
Stocks, Dec. 31: Consumer	18,581	20,443	r19,518	r15,231	22,508
Price, cents per pound	241-208	210-193	193-320	320-345	345-320
World: Mine production	r912,875	r722,786	r748,774	p820,947	e771,969

eEstimated. pPreliminary. rRevised. NA Not available.
[1]Mine shipments.
[2]Nonferrous scrap only; does not include nickel from stainless or alloy steel scrap.

Legislation and Government Programs.—The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (Superfund), under which producers of metals and chemical substances are to be taxed in order to fund toxic waste cleanup, became effective April 1. Industry was to provide 88% of the 5-year $1.6 billion fund. The Environmental Protection Agency was to administer the act, but the Internal Revenue Service was to be responsible for collection of the industry tax. Nickel companies paid a tax of 0.225 cent per pound on pure nickel products produced or brought into the United States.

The U.S. Bureau of the Mint issued a

tender in August for 8 million pounds of cupronickel 5-cent coinage strip for delivery to the Denver Mint. Delivery was scheduled to begin January 4, 1982, in 160,000-pound increments. Also solicited were sealed bids for the sale of 3.5 million pounds of electrolytic cut nickel cathodes or briquettes for delivery to the Philadelphia Mint. Shipments were made in 120,000-pound increments beginning October 5, 1981. F. W. Hempel, Inc., bid $2.7189 per pound and won the latter contract.

The National Oceanic and Atmospheric Administration of the U.S. Department of Commerce issued regulations September 15 to implement the Deep Seabed Hard Mineral Resources Act of 1980. The regulations cover procedures mining companies must follow to obtain seabed exploration licenses. The license applications were to be processed over a 15-month period, but no mining permits would be issued for several years. Licenses for exploration would extend over a 10-year period. Under the act, commercial mining cannot begin before January 1, 1988.

DOMESTIC PRODUCTION

The nickel mine of Hanna Mining Co., at Riddle, Oreg., shipped 12,099 tons of nickel in laterite ore in 1981. Nickel recovered at the smelter as ferronickel, and byproduct nickel salts and metal produced at copper and other metal refineries, totaled 10,305 tons. The Port Nickel refinery of AMAX Nickel, Inc., at Braithwaite, La., was operated at about 75% of capacity, processing nickel matte from Botswana, Australia, and the Republic of South Africa. Production of nickel at the facility totaled about 38,500 tons.

A strike at Riddle by the United Steelworkers of America (USWA), that began August 1, ended August 8. A 1-year agreement, which was to terminate on July 31, 1982, provided for quarterly cost-of-living adjustments equal to 1 cent for each 0.3 point increase in the consumer price index. The operation also experienced a significant increase in energy costs. Although rate increases were moderated by a clause in the Pacific Northwest Electric Power Planning and Conservation Act of 1980, utility charges by the Bonneville Power Administration (BPA) rose about 40% during the year. The specific clause permitted an easing of rates for industrial operations using indigenous resources of the Northwest United States. The BPA created a special industrial power rate for the nickel operations. The grant of the special rate was contingent on the acceptance by Hanna of a lower quality of power than would be provided under the standard contract. Certain aspects of the rate were negotiated with the BPA.

AMAX Nickel also scaled back its Minnamax copper-nickel project near Babbitt, Minn., by laying off 5 of the 17 workers stationed at the site. However, about $100,000 was to be spent annually to pump water out of the 1,728-foot shaft that was sunk in 1977. About $20 million had been spent in sinking the shaft, geological exploration, and numerous environmental studies. AMAX Nickel negotiated with Bear Creek Mining Co. for renewal of its lease, which was to expire in October 1982. Phase II of the project, if carried out, would include construction of a small pilot plant for testing the metallurgical process that had been developed. The facility would cost about $40 million and employ about 35 people.

International Metals Reclamation Co., Inc. (INMETCO), Ellwood City, Pa., a subsidiary of Inco United States, Inc., began construction in August of a $2 million facility to recover nickel from chemical wastes. Capacity of the new plant was to be 12,500 tons per year of materials containing spent nickel catalysts, from which about 1,800 tons of nickel could be recovered. The catalysts were mainly those generated in industrial facilities that process edible and inedible fats and oils, and fatty amines. The spent material was to be converted into a salable nickel-containing product for use in stainless and alloy steels. Construction of the facility, to be run by INMETCO's Pittsburgh Pacific Processing Div., on Neville Island in Pittsburgh, Pa., was to be completed by February 1982. INMETCO's other operating plant in Ellwood City recycled wastes generated by the specialty steel industry.

CONSUMPTION AND USES

Demand for nickel remained depressed throughout the year and approximated the low point of 1975. Total demand, including secondary nickel, was estimated at 195,000 tons, the lowest since 1964. Only nickel-copper and copper-nickel alloy and electroplating (sales to platers) consumption showed significant gains. Stainless steel, alloy steel, high-nickel heat- and corrosion-resistant alloys, and superalloys all experienced a reduction in consumption of nickel. Reported consumption (primary nickel) was the lowest since 1971.

Pure unwrought nickel lowered its share of the total primary nickel market for the first time in 3 years, from 71% in 1980 to 70% in 1981; ferronickel dropped from 19% in 1980 to 18% in 1981; and nickel oxide sinter dropped from 7% to 6% of the market. The pure nickel forms (Class I) were utilized principally in the production of nickel wrought products, high-nickel heat- and corrosion-resistant alloys, copper-base alloys, and in electroplating; whereas ferronickel and oxide sinter were used largely in the production of stainless and alloy steels. The latter is referred to as charge or Class II nickel.

Although primary nickel consumption declined during the year, the pattern of consumption by type of product remained similar, as follows: Stainless and heat-resisting steels, 35%; high-nickel heat- and corrosion-resistant alloys, 22%; electroplating, 15%; alloy steels, 11%; superalloys, 9%; and other, 8%.

STOCKS

In October, 32,209 tons of nickel was transferred from the U.S. Mint to the national stockpile. The goal for nickel in the stockpile remained at 200,000 tons. Consumer stocks at yearend increased by 48% compared with those at the end of 1980, from 15,231 tons to 22,508 tons, owing to exceptionally large discounts offered by producers during the fall. Stocks held by producers or their agents in the United States more than doubled to 110,000 tons because of depressed demand conditions and contractual obligations.

PRICES

Prices deteriorated significantly during the year, as most consumers bought nickel at prices considerably below the producer list price. Throughout most of the year, list prices for principal product forms (per pound) were $3.50 for plating cathode, $3.45 for melting cathodes, $3.40 for domestic ferronickel, $3.44 for imported ferronickel, and $3.35 for charge nickel. Computed average import prices, based on custom declared value per pound for 1981, were $3.04 for cathode nickel, pellets, and briquets; $2.95 for ferronickel; and $3.27 for nickel oxide.

An announced 6% discount, which had been put into effect by INCO, Ltd., on November 7, 1980, was officially lifted by INCO effective February 28, but discounting at equivalent or greater levels continued throughout the year. In its 1981 annual report, INCO stated that the average realized price on all product forms sold in 1981 was $3.10 per pound, compared with $3.14 per pound in 1980.

Heavy discounting began in August after the U.S. Mint purchased melting nickel for $3.71 per pound. The discounting continued to the end of the year in response to low demand. Producers, led by INCO, attempted to counter this price collapse in late November by lowering asking prices by 7% to what was believed to be a more realistic level. New base prices were $3.12 per pound for charge nickel, $3.20 per pound for melting nickel, and $3.29 per pound for plating-grade material.

Table 2.—Nickel recovered from nonferrous scrap processed in the United States, by kind of scrap and form of recovery

(Short tons)

	1980	1981
KIND OF SCRAP		
New scrap:		
Nickel-base	1,585	1,315
Copper-base	1,887	NA
Aluminum-base	1,750	NA
Total	5,222	NA

See footnotes at end of table.

Table 2.—Nickel recovered from nonferrous scrap processed in the United States, by kind of scrap and form of recovery —Continued

(Short tons)

	1980	1981
KIND OF SCRAP —Continued		
Old scrap:		
Nickel-base	5,244	4,889
Copper-base	575	NA
Aluminum-base	297	NA
Total	6,116	NA
Grand total	11,338	NA
FORM OF RECOVERY		
As metal	556	NA
In nickel-base alloys	2,637	NA
In copper-base alloys	4,125	NA
In aluminum-base alloys	2,173	NA
In ferrous and high-temperature alloys[1]	1,197	NA
In chemical compounds	650	NA
Total	11,338	NA

NA Not available.
[1]Includes only nonferrous scrap added to ferrous high-temperature alloys.

Table 3.—Stocks and consumption of new and old nickel scrap in the United States in 1981

(Gross weight, short tons)

Class of consumer and type of scrap	Stocks, beginning of year	Receipts	Consumption: New	Consumption: Old	Consumption: Total	Stocks, end of year
Smelters and refiners:						
Nickel and nickel alloys	25	6,258	1,820	4,246	6,066	217
Nickel-copper metal	201	870	505	396	901	170
Nickel-silver[1]	536	2,756	315	2,301	2,616	676
Cupronickel[1]	8	7	--	7	7	8
Nickel residues	W	468	47	421	468	W
Total	226	7,596	2,372	5,063	7,435	387
Foundries and other manufacturers:						
Nickel and nickel alloys	120	982	844	197	1,041	61
Nickel-copper metal	34	--	--	--	--	34
Nickel-silver[1]	2,282	328	526	e380	e906	e1,704
Cupronickel[1]	1,488	1,743	e1,885	e20	e1,905	e1,326
Nickel residues	150	161	119	191	310	1
Total	304	1,143	963	388	1,351	96
Grand total:						
Nickel and nickel alloys	145	7,240	2,664	4,443	7,107	278
Nickel-copper metal	235	870	505	396	901	204
Nickel-silver[1]	2,818	3,084	841	2,681	3,522	2,380
Cupronickel[1]	1,496	1,750	e1,855	e27	e1,912	1,334
Nickel residues	150	629	166	612	778	1
Total	530	8,739	3,335	5,451	8,786	483

e Estimated. W Withheld to avoid disclosing company proprietary data; included in "Nickel and nickel alloys."
[1]Excluded from totals because it is copper-base scrap, although containing considerable nickel.

Table 4.—Nickel (exclusive of scrap) consumed in the United States, by form

(Short tons, contained nickel)

Form	1977	1978	1979	1980	1981
Metal	96,058	122,972	135,987	111,609	101,847
Ferronickel	31,784	33,272	39,977	29,919	26,290
Oxide powder and oxide sinter	22,446	19,817	14,189	8,492	9,346
Salts[1]	2,395	2,026	3,944	3,330	4,161
Other	2,577	2,636	2,196	2,949	3,104
Total	155,260	180,723	196,293	156,299	144,748

[1]Metallic nickel salts consumed by plating industry are estimated.

Table 5.—U.S. consumption of nickel (exclusive of scrap) in 1981, by use and form

(Short tons, contained nickel)

Use	Commercially pure unwrought nickel	Ferronickel	Nickel oxide	Nickel sulfate and other nickel salts	Other forms	Total
Steel:						
Stainless and heat-resisting	25,375	21,179	2,952	1	1,140	50,647
Alloys (excludes stainless)	8,264	3,381	4,775	--	61	16,481
Superalloys	12,586	739	2	78	83	13,488
Nickel-copper and copper-nickel alloys	10,046	3	310	73	198	10,630
Permanent magnet alloys	484	--	--	--	--	484
Other nickel and nickel alloys	19,063	678	647	22	78	20,488
Cast irons	1,732	300	328	4	1,332	3,696
Electroplating (sales to platers)[1]	18,775	--	--	3,518	27	22,320
Chemicals and chemical uses	1,329	--	162	408	93	1,992
Other[2]	4,193	10	170	57	92	4,522
Total reported by companies canvassed and estimated	101,847	26,290	9,346	4,161	3,104	144,748

[1]Based on monthly estimated sales to platers.
[2]Includes batteries, ceramics, and other alloys containing nickel.

Table 6.—Nickel (exclusive of scrap) in consumer stocks in the United States, by form

(Short tons, contained nickel)

Form	1979	1980[r]	1981
Metal	14,716	10,825	18,355
Ferronickel	2,467	2,046	2,257
Oxide powder and oxide sinter	1,314	1,503	1,039
Salts	427	547	508
Other	594	310	349
Total	19,518	15,231	22,508

[r]Revised.

Table 7.—Consumption, stocks, receipts, shipments, and/or sales of secondary nickel in 1981, by use

(Short tons, contained nickel)

Use	Receipts	Consumption	Shipments or sales	Stocks, end of year
Steel (stainless and heat-resisting and alloy)	36,838	31,155	3,657	10,744
Nonferrous alloys (super, nickel-copper and copper-nickel, permanent magnet, other nickel)	5,942	5,919	18	564
Foundry (cast irons)	602	604	--	15
Chemicals (catalysts, ceramics, plating salts, other chemical uses)	2	2	--	3
Total reported by companies canvassed and estimated	43,384	37,680	3,675	11,326

FOREIGN TRADE

The estimated contained nickel in U.S. exports of unwrought nickel, powders, flakes, and anodes in 1981 was 13% of total primary demand.

Canada remained the principal supplier of nickel to the United States in 1981, and accounted for 37% of total imports. The next most important sources in decreasing order of magnitude were Botswana (matte for domestic refining), Australia, Norway, the Philippines, the Dominican Republic, New Caledonia, and the Republic of South Africa. In the aggregate, these eight countries accounted for 91% of U.S. imports. Imports increased in 1981 compared with those of 1980 in spite of the weak domestic market. Consequently, producer stocks held in the United States rose to over 110,000 tons, double that of yearend 1980, while consumer stocks also rose dramatically compared with those of the previous year. World consumption of primary nickel was approximately 675,000 tons in 1981 compared with approximately 750,000 tons consumed in 1980.

Table 8.—U.S. exports of nickel and nickel alloy products, by class

Class	1979		1980		1981	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Unwrought	19,759	$106,743	13,886	$114,779	16,298	$116,494
Bars, rods, angles, shapes, sections	3,162	38,095	3,443	48,270	2,463	39,066
Plates, sheets, strip	5,379	52,558	7,113	82,865	8,057	81,648
Anodes	108	725	139	979	94	909
Wire	733	7,993	1,087	11,766	660	8,262
Powders and flakes	4,082	24,836	5,438	37,101	3,224	23,929
Catalysts	5,197	19,993	3,530	18,559	3,890	25,601
Tubes, pipes, blanks, and fittings thereof, hollow bars	2,228	23,468	1,416	18,512	1,333	16,164
Waste and scrap	10,162	22,822	20,623	38,652	10,759	21,595
Total	50,810	297,233	56,675	371,483	46,778	333,668

Table 9.—U.S. imports for consumption of nickel products, by class

Class	1979		1980		1981	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Ore	4,977	$12	1,124	$13	513	$42
Unwrought	113,280	510,535	116,193	708,693	123,141	747,920
Oxide and oxide sinter	1,820	8,079	4,182	21,753	4,330	21,779
Slurry[1]	61,291	123,060	77,459	208,742	94,796	223,060
Bars, plates, sheets, anodes	1,937	13,249	2,396	20,918	1,011	9,321
Rods and wire	1,808	11,333	2,635	21,583	2,198	18,317
Shapes, sections, angles	14	142	83	892	21	552
Pipes, tubes, fittings	1,617	21,783	717	11,554	634	8,707
Powder	13,393	66,681	15,129	98,001	13,909	91,944
Flakes	784	3,522	115	665	215	1,381
Waste and scrap	3,596	16,634	3,572	18,481	5,226	17,496
Ferronickel	62,593	91,340	51,741	104,156	69,853	119,321
Total (gross weight)	267,110	866,370	275,346	1,215,451	315,847	1,259,840
Nickel content[2]	177,205	XX	189,188	XX	200,348	XX

XX Not applicable.
[1]Nickel-containing material in slurry, or any form derived from ore by chemical, physical, or any other means, and requiring further processing to recover nickel or other metals; principally matte for refining.
[2]Estimated from gross weight of primary nickel products.

Table 10.—U.S. imports for consumption of new nickel products, by country

(Short tons of nickel)

Country	Metal		Powder and flakes		Oxide and oxide sinter		Ferronickel		Slurry and other[e 1]	
	1980	1981	1980	1981	1980	1981	1980	1981	1980	1981
Australia	6,573	10,659	2,905	1,804	--	7	--	5	9,334	10,147
Botswana	--	--	--	--	--	--	--	--	15,608	24,625
Canada	61,652	62,414	7,795	8,659	3,115	3,085	65	525	1,614	1,711
Dominican Republic	20	--	--	--	--	--	12,077	9,390	36	--
Finland	4,262	3,122	--	--	--	--	--	--	13	106
France	843	604	--	--	90	31	--	--	5	1
Germany, Federal Republic of	150	56	114	167	--	136	--	38	23	75
Japan	737	799	--	--	--	--	1,007	3,586	18	23
Netherlands	72	77	--	--	--	--	--	--	--	43
New Caledonia	--	--	--	--	--	--	3,485	5,294	4,408	2,710
Norway	21,055	22,223	--	58	17	11	15	7	--	--
Philippines	10,755	9,740	2,766	1,830	--	--	--	--	--	--

See footnotes at end of table.

Table 10.—U.S. imports for consumption of new nickel products, by country —Continued

(Short tons of nickel)

Country	Metal		Powder and flakes		Oxide and oxide sinter		Ferronickel		Slurry and other[e] [1]	
	1980	1981	1980	1981	1980	1981	1980	1981	1980	1981
South Africa, Republic of	3,816	4,353	790	816	--	--	10	12	6,725	--
Sweden	282	--	2	--	--	--	--	--	11	4
U.S.S.R	3,839	6,638	--	--	--	--	--	--	--	--
United Kingdom	554	696	835	786	--	--	--	--	2	--
Zimbabwe	1,437	1,492	--	--	--	--	--	--	--	--
Other	146	268	37	4	--	64	8	1,391	65	56
Total	116,193	123,141	15,244	14,124	3,222	3,334	16,667	20,248	37,862	39,501

[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

Discussions between major producer and consumer governments, related to the creation of an international organization to improve world nickel statistics, continued. However, no final action was taken. The 10th Session of the 3d United Nations Conference on the Law of the Sea was concluded in Geneva in August. No final treaty was developed. The U.S. position, with respect to the proposed treaty, was under review.

Australia.—A major sulfide deposit was located at Mount Keith in Western Australia by Cliff's International Ltd. Cliffs is a major partner in exploration with Charterhall Mining Corp. Pty., Petroleum Securities, Ltd., and Greenbushes Tin N.L. An average of 3.5% nickel was determined over a large portion of the deposit. The prospect is 53 miles north of the Agnew nickel project, owned jointly by Mount Isa Mines, Ltd., and Western Selcast Pty., Ltd. At the Agnew Mine, it was found that the disseminated ore body near the surface was not as uniformly distributed as drilling had indicated, which could necessitate mining underground earlier than planned.

Western Mining Corp., Ltd., considered reopening its Windarra Mine in Western Australia. However, the reopening was contingent on the reopening of the nearby Lancefield gold mine. The Windarra concentrator would process ores from both mines. The Windarra Mine is jointly owned with Billiton Metals and Ores, Ltd., a subsidiary of the Royal Dutch/Shell Group.

At the Greenvale nickel laterite mine, jointly owned by Metals Exploration, Pty., and Freeport Queensland Nickel Pty., Ltd., work continued to convert the power source for the boilers and dryers from oil to coal. By yearend both dryers were converted, and work on the boilers was expected to be completed by mid-1982.

Botswana.—Sinking of the third shaft at Botswana RST Ltd.'s Pikwe Mine was completed early in the year to a depth of 3,163 feet. During the year, the shaft was equipped with 10 fuel stations spaced 197 feet apart. Total ore production at the Selebi-Pikwe complex totals about 220,000 short tons per month, about 70% of which comes from the Pikwe Mine. According to an interim report of Botswana RST, AMAX Nickel made a request to BCL, Ltd., which operates the Selebi-Pikwe Mines, to reduce contracted matte sales to AMAX Nickel by about 25% to about 33,000 tons annually. By yearend no decision had been made on the request.

Burundi.—The Government of Burundi received a $4 million line of credit from the International Development Association to continue exploration for nickel resources. Additional holes were to be drilled in the Musongati area to determine the nickel content. Studies will also be carried out on the quality and availability of local peat to determine its suitability for use as a fuel should a processing facility be built. A search will also be made for sulfide minerals. Aside from the question of power supply, the difficulty of transport in and out of the remote, landlocked country was a major consideration.

Canada.—A strike at INCO's Thompson, Manitoba, refinery by 1,900 workers began September 16. Pay rates and contract length were the main issues in the labor dispute. The workers, who are members of the USWA, sought a 1-year contract in order that bargaining in 1982 might be coordinated with six other locals in North America. These locals' contracts were to expire May 30, 1982. Although the Thompson works supplied the Fort Saskatchewan refinery at Sherritt Gordon Mines, Ltd., with part of its feedstock, the latter operation was not significantly affected by the strike. The strike ended December 14, when the USWA voted to ratify a 33-month contract. The new contract called for a 52.5% wage increase to be spread over 33 months, with some additional benefits. The nickel market lost about 10,000 tons of nickel production because of the strike, but there was little effect on prices. Production was resumed by yearend. The Thompson works provided an estimated one quarter of INCO's Canadian nickel production in 1980.

Late in the year, INCO announced the development of a new open pit mine at Thompson to replace its existing open pit mine there. About $72 million was to be spent on the first phase of mine development, with new production targeted for 1984.

As part of its effort to reduce inventories and costs, INCO planned to cut 1982 production below 1981 levels (70% of capacity) by putting one mine on standby, reducing shifts at another, and scheduling a 4-week vacation shutdown for its Ontario operations. Production at the company's Indonesia facility was also to be greatly curtailed. The Coleman Mine, accounting for about 5% of INCO's Sudbury output, was to be put on standby. Production was to be reduced at the Garson and Shebandowan Mines, 60 miles west of Thunder Bay. In December, INCO announced its withdrawal from the battery business, which sustained significant losses in 1980-81. INCO acquired the subsidiaries in 1974 and named the company INCO Electro-Energy Corp. This group included Exide Corp., Exide Electronics Corp., and Ray-O-Vac Corp.

Late in the year, Falconbridge Nickel Mines, Ltd., opened its new Fraser nickel-copper mine in the Sudbury District. The mine was expected to produce 2,300 tons of ore per day by 1983, to be shipped to the Strathcona mill for processing.

Colombia.—Significant progress was made at the Cerro Matoso S.A. nickel laterite project in Colombia, where production is scheduled to begin by mid-1982. With an investment of about $350 million, a consortium that includes Econiquel (state-owned, 45%), Billiton Overseas, Ltd. (35%), and Hanna Mining Co. with Standard Oil of California (20%), expected to complete 80% of the facility and infrastructure by yearend. Capacity of the mine, located about 250 miles northwest of Bogotá, will be about 21,000 tons of contained nickel in ferronickel. The deposits are estimated to contain 40 million tons of ore averaging 2.71% nickel. The ferronickel product, with 35% to 40% nickel, was to be marketed by Billiton during the first 12 years of operation.

Cuba.—Nickel-cobalt matte was shipped to Eastern Europe for further refining and a finished nickel oxide sinter (76% nickel) was shipped to Western and Eastern European countries. Mine production totaled about 44,600 tons of contained nickel.

Dominican Republic.—In January, after a 5-month shutdown, Falconbridge Dominicana C. por A. near Bonao, restarted production at its nickel-bearing laterite operation. During this period, a number of improvements were made, including plant overhaul, road construction, and community projects. Also, five new hydraulic excavators were erected, replacing those used since the mine began production in 1971. At full production of 31,500 tons of nickel per year, three electric furnaces smelt the ore to ferronickel after drying and calcining. Crude oil to run the powerplant is imported from Venezuela to Haina on the Dominican south coast and then delivered through a 50-mile pipeline to the mine. Naphtha is used to fuel the ore dryers. Mining of the garnierite layer, enriched with up to 3% nickel, is accomplished without drilling or blasting. Ore thickness ranges from about 10 to 200 feet. About 1,500 people work at the site.

In the second quarter, Falconbridge Dominicana shut down the second of its three electric furnaces at Bonao to prevent an excessive inventory buildup, owing to continuing recessionary markets in nickel. Production in 1981 was 21,500 tons of nickel in ferronickel. Falconbridge Nickel of Canada and ARMCO Steel Corp. of the United States provided significant financial support to Falconbridge Dominicana during the year. Payments of about $43 million were made to cover operating deficit and debt service.

Finland.—Outokumpu Oy was to expand

capacity of its Harjavalta smelter from 14,300 tons per year of nickel to 18,200 tons per year by about 1985. The expansion was to handle ore from a new mine to be developed at Enonkoski near Savonlinna. The mine was to replace the Kotalahti Mine, which was expected to be depleted of ore by 1985. About 500,000 tons of ore per year, containing better than 1% nickel, could be mined over a 10-year period.

Greece.—LARCO, S.A., shelved plans to raise its nickel capacity to 40,000 tons per year from the current 27,000 tons. The project would have cost about $170 million. In 1979, LARCO completed a $68 million expansion program, and in November 1980, the company completed and brought onstream a new crushing facility near its mines on the island of Euboea. During 1981, a 10-kilometer, closed-top ore conveyor belt linking this new crushing facility to the Politika Port was scheduled for completion.

Eleusis Bauxite Mines, Mining, Industrial and Shipping, Inc. (Scalistiri Group), planned to build a 10,000-ton-per-year nickel plant when nickel market conditions improve. The estimated cost of the project was $100 million, and Bechtel Corp. of Canada reportedly was involved in the feasibility study.

Guatemala.—In the third quarter, INCO decided to indefinitely mothball its 12,500-ton-per-year laterite nickel operation beginning early in 1982. The complex, known as Exploraciones y Explotaciones Mineras Izabel, S.A. (EXMIBAL), is 20% owned by Hanna of Cleveland, Ohio, and produced nickel matte until it was put on a standby status late in 1980. In the 9 months the plant was operating that year, 15.3 million pounds of nickel was produced. It was estimated that a nickel price of $4.15 per pound would be required for the operation to break even. The high cost of oil and poor market for nickel were the principal impediments to resumption of production. Conversion of energy source to coal had been considered, but was regarded as too costly. It would take about 6 months to bring the facility back onstream.

India.—It was reported that a Canadian firm began preparation of a prefeasibility study for the development of the Sukinda ultramafic complex in Orissa Province. Ore reserves are estimated at about 72 million tons of 0.85% nickel. The prefeasibility study was expected to be completed by yearend. A full feasibility study may be undertaken in 1982.

Indonesia.—A feasibility study on the expansion of the ferronickel plant at Pomalla in southeast Sulawesi was completed. Construction of the plant expansion was scheduled to begin in 1982 and when finished would triple capacity to 75,000 tons per year of ferronickel ingots. Indonesian Government officials announced the purchase of a 4% share in the P. T. International Nickel project, which is owned primarily by INCO, Ltd., of Canada. The Government plans eventually to increase its stake in the project to 20%.

No new developments took place on the P. T. Pacific Nikkel Indonesia (P.T. PNI) project on Gag Island because of inability to obtain financing. The nickel-cobalt laterite deposit was estimated to contain 160 million tons of ore grading about 1.64% nickel and 0.12% cobalt. Extensive engineering and financial studies have been made on the project, and plans called for the annual production of 115 million pounds of nickel and 1.1 million pounds of cobalt during the initial 10-year period. Equity in P.T. PNI is held by United States Steel Corp., Amoco Minerals Inc., and Hoogovens Ijmuiden, B. V., of Holland. As with P. T. International Nickel, the Indonesian Government has an option of 20% participation.

Japan.—Pacific Metal Co. began sintering and prereducing its ore in a kiln in order to lower the energy costs in its electric furnace operation. The company also experimented jointly with a Swedish company on a segregation process to upgrade ore of less than 2% nickel from sources in New Caledonia, Indonesia, and the Philippines to shipping grade, averaging about 2.5% nickel.

Nippon Mining Co., Ltd., spent $24 million to boost ferronickel capacity at its Saganosiki smelter by 180 to 1,500 short tons per month.

The Ministry of Trade and Industry estimated a 7% drop in Japanese consumption of nickel in fiscal year 1981 (to March 31, 1982), to 120,000 tons. Nickel stocks were estimated at about one-third of this figure.

New Caledonia.—Société Le Nickel S.A. (SLN) announced a temporary shutdown of two of its furnaces at Doniambo. The reduced operating level resulted in a lowering of the annual production to about 38,600 tons of nickel, about 50% of capacity. SLN produced nickel in matte and ferronickel. The matte was treated at the company's refinery at Sandouville, France. SLN is owned equally by Imetal, S.A., and Société

Nationale Elf-Aquitaine, the 70% state-owned energy company. Two representatives from New Caledonia in the French National Assembly petitioned the French Government for financial assistance to SLN. An official of the French Government responded that the Government would take all necessary measures to insure the financial viability of SLN, and that assistance would be provided to carry out a coal conversion program.

Philippines.—Marinduque Mining and Industrial Corp. began conversion of its energy source for refining of nickel from oil to coal and expected the project to be completed by the end of 1982. The project was an attempt to stabilize long-term operating costs. Initially, coal would be imported from Australia, but exploration for Philippine coal was undertaken to find a domestic source. The Philippine Government provided financing for the conversion. A new financial package was also provided by the Philippine Government to the company to keep it financially viable and which also made the Government a controlling stockholder.

South Africa, Republic of.—Matthey Rustenburg Refiners, Pty., Ltd. (MRR), opened a 21,000-ton-per-year nickel refinery on October 13, 1981. At capacity, about 12,000 tons per year of copper and 2,800 tons per year of cobalt sulfate could also be produced. Previously, a large portion of MRR's production was shipped in matte form to the Port Nickel, La., facility of AMAX, Inc., for refining. The nickel feedstock for the new plant is a byproduct of MRR's platinum mining. Sherritt Gordon Mines, Ltd., provided technical services.

Western Platinum Mines, Ltd., mining for platinum-group metals from the Merensky Reef, produced copper, nickel, and cobalt in matte form for shipment to the Kristiansand, Norway, refinery of Falconbridge.

U.S.S.R.—A new copper-nickel facility was completed in the Norilsk region of Siberia. Potential production of concentrates was estimated at 550,000 tons per year of nickel-bearing concentrates and 650,000 tons per year of copper-bearing concentrates.

United Kingdom.—Construction of a new nickel-cobalt refining facility in North Wales was begun in September. High-purity nickel and cobalt and their salts were to be recovered from superalloy grindings. The refinery was to be operated by Chapman Metallurgical and be in production by mid-1982. Superalloy scrap would be processed to nickel and cobalt suitable for reuse in the aerospace industry. Capacity of the plant, expected to be reached by 1983, is about 1,000 tons per year of nickel and cobalt.

Zimbabwe.—Production at the Bindura nickel refinery north of Salisbury, was suspended for about 8 weeks beginning in late April because of an explosion that damaged an electric furnace. The Bindura Nickel Corp. refinery is managed by Anglo American Zimbabwe, Ltd., and accounts for more than one-half of Zimbabwe's nickel output, which was 16,617 tons in 1980. Planned production for Bindura in 1981 was 7,800 tons. The refinery is supplied by the Madziwa, Trojan, Epoch, and Shangani Mines. Rio Tinto Zinc, Ltd., operates another refinery and two mines in Zimbabwe, the Empress and Perseverance. Early in the year, the London Metal Exchange approved the listing of Rio Tinto nickel on the Exchange. Total output of Zimbabwe in 1981 was about 12,700 tons of nickel.

Table 11.—Nickel: World mine production, by country[1]

(Short tons)

Country[2]	1977	1978	1979	1980[p]	1981[e]
Albania[e]	5,500	5,600	5,800	6,100	6,200
Australia (content of concentrate)	94,653	90,785	76,841	81,927	[3]81,600
Botswana	13,331	17,691	17,828	17,022	18,200
Brazil (content of ore)	4,675	3,968	3,267	2,800	2,600
Burma (content of speiss)	19	20	19	15	15
Canada[4]	256,300	[r]141,437	139,422	203,709	[3]176,032
China[e]	[r]12,000	[r]12,000	[r]12,000	[r]12,000	12,000
Cuba (content of oxide and sulfide)	[r]40,510	[r]38,346	35,631	42,108	44,600
Dominican Republic	[r]27,446	[r]15,765	27,680	18,019	21,500
Finland:					
Content of concentrate	6,434	4,858	6,393	7,199	7,600
Content of nickel sulfate	246	191	NA	NA	NA
German Democratic Republic[e]	2,800	3,000	2,800	[r]3,000	3,000
Greece (recoverable content of ore)[5]	[r]24,857	[r]20,431	22,214	16,796	17,200
Guatemala	328	[r]1,189	6,833	7,434	NA
Indonesia (content of ore)[5]	36,468	[r]34,628	34,212	33,644	28,700
Mexico (content of ore)	37	24	1	--	--
Morocco (content of nickel ore and cobalt ore)	172	192	176	148	140
New Caledonia (recoverable)[6]	[r]124,913	[r]71,839	88,696	95,451	[3]82,103

See footnotes at end of table.

Table 11.—Nickel: World mine production, by country[1] —Continued

(Short tons)

Country[2]	1977	1978	1979	1980[p]	1981[e]
Norway (content of concentrate)	599	591	[e]550	[e]550	550
Philippines	40,544	32,549	36,693	42,196	40,800
Poland (content of ore)[e]	[r]1,230	[r]1,230	[r]1,230	[r]1,230	1,230
South Africa, Republic of	[r]25,089	[r]31,636	33,339	28,329	29,100
U.S.S.R. (content of ore)[e]	[r]162,000	[r]164,000	[r]166,000	170,000	174,000
United States (content of ore shipped)	14,347	13,509	15,065	14,653	[3]12,099
Zimbabwe (content of concentrate)	18,377	17,307	16,084	16,617	12,700
Total	[r]912,875	[r]722,786	748,774	820,947	771,969

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

[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 5, 1982.

[2]In addition to the countries listed, Yugoslavia began producing nickel in small quantities in either 1978 or 1979, but output has not yet been officially reported quantitatively, and no basis is available for estimating the output level.

[3]Reported figure.

[4]Refined nickel and nickel content of oxides and salts produced, plus recoverable nickel in exported mattes and speiss.

[5]Includes a small amount of cobalt not reported nor recovered separately.

[6]Series revised to reflect reported nickel content of all ore produced.

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

(Short tons)

Country[2]	1977	1978	1979	1980[p]	1981[e]
Australia[3]	37,633	41,146	43,366	38,921	[4]46,854
Brazil[5]	2,789	[r]2,522	2,715	2,760	[4]2,579
Canada[6]	167,515	98,360	92,315	167,881	127,000
China[e]	11,000	11,000	11,000	11,000	11,000
Cuba[7]	[r]7,637	[r]7,414	6,951	8,200	8,600
Czechoslovakia	[e]2,400	[e]2,400	2,202	2,240	2,400
Dominican Republic[5]	[r]27,446	[r]15,765	27,680	18,019	21,500
Finland	10,414	8,268	12,638	14,117	[4]14,672
France[6]	11,331	[r]8,543	3,660	10,802	11,000
German Democratic Republic[e]	3,100	3,300	3,300	3,300	3,300
Germany, Federal Republic of[8]	100	993	1,348	1,361	1,300
Greece[5]	10,582	[r]16,410	16,129	15,300	15,900
Indonesia[5]	5,432	4,959	4,409	4,625	5,300
Japan	103,507	87,303	111,333	108,421	[4]103,176
Mexico	37	24	1	--	--
New Caledonia[5]	31,177	21,924	33,480	35,913	[4]30,852
Norway	42,134	26,166	33,778	40,716	[4]40,791
Philippines	24,111	20,654	23,675	27,778	27,600
Poland[e]	[r]1,230	[r]1,230	[r]1,230	[r]1,230	1,230
South Africa, Republic of	[r]25,304	[r]24,802	8,863	19,950	19,800
U.S.S.R.[e]	[r]184,000	[r]186,000	[r]188,000	192,000	196,000
United Kingdom	25,525	23,553	20,793	21,275	19,800
United States[9]	37,897	37,298	44,191	44,225	[4]48,805
Zimbabwe[e]	14,300	14,300	14,600	15,500	11,000
Total	[r]786,601	[r]664,334	707,657	805,534	770,459

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

[1]Refined nickel plus nickel content of ferronickel produced from ore and/or concentrates unless otherwise specified. Table includes data available through May 21, 1982.

[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 mattes, 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: 1977—36,650; 1978—36,045; 1979—42,626; 1980—35,825; 1981—36,223; Botswana: 1977—13,331; 1978—17,691; 1979—17,828; 1980—17,063; 1981—16,954 (estimated); Indonesia: 1977—none; 1978—(none) revised; 1979—7,403; 1980—17,428; 1981—16,100 (estimated); New Caledonia: 1977—25,395; 1978—18,853; 1979—13,296; 1980—17,063; 1981—16,954 (estimated).

[3]Refined nickel plus the nickel content of oxide.

[4]Reported figure.

[5]Nickel content of ferronickel only. (No refined nickel is produced.)

[6]Includes nickel content of ferronickel, refined nickel and nickel oxide.

[7]Content of nickel oxide and powder only; Cuba also produces nickel 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: 1977—9,553; 1978—9,496; 1979—10,776; 1980—10,800 (estimated); 1981—11,200 (estimated). Output of processed sulfide was as follows in short tons: 1977—9,989; 1978—9,083; 1979—7,315; 1980—9,800 (estimated); 1981—10,500 (estimated).

[8]Includes nickel content of nickel alloys.

[9]Byproduct of metal refining, including that derived from both domestic ores and imported materials.

TECHNOLOGY

Bureau of Mines researchers continued testing a process for recovery of nickel, copper, and cobalt from the Duluth Gabbro complex of Minnesota. The work was conducted at the Twin Cities Research Center, Twin Cities, Minn. Differential flotation and matte separation techniques to separate the nickel and copper content of their respective fractions were evaluated. Also, a report on the extraction of metals from Pacific sea nodules was published.[2] The Albany Research Center in Albany, Oreg., continued development of a method to recover nickel, cobalt, and copper from laterites containing less than 1.2% nickel and 0.25% cobalt. Pilot plant testing of the process was carried out by UOP, Inc., in Tucson, Ariz., and a final report was expected in early 1982. The Rolla (Mo.) Research Center continued its research into methods to recover nickel, cobalt, and copper from mattes and drosses generated during the smelting of lead ore concentrates. Beneficiation procedures for recovering cobalt and nickel from commercial lead, zinc, and copper concentrates by modifying milling procedures now practiced in the Missouri Lead Belt, were also developed. Contract studies on recovery of nickel and chromium and other metals from superalloy scrap were completed under the guidance of researchers at the Avondale Research Center, Avondale, Md.[3] A report was also issued from this Center on the processing of nickel-cadmium scrap batteries.[4]

AMAX Nickel developed an acid-leach process for oxide nickel ores. In the process, nickel and cobalt were selectively precipitated using H_2S gas at relatively low temperatures and pressures. With a high concentration of recycled solids, almost complete precipitation was obtained in about 1 hour. Claimed advantages of this technique were (1) elimination of the use of high-pressure reactors and equipment; (2) recovery, compression, and recycle of large quantities of H_2S gas; and (3) elimination of heavy scaling of precipitation vessels. The process was demonstrated on several leach liquors in a pilot plant operated for more than a year.[5]

Teledyne Vasco, Inc., of Latrobe, Pa., began marketing a new high-strength nickel maraging steel developed by Inco Research and Development Center, Inc. The new cobalt-free alloy contained less molybdenum than the conventional 250-grade maraging steel. Cobalt was replaced with titanium, but the titanium constituted a lower percentage of the alloy composition. Nickel content was about 18%. Maraging steel is used in dies for working various metals and for high-strength components such as gun recoil springs, trunnion pins in aircraft, and drive shafts.[6]

The use of manganese as a substitute for nickel, and aluminum as a substitute for chromium, in austinitic stainless steels was investigated. Researchers found that the Fe-Mn-Al alloy was ideal for cryogenic applications such as liquid gas pipelines. However, oxidation resistance was inferior to the Fe-Ni-Cr alloy. Additions of carbon and silicon contributed to the Fe-Mn-Al alloy's good ductility and mechanical properties.[7]

Scientists at General Motors Research Laboratories in Warren, Mich., developed a process for reclaiming nickel from used batteries. The nickel-bearing batteries were considered prime candidates for use in the first generation of electric vehicles, which were not expected to be commercialized on a large scale before 1986. The ability to recycle nickel from zinc-nickel oxide batteries is of great importance to their continued development because nickel accounts for about one-half of material cost. In the process developed, dislodged electrodes were fed into a magnetic separator to segregate the magnetic nickel hydroxide electrodes from the zinc electrodes. The addition of dilute sulfuric acid at 90° C dissolved nickel hydroxide and zinc contaminant and oxidized nickel in the nickel metal matrix. Controlled amounts of sodium hydroxide were then added to selectively precipitate first the contaminants and then nickel as nickel hydroxide. In bench-scale testing, the process enabled 96% recovery of the nickel.[8]

Gould, Inc., of Rolling Meadows, Ill., which had been conducting research and development work on the use of a nickel-oxide zinc battery for use in electric vehicles, discontinued the project early in the year. The effort to develop the battery was a joint project with Ford Motor Co. Officials at Gould stated that lack of technical progress and a belief that nickel would be too high in cost compared with competitive materials, motivated their decision. Gould planned to continue to develop a lighter lead acid battery with the same performance characteristics as the current heavier models.[9]

The relatively high cost of tin in making cans spurred development of nickel coating on steel as an alternative, lower cost material. Inroads made by aluminum into this market also contributed to this research by several major steelmakers. In 1981, nickel was about one-half the price of tin and could be coated on steel to a thickness of fifteen ten-millionths of an inch, about one-tenth that of tin. Another substitute, chromium, was already in use. Although this application for nickel was still in the research stage, advancement in technology and increases in raw materials cost indicated the probable eventual use of nickel.[10] Nippon Steel Corp. and National Steel Corp. conducted some of the research in this field. In another plating application, that of electronics, M&T Chemicals, Inc., of Rahway, N.J., focused its research and development efforts on chromium and nickel plated parts for the electronics industry as substitutes for more costly precious metals. A tin-nickel alloy was considered for use in the circuit board industry.[11]

A study conducted by the Maritime Administration, U.S. Department of Commerce, found that use of copper-nickel sheathing for ship hulls could result in significant savings in fuel costs, as well as reduced maintenance time. The copper-nickel hulls would provide a low-friction surface without the corrosion, pitting, and salt water damage that characterize painted steel hulls. Because of reduced drag, less fuel would be used, according to the study. Even though the sheathing might add as much as $3.4 million to the cost of the ship, fuel savings would more than offset this cost, resulting in a savings of nearly $100 million over a 20-year operating life. While most savings were credited to lower fuel usage, about $4 million could be saved in reduced drydock time and credits from sale of the hull for scrap upon retirement of the vessel. In addition, because a ship's effective speed would be increased, a smaller engine could be used and, therefore, more space would be available on board for cargo.[12]

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Nitrogen

By Charles L. Davis[1]

Ammonia production in 1981 in the United States was less than the 1980 level. Production was greatest in the first quarter of the year and decreased to the yearly low in the fourth quarter, followed by increased production at the end of the year. Ammonia production in 1981 was valued at $3.1 billion, and the value of 1980 ammonia production was $2.7 billion. U.S. consumption of ammonia in 1981 was less than 1980 consumption, but the value of 1981 consumption was $3.3 billion, compared with the 1980 consumption value of $2.9 billion. Production and apparent consumption values were based on the average annual 1980 and 1981 f.o.b. gulf coast prices.

Exports of ammonia and other major nitrogen compounds were down compared with 1980 levels. Ammonia imports were 11% less than 1980 tonnage, and total imports of major nitrogen compounds were down 5% compared with that of 1980.

Table 1.—Salient ammonia statistics

(Thousand short tons of contained nitrogen)

	1977	1978	1979	1980	1981[p]
United States:					
Production[1 2]	14,712	14,169	[r]15,420	16,244	15,648
Exports	346	434	649	681	506
Imports for consumption	884	1,247	1,603	1,921	1,719
Consumption[2 3]	14,831	15,270	[r]16,574	17,664	16,384
World: Production	[r]68,311	[r]72,562	[r]76,899	[p]78,673	[e]78,778

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Synthetic anhydrous ammonia and coke oven ammonia.
[2]1981 coke oven ammonia not available.
[3]Includes producers' stock changes in synthetic anhydrous ammonia and coke oven ammonia.

Legislation and Government Programs.—The fiscal year 1982 budget, submitted to Congress by President Carter, increased the funding for the Tennessee Valley Authority (TVA) fertilizer development center. However, the TVA budget for the ammonia-from-coal facility was reduced from the 1981 level of $1.6 million to the 1982 level of $0.4 million.

Since November 1, 1981, fertilizer producers could obtain exemption from gas prices based on incremental rates by submitting an affidavit to the Federal Energy Regulatory Commission for the exemption.

DOMESTIC PRODUCTION

Production of ammonia in the United States in 1981 was 15.6 million tons of contained nitrogen. Anhydrous ammonia plant capacity was more than 19 million tons. Some plants became idle, others resumed production after periods of inactivity, and a few plants increased capacity. Most U.S. ammonia plants operated near 1980's 93% of design capacity. High operating costs contributed to the closing of eight plants totaling 1.5 million tons per year of capacity. Because of the current weak export market and potentially low future demand for exports, plans to increase capacity were delayed.

Table 2.—Fixed nitrogen production in the United States

(Thousand short tons of contained nitrogen)

	1977	1978	1979	1980	1981[p]
Anhydrous ammonia, synthetic plants[1]	14,602	14,072	[r]15,317	16,155	15,648
Ammonium compounds, coking plants:					
Ammonia liquor	7	7	7	7	NA
Ammonium sulfate	103	90	96	82	NA
Ammonium phosphates	(2)	(2)	(2)	(2)	NA
Total	14,712	14,169	[r]15,420	16,244	15,648

[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	1979	1980	1981[p]
Acrylonitrile	1,009	915	1,003
Ammonium nitrate	[r]8,293	9,127	8,791
Ammonium sulfate[1]	[r]2,479	2,236	[2]2,111
Ammonium phosphates	12,082	13,378	12,141
Nitric acid	[r]8,916	9,231	9,040
Urea	[r]7,000	7,830	7,610

[p]Preliminary. [r]Revised.
[1]Includes ammonium sulfate from coking plants.
[2]Excludes ammonium sulfate from coking plants.

Sources: Bureau of the Census and International Trade Commission.

Table 4.—Domestic producers of anhydrous ammonia in 1981

(Thousand short tons per year of ammonia)

Company	Location	Capacity
Agrico Chemical Co. - Williams	Blytheville, Ark	407
Do	Donaldsonville, La	468
Do	Verdigris, Okla	840
Air Products & Chemicals, Inc	New Orleans, La	210
Do	Pace Junction, Fla	100
Allied Chemical Corp	LaPlatte, Nebr	172
Do	Hopewell, Va	340
Do	Geismar, La	340
Do	Helena, Ark	210
American Cyanamid Co	Fortier, La	580
Atlas Chemical Industries, Inc	Joplin, Mo	136
Borden Chemical Co	Geismar, La	340
Cargill, Inc	Columbus, Miss	68
CF Industries, Inc	Donaldsonville, La	1,540
Do	Fremont, Nebr	48
Do	Terre Haute, Ind	150
Do	Tunis-Ahoskie, N.C	210
Do	Tyner, Tenn	170
Chemical Distributors	Chandler, Ariz	33
Chevron Chemical Co	Pascagoula, Miss	530
Do	Fort Madison, Iowa	95
Do	El Segundo, Calif	20
Columbia Nitrogen Corp	Augusta, Ga	510
Cominco American	Boger, Tex	400
Diamond Shamrock Chemical Co	Dumas, Tex	160
Dow Chemical Co	Freeport, Tex	115
E. I. du Pont de Nemours & Co	Beaumont, Tex	340
Do	Victoria, Tex	100
El Paso Products Co	Odessa, Tex	115
Farmland Industries, Inc	Fort Dodge, Iowa	210
Do	Dodge City, Kans	210
Do	Hastings, Nebr	140
Do	Enid, Okla	840
Do	Lawrence, Kans	340
Do	Pollock, La	420
Felmont Oil Corp	Olean, N.Y	85
First Mississippi Corp (AMPRO)	Donaldsonville, La	400
Gardinier, Inc	Tampa, Fla	120

Table 4.—Domestic producers of anhydrous ammonia in 1981 —Continued

(Thousand short tons per year of ammonia)

Company	Location	Capacity
Georgia Pacific Corp	Plaquemine, La	196
Goodpasture, Inc	Dimmitt, Tex	40
Grace-Oklahoma Nitrogen	Woodward, Okla	400
W. R. Grace & Co	Woodstock, Tenn	340
Green Valley Chemical Co	Creston, Iowa	35
Hawkeye Chemical Co	Clinton, Iowa	138
Hercules, Inc	Louisiana, Mo	70
Hooker Chemical Co	Tacoma, Wash	28
International Minerals & Chemical Corp	Sterlington, La	400
Jupiter Chemical Co	Lake Charles, La	78
Kaiser Agricultural Chemicals Co	Savannah, Ga	100
Do	Pryor, Okla	105
Mississippi Chemical Corp	Yazoo City, Miss	393
Do	Pascagoula, Miss	175
Monsanto Co	Luling, La	850
New Jersey Zinc Gulf & Western	Palmerton, Pa	35
N-Ren Corp	Pryor, Okla	94
Do	East Dubuque, Ill	238
Do	Carlsbad, N. Mex	68
Do	Pine Bend, Minn	30
Olin Corp	Lake Charles, La	490
Pennwalt Chemical Co	Portland, Oreg	8
Phillips Pacific Chemical Co	Kennewick, Wash	155
Phillips Petroleum Co	Beatrice, Nebr	210
PPG Industries	Natrium, W. Va	50
Reichhold Chemicals, Inc	St. Helens, Oreg	90
SimCal Chemical Co	El Centro, Calif	210
J. R. Simplot Co	Pocatello, Idaho	108
Tennessee Valley Authority	Muscle Shoals, Ala	74
Terra Chemicals International, Inc	Port Neal, Iowa	210
Triad Chemical Co	Donaldsonville, La	340
Union Chemical Co	Kenai, Alaska	1,100
Do	Brea, Calif	250
U.S.S. Agri-Chemicals, Inc	Cherokee, Ala	175
Do	Geneva, Utah	70
Vistron Corp	Lima, Ohio	475
Wycon Chemical Co	Cheyenne, Wyo	167
Total		19,507

Source: Economics and Marketing Research Section, Tennessee Valley Authority. World Fertilizer Capacity, Ammonia. Muscle Shoals, Ala., Jan. 6, 1982.

CONSUMPTION AND USES

Domestic ammonia consumption decreased to 16.4 million tons of contained nitrogen in 1981. The decrease was attributed to fewer applications of nitrogen fertilizers and lower demand for downstream ammonia products. Fertilizers amounted to an estimated 75% of ammonia use either in direct application or in the manufacture of downstream compounds. Ammonia also was used to produce other chemicals, including explosives, resins, fibers, plastics, and animal feeds.

STOCKS

At yearend 1981, producers' stocks totaled 2.4 million tons of anhydrous ammonia, containing almost 2 million tons of nitrogen. This amount of ammonia was up 32% from the previous year's ending inventory.

PRICES

U.S. price increases of ammonia did not increase profitability for the producers. Rising natural gas costs and competitively priced ammonia from offshore brought pressure on the domestic market. In 1981, ammonia prices, f.o.b. gulf coast, were $122 at the beginning of the year gradually increasing to $190 by late summer, and gradually decreasing to $132 by yearend.

Table 5.—Price quotations for major nitrogen compounds at yearend 1981

(Per short ton)

Compound	Price
Anhydrous ammonia:	
F.o.b. gulf coast	$131 -$133
Delivered Corn Belt	190 - 195
Ammonium sulfate: F.o.b. Corn Belt	70 - 86
Ammonium nitrate: Delivered Corn Belt	138 - 150
Urea:	
F.o.b. gulf coast	130 - 135
Delivered Corn Belt	170 - 180
Diammonium phosphate: F.o.b. Tampa	168 - 172

FOREIGN TRADE

The tonnage of ammonia exported by the United States decreased 26% in 1981. Exports of downstream ammonia products decreased by 25%. Diammonium phosphate and urea continued to lead exported nitrogen compound tonnage.

U.S. ammonia imports for 1981 were 11% below 1980 totals. The U.S.S.R. was the leading foreign supplier of ammonia to the United States with more than 796,000 tons. Canada followed with almost 488,000 tons, followed by Mexico with nearly 434,000 tons, and Trinidad and Tobago with 340,000 tons.

Table 6.—U.S. exports and imports for consumption of major nitrogen compounds in 1981

(Thousand short tons and thousand dollars)

Compound	Gross weight	Nitrogen content	Value
EXPORTS			
Industrial chemicals:			
Ammonia, aqua (ammonia content)	3	2	294
Ammonium nitrate	14	5	1,020
Ammonium phosphate	8	1	6,001
Ammonium sulfate	1	(1)	70
Fertilizer materials:			
Ammonium nitrate	60	20	10,635
Diammonium phosphates	4,345	808	789,770
Other ammonium phosphates	428	47	82,386
Ammonium sulfates	738	155	62,063
Anhydrous ammonia	616	507	90,740
Sodium nitrate	23	4	3,306
Urea	1,578	726	272,056
Nitrogen solutions	247	79	30,263
Other nitrogen fertilizers	147	29	19,443
Mixed chemical fertilizers	163	16	29,739
Total	8,371	2,399	1,397,786
IMPORTS			
Industrial chemicals:			
Anhydrous ammonia and chemical-grade aqua	19	16	2,804
Ammonium nitrate	198	69	21,363
Ammonium phosphate	1	(1)	832
Ammonium sulfate	(1)	(1)	40
Fertilizer materials:			
Ammonium nitrate	264	88	29,711
Ammonium nitrate-limestone mixtures	(1)	(1)	5
Diammonium phosphates	117	22	20,067
Other ammonium phosphates	207	23	39,229
Ammonium sulfate	327	69	28,537
Calcium cyanamide or lime nitrogen	1	(1)	288
Calcium nitrate	153	23	10,765
Nitrogen solutions	147	47	17,955
Anhydrous ammonia	2,091	1,719	244,865
Potassium nitrate	43	5	10,185
Potassium nitrate-sodium nitrate mixtures	29	4	3,615
Sodium nitrate	159	25	7,523
Urea	853	392	131,238
Other nitrogenous fertilizers	86	17	14,946
Mixed chemical fertilizers	149	15	26,606
Total	4,844	2,534	610,574

[1]Less than 1/2 unit.

WORLD REVIEW

World fertilizer nitrogen consumption was higher in 1981 because of the increasing application of fertilizers in Eastern Europe and the U.S.S.R. and the growth in fertilizer consumption in Asia. Some countries with new ammonia production exported most of their product initially to help reduce the debt for plant construction.

European nitrogen fertilizer companies with a naphtha-based ammonia industry had to decide whether to build more energy-efficient plants designed to use natural gas, which continues to increase in price, or to import, and if they import, whether to import ammonia or fertilizer in finished form. Similar decisions must be made by North American nitrogen fertilizer producers operating energy-inefficient natural gas plants. Some U.S. companies were making their plants more energy efficient and some have increased their imports of ammonia. The decisions to import could be affected as marketing pressures increase from Government-owned world capacity ammonia plants that were commissioned in 1981, and whose production was designated for export. The decision to produce or import will of course be determined by the economics of the industry and the price of ammonia on the international market. For ammonia producers that pay high prices for natural gas, such as in Western Europe, the prospect of increased export of cheaper ammonia from the Middle East could lead to plant closings and a decline in exports from Western Europe, especially at the present time when the nitrogen market is depressed by oversupply and slack demand.

As competition from the Middle East builds up again in the markets of Asia, export-bound production in Western Europe and the United States will be reduced.

World nitrogen production capacity exceeds demand. Continuing high production rates, high inventories, and flat demand have brought reduced prices.

Argentina.—Petrosur of Argentina was granted a loan of $21.5 million to increase its urea capacity at Campana from 27,000 tons per year of nitrogen to 41,000 tons per year.[2]

Bahrain.—Gulf Petrochemical Industries of Bahrain awarded a contract for technology and engineering to Uhde GmbH of the Federal Republic of Germany. The $400 million petrochemical complex will consist of a 1,000-ton-per-day ammonia plant using natural gas as feedstock, with construction to begin in 1981.[3]

Burma.—Construction of a new fertilizer complex was initiated by Vöest Alpine of Austria and Coppee-Rust of Belgium at the existing complex at Sale, Burma. The new nitrogen complex is to come onstream in mid-1982 producing 180 tons per day of ammonia and 260 tons per day of urea.[4]

Petrochemical Industries Corp. of Rangoon awarded Uhde GmbH a contract to supply a fertilizer complex for Burma. The contract was for ammonia and urea plants located at Kyaw-Zwa near the Irawadi River. The complex was scheduled to come onstream in 1984.[5]

Canada.—A four-company consortium proposed a $670 million nitrogen fertilizer complex. The complex would consist of three plants with production capacity of 1,600 tons per day of ammonia, 1,600 tons per day of urea, and 900 tons per day of nitrogen solutions.[6]

CIL, Inc., signed a letter of intent retaining Uhde GmbH as engineering-procurement contractor for the 1,200-ton-per-day expansion of its 296,000-ton-per-year ammonia facility at Courtbright, Ontario.[7]

India.—A new fertilizer complex was commissioned in India at Panki, near Kanpur, in Uttar Pradesh. The new complex consists of a 150,000-ton-per-year ammonia plant and a 225,000-ton-per-year urea unit.[8]

Indonesia.—Toyo Engineering of Japan was to build the first joint Association of Southeast Asian Nations fertilizer complex at Aceh on the Island of Sumatra. The plant would have a capacity of 272,000 tons per year of ammonia and 262,000 tons per year of urea and would use natural gas from the Arun Gasfield in Sumatra.[9]

Korea, Republic of.—The second urea plant of the Namhae Chemical Co. was scheduled to come online in 1981, which would double the urea capacity at the company's Yosu site from 152,000 tons per year of nitrogen to 304,000 tons per year. The expansion was needed to meet domestic and export demands.[10]

Kuwait.—Technipetrol of Italy won a major contract in Kuwait to construct a 1,000-ton-per-day ammonia plant, for a Government-owned firm, in the industrial region of Shuaiba.[11]

Mexico.—Petroleos Mexicanos has awarded contracts to M. W. Kellogg Co. for construction of two 1,500-ton-per-day ammonia plants. One plant will be located at Salina Cruz, Oaxaca, on the Pacific coast and the other at Camargo, Chihuahua, in northern Mexico. The plants were scheduled to come onstream in 1984.[12]

Netherlands.—Onie van Kunstmestfabrieken of the Netherlands has selected Kellogg Continental of Amsterdam to construct a new world-scale ammonia plant at its South Limburg site. The project will have a capacity of 360,000 tons per year of nitrogen of ammonia.[13]

Nigeria.—The Nigerian Government plans to construct a large fertilizer complex at Port Harcourt using natural gas as the feedstock. The complex was scheduled to start production in 1984 and will produce 272,000 tons per year of ammonia and 228,000 tons per year of urea.[14]

Portugal.—The Quimigal Group started construction of a 310,000-ton-per-year ammonia and 33,000-ton-per-year sulfuric acid complex at Barreiro, Portugal.[15]

Somalia.—The Somalia Government awarded a contract to an Italian company for a nitrogen fertilizer complex. The contract calls for a 165-ton-per-day ammonia and a 220-ton-per-day urea plant at Mogadishu on the Indian Ocean.[16]

South Africa, Republic of.—Sasol Fertilizer Secunda Ltd. was undergoing a major expansion of its ammonia facilities from 47,000 tons per year to 137,000 tons per year of nitrogen, and an additional 137,000 tons per year was to come onstream in 1982.[17]

Sri Lanka.—Construction of the fertilizer complex at Sapugaskanda has been completed. The complex had a planned capacity of 540 tons per day of ammonia and 940 tons per day of urea.

Sudan.—A large fertilizer complex, comprising a 109,000-ton-per-year ammonia plant and a 46,000-ton-per-year urea unit, was under construction near Khartoum. The first phase of the project was due onstream in 1982.[18]

Trinidad and Tobago.—The new world-scale ammonia plants were commissioned in Trinidad. The Fertrin plants have a capacity of 630,000 tons per year of ammonia, and all production is available for export.[19]

Yugoslavia.—The ammonia capacity at the Hemijska Industrija Pancevo complex was being expanded with the installation of a new 1,000-ton-per-day plant due onstream at the end of 1981. Part of the ammonia output was to produce urea in a 33,000-ton-per-year unit due onstream in 1982.[20]

Zambia.—The 200-million-pound expansion of fertilizer facilities by Nitrogen Chemicals of Zambia at Kafve was to be commissioned. Part of the increased capacity will be 130 million pounds of ammonia that will be used as feedstock for nitric acid and ammonium nitrate facilities.[21]

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

(Thousand short tons of contained nitrogen)

Country	1977	1978	1979	1980[p]	1981[e]
North America:					
Canada	1,944	2,123	2,184	2,200	[2]2,404
Cuba[3]	[r]64	43	171	220	240
Mexico	860	[r]1,437	1,498	1,706	[2]1,902
Netherlands Antilles	[r]37	--	--	--	--
Trinidad and Tobago	195	442	428	506	[2]437
United States	14,712	[r]14,169	15,420	16,244	[2]15,648
South America:					
Argentina	46	52	67	72	[2]44
Brazil	160	224	293	388	[2]414
Colombia	72	70	77	77	[2]101
Peru[e]	91	89	90	68	[2]108
Venezuela	299	299	285	397	[2]457
Europe:					
Albania[e]	72	83	79	83	85
Austria	513	518	573	529	[2]536
Belgium	644	[r]595	585	597	[2]635
Bulgaria	[r]899	[r]868	860	912	910
Czechoslovakia	[r]869	[r]892	883	930	940
Denmark	36	36	36	34	[2]34
Finland	145	165	126	77	[2]76
France	2,242	[r]2,227	2,370	2,298	[2]2,480
German Democratic Republic	1,245	1,253	1,188	1,303	1,310
Germany, Federal Republic of	2,192	2,155	2,382	2,253	[2]2,162
Greece	248	252	316	249	[2]281
Hungary	804	822	885	876	[2]902
Iceland[e]	7	8	8	8	8
Ireland	31	[r]26	188	280	[2]320
Italy	1,287	1,591	1,577	1,540	[2]1,323
Netherlands	2,359	2,368	2,244	2,195	[2]2,172

See footnotes at end of table.

Table 7.—Ammonia: World production, by country[1] —Continued

(Thousand short tons of contained nitrogen)

Country	1977	1978	1979	1980[p]	1981[e]
Europe —Continued					
Norway	556	580	600	568	[2]574
Poland	1,835	1,776	1,681	1,700	1,650
Portugal	204	278	245	220	[2]147
Romania	1,975	2,488	2,573	2,478	2,400
Spain	1,064	970	904	881	[2]819
Sweden	112	105	99	95	[2]87
Switzerland[e]	50	50	50	50	[2]36
U.S.S.R	11,843	12,456	13,448	13,754	13,900
United Kingdom	1,798	1,764	1,836	1,800	[2]1,962
Yugoslavia	460	459	461	459	[2]464
Africa:					
Algeria	[e]35	[r]50	23	33	[2]47
Egypt	231	275	290	441	[2]652
Libya[e]	--	90	147	165	155
South Africa, Republic of	560	621	620	605	[2]608
Zambia	[e]20	[e]20	[e]20	22	[2]19
Zimbabwe[e]	80	70	70	66	[2]57
Asia:					
Afghanistan[e]	40	30	30	11	10
Bangladesh	118	116	184	154	[2]192
Burma[e]	64	61	61	66	70
China[e]	6,200	7,400	7,900	8,300	8,200
India[4]	2,245	[r]2,447	2,487	2,448	[2]3,249
Indonesia	[r]452	[r]645	837	796	[2]1,160
Iran	299	196	202	240	[2]32
Iraq	150	200	500	551	90
Israel	76	75	76	60	[2]46
Japan	2,526	2,705	2,561	2,369	[2]2,039
Korea, North[e]	450	500	500	500	500
Korea, Republic of	799	989	1,059	934	[2]826
Kuwait	443	475	[e]480	485	[2]420
Malaysia	37	44	57	45	[2]41
Pakistan	348	341	425	474	[2]654
Philippines	[e]45	[e]45	44	43	[2]35
Qatar	116	183	334	460	[2]404
Saudi Arabia	138	154	171	184	[2]188
Syria	25	21	84	53	220
Taiwan	359	483	431	457	[2]446
Thailand[e]	8	10	--	--	--
Turkey	118	239	226	275	[2]66
Vietnam[e]	10	20	30	([5])	([5])
Oceania: Australia	[r]349	324	340	389	[2]384
Total	[r]68,311	[r]72,562	76,899	78,673	78,778

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through May 12, 1982.
[2]Reported figure.
[3]Series revised to reflect officially reported Cuban data for 1977-80 (1981 figure is an estimate).
[4]Data are for years beginning April 1 of that stated.
[5]Nitrogen (N content of ammonia) production capacity in Vietnam is 60,000 tons per year; it is not known at what output level plant is operating.

TECHNOLOGY

The TVA of Muscle Shoals, Ala., has tested a new technique for granulating urea. The method was melt granulation by the falling-curtain process and evaporative cooling. As the rotary drum granulator turns, the feed to the drum and undersized granules are raised in the drum. Before reaching the drum apex, the granules are discharged onto a pan from which they flow onto another lower pan. Granules falling off the lower pan form a thin dense curtain onto which sprays of molten urea are directed. As the coating cools, it solidifies and enlarges the granule size.[22]

Monsanto Co. developed a hollow fiber, permeable membrane, large-scale gas separator used in the purge system of synthesis gas loops in ammonia plants. Air is introduced into the loop to provide the necessary nitrogen for ammonia synthesis, but unfortunately levels of inert gases, methane, carbon dioxide, and carbon monoxide also are brought in and accumulated in the loop. When the loop is purged of the gas buildup, hydrogen is lost in the purge. The loss of hydrogen reduces the efficiency of the ammonia synthesis process. To reduce hydrogen loss, the membrane separator is used and has been very efficient and maintenance free.[23]

Uhde GmbH, Dortmund, Federal Republic of Germany, has developed a low-energy concept for ammonia plants. The concept deviates from the conventional ammonia plant in the following ways: (1) Application of a process-integrated gas turbine as driver of the process air compressor; (2) preheating of the gas turbine combustion air in the connection bank of the primary reformer; (3) higher reforming pressure; (4) CO_2 removal systems; (5) application of an absorption refrigeration system; (6) low-pressure ammonia synthesis; and (7) purge gas recovery unit incorporated in a plant. Uhde suggested that if these specific features are incorporated, it would be possible to have a specific energy consumption lower than 25 million British thermal units per ton based on an inlet pressure of 15-bar for the feedstock and production of liquid ammonia at -33° C.[24]

Research and development activity focusing on mechanisms, catalysts, and reactor designs initiated a new life for the old Fischer-Tropsch (F-T) technology. This activity yielded a three-pronged program to convert F-T technology to chemical feedstock production. One program was aimed at development of more selective catalysts to improve the yield of C_2 to C_4 olefins. A second program was aimed at the production of a coal-derived naphtha suitable for cracker feedstock. The third program was aimed at producing C_{10} to C_{20} aliphatic, straight-chain hydrocarbons for making detergents. These programs and other efforts in plant management were directed toward improving energy efficiency and reducing operating costs.[25]

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[1]Physical scientist, Division of Industrial Minerals.
[2]Nitrogen (London). Plant and Project News. No. 129, January-February 1981, p. 13.
[3]Page 14 of work cited in footnote 2.
[4]European Chemical News. V. 36, No. 971, Mar. 2, 1981, p. 24.
[5]Nitrogen (London). Plant and Project News. No. 133, September-October 1981, p. 15.
[6]European Chemical News. V. 36, No. 970, Feb. 23, 1981, p. 23.
[7]Page 14 of work cited in footnote 5.
[8]European Chemical News. V. 37, No. 995, Aug. 17-24, 1981, p. 11.
[9]Page 15 of work cited in footnote 2.
[10]Page 15 of work cited in footnote 2.
[11]European Chemical News. V. 37, No. 1004, Oct. 26, 1981, p. 29.
[12]Chemical Marketing Reporter. Feb. 23, 1981, pp. 7, 32.
[13]Page 23 of work cited in footnote 8.
[14]Fertilizer International. No. 141, March 1981, p. 7.
[15]Chemical Age. V. 121, No. 3196, Jan. 16, 1981, p. 7.
[16]Page 15 of work cited in footnote 6.
[17]Page 14 of work cited in footnote 5.
[18]Work cited in footnote 14.
[19]European Chemicals News. V. 37, No. 994, Aug. 13, 1981, p. 6.
[20]Work cited in footnote 2.
[21]Page 14 of work cited in footnote 2.
[22]Page 30 of work cited in footnote 5.
[23]Chemical Engineering. Unique Membrane System Spurs Gas Separations. V. 88, No. 24, Nov. 30, 1981, p. 62.
[24]Chemical Engineering Progress. High Pressure Steam Equipment for a Low Energy Ammonia Plant. V. 77, No. 10, October 1981, p. 54.
[25]Chemical and Engineering News. Fisher-Tropsch: New Life for Old Technology. V. 59, No. 43, Oct. 26, 1981,p. 22.

Peat

By Charles L. Davis[1]

The U.S. peat industry produced nearly 686,000 short tons of peat of all types in 1981. Compared with the previous year's production of 785,000 short tons, production for 1981 declined by nearly 13%. Michigan produced more peat than any other State, accounting for 236,540 tons, which was 31% of the U.S. total. Michigan, Florida, Indiana, and Illinois were the major peat-producing States in 1981. Reed-sedge peat accounted for 61% of the U.S. domestic peat production. Humus peat amounted to 20%, hypnum moss peat to 5%, sphagnum moss peat to 3%, and other unclassified types to 11%.

The sale of peat in the United States totaled $18.8 million, an increase of 16% compared with 1980 sales. About 64% of domestic peat sold in 1981 was packaged. The average apparent peat price in 1981 was $24.82 per ton, f.o.b. plant, 21% higher than the 1980 average.

Peat imports decreased 15% to 341,930 tons in 1981. About 99% of the 1981 peat imports were premium-grade sphagnum moss peat from Canada. Apparent consumption of peat decreased 8% to 1.1 million tons. Imports contributed about 31% of apparent consumption tonnage in 1981 and 70% of apparent consumption value. World production in 1981 was approximately 225 million tons, with the U.S.S.R. producing about 94% of the total.

Table 1.—Salient peat statistics

	1978	1979	1980	1981
United States:				
Number of active operations	100	97	96	90
Production thousand short tons	822	825	785	686
Sales by producers do	750	798	788	757
Bulk do	328	324	298	276
Packaged do	422	474	491	481
Value of sales thousands	$12,988	$15,517	$16,190	$18,784
Average per ton	$17.32	$19.44	$20.54	$24.82
Average per ton—bulk	$13.98	$15.05	$15.46	$17.28
Average per ton—packaged or baled	$19.92	$22.46	$23.61	$29.14
Imports thousand short tons	380	381	402	342
Apparent consumption[1] do	1,130	1,179	1,190	1,099
Yearend producers' stocks do	394	350	330	269
World: Production do	[r]224,379	[r]223,372	[p]224,711	[e]224,959

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Sales plus imports.

DOMESTIC PRODUCTION

Peat was produced by 90 active mines in the United States in 1981. Approximately 46% of U.S. production in 1981 was from six large mines with annual capacities greater than 25,000 tons. The six peat mines included one reed-sedge mine each in the States of Florida, Indiana, and Michigan, one humus mine in New York, and one unclassified peat mine each in the States of Florida and Colorado.

Reed-sedge production decreased 6% in 1981 and was 61% of the U.S. total peat production. Humus production declined 15% in 1981 and was 20% of the U.S. total peat production.

Table 2.—Relative size of peat operations in the United States

Size in tons per year	Number of active plants		Production (thousand tons)	
	1980	1981	1980	1981
25,000 and over	7	6	362	316
15,000 to 24,999	10	6	184	106
10,000 to 14,999	4	4	47	53
5,000 to 9,999	15	19	108	134
2,000 to 4,999	17	15	56	49
1,000 to 1,999	12	12	19	17
Under 1,000	31	28	9	11
Total	96	90	785	686

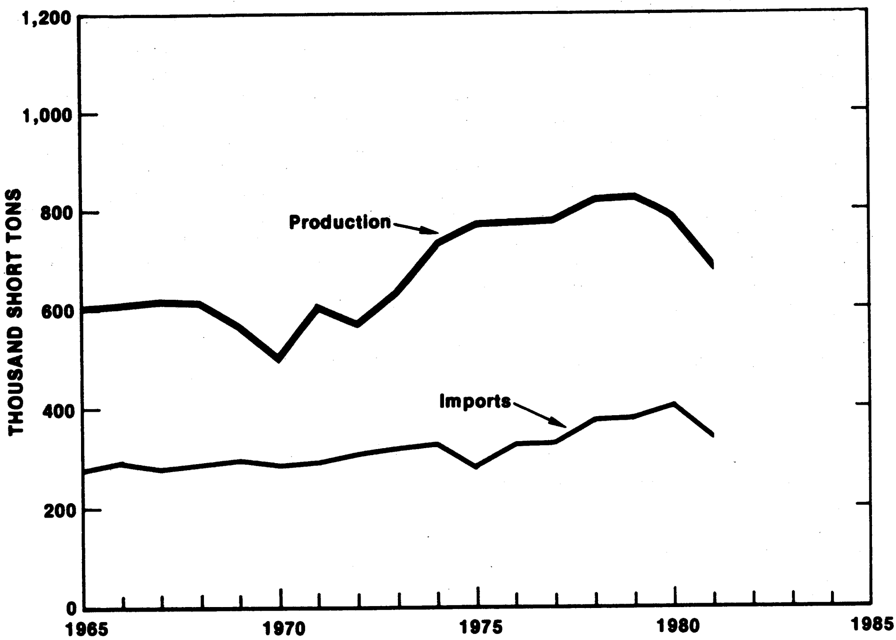

Figure 1.—Production and imports of peat in the United States.

CONSUMPTION AND USES

Domestic sales by U.S. peat producers in 1981 reached 757,000 tons, a decrease from 1980 sales. Peat sold in packaged form was 64% of 1981 sales, slightly less than that of 1980. Bulk sales declined 7%. The percentage of each peat type packaged in 1981 was sphagnum moss, 85%; reed-sedge, 81%; hypnum moss, 48%; humus, 41%; and other unclassified peat, less than 1%.

Domestic peat sales for soil conditioning decreased slightly from that of 1980 to 59% in 1981. Sales of peat in 1981 for potting soils decreased by 15% from 1980 sales. Apparent consumption of peat decreased by 8% in 1981 to 1.1 million tons.

Table 3.—U.S. peat sales by producers in 1981, by use

Use	In bulk		In packages		Total	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Earthworm culture medium	13,931	$233	21,247	$549	35,178	$782
General soil improvement	60,973	1,027	383,451	9,950	444,424	10,977
Golf course	25,372	540	729	42	26,101	582
Ingredient for potting soils	77,282	1,328	51,608	2,025	128,890	3,353
Mixed fertilizers	17,549	190	4,292	91	21,841	281
Mushroom beds	1,353	53	1,752	127	3,105	180
Nursery	60,195	1,026	6,223	233	66,418	1,259
Packing flowers, plants, shrubs, etc	2,972	57	4,142	316	7,114	[1]374
Seed inoculant	268	41	4,759	549	5,027	590
Vegetable growing	4,135	53	292	21	4,427	74
Other	11,636	208	2,986	124	14,622	332
Total	275,666	4,756	481,481	[1]14,028	757,147	18,784

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

PRICES AND SPECIFICATIONS

The average price per ton, both f.o.b. mine for domestic and at port of entry for imported peat, was $24.82, an increase of 21% compared with that of 1980. The average domestic price per ton for bulk peat was $17.28, an increase of 12%. The average domestic price per ton for packaged peat in 1981 was $29.14, an increase of 23% compared with that of 1980.

Table 4.—U.S. peat sales by producers in 1981, by State

State	Quantity (short tons)	Value[1] (thousands)	Percent packaged
Colorado	33,365	$299	4
Florida	157,120	2,885	35
Illinois	45,834	1,502	87
Indiana	104,935	3,140	79
Iowa	10,180	452	20
Michigan	236,540	4,540	93
Minnesota	24,622	940	91
New Jersey	26,020	1,475	57
New York	38,999	811	94
North Dakota	W	36	--
Ohio	10,479	191	74
Pennsylvania	25,302	647	15
Wisconsin	9,878	535	45
Other[2]	33,873	1,335	XX
Total	757,147	[3]18,784	63

W Withheld to avoid disclosing company proprietary data. XX Not applicable.
[1]Values are f.o.b. producing plant.
[2]Includes California, Georgia, Maine, Maryland, Massachusetts, Montana, and Washington.
[3]Data do not add to total shown because of independent rounding.

Table 5.—U.S. peat sales by producers in 1981, by use and kind

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	210	700	$6	--	--	--	32,598	71,430	$750
General soil improvement	16,972	111,058	1,269	35,809	84,547	$1,059	295,311	654,968	6,078
Golf course	922	5,020	37	695	1,390	9	17,634	35,418	437
Ingredient for potting soils	292	2,920	21	1,376	3,440	16	56,503	134,583	2,108
Mixed fertilizers	292	2,920	21	--	--	--	200	499	8
Mushroom beds	1,752	17,520	127	75	1,500	23	638	1,298	15
Nursery	1,768	12,880	97	759	1,728	22	41,684	91,306	818
Packing flowers, plants, shrubs, etc	292	2,920	21	--	--	--	5,067	12,626	327
Seed inoculant	292	2,920	21	--	--	--	4,212	8,000	480
Vegetable growing	292	2,920	21	--	--	--	1,050	2,500	18
Other	--	--	--	1,265	4,780	51	5,636	13,270	72
Total[2]	23,084	161,778	1,642	39,979	97,385	1,181	460,533	1,025,898	11,111

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	1,845	3,090	$22	525	1,000	$5	35,178	76,220	$782
General soil improvement	83,182	150,730	2,413	13,150	24,271	158	444,424	1,025,574	10,977
Golf course	5,650	11,100	86	1,200	2,000	12	26,101	54,928	582
Ingredient for potting soils	31,019	73,578	502	39,375	83,000	706	128,565	297,521	3,354
Mixed fertilizers	4,225	8,298	81	17,124	28,540	171	21,841	40,257	281
Mushroom beds	640	1,060	15	--	--	--	3,105	21,378	180
Nursery	18,483	35,472	249	7,136	12,727	73	69,830	154,113	1,259
Packing flowers, plants, shrubs, etc	205	410	4	1,550	3,000	22	7,114	18,956	374
Seed inoculant	523	717	89	--	--	--	5,027	11,637	590
Vegetable growing	2,785	5,350	32	300	500	3	4,427	11,270	74
Other	1,683	3,366	162	2,951	6,127	46	11,535	27,543	332
Total[2]	150,240	293,171	3,655	83,311	161,165	1,196	757,147	1,739,397	18,784

[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.—Prices for peat in 1981,[1] by type

(Dollars per unit)

	Sphagnum moss	Hypnum moss	Reed-sedge	Humus	Other	Total
Domestic:						
Bulk:						
Per ton	46.53	18.23	20.81	15.00	14.35	17.28
Per cubic yard	16.78	7.99	9.77	7.42	7.42	8.41
Packaged or baled:						
Per ton	74.07	38.15	25.04	33.41	15.97	29.14
Per cubic yard	9.98	14.94	11.10	17.75	8.00	11.95
Total:						
Per ton	72.29	29.53	24.12	24.33	14.36	24.82
Per cubic yard	10.15	12.12	10.83	12.47	7.42	10.80
Imported, total, per ton[2]	130.72	XX	XX	XX	XX	130.72

XX Not applicable.
[1]Prices are f.o.b. mine.
[2]Average customs price.

Table 7.—Average density of domestic peat sold in 1981

(Pounds per cubic yard)

	Sphagnum moss	Hypnum moss	Reed-sedge	Humus	Other
Bulk	720	965	958	1,179	1,138
Packaged	200	783	908	1,235	1,002
Bulk and packaged	233	852	918	1,200	1,137

FOREIGN TRADE

Peat imports decreased 15% to 341,930 tons in 1981. Most of the imports, about 99%, came from Canada. Canadian sphagnum moss peat has more desirable qualities than some domestically produced peat. Minor amounts of peat were imported from the Federal Republic of Germany.

Table 8.—U.S. imports for consumption of peat moss in 1981, by country

Country	Poultry- and stable-grade		Fertilizer-grade		Total	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Canada	50,125	$6,795	291,391	$37,849	341,516	$44,644
Finland	2	6	--	--	2	6
Germany, Federal Republic of	46	8	213	32	259	40
Honduras	[e]2	([1])	--	--	[e]2	([1])
Japan	--	--	22	2	22	2
Netherlands	22	35	--	--	22	35
Norway	--	--	34	60	34	60
South Africa, Republic of	--	--	70	10	70	10
Sweden	--	--	2	1	2	1
Total[2]	50,198	6,845	291,732	37,955	341,930	44,800

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

Source: Bureau of the Census.

Table 9.—U.S. imports for consumption of peat moss in 1981, by customs district

Customs district	Poultry- and stable-grade		Fertilizer-grade		Total	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Anchorage, Alaska[1]	--	--	14	$2	14	$2
Boston, Mass	3	$2	37	31	40	33
Buffalo, N.Y.[1]	21,792	3,237	3,613	414	25,405	3,651
Chicago, Ill	2	6	[e]1	(2)	[e]3	6
Detroit, Mich.[1]	26,274	3,276	5,687	746	31,961	4,022
Duluth, Minn.[1]	--	--	2,776	538	2,776	538
Great Falls, Mont.[1]	148	15	33,793	4,859	33,941	4,874
Los Angeles, Calif	--	--	289	39	289	39
Miami, Fla.[1]	177	9	--	--	177	9
Milwaukee, Wis.[1]	--	--	58	10	58	10
New York, N.Y.[1]	3	(2)	--	--	3	(2)
Norfolk, Va	1	(2)	--	--	1	(2)
Ogdensburg, N.Y.[1]	431	47	112,680	12,670	113,111	12,717
Pembina, N. Dak.[1]	493	80	49,029	7,900	49,522	7,980
Portland, Maine[1]	574	104	24,627	3,218	25,201	3,322
Portland, Oreg	17	2	--	--	17	2
St. Albans, Vt.[1]	64	6	20,165	2,391	20,229	2,397
San Juan, P.R.[1]	47	37	13	31	60	68
Savannah, Ga.[1]	3	(2)	--	--	3	(2)
Seattle, Wash.[1]	169	23	38,821	5,088	38,990	5,111
Tampa, Fla.[1]	--	--	89	9	89	9
Virgin Islands[1]	--	--	40	6	40	6
Total[3]	50,198	6,845	291,732	37,955	341,930	44,800

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

WORLD REVIEW

World production of peat was approximately 225 million short tons in 1981. The U.S.S.R. produced more peat than any other country, approximately 94% of the world total. Other significant producers were Ireland, the Federal Republic of Germany, Finland, and the United States.

Brazil.—The Mineral Reserves Prospecting Co. reported discovery of more than 110 million short tons of peat about 120 miles from Salvador, the capital city of Bahia State. Total reserves of peat in Bahia and Sergipe are reported to be 440 million short tons.[2]

Canada.—Peat Resources completed phase one of a five-part feasibility study into the viability of peat fuel in Canada. The $281,000 study included engineering, reconnaissance, and environmental studies on northern Ontario bogs.[3]

A 720-kilowatt, peat-fueled, gas-fired generator is expected to produce its first power in 1985 on Anticoste Island in the Gulf of St. Lawrence. The thermal plant, to be completed in 1984, will operate the first year on wood chips and then switch to peat.

Saskatchewan was to demonstrate peat's potential for home heating by installing four hybrid furnaces and evaluating results over two heating seasons.

Table 10.—Peat: World production, by country[1]

(Thousand short tons)

Country[2]	1977	1978	1979	1980[p]	1981[e]
Argentina: Agricultural use	7	[r]5	4	5	5
Australia	7	[r]7	13	11	11
Canada: Agricultural use	426	480	529	538	535
Denmark: Agricultural use[3]	44	52	50	34	33
Finland:					
Agricultural use	255	224	852	637	550
Fuel	661	2,061	1,710	2,029	2,205
France: Agricultural use	[r]204	[e]155	[e]155	[e]155	155
Germany, Federal Republic of:					
Agricultural use	2,107	[r]2,256	2,038	2,348	2,315
Fuel	244	251	254	308	310
Hungary: Agricultural use[e]	80	80	80	80	80
Ireland:					
Agricultural use	91	91	99	97	100
Fuel	6,009	5,443	4,330	5,251	5,555
Israel: Agricultural use[e]	22	22	20	22	22
Netherlands[e]	450	450	450	450	450
Norway:					
Agricultural use[e]	66	66	66	66	66
Fuel[e]	1	1	1	1	1
Poland:					
Fuel and agricultural use[e]	[r]220	[r]220	220	220	225
Spain	46	[r]35	51	49	50
Sweden:					
Agricultural use	[r]101	[r]105	105	105	105
Fuel	33	[r]33	--	--	--
U.S.S.R.:					
Agricultural use	145,500	145,500	145,500	145,500	145,500
Fuel[e]	66,000	66,000	66,000	66,000	66,000
United States: Agricultural use	781	822	825	785	[4]686
Venezuela: Agricultural use[e]	10	20	20	20	NA
Total	[r]223,365	[r]224,379	223,372	224,711	224,959
Fuel peat included in total	[r]73,168	[r]74,009	72,515	73,809	74,296

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available.
[1]Table includes data available through May 15, 1982.
[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. However, output is not officially reported and available information is inadequate for formulation of reliable estimates of output levels.
[3]Sales.
[4]Reported figure.

TECHNOLOGY

The Darvon Co. analyzed competing methods of harvesting and dewatering peat. Rockwell International and Dynatech studied the relatively new fields of hydrogasification and alcohol-from-peat processes.[4]

A team of researchers at the University of Sherbrooke, Sherbrooke, Ontario, experimented with a conversion process using a vacuumized pyrolytic reaction to extract solid and liquid products from peat.[5]

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[1]Physical scientist, Division of Industrial Minerals.
[2]F & M Journal. September 1981, p. 304.
[3]The Northern Miner. V. 67, No. 33, Oct. 22, 1981, p. 31.
[4]Canadian Renewable Energy News. U.S. Peat Activity Mounting Despite Government Cuts. V. 4, No. 8, October 1981, p. 40.
[5]——. Results Promising in Liquefaction Pilot Plant. V. 4, No. 8, October 1981, p. 43.

Perlite

By A. C. Meisinger[1]

U.S. production of processed perlite sold and used by producers in 1981 declined 7% to 591,000 tons valued at $17.4 million. Total ore output for processing by 11 companies at 13 operations in 7 Western States was 710,000 tons, a 14% decrease from the 1980 output. Five New Mexico operations accounted for 83% of the perlite ore total in 1981.

Expanded perlite sold and used declined 12% to 475,000 tons. New Jersey led all States in total quantity of expanded perlite sold and used. Active plant operations declined from 78 in 33 States in 1980 to 73 in 32 States in 1981. California and Texas each had seven active plants.

Domestic consumption of expanded perlite in 1981 totaled 475,000 tons, a 12% decrease from that of 1980. Construction industry use of perlite decreased 14% compared with that of 1980.

The average value of processed perlite sold and used increased 14% to $29.47 per ton, f.o.b. plant. The average value of expanded perlite sold and used increased 8% to $138.74 per ton, f.o.b. plant.

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		Processed perlite: Used at own plant to make expanded material		Processed perlite: Total quantity sold and used	Expanded perlite: Quantity produced	Expanded perlite: Sold and used	
		Quantity	Value	Quantity	Value			Quantity	Value
1977	871	298	5,514	299	5,239	597	504	498	53,600
1978	939	320	6,813	321	6,927	641	553	546	64,300
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	9,888	267	7,530	591	484	475	65,900

[1]Crude ore mined and stockpiled for processing.

DOMESTIC PRODUCTION

The quantity of perlite mined for processing by 11 companies from 13 operations in 7 Western States in 1981 was 710,000 tons, a 14% decrease from the quantity mined in 1980. Five New Mexico operations accounted for 83% of the total ore mined compared with 86% the previous year; the remaining 17% was mined from deposits in Arizona, California, Colorado, Idaho, Nevada, and Utah.

The quantity of processed perlite sold and used by producers in 1981 decreased 7% to 591,000 tons. The value of the processed perlite was $17.4 million, an increase of 5% compared with that of 1980.

Perlite ore producers in 1981 were Filters International, Inc., and Harborlite Corp. 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 Co. in New Mexico; and Mountain Maid, Inc., in Utah.

Expanded perlite was produced in 73 plants in 32 States in 1981, compared with 78 plants in 33 States in 1980. The quantity of expanded perlite produced was 484,000 tons, an 11% decrease from that of 1980. The quantity sold and used by producers declined 12% in 1981 to 475,000 tons, valued at nearly $65.9 million compared with $69.2 million in 1980.

Leading States in descending order of expanded perlite produced in 1981 were New Jersey, Illinois, Mississippi, Texas, California, Pennsylvania, Virginia, Colorado, Florida, Kentucky, and Indiana. The leading States in descending order of value of expanded perlite sold and used in 1981 were Illinois, Texas, California, Mississippi, Pennsylvania, New Jersey, Florida, Virginia, Indiana, Colorado, and Kentucky. In 1981, California and Texas each had seven producing plants, followed by Pennsylvania with six, and Illinois and Indiana with five each.

Table 2.—Expanded perlite produced and sold and used by producers in the United States

State	1980				1981			
	Quantity produced (short tons)	Sold or used			Quantity produced (short tons)	Sold or used		
		Quantity (short tons)	Value (thousands)	Average value per ton[1]		Quantity (short tons)	Value (thousands)	Average value per ton[1]
Arkansas	700	700	$120	$182.00	1,000	1,000	W	W
California	53,600	52,500	7,000	132.80	36,500	35,000	$5,100	$146.60
Florida	31,700	31,600	3,700	116.11	29,900	29,700	3,900	130.10
Illinois	53,900	51,500	8,500	165.15	44,500	43,100	7,600	176.19
Indiana	44,900	45,100	6,000	134.04	20,100	19,800	3,600	179.92
Maine	7,300	7,300	1,100	147.00	W	W	W	W
Massachusetts	3,100	3,100	600	202.34	2,400	2,400	650	264.27
Michigan	9,100	9,100	W	W	W	W	W	W
Nevada	2,900	2,900	300	107.39	W	W	W	W
New York	W	W	W	W	5,900	5,600	1,000	180.34
Ohio	8,400	8,400	1,000	131.24	W	W	W	W
Pennsylvania	39,000	38,900	5,200	133.42	36,500	36,300	4,800	132.81
Tennessee	4,300	4,400	800	179.00	W	W	W	W
Texas	39,800	39,200	6,300	160.13	39,900	38,900	7,000	180.83
Other[2]	245,000	242,000	28,500	113.50	266,900	263,500	32,200	122.28
Total[3]	544,000	537,000	69,200	128.90	484,000	475,000	65,900	138.58

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Average value per ton based on unrounded data.
[2]Includes Alabama, Colorado, Georgia, Idaho, Iowa, Kansas, Kentucky, Louisiana, Minnesota, Mississippi, Missouri, New Hampshire (1980), New Jersey, North Carolina, Oregon, Utah, Virginia, Wisconsin, and Wyoming, and items indicated by symbol W.
[3]Data may not add to totals shown because of independent rounding.

CONSUMPTION AND USES

In 1981, domestic consumption (quantity sold and used by producers) of expanded perlite declined nearly 12% from that of 1980 (table 3). Construction-industry-related uses, such as concrete and plaster aggregates, loose fill insulation, wallboard, and ceiling tile, decreased 14%. With the exception of "Other" uses, all principal end uses for expanded perlite declined in quantity sold and used compared with those of 1980. The significant decreases were 38% for fillers, 30% for plaster aggregate, 27% for concrete aggregate, and 23% for low-temperature insulation.

Table 3.—Expanded perlite sold and used by producers in the United States, by use

(Short tons)

Use	1980	1981
Concrete aggregate	29,800	21,800
Fillers	10,000	6,200
Filter aid	102,300	94,400
Formed products[1]	289,900	256,000
Horticultural aggregate[2]	40,900	40,200
Low-temperature insulation	7,700	5,900
Masonry and cavity fill insulation	20,900	20,000
Plaster aggregate	24,000	16,700
Other[3]	11,200	14,100
Total[4]	537,000	475,000

[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

Processed (crushed, cleaned, and sized) perlite ore was sold by producers to expanders in 1981 at an average price of $30.52 per ton, a 13% increase over the 1980 price of $27.10 per ton. Processed perlite used by producers in their own expanding plants was valued at $28.20 per ton, a 15% increase over the 1980 price of $24.50 per ton. The average price of all processed perlite in 1981 was $29.47 per ton, a 14% increase compared with the 1980 average price of $25.86 per ton.

The value of expanded perlite sold and used in 1981 averaged $138.74 per ton, an 8% increase over that of 1980. Average values for expanded perlite sold and used at plants in 32 States in 1981 ranged from $95 to $260 per ton, compared with the 1980 range in 33 States of $79 to $220 per ton.

WORLD REVIEW

Production of crude and/or processed perlite by the principal producing countries in 1981 was estimated to be 1.58 million tons, a decrease of 3% from the 1.63 million tons estimated for 1980. The United States, the U.S.S.R., and Greece, together, continued to account for nearly three-fourths of the world's output.

A world review article published near yearend highlighted recent developments in the perlite industries in the principal producing countries.[2]

Greece.—Processed perlite production was estimated to be 165,000 tons, a slight increase over the 1980 production of 163,000 tons. Total ore production was not available for 1981, but was reported in 1980 to be 307,000 tons.

Peletico Ltd., which mines perlite on the Island of Milos through a subsidiary (Peletico Minerals Ltd.) and has perlite expanded by Peletico Plasters Ltd. at Larnaca, Cyprus, was reported to have established perlite expansion facilities in Kuwait to directly supply Middle East consumers.[3]

United Kingdom.—Silvaperl Products Ltd. announced plans in 1981 to install a second expansion furnace in the company's plant at Lowestoft, Suffolk, in 1982, to increase production of six industrial grades and four horticultural grades of perlite.

Tilcon Ltd. initiated construction of an expanding plant at Cliffe near Rochester in Kent to facilitate the company's marketing in southern England.[4]

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[1]Industry economist, Division of Industrial Minerals.
[2]Pettifer, L. Perlite—Diversification, the Key to Overall Expansion. Ind. Miner. (London), No. 171, December 1981, p. 69.
[3]Work cited in footnote 2.
[4]Smith, M. Tilcon—"All Rounders" in the Minerals Industry. Ind. Miner. (London), No. 169, October 1981, p. 71.

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

(Thousand short tons)

Country[2]	1977	1978	1979	1980[p]	1981[e]
Australia[3]	2	2	2	2	3
Czechoslovakia[e]	11	22	33	44	44
Greece	[r]157	[r]166	189	163	165
Hungary[3]	114	102	108	109	110
Italy[e]	100	100	100	100	100
Japan[e]	77	80	83	85	83
Mexico[3]	25	27	46	49	50
New Zealand[3]	1	1	2	1	1
Philippines	2	[r]3	4	9	9
Turkey	33	30	33	28	29
U.S.S.R.[e]	380	400	400	400	400
United States (processed ore sold and used by producers)	597	641	660	638	[4]591
Total	[r]1,499	[r]1,574	1,660	1,628	1,585

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Unless otherwise specified, figures represent processed ore output. Table includes data available through June 9, 1982.
[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 1977-81 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 phosphate industry of the United States produced 53.6 million metric tons of phosphate rock in 1981, similar to the 1980 level. The value of the marketable rock increased to $1.4 billion. To complete the perspective of the year, it should be noted that the quantity of both domestic and export sales of phosphate rock and processed phosphates declined compared with those of the previous year. Inventory levels rose, particularly in Florida, to record highs. At the end of the year, most Florida producers reduced operating levels by approximately 50%, and several companies suspended operations to reduce unmanageable inventories.

The phosphate industry of the United States appears to be in transition. Historically, the industry performed as though demand would continue to expand forever. The change in demand and foreign competition are moving the industry to recognize that there are limits to continued expansion. The transition will be slow as the phosphate industry moves from growth and expansion to supply/demand equilibrium.

Table 1.—Salient phosphate rock statistics

(Thousand metric tons and thousand dollars unless otherwise specified)

	1977	1978	1979	1980	1981
United States:					
Mine production	166,893	173,429	185,757	209,883	183,733
Marketable production	47,256	50,037	51,611	54,415	53,624
Value	$821,657	$928,820	$1,045,655	$1,256,947	$1,437,986
Average per metric ton	$17.39	$18.56	$20.26	$23.10	$26.82
Sold or used by producers	47,437	48,774	53,063	54,581	45,526
Value	$829,084	$901,378	$1,063,517	$1,243,297	$1,212,433
Average per metric ton	$17.48	$18.48	$20.04	$22.78	$26.63
Exports[1]	13,230	12,870	14,358	14,276	10,395
P_2O_5 content	4,251	4,118	4,611	4,554	3,300
Value	$288,603	$297,357	$356,481	$431,419	$373,192
Average per metric ton	$21.81	$23.10	$24.83	$30.22	$35.90
Imports for consumption[2]	158	908	886	486	13
Customs value	$6,079	$24,379	$21,595	$12,856	$420
Average per metric ton	$38.47	$26.85	$24.37	$26.45	$32.31
Consumption[3]	34,365	36,812	39,591	40,791	35,144
World: Production	[r]119,310	[r]128,620	[r]132,913	[p]138,333	[e]138,630

[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.—In response to the U.S.S.R.'s invasion of Afghanistan, President Carter embargoed grain shipments to the U.S.S.R. on January 4, 1980. On February 4, 1980, the U.S. Department of Commerce's Secretary Philip Klutznick ordered that validated licenses would be required for phosphate exports to the U.S.S.R. Exports of superphosphoric acid (SPA) from Occidental Chemical Co. to the U.S.S.R. were terminated. The original agreement between Occidental Chemical and the U.S.S.R. specified that Occidental Chemical would ship 700,000 metric tons of P_2O_5 as SPA annually. The grain and phosphate embargoes were lifted by the Reagan administration, and Occidental Chemical announced that shipments of SPA to the U.S.S.R. would immediately resume. It was understood that the first SPA shipment left Jacksonville, Fla., on June 14, 1981, and that Occidental Chemical shipped about 500,000 metric tons by the end of 1981.

Among the taxes levied by States on the phosphate industry are severance taxes. Of the producing States, Tennessee, North Carolina, and Utah have not levied a severance tax. Idaho taxes 2% of net value, and Florida taxes at the rate of 10% of market value.

DOMESTIC PRODUCTION

Marketable phosphate rock production and value are shown in table 1. In 1981, Florida and North Carolina produced 47.3 million metric tons, 87% of the total marketable phosphate rock production; the Western States and Alabama produced 6 million metric tons, 11%; and Tennessee produced 1.3 million metric tons, 2%.

Florida and North Carolina.—Production and value of marketable phosphate rock are shown in table 2. Agrico Chemical Co., Amax Phosphate, Inc., Beker Phosphate Corp., Brewster Phosphates, CF Industries, Inc., Estech, Inc., Gardinier, Inc., W. R. Grace & Co., International Minerals & Chemical Corp. (IMC), Mobil Chemical Co., and USS Agri-Chemicals produced marketable phosphate rock from the Bone Valley Formation in central Florida. Occidental Chemical produced marketable phosphate rock from a similar matrix in Hamilton County in north Florida. Howard Phosphate Co., Kellogg Co., Loncala Phosphate Co., Manko Co., and Sun Phosphate Co. mined an estimated 45,000 metric tons of soft rock in 1981 from tailing ponds remaining from past hard-rock phosphate mines in north-central Florida. The soft-rock producers will not in the future be surveyed by the Bureau of Mines. The production of the recovered tailings are included in the Florida and North Carolina marketable phosphate rock production as shown in table 10.

In North Carolina, Texasgulf Chemicals Co., a subsidiary of Société Nationale Elf Aquitaine, operated a mine and fertilizer complex near Aurora, N.C. A mining system of hydraulic dredges and draglines are used to strip overburden and mine ore from an estimated 1.8 billion metric tons of reserves, recoverable by today's mining and processing technology. An expansion program at Texasgulf's Lee Creek phosphate operation included the addition of a 30-inch dredge to increase mining capacity. In 1981, the plant's P_2O_5 production capacity was about 3.4 million metric tons.

In 1984, North Carolina Phosphate Corp. plans to start producing phosphate rock at an annual rate of 3.4 million metric tons in eastern North Carolina. A design and construction contract was awarded to complete this phase by January 1984. North Carolina Phosphate will use both draglines and bucket wheels to strip and mine ore. North Carolina Phosphate first formed a 50-50 partnership with Francaise de l'Azote for a 19% share of the mine and another 50-50 partnership with ANIC, the Italian state-owned fertilizer company, for a 21.6% share of the mine.

Occidental Petroleum Corp. announced on June 8, 1981, that Occidental Chemical would resume shipping SPA to the U.S.S.R. after the Reagan administration lifted the embargo imposed by the Carter administration. Occidental Chemical announced plans to ship about one-half million metric tons to the U.S.S.R. by the end of the year.

Agrico Chemical, in central Florida, operated the Fort Green, Payne Creek, and Saddle Creek Mines in 1981. The Saddle Creek Mine was closed during the latter part of the year. When Agrico Chemical decided to mine its Palmetto tract, located about 13 kilometers from the Payne Creek washer, the rail haul concept was selected to recover the matrix from the small deposit. A dragline stacks the matrix in a line parallel to the mining cut. Front-end loaders are used to load 63-metric-ton hopper cars. The railcars are unloaded at the dump station with two pit guns that wash the matrix out of the open-bottom cars onto a grizzly.

Amax Phosphate, Lakeland, Fla., purchased the Big 4 Mine, a phosphate fertilizer complex, and a feed phosphate plant from Borden Inc., in May 1980. Amax Phosphate plans to expand the capacity of the Big 4 Mine from its current base of 1.5 million metric tons per year to 2.3 million metric tons per year in 1983 and expects that by 1987 the reserve will be depleted at planned operating rates. As reserves at this mine are depleted, Amax Phosphate plans to phase in production from the Pine Level property.

Beker Phosphate announced the start of mining phosphate rock in November 1981 at its Wingate Creek phosphate mine in Manatee County, Fla. The capacity is about 1 million metric tons per year and is planned to triple by 1983. Shipments of phosphate rock from the mine were held up in 1981 when a local court in Manatee County prohibited truck transport to the loading facility at Port Manatee.

Brewster Phosphates is a partnership between American Cyanamid Co. and Kerr-McGee Corp. It operates the Haynsworth and Lonesome Mines at an annual average rate of 4.3 million metric tons. Most of Brewster's phosphate rock moves through the port of Tampa to the phosphoric acid plant at Uncle Sam, La. It is estimated that the Haynsworth Mine, with the planned expansion along State Road 37, will extend its life into the 1980's. The life of the Lonesome Mine at projected mining rates is 1997.

CF Industries phosphate operations are located in Hardee County, Fla., and complex No. 1 reached its design capacity of about 1 million metric tons per year. CF Industries plans to develop and operate another phosphate mine in Hardee County on the company's South Pasture tract. The proposed South Pasture Mine is planned to start in 1985 with an initial capacity of 2 million metric tons per year. After operating 4 years at this rate, the mine will be expanded to a capacity of about 4 million metric tons per year and operate at this level for its remaining life.

Estech has a 10,000-acre site in Florida's Manatee County with an estimated 60 million metric tons of recoverable phosphate rock. The county has opposed mining in the Manatee River watershed and voiced concern over a proposed 480-acre settling pond that would threaten the area's drinking water from Lake Manatee. The issue was not resolved in 1981.

Farmland Industries Inc. received approval from the Hardee County Commission to mine phosphate rock on 7,800 acres near Ona, Fla. A 1.8-million-metric-ton-per-year mine is scheduled to start up in late 1984. The Hardee County Commissioners refused to rezone adjacent land for a proposed Farmland Industries fertilizer plant.

Gardinier continued to produce phosphate rock from the Fort Meade Mine and increased the capacity from 2.3 to 2.7 million metric tons per year. Gardinier plans, in the next several years, to install a waste slime dewatering system that was successfully tested in 1981.

W. R. Grace's Four Corners Mine is due onstream in 1982 after almost 10 years of planning and construction. The Four Corners project, a 4.5-million-metric-ton-per-year mine, is a joint venture with IMC. W. R. Grace will manage construction and production. IMC's financial contribution will entitle it to 50% of the product. Grace's Bonny Lake Mine is nearing depletion and will probably operate only when demand warrants. Grace's Hookers Prairie Mine is scheduled to operate into the 1990's.

In addition to participating in the Four Corners Mine, IMC produces phosphate rock from Clear Springs, Noralyn, and Kingsford Mines. IMC acquired the Atlantic Richfield property, the Hunt Brothers property, and some land from Farmland Industries in Hillsborough County that may form the basis for a replacement mine as Noralyn will probably be depleted by the end of the decade. IMC's Florida phosphate rock production capacity is about 12 million metric tons per year, which makes IMC the largest phosphate rock producing company in the market economy countries.

Mobil Chemical plans to construct a new phosphate rock terminal in Tampa's port. The terminal is scheduled to start operating in 1984. The South Fort Meade Mine, planned on a 6,591-hectare tract, is scheduled to start producing in 1985.

USS Agri-Chemicals continued to produce phosphate rock from the Rockland Mine but agreed with Freeport Phosphate Rock Co., its partner in the Rockland Mine, to defer some expansion and renovation work. USS Agri-Chemicals awarded a contract to engineer, design, and construct a 1,270-metric-ton-per-day P_2O_5 phosphoric acid plant at South Fort Meade.

Western States.—Production tonnage and value of marketable phosphate rock are shown in table 2. Production of phosphate rock for agricultural purposes was 3.2 million metric tons, and 2.8 million metric tons were used in electric furnaces.

Conda Partnership, a 50-50 association of Western Cooperation Fertilizers, Ltd., and Beker Industries, operated the Mabie Canyon Mine in Idaho. Monsanto Co. produced phosphate rock from the Henry Mine in Idaho. The total deposit is about 10 kilometers long, and the mining pit is currently about 2,300 meters long. The capacity of the Henry Mine is about 900,000 metric tons per year. The ore is trucked to the electric furnace plant at Soda Springs, Idaho. Stauffer Chemical Co. continued to operate the Wooley Valley Mine northeast of Soda Springs, Idaho. The ore was shipped to Silver Bow, Mont., for reduction to elemental phosphorus in electric furnaces. Stauffer sold its Vernal, Utah, phosphate rock mine, a fertilizer plant at Garfield, Utah, and phosphate handling facilities and a rail terminal at Phoston, Utah, to Standard Oil of California through Chevron U.S.A., Inc., a Standard Oil unit, at the beginning of the year. J. R. Simplot Co. proceeded to develop the Smokey Canyon Mine near Afton, Wyo. The plan is to start mining in 1984 and to produce 1.8 million metric tons per year over the mine's projected 30-year life. This mine will replace the Conda, Idaho, mine that will be depleted in 3 years. The Smokey Canyon Mine is in the Caribou National Forest about 40 kilometers east of Soda Springs, Idaho, and 16 kilometers west of Afton, Wyo.

J. R. Simplot operates the Gay Mine, located approximately 48 kilometers northeast of Pocatello, Idaho. It is a joint venture with FMC Corp. J. R. Simplot uses acid-grade ore of at least 31% P_2O_5 and FMC uses 24.5% P_2O_5 electric furnace-grade material. Ore that grades between 16% and 24% P_2O_5 is stockpiled.

Cominco American, Inc., operated the only phosphate underground mine in the United States near Garrison, Mont.

It is not certain how rapidly Chevron Resources Co. will expand the Vernal Mine, near Vernal, Utah, to supply a proposed fertilizer plant near Rock Springs, Wyo. It is proposed that the concentrate will be slurried and pumped through a 130-kilometer pipeline to Rock Springs. Sulfur from a sour gasfield will be piped about the same distance from Evanston, Wyo. If Chevron Resources plans to consume all of the byproduct sulfur generated, phosphate rock production at Vernal will approach 1 million metric tons per year initially and gradually increase to 3.2 million metric tons per year by 1986 to consume all of the recovered sulfur.

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
1980:									
Florida and North Carolina	198,332	21,020	29	6	47,214	14,652	47,243	14,658	1,124,929
Tennessee	2,981	602	--	--	1,582	410	1,582	410	12,765
Western States[1]	8,570	2,146	2,535	666	3,055	977	5,590	1,643	119,254
Total[2]	209,883	23,767	2,564	672	51,851	16,039	54,415	16,711	1,256,947
1981:									
Florida and North Carolina	173,898	21,434	27	5	46,254	14,283	46,281	14,288	1,290,134
Tennessee	2,547	516	--	--	1,328	340	1,328	340	16,201
Western States[1]	7,288	1,809	2,809	741	3,205	996	6,015	1,737	131,651
Total[2]	183,733	23,759	2,836	746	50,788	15,619	53,624	16,365	1,437,986

[1]Includes Alabama, Idaho, Montana, and Utah.
[2]Data may not add to totals shown because of independent rounding.

Tennessee.—Production and value of phosphate rock are shown in table 2. Hooker Chemical Co., Monsanto, and Stauffer mined and beneficiated phosphate rock in Tennessee for reduction to elemental phosphorus in electric furnaces located in the Columbia and Mt. Pleasant, Tenn., areas. Monsanto is mining phosphate rock in Alabama to augment production from Tennessee mines. Production of phosphate rock in Tennessee declined from 1.9 million metric tons in 1979, to 1.6 million metric tons in 1980, and to 1.3 million metric tons in 1981. Both Monsanto and Stauffer have electric furnace plants in the Western United States. With lower power costs in the West, the companies favor production from plants in Idaho and Montana.

CONSUMPTION AND USES

Consumption of marketable phosphate rock, defined as the quantity sold or used plus imports minus exports, is shown in table 1. Table 1 also reports the quantity of phosphate rock sold or used.

The consumption pattern as reported by producers is shown in table 7.

The percent distribution by grade of marketable phosphate rock consumed in the United States and sold in the export market in 1981 is compared with the distribution patterns for prior years 1977-80 in table 3. Trends in U.S. grade distribution patterns of phosphate rock are somewhat disguised in these data because of the mix of furnace and wet-process phosphoric acid-phosphate rock feed in the total distribution pattern.

Table 3.—United States phosphate rock grade distribution pattern

Grade (percent BPL[1] content)	Distribution (percent)				
	1977	1978	1979	1980	1981
Less than 60	5.7	6.2	5.4	5.3	5.6
60 to 66	11.6	13.3	14.2	15.7	15.7
66 to 70	57.3	54.3	56.3	56.7	60.1
70 to 72	12.2	13.3	13.6	12.7	9.6
72 to 74	7.4	8.6	6.6	6.0	6.0
Over 74	5.8	4.3	3.9	3.6	3.0

[1]1.0% BPL (bone phosphate of lime or tricalcium phosphate) = 0.458% P_2O_5.

Florida and North Carolina.—The quantity of phosphate rock sold or used is shown in table 8. Table 9 shows the distribution of phosphate rock sold or used in Florida and North Carolina by domestic and export tonnages.

The percent distribution by grade of the marketable rock sold or used from Florida and North Carolina, including exports, is shown in table 4 for the years 1977-81.

Tennessee.—The quantity and value of marketable phosphate rock sold or used is shown in table 8. All of this rock 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 4.—Florida and North Carolina phosphate rock grade distribution pattern

Grade (percent BPL[1] content)	Distribution (percent)				
	1977	1978	1979	1980	1981
Less than 60	0.1	0.1	0.2	0.1	0.2
60 to 66	10.5	11.9	12.6	15.3	14.4
66 to 70	62.7	60.8	62.4	62.2	67.0
70 to 72	14.1	15.7	12.7	11.2	7.7
72 to 74	5.9	6.5	7.6	7.0	7.1
Over 74	6.7	5.0	4.6	4.2	3.6

[1]1.0% BPL (bone phosphate of lime or tricalcium phosphate) = 0.458% P_2O_5.

The percent distribution by grade of marketable rock sold or used in Tennessee during the 1977-81 period is shown in table 5.

Western States.—The quantity of marketable phosphate rock sold or used is shown in tables 8-9. In 1981, 80% was consumed in the United States and 20% was exported to Canada. The percent distribution by grade of marketable rock sold or used from the Western States during the 1977-81 period is shown in table 6.

Table 7 shows the phosphate rock sold or used by producers by use, domestic (agriculture or industrial) and exports, and by State groupings.

The recent history of phosphate rock sold or used by producers by kind is shown in tables 10-12 for Florida, Tennessee, and the Western States, respectively.

Table 5.—Tennessee phosphate rock grade distribution pattern

Grade (percent BPL[1] content)	Distribution (percent) 1977	1978	1979	1980	1981
Less than 60	75.4	68.3	60.3	75.3	50.6
60 to 66	24.6	31.7	37.0	24.7	49.4
66 to 70	--	--	2.7	--	--

[1]1.0% BPL (bone phosphate of lime or tricalcium phosphate) = 0.458% P_2O_5.

Table 6.—Western States phosphate rock grade distribution pattern

Grade (percent BPL[1] content)	Distribution (percent) 1977	1978	1979	1980	1981
Less than 60	29.7	32.6	27.4	27.7	31.4
60 to 66	16.3	17.9	18.9	16.5	16.0
66 to 70	31.5	23.2	26.8	27.7	28.5
70 to 72	--	--	26.5	28.1	24.1
72 to 74	22.6	26.3	.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	1980 Rock	1980 P_2O_5 content	1981 Rock	1981 P_2O_5 content
Domestic:[1]				
Wet-process phosphoric acid	33,884	10,444	29,085	8,956
Normal superphosphate	333	107	184	60
Triple superphosphate	1,348	436	1,198	378
Defluorinated rock	430	145	492	166
Direct applications	37	8	27	6
Elemental phosphorus	4,083	1,067	4,055	1,049
Ferrophosphorus	190	49	89	22
Total[2]	40,305	12,256	35,131	10,638
Exports[3]	14,276	4,554	10,395	3,300
Grand total[2]	54,581	16,810	45,526	13,939

[1]Includes rock converted to products and exported.
[2]Data may not add to totals shown because of independent rounding.
[3]Exports reported to the Bureau of Mines by companies.

Table 8.—Phosphate rock sold or used by producers in the United States, by grade and State in 1981

(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	79	17	1,274	698	170	5,732
60 to 66	5,553	1,585	171,443	681	187	11,669
66 to 70	25,727	7,962	639,586	--	--	--
70 to 72	2,984	967	90,303	--	--	--
72 to 74	2,761	929	102,219	--	--	--
Plus 74	1,371	477	60,015	--	--	--
Total[2]	38,475	11,938	1,064,839	1,379	357	17,401

Grade (percent BPL[1] content)	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	1,783	445	16,999	2,560	632	24,005
60 to 66	907	250	14,243	7,140	2,022	197,354
66 to 70	1,614	506	46,353	27,341	8,468	685,939
70 to 72	1,368	443	52,599	4,353	1,410	142,902
72 to 74	--	--	--	2,761	929	102,219
Plus 74	--	--	--	1,371	477	60,015
Total[2]	5,672	1,644	130,194	45,526	13,939	1,212,433

[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 United States	
	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content
1980:								
Domestic:[1]								
Agricultural	33,877	10,452	--	--	2,155	687	36,032	11,140
Industrial	271	78	1,665	432	2,337	606	4,273	1,116
Total[2]	34,148	10,530	1,665	432	4,493	1,293	40,305	12,256
Exports[3]	13,055	4,166	--	--	1,221	388	14,276	4,554
Total[2]	47,203	14,696	1,665	432	5,713	1,681	54,581	16,810
1981:								
Domestic:[1]								
Agricultural	29,021	8,944	--	--	1,965	623	30,986	9,566
Industrial	222	62	1,379	357	2,544	653	4,145	1,072
Total	29,243	9,006	1,379	357	4,509	1,276	35,131	10,638
Exports[3]	9,232	2,933	--	--	1,163	368	10,395	3,300
Total[2]	38,475	11,938	1,379	357	5,672	1,644	45,526	13,939

[1]Includes rock converted to products and exported.
[2]Data may not add to totals shown because of independent rounding.
[3]Exports reported to the Bureau of Mines by companies.

Table 10.—Florida and North Carolina phosphate rock sold or used by producers, by kind

Year	Land pebble				Soft rock[e]				Total[1]			
	Rock (thousand metric tons)	P_2O_5 content (thousand metric tons)	Value: Total (thousands)	Value: Average per ton	Rock (thousand metric tons)	P_2O_5 content (thousand metric tons)	Value: Total (thousands)	Value: Average per ton	Rock (thousand metric tons)	P_2O_5 content (thousand metric tons)	Value: Total (thousands)	Value: Average per ton
1976	33,886	10,568	$774,517	$22.86	29	6	$580	$20.00	33,915	10,574	$775,096	$22.85
1977	40,970	12,838	726,950	17.74	25	5	504	20.16	40,994	12,843	727,454	17.75
1978	41,388	12,861	778,339	18.81	27	6	537	19.89	41,415	12,866	778,876	18.81
1979	45,459	14,189	935,127	20.57	26	5	545	20.96	45,484	14,194	935,672	20.57
1980	47,171	14,690	1,108,991	23.51	32	6	668	20.88	47,203	14,696	1,109,659	23.51
1981	38,458	11,935	1,064,459	27.68	17	3	380	22.35	38,475	11,938	1,064,839	27.68

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

Table 11.—Tennessee phosphate rock sold or used by producers

Year	Rock (thousand metric tons)	P_2O_5 content (thousand metric tons)	Value: Total (thousands)	Value: Average per ton
1976	1,731	448	$15,326	$8.85
1977	1,723	436	14,064	8.16
1978	1,688	434	13,833	8.19
1979	2,140	545	17,008	7.95
1980	1,665	432	13,330	8.01
1981	1,379	357	17,401	12.62

Table 12.—Western States phosphate rock sold or used by producers

Year	Rock (thousand metric tons)	P_2O_5 content (thousand metric tons)	Value: Total thousands)	Value: Average per ton
1976	4,877	1,383	$66,767	$13.69
1977	4,719	1,382	87,566	18.56
1978	5,671	1,647	108,669	19.16
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

STOCKS

At the end of 1980, inventories of marketable phosphate rock had declined to 13.8 million metric tons. The gradual decline of stocks that characterized 1980 changed abruptly as stocks increased every month during 1981 to a record level of 20.2 million metric tons in November. The increase in stocks was finally halted as several companies stopped producing during the last month of the year.

Rising inventory levels in Florida and North Carolina were the principal cause for the national increase in phosphate rock stocks. Inventories rose from 12.3 million tons at the beginning of the year to 19.7 million metric tons at the end of the year.

Stocks in Tennessee were at 167,000 metric tons at the beginning of the year and were at a similar level at the end of the year. Western States phosphate rock stocks were at 1.5 million metric tons at the beginning of the year and about the same at the end of the year. Because of climate, stocks in the Western States are increased during mild temperature months and are drawn down during subfreezing winter months.

PRICES

Phosphate rock exporters and buyers negotiated the selling price of phosphate rock in late 1981 and early 1982. The negotiated prices between buyers and sellers in both domestic and international markets are not published. List prices are published by the Phosphate Rock Export Association, Tampa, Fla., and can be used as a guide to export contract prices. The Office Cherifien des Phosphates, Casablanca, Morocco, occasionally publishes a price list.

Florida export prices as estimated in table 13 include the f.o.b. mine price, rail freight, loading, and weighing charges. In December 1981, the cost of moving phosphate rock from the mine to the vessel was $5 per metric ton. The severance tax collected on all phosphate rock was $1.84 per metric ton and is included in the tabulated prices.

The Moroccan Office Cherifien des Phosphates changed phosphate rock export prices at the beginning of 1981. Published prices were not available. Estimated contract prices are shown in table 14.

The Phosphate Rock Export Association attempted to increase prices by about 15% at the beginning of the year to offset increases in sulfur prices, rail rates, taxes, and other inflation-induced costs. It is probable that U.S. export prices in 1982 will not differ significantly from those of 1981.

The price or value of Florida and North Carolina, Western States, Tennessee, and the United States phosphate rock by grade is shown in tables 15, 16, 17, and 18, respectively.

Table 13.—Phosphate rock estimated export prices per metric ton, unground, f.o.b. vessel Tampa Range or Jacksonville, Fla.

Grade (percent BPL[1] content)	1978[2]	1979[3]	1980[4]	1981[5]
77	--	$38.00	--	--
75	$34.55	34.00	$44.00	$50.00
72	32.55	30.00	40.00	43.00
70	30.55	26.00	36.00	39.00
68	28.55	25.00	34.00	38.00
66	26.55	25.00	34.00	38.00

[1]1.0% BPL (bone phosphate of lime or tricalcium phosphate) = 0.458% P_2O_5.
[2]Estimated selling price including $0.55 severance tax.
[3]Estimated selling price including $1.15 severance tax.
[4]Estimated selling price including $1.54 severance tax.
[5]Estimated selling price including $1.84 severance tax.

Table 14.—Moroccan phosphate rock export prices, U.S. dollars per metric ton, f.a.s. Safi or Casablanca

Grade (percent BPL[1] content)	1978	1979	1980	1981[e]
Khouribga:				
76 to 77	41.00	43.00	56.00	55.00
75 to 76	37.00	42.00	54.00	53.00
72 to 73	32.00	40.00	52.00	50.00
70 to 71	--	43.00	48.50	47.50
Youssoufia:				
68 to 69	30.00	35.25	45.50	44.00
74 to 75	--	42.00	53.00	53.50

[e]Estimated.
[1]1.0% BPL (bone phosphate of lime or tricalcium phosphate) = 0.458% P_2O_5.

Table 15.—Price or value of Florida and North Carolina phosphate rock

(Dollars per metric ton, f.o.b. mine)

Grade (percent BPL[1] content)	1980			1981		
	Domestic	Export	Average	Domestic	Export	Average
Less than 60	20.91	--	20.91	16.04	--	16.04
60 to 66	24.98	24.53	24.89	31.66	27.54	30.88
66 to 70	19.63	27.83	21.08	23.57	31.29	24.86
70 to 72	22.11	30.61	26.87	25.26	33.93	30.26
72 to 74	25.72	33.83	31.36	32.81	37.93	37.02
Over 74	24.90	37.11	32.24	32.00	45.54	43.77
Average	21.01	30.03	23.51	25.17	33.74	27.68

[1]1.0% BPL (bone phosphate of lime or tricalcium phosphate)= 0.458% P_2O_5.

Table 16.—Price or value of Western States phosphate rock

(Dollars per metric ton, f.o.b. mine)

Grade (percent BPL[1] content)	1980			1981		
	Domestic	Export	Average	Domestic	Export	Average
Less than 60	8.86	--	8.86	9.54	--	9.54
60 to 66	10.00	33.70	14.36	10.46	35.33	15.71
66 to 70	24.83	33.07	26.62	24.25	37.88	28.71
70 to 72	--	--	--	35.94	37.08	38.44
72 to 74	31.50	31.49	31.49	--	--	--
Average	18.02	32.25	21.06	18.06	37.09	22.95

[1]1.0% BPL (bone phosphate of lime or tricalcium phosphate)= 0.458% P_2O_5.

Table 17.—Price or value of Tennessee phosphate rock

(Dollars per metric ton, f.o.b. mine)

Grade (percent BPL[1] content)	1980	1981
Less than 60	7.50	8.21
60 to 66	9.57	17.15
66 to 70	--	--
Average	8.01	12.62

[1]1.0% BPL (bone phosphate of lime or tricalcium phosphate)= 0.458% P_2O_5.

Table 18.—Price or value of United States phosphate rock

(Dollars per metric ton, f.o.b. mine)

Grade (percent BPL[1] content)	1980			1981		
	Domestic	Export	Average	Domestic	Export	Average
Less than 60	8.26	--	8.26	9.38	--	9.38
60 to 66	22.44	25.57	23.00	27.11	28.15	27.64
66 to 70	19.88	28.16	21.37	23.60	31.75	25.09
70 to 72	24.73	30.78	27.94	28.35	34.36	32.83
72 to 74	25.72	33.83	31.36	32.81	37.93	37.02
Over 74	24.90	37.11	32.24	32.00	45.54	43.77
Average	20.14	30.22	22.78	23.82	33.93	26.63

[1]1.0% BPL (bone phosphate of lime or tricalcium phosphate)= 0.458% P_2O_5.

FOREIGN TRADE

In 1981, producers reported that exports of phosphate rock from the United States were 10.4 million metric tons.

Except for 5,388 metric tons imported from the Netherlands Antilles and 7,998 metric tons imported from Mexico in 1981, no other reports of phosphate rock imports were received. Imports of phosphate rock were 0.9 million metric tons in 1979 and 0.5 million metric tons in 1980. Imports from Morocco were terminated in 1980 as their landed costs rose. Imports of low-fluorine phosphate rock from the Netherlands Antilles declined as remaining stocks were depleted.

Tables 19-25 are included to show the quantities of phosphate rock, phosphate fertilizers, and phosphate intermediates exported from the United States in 1980.

Table 26 lists phosphate fertilizers and chemicals imported during 1981.

Table 19.—U.S. exports of phosphate rock, by country

(Thousand metric tons and thousand dollars)

Destination	1980		1981	
	Quantity	Value[1]	Quantity	Value[1]
Australia	462	16,419	126	4,855
Austria	132	5,306	208	10,823
Belgium-Luxembourg	831	29,664	849	35,959
Brazil	113	4,901	115	5,563
Canada	3,825	122,879	3,080	106,483
Denmark	104	4,307	68	3,170
Finland	108	5,088	62	3,080
France	907	31,547	763	29,375
Germany, Federal Republic of	857	30,400	430	16,861
India	236	9,757	263	11,921
Italy	290	10,379	120	4,480
Japan	1,471	57,723	1,365	61,204
Korea, Republic of	1,751	60,915	993	36,701
Mexico	265	8,869	325	15,800
Netherlands	757	26,284	851	29,568
New Zealand	20	745	97	4,834
Norway	99	3,249	52	1,859
Philippines	99	4,701	124	6,472
Poland	900	31,672	187	6,691
Romania	382	17,275	136	6,397
Sweden	120	4,796	138	6,391
Taiwan	32	1,452	41	1,969
United Kingdom	391	12,415	15	614
Other	167	7,779	148	8,933
Total[2]	14,320	508,524	10,554	419,999

[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 20.—U.S. exports of superphosphates more than 40% P_2O_5, by country

(Thousand metric tons and thousand dollars)

Destination	1980 Quantity	1980 Value[1]	1981 Quantity	1981 Value[1]
Algeria	85	19,339	--	--
Argentina	4	562	9	1,570
Belgium-Luxembourg	107	19,320	77	10,811
Brazil	277	49,715	104	16,737
Bulgaria	58	9,943	196	29,872
Burma	27	6,107	53	9,766
Canada	61	9,395	140	18,242
Chile	86	15,220	84	14,219
China	153	29,545	203	32,579
Colombia	23	4,295	20	3,788
Costa Rica	14	2,889	4	648
Dominican Republic	11	2,349	9	1,890
France	39	7,216	48	7,875
Germany, Federal Republic of	178	31,694	171	26,930
Hungary	--	--	45	7,278
Indonesia	105	20,149	67	13,376
Ireland	14	2,272	41	6,345
Italy	25	5,184	10	1,468
Japan	26	3,938	25	3,739
Kenya	11	1,821	10	1,847
Libya	11	3,433	--	--
Pakistan	29	4,746	--	--
Peru	15	2,768	15	1,976
Singapore	34	5,750	(2)	121
Turkey	79	13,263	--	--
Uruguay	15	2,645	7	1,133
Venezuela	32	7,190	10	1,928
Other	25	5,046	149	30,561
Total[3]	1,544	285,792	1,499	244,701

[1]All values f.a.s. (free alongside ship).
[2]Less than 1/2 unit.
[3]Data may not add to totals shown because of independent rounding.

Source: U.S. Bureau of the Census.

Table 21.—U.S. exports of superphosphates, less than 40% P_2O_5, by country

Destination	1980 Quantity (metric tons)	1980 Value[1] (thousands)	1981 Quantity (metric tons)	1981 Value[1] (thousands)
Brazil	8,530	$751	2,626	$250
Canada	18,899	413	17,716	385
Chile	5,371	399	--	--
Other	68	12	256	6
Total[2]	32,868	1,574	20,598	640

[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 22.—U.S. exports of diammonium phosphates, by country

(Thousand metric tons and thousand dollars)

Destination	1980 Quantity	1980 Value[1]	1981 Quantity	1981 Value[1]
Algeria	11	3,913	--	--
Argentina	97	22,754	83	15,579
Australia	22	5,282	60	13,177
Bangladesh	11	2,568	59	14,714
Belgium-Luxembourg	242	55,349	347	66,789
Brazil	431	92,297	149	28,351
Canada	108	20,861	116	23,184
Chile	51	11,541	44	9,057
China	355	85,168	348	76,411
Colombia	37	8,234	39	7,709
Costa Rica	22	5,556	16	3,127
Dominican Republic	52	12,279	15	2,980
Ecuador	28	5,503	20	4,407
Ethiopia	64	18,344	--	--
Finland	43	8,865	17	3,373
France	168	40,339	83	16,657
Germany, Federal Republic of	73	9,603	79	11,846
Guatemala	9	2,400	20	4,584
India	841	171,872	787	155,909
Ireland	13	2,505	56	10,992
Italy	399	85,844	457	89,216
Japan	195	42,484	185	33,213
Mexico	245	44,763	232	49,473
Mozambique	80	21,596	6	1,231
Netherlands	1	283	49	9,605
New Zealand	10	2,617	25	4,744
Nicaragua	44	10,469	--	--
Pakistan	496	111,371	40	11,063
Spain	201	41,593	82	15,293
Thailand	87	16,361	40	7,987
Turkey	269	66,551	44	9,145
Uruguay	61	13,871	31	5,883
Yugoslavia	40	8,340	120	24,080
Other	192	44,566	291	59,990
Total[2]	4,995	1,095,944	3,942	789,770

[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 23.—U.S. exports of phosphoric acid, less than 65% P_2O_5, by country

(Thousand metric tons and thousand dollars)

Destination	1980 Quantity	1980 Value[1]	1981 Quantity	1981 Value[1]
Argentina	10	1,321	--	--
Brazil	619	153,701	204	65,171
Canada	2	382	3	466
Colombia	26	5,728	19	4,054
Czechoslovakia	6	1,051	--	--
Germany, Federal Republic of	23	6,915	15	3,821
India	228	42,490	208	42,241
Indonesia	79	15,885	125	38,335
Mexico	32	5,415	([2])	18
Netherlands	22	4,307	--	--
Turkey	122	34,116	150	47,301
U.S.S.R	--	--	231	88,249
Venezuela	34	8,511	46	12,764
Other	8	1,524	3	971
Total[3]	1,212	281,348	1,004	303,390

[1]All values f.a.s. (free alongside ship).
[2]Less than 1/2 unit.
[3]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, more than 65% P_2O_5, by country

(Thousand metric tons and thousand dollars)

Destination	1980 Quantity	1980 Value[1]	1981 Quantity	1981 Value[1]
Brazil	5	997	--	--
Canada	83	3,246	23	5,925
Colombia	--	--	9	2,084
U.S.S.R	67	17,440	498	168,898
Other	([2])	2	20	6,600
Total[3]	156	21,686	549	183,506

[1]All values f.a.s. (free alongside ship).
[2]Less than 1/2 unit.
[3]Data may not add to totals shown because of independent rounding.

Source: U.S. Bureau of the Census.

Table 25.—U.S. exports of elemental phosphorus, by country

Destination	1980 Quantity (metric tons)	1980 Value[1] (thousands)	1981 Quantity (metric tons)	1981 Value[1] (thousands)
Argentina	2	$7	20	$44
Australia	287	411	2	3
Brazil	6,476	9,800	7,049	11,459
Canada	1,010	1,514	1,777	2,656
Denmark	501	825	--	--
Japan	5,221	7,435	6,493	10,139
Korea, Republic of	475	442	324	502
Mexico	16,006	23,929	11,754	17,055
Taiwan	190	280	422	594
Other	275	987	88	271
Total	30,443	[2]45,631	27,929	42,723

[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 26.—U.S. imports for consumption of phosphate rock and phosphatic materials

(Thousand metric tons and thousand dollars)

Fertilizer	1980 Quantity	1980 Value[1]	1981 Quantity	1981 Value[1]
Phosphates, crude and apatite	486	12,856	5	162
Phosphatic fertilizers and fertilizer materials	32	5,737	16	3,112
Ammonium phosphates, used as fertilizers	294	53,053	--	--
Bone ash, bone dust, bone meal, and bones ground, crude or steamed	3	1,143	--	--
Dicalcium phosphate	1	1,027	1	958
Basic slag	(2)	113	(2)	38
Manures including guano	(2)	1,111	--	--
Phosphorus	(2)	928	(2)	1,247
Phosphoric acid	(2)	337	2	816
Phosphoric acid, fertilizer grade	24	4,182	56	7,791
Normal superphosphate	24	3,949	20	3,855
Triple superphosphate	25	4,768	13	2,051

[1]Declared customs valuation.
[2]Less than 1/2 unit.

Source: U.S. Bureau of the Census.

WORLD REVIEW

World phosphate rock production increased in 1981 to an estimated 138.6 million metric tons. Phosphate rock expansions occurred in Brazil, China, Jordan, Mexico, Morocco, the Republic of South Africa, Syria, Tunisia, the U.S.S.R., and the United States. World production has steadily increased, rising from 108, 119, 129, 133, and 138 million metric tons in 1976, 1977, 1978, 1979, and 1980, respectively. With expansion plans expected to be implemented during the 1980's, adequate supplies of phosphate rock appear assured for this period.

World demand for phosphate rock and processed phosphates declined in 1981, which was dramatically demonstrated by the reduction in both phosphate rock and processed phosphate exports from producing countries. Lower demand has not altered the expansion plans in most producing countries to increase capacity for phosphate rock and increase capacity to convert phosphate rock into phosphate intermediates or finished phosphate fertilizer.

Algeria.—The expansion of mining operations at Djebel Onk, which was to replace the exhausted reserve from El Kouif, was canceled. The current capacity of the mine is 2.4 million metric tons of ore, which is sent to the beneficiation plant. The scheduled expansion of 600,000 metric tons per year of 63% bone phosphate of lime (BPL) product was planned for 1981-82. The 2.4 million metric tons of ore is concentrated to 1.43

million metric tons of 63% to 65% BPL product of which 800,000 tons are washed and calcined to 500,000 metric tons of 75% to 77% BPL product. The calcined products are exported, and the lower grade 63% BPL rock is used in domestic phosphoric acid plants.

Australia.—Mining the Duchess phosphate rock deposit began in 1975 but was stopped in 1978 when it became uncompetitive in Pacific markets and when problems developed in phosphoric acid manufacture. Western Mining reopened the mine in late 1981 with the intention of producing 200,000 metric tons per year. About one-half will be used in Australia and one-half will be exported.

Brazil.—Brazil was for many years the only significant producer of phosphate rock in the South American continent but was only able to supply about one-half of the country's demand. As the demand for phosphate fertilizer increased, the Government encouraged development of domestic phosphate rock deposits to reduce reliance on imports. Since 1967, all production of phosphate rock has come from the carbonatite-apatite complexes located in the States of São Paulo and Minas Gerais. The Institudo Brasileiro do Fosfato forecasts that there will be 1.3 million metric tons of installed capacity in 1981 and 1.5 million metric tons in 1982.

China.—China produces most of its phosphate fertilizers in small plants using local raw materials. Recent exploration by Chinese geologists indicates that in Yunnan Province there are potential reserves of the order of 4 billion metric tons. The deposit is located 60 to 70 kilometers southwest of Kunming, the provincial capital of the Province. The Kunyang open pit phosphate mine produced an estimated 1.5 million metric tons of 22% to 30% P_2O_5 product in 1981. Another deposit, located about 60 kilometers south of Kunming, is considered by the Chinese to be a potential 2-million-metric-ton-per-year operation. It is called the Haikow deposit, and because the grade of the rock is less than that at Kunyang, it will be necessary to beneficiate the ore to obtain an acceptable product. The Bureau of Mines Albany Research Center has assisted to develop a beneficiation flowsheet under a memorandum of agreement with a contracting company.

Christmas Island.—The Australian Territory of Christmas Island lies in the Indian Ocean 2,400 kilometers northwest of Perth, Western Australia, and about 300 kilometers south of Java. The annual capacity is 1.4 million metric tons A Grade per year, 150,000 metric tons of dust, and up to 200,000 metric tons of B Grade. At an annual production rate of 1.4 million metric tons of A Grade material, mining will end about 1986. It is possible that after 1986, mining could be organized on a smaller scale to utilize remaining B and C Grade phosphates.

Egypt.—Although the mining and marketing of phosphates from the Abu Tartour area was considered a most important mineral project in terms of future exports, implementation of the project has not advanced during this year. Opposition to the project, which will cost in excess of $1 billion, was voiced by the Egyptian People's Assembly because of costs and low international demand for phosphates.

Finland.—Kemira announced plans to expand the phosphate rock mine at Kuopia in central Finland from 210,000 to 500,000 metric tons per year of apatite concentrates. The ore as mined analyzes 4% P_2O_5 and is concentrated to 36% P_2O_5. The expansion is scheduled for completion in 1982.[2]

Iraq.—Despite the adverse effects of the Iraq-Iran war on construction schedules, the Akashat Mine, which will have a capacity of 3.4 million metric tons per year, was inaugurated on April 7, 1981. The fertilizer plant at Al Qain was scheduled to start up before the end of 1981, but this was dependent on completing the rail link between the mine and the fertilizer plant.[3]

Israel.—Phosphate rock is the only source of uranium available in Israel. In Israel, phosphorites are found throughout southern parts of the country in the Negev Desert in relatively small synclinal basins. Of the 20 identified basins, 4 were proven to have commercial value and are exploited. All of the phosphates in Israel contain uranium, and in general, uranium concentrations vary with P_2O_5 concentrations.

The principal phosphate deposits in Israel are Zefa-Ef'e, Makhtesh, Qatan, Oron, Hor-Ha'ar (Zin), and En Yahav. At present, the recovery of uranium from phosphates is feasible only as a byproduct, when the costs of mining, handling, and digesting the rock are paid by the phosphate industry. It is estimated that from 58 to 75 metric tons of uranium are being recovered per year.[4]

Jordan.—Phosphate rock is produced from the three principal mines at El Hassa, Wadi al Abyad, and Ruseifa. Studies are being made to determine the feasibility of opening a new phosphate mine at Shidiya in southeastern Jordan along the Saudi border. The plans are to design a mine to produce from 5 to 6 million metric tons per year in the late 1980's.

Mexico.—Roca Fosforica Mexicana S.A. de C.V. (Rofomex) started mining phosphate rock at San Juan de la Costa, Baja California, on the Gulf of California, about 60 miles from LaPaz. Some tonnage was shipped to Lazaro Cardenas on Mexico's Pacific coast, a distance of 1,390 kilometers by sea. From Lazaro Cardenas, the concentrates were shipped by rail to Fertimex plants at San Luis Potosi, Quenetaro, and Guadalajara. At capacity, the mine is designed to produce 730,000 metric tons per year. The San Juan de la Costa deposit has proven reserves of 45 million metric tons assaying 18% P_2O_5 in the ground.

At Santo Domingo on the Pacific shore of the Baja California peninsula, Rofomex is constructing a mine to produce 1.5 million metric tons per year of concentrates by dredging a 4% P_2O_5 beach sand deposit. The mine is scheduled to start in 1982 and will ultimately produce 4.5 million metric tons per year to meet Mexico's anticipated growing demand. The resource at Santo Domingo is estimated to total 1.1 billion metric tons.

Morocco.—Phosphate rock is produced from the Oulad Abdoun Plateau with Khouribga as its mining center, the Ganntour Plateau where mining is centered at Youssoufia, and the Meskala area where no mining has taken place. The Office Cherifien des Phosphates estimated that these areas contain about 40 billion metric tons of phosphate rock. The Bu-Craa deposit in the Western Sahara is estimated to contain another 1.6 billion metric tons of phosphate rock reserves. Production peaked at Bu-Craa in 1975 when a total of 2,681,000 metric tons was produced. It is rumored that after repairs to equipment are completed, limited production will resume at Bu-Craa in 1982.

The planned expansions of Moroccan phosphate rock mines, soluble phosphate production capacity, and new port facilities indicate the Office Cherifien des Phosphates intends to change from a supplier of phosphate raw material to a supplier of intermediate and finished phosphate fertilizer. New processing capacity at Safi, Jorf Lasfar, and Nador will be capable of processing about 10 million metric tons of phosphate rock annually. At Safi, Maroc Chemie I and II and Maroc Phosphore I and II were constructed during the 1965-81 period. At Jorf Lasfar, Maroc Phosphore III will be constructed in the 1983-86 period. Further ahead, Maroc Phosphore IV is scheduled to be constructed at Nador from 1984 to 1987.

Peru.—Empresa Promotora Bayovar (Probayovar), a new company owned by Minero Peru, Cofide, and the Empresa Nacional de Comercializacion de Insumos, was formed in 1980 to promote the development of the Bayovar phosphate deposit. In July 1980, the World Bank granted a $7.5 million loan to Probayovar for technical and economic studies to determine the viability of developing the 600-million-ton phosphate reserve. The estimated resource is of the order of 10 billion tons of recoverable phosphate rock and 8.3 million tons of potassium chloride. The studies will establish the economics of producing phosphoric acid, phosphate fertilizers, and potash from the deposits.

Senegal.—Industries Chimiques du Senegal started constructing a fertilizer complex that is scheduled to start producing in 1984. A 560,000-metric-ton-per-year sulfuric acid plant and a 400,000-metric-ton-per-year phosphoric acid plant will be built near the phosphate mine at Taiba, about 100 kilometers north of Dakar. A 165,000-metric-ton-per-year diammonium phosphate plant will also be constructed at Mbao near an existing fertilizer complex.

South Africa, Republic of.—Foskor, the Phosphate Development Corp. Ltd., has increased capacity to over 3 million metric tons per year from Phalaborwa. Foskor supplies concentrates to the Federal Fertilizer Co. (Fedmis), the Triomf Fertilizer Company, and Omnia. Starting in 1976, phosphoric acid from Fedmis and Triompf was exported from Richards Bay. Foskor began exporting phosphate concentrates for the first time in 1981 and plans to ship as much as 2 to 3 million tons of phosphate rock in future years to markets where it can compete with selling prices and freight rates.

Syria.—The principal phosphate deposits are located near the city of Palmyra, 45 kilometers east of Homs. The mines are the Kneifiss, Sharkya A, and Sharkya B. The combined capacity of the mines is 1.2 million metric tons per year. Identified reserves are in the range of 500 to 600 million metric tons. The phosphate rock produced from Kneifiss averages 31% to 32% P_2O_5. The overburden ranges from 7 to 40 meters in thickness, and the phosphate bed averages 7 meters. The mines at Sharkya are both open pit operations. The overburden is a maximum 13 meters thick. The stripping ratio is 1 to 2 and the phosphate bed is about 12 meters. The ore grades analyze from 29% to 31% P_2O_5.

Togo.—In 1980, Togo's phosphate rock capacity was increased to 3.4 million metric tons per year when a fifth production line was started. In March 1981, the new line was shut down to synchronize production with current sales volume. A new slimes recovery plant was reported to be operating. The product from this line contains 8% iron and aluminum oxides, high water and chlorine levels, and grades 31% to 32% P_2O_5. The market for this phosphate rock will be limited to perhaps secondary rock for triple superphosphate production.

Tunisia.—Because phosphate rock from the Gafsa district is relatively low grade, Tunisia converts some of this ore to phosphoric acid for export. Tunisia was the first producer to develop this practice and is increasing its capacity of phosphoric acid and diammonium phosphate. To be able to meet the demand of these fertilizer plants for phosphate rock and maintain phosphate rock exports, Tunisia plans to increase phosphate rock capacity to about 10 million metric tons by the end of this decade. Three new phosphate rock mines are planned for the Gafsa district and a fourth is planned at Sra Ouertane near El Kef in the northwest part of the country for the early 1980's. The new Gafsa mines include the Jellabia-Mzinda, the Kef Eddour, and the Oum el Khjer with projected production of 1.5, 1.0, and 0.5 million metric tons per year, respectively.

U.S.S.R.—Production information about individual phosphate rock mines in the U.S.S.R. are not published. It is estimated that the mining areas in decreasing order of production are (1) Kola Apatite, (2) Kingisepp-Fosforit, (3) Podmoskovsk, (4) Maardu, (5) Bryansk, (6) Verkhrekamsk, and (7) Chelsaisk. The Kara Tau sedimentary mines were not included in this listing of apatite deposits released by Soyuzgorkhimprom, the Soviet chemical combine.

The Soviet press indicated that increases in the beneficiation capacity at the Kola Apatite combine and at the Kara Tau complex will boost production of phosphate rock during the 1981-85 period to meet the demand for increased fertilizer production. Near the end of this period, a new apatite combine based on the Oshurkon deposit will be completed near Lake Baikal.

President Reagan canceled the grain embargo, imposed in February 1980, and lifted the embargo on fertilizer exports to the U.S.S.R. in April 1981. The lifting of the embargo permitted Occidental Petroleum to resume shipping 1 million tons per year of SPA from north Florida to the U.S.S.R.

Table 27.— Phosphate rock and guano: World production, by country[1]

(Thousand metric tons)

Commodity and country[2]	1977	1978	1979	1980[p]	1981[e]
Phosphate rock:					
Algeria	1,173	1,136	1,084	1,025	[3]858
Australia	450	[r]248	7	4	7
Brazil[4]	[r]676	[r]1,096	1,628	2,472	[3]2,637
China[e]	4,000	4,500	5,500	5,500	5,500
Christmas Island (Indian Ocean)	1,186	[r]1,386	1,357	1,638	[3]1,336
Colombia	[r]6	[r]1	7	8	9
Egypt	472	639	623	658	700
Finland	--	--	2	125	130
France	25	25	12	25	25
Germany, Federal Republic of	80	--	--	--	--
India	740	789	681	541	550
Indonesia	4	6	5	[e]5	5
Israel	1,227	1,725	2,086	2,307	[3]2,290
Jordan	1,782	2,303	2,825	3,911	[3]3,523
Kiribati (Banaba Island, formerly Ocean Island)	446	465	420	--	--
Korea, North[e]	500	500	550	550	550
Mexico	285	322	171	283	355
Morocco	17,572	[5]19,713	[5]20,032	[5]18,824	[3] [5]19,696
Nauru	1,146	1,999	1,828	2,087	2,000
Netherlands Antilles (Curacao)	79	81	49	--	--
Philippines	10	1	2	17	16
Senegal[6]	1,871	1,759	1,835	1,632	[3]2,017
South Africa, Republic of	2,403	2,699	3,221	3,282	[3]2,910

See footnotes at end of table.

Table 27.— Phosphate rock and guano: World production, by country[1] —Continued

(Thousand metric tons)

Commodity and country[2]	1977	1978	1979	1980[p]	1981[e]
Phosphate rock —Continued					
Sweden[7]	50	83	58	83	75
Syria	425	800	1,272	1,319	[3]1,321
Thailand	3	3	5	6	6
Togo	2,857	2,827	2,920	2,933	[3]2,244
Tunisia	3,615	3,712	4,154	4,582	[3]4,596
Turkey	65	32	27	21	25
Uganda[e]	5	5	--	--	--
U.S.S.R.[e]	[r]26,925	[r]27,712	[r]28,405	[r]29,450	30,950
United States	47,256	50,037	51,611	54,415	[3]53,624
Venezuela	139	109	--	--	--
Vietnam[e]	1,500	1,800	400	500	550
Western Sahara	232	([5])	([5])	([5])	([5])
Zimbabwe	[r]105	[r]107	136	130	125
Total	[r]119,310	[r]128,620	132,913	138,333	138,630
Guano:					
Chile	7	([8])	--	--	--
Kenya	([8])	20	--	--	([8])
Philippines	([8])	1	3	25	25
Seychelles Islands[9]	5	6	7	4	5
Total	12	27	10	29	30

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

[1]Table includes data available through Apr. 7, 1982. Prepared by Division of Foreign Data.

[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]Reported figure.

[4]Figure represents total of direct sales of run-of-mine product plus output of marketable concentrate. Direct sales of run-of-mine product were as follows, in thousand metric tons: 1977, 26; 1978, 27; 1979, 39; 1980, 40; 1981, 40 (estimated). Total output of crude ore reported in Brazilian sources is far higher than figures presented here, but such figures are not equivalent to data shown for other countries in this table.

[5]Production from Western Sahara area (former Spanish Sahara) included with Morocco.

[6]Includes aluminum phosphate as follows, in thousand metric tons: 1977, 275; 1978, 204; 1979, 184; 1980, 224; 1981, 225 (estimated). Data do not include figures for output of several types of manufactured phosphatic fertilizers that are produced from the reported calcic phosphate and aluminum phosphate to avoid double counting.

[7]As reported by the International Superphosphate Manufacturer's Association; official Swedish statistics show no production of phosphate rock; this material is byproduct apatite concentrate derived from iron ore.

[8]Less than 1/2 unit.

[9]Exports.

TECHNOLOGY

In July 1980, the Bureau of Mines advertised for assistance to collect information on phosphate deposits in the market economy countries and centrally controlled economy countries. A contract was awarded in September 1980. A total of 102 individual deposit profile reports were completed by September 1981. The comprehensive investigation of worldwide phosphate occurrences was made to acquire the information to characterize the deposits, develop capital and operating costs for each deposit, and prepare deposit profile reports. The final report will be issued in 1983.

A study to characterize and cost all known phosphate deposits in the United States was initiated by the Bureau of Mines, Division of Minerals Availability. The report will be issued in 1983.

After operating a pilot plant designed by the Bureau of Mines, a producer of Western phosphate rock was able to increase P_2O_5 recovery by 13% and improve concentrate quality. The objective of the program was to reduce MgO levels in concentrates to the range of 0.4% to 0.7% and increase mill P_2O_5 recovery by treating ore fines that were discarded with tailings. A full-scale flotation section to utilize the Bureau's carbonate-silicate flotation process was installed and is operating.

The carbonate-silicate process was used to float samples of phosphate ores obtained from the Haikow Mine near Kunming, China. Bench-scale tests on one sample produced a 32% P_2O_5 concentrate with 94% flotation recovery. Another sample produced a 32% P_2O_5 product with a 79% flotation recovery.

The Bureau of Mines rotary screen dewatering unit, designed to separate water from flocculated phosphate slimes, was installed and operated in several Florida phosphate mining and beneficiating plants. Slimes containing 3% solids were dewatered to a solid content as high as 20%.

Samples of low-grade phosphate pebble and flotation feed characterized by high magnesium content were obtained from Florida to study procedures necessary to produce an acceptable grade of concentrate with low MgO concentrations. The flotation studies will continue to attempt to improve concentrate quality and recovery.

Tailings from seven Florida phosphate operations were analyzed for P_2O_5, uranium, and radium-226. The P_2O_5 content ranged from 1.1% to 18.7%. The radiation levels from both uranium and radium-226 ranged from 1.7 to 18.4 picocuries per gram and 1.7 to 19.1 picocuries per gram, respectively. A technical progress report will be published. Only two of the seven samples had flotation tailings less than the proposed Environmental Protection Agency radium-226 level of 5 picocuries per gram.

The boreholed technology that was used to slurry mine coal and uranium in the Western United States was tested in St. Johns County, Fla. Joint experiments were concluded in 1981 by the Bureau of Mines and a phosphate producing company. In the first experiment, the high-pressure mining jet was operated in a flooded cavity. Over 700 metric tons of matrix were extracted from a 4.6-meter-radius cavity at a rate of about 33 metric tons per hour. When the cavity water level was pumped down to conduct an air experiment, the roof cap rock failed, terminating the test. The second experiment, well number 2, was conducted to determine the effective radius of the mining jet in an air environment. Mining progressed to the monitoring well, a distance of 6 meters from the slurry well, when the roof suddenly failed. The test was terminated. The third experiment was conducted to confirm test number 1 and to test an air shroud around the mining jet. The test was initially conducted in a water environment, and almost 400 metric tons were extracted. At this point, the air shroud was activated, and another 160 metric tons were extracted. The improvement in extraction was confirmed with the air shroud, and the cavity radius was extended 5 to 6 meters. No roof collapse problems were encountered, and the first program phase ended. During the second phase of the program, scheduled for 1982, tests will be conducted to establish costs, to pump matrix from the ground to a slurry pond, deslime and store products, and backfill the cavity with slimes and flotation feed.

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[1]Physical scientist, Division of Industrial Minerals.
[2]Industrial Minerals. January 1981, p. 11.
[3]Mining Journal. May 1, 1981, p. 232.
[4]Ketzinel, Z., Y. Yolksman, and M. Hassid. Research on Uranium Recovery From the Phosphate Industry in Israel. Nuclear Research Center, Nagen, Israel.

Platinum-Group Metals

By J. Roger Loebenstein[1]

World production of platinum-group metals (PGM) in 1981 was estimated at 6.8 million troy ounces, the same level as production in 1980. The Republic of South Africa remained the leading producer of platinum and accounted for 44% of world production of PGM. The U.S.S.R. remained the leading producer of palladium and accounted for 49% of world production of PGM. Canadian production of PGM, a byproduct of nickel production, accounted for 6% of the total world production.

Mine production of PGM in the United States is a byproduct of copper refining. Following the settlement of the 1980 U.S. copper strike, mine production of PGM increased to 6,150 troy ounces. Total refined production of PGM increased for the 5th consecutive year to 1.6 million troy ounces in 1981. Sales of PGM in 1981 decreased 13% from the 1980 level, primarily as a result of decreased sales to the automotive, chemical, and petroleum industries. Stocks of platinum, osmium, and rhodium decreased, while stocks of palladium, iridium, and ruthenium increased.

Lower world demand for PGM prompted the two world leading producers, Rustenburg Platinum Mines, Ltd., (RPM) and Impala Platinum Ltd., to reduce production. Lower demand also caused PGM prices to decline sharply in 1981. There was considerably less investor interest in platinum and other precious metals in 1981 than in 1979 and 1980.

Table 1.—Salient platinum-group metals[1] statistics

(Troy ounces)

	1977	1978	1979	1980	1981
United States:					
Mine production[2]	5,545	8,246	7,300	3,348	6,150
Value	$396,649	$759,925	$1,288,155	$923,423	$1,335,722
Refinery production:					
New metal	5,199	8,303	8,392	2,300	5,607
Secondary metal	195,219	257,191	309,022	330,923	391,637
Toll-refined metal	1,005,023	1,023,314	1,090,678	1,079,813	1,192,315
Total refined metal	1,205,441	1,288,808	1,408,092	1,413,036	1,589,559
Exports (except manufactured goods)	426,631	702,547	899,598	764,964	863,365
Imports for consumption	2,510,374	2,921,411	3,479,128	3,501,782	2,849,617
Stocks Dec. 31: Refiner, importer, dealer	1,012,812	861,411	761,282	973,261	946,769
Consumption (sales)	1,592,277	2,259,558	2,756,021	2,205,910	1,920,672
World: Production	[r]6,510,617	[r]6,440,190	[r]6,486,402	[p]6,836,137	[e]6,823,265

[e]Estimated. [p]Preliminary. [r]Revised.
[1]The platinum group comprises six metals: Platinum, palladium, iridium, osmium, rhodium, and ruthenium.
[2]Recovered from platinum placers and as byproducts of copper refining.

Legislation and Government Programs.—U.S. Government inventories of platinum, palladium, and iridium were unchanged in 1981. The quantities, in troy ounces, held in the national defense stockpile and the goals (objectives) at yearend were as follows:

	Goal	Inventory
Platinum	1,310,000	452,640
Palladium	3,000,000	1,255,003
Iridium	98,000	16,991

The General Services Administration entered into basic ordering agreements with suppliers for the purchase of iridium for the national stockpile. The agreements set the purity and conditions for purchase without specifying the price or quantity to be purchased.

Automobile emission standards for 1982 models remained unchanged from those set for 1981 models. The current standards allow emissions of 3.4 grams of carbon monoxide per mile, 0.41 gram of hydrocarbons per mile, and 1.0 gram of nitrogen oxides per mile. About 30% of engines manufactured in 1981 were allowed to meet a less stringent carbon monoxide standard of 7.0 grams per mile.

DOMESTIC PRODUCTION

In 1981, domestic mine production of PGM, largely a byproduct of copper mining, increased following the settlement of the 1980 U.S. copper strike. Production of platinum and palladium accounted for 95% of total secondary refined production of PGM shown in table 2. Platinum and palladium were produced in nearly equal amounts both in 1980 and in 1981. Secondary refined production of ruthenium nearly tripled from the amount recovered in 1980.

Platinum and palladium were recovered from copper ores by U.S. Metals Refining Co., a subsidiary of AMAX Copper Inc., ASARCO Incorporated, and Kennecott Corp. Numerous refiners process PGM scrap on a toll and a nontoll basis. The largest processors in the United States are Engelhard Minerals & Chemicals Corp., Johnson Matthey Inc., and U.S. Metals Refining Co.

The Anaconda Company continued exploration and test production of platinum and palladium at its deposit near Nye, Mont., within the Stillwater complex. In August 1981, Anaconda submitted an operating permit application to the Montana Department of State Lands. The application was reportedly filed in order to expedite completion of an environmental impact statement being prepared by the Montana Department of State Lands and the U.S. Forest Service. A final decision by Anaconda on whether to proceed with production will probably be made sometime in 1982. Anaconda expects the earliest date for production to be late 1984 or early 1985. Production is planned in the range of 30,000 to 35,000 troy ounces per year of platinum, or about 4% of 1981 U.S. consumption of 873,000 troy ounces. Production of palladium is expected to total about 100,000 troy ounces per year, or about 11% of 1981 U.S. consumption of 889,000 troy ounces.

Stillwater PGM Resources, a joint venture of Manville Products Corp. and Chevron USA, Inc., continued exploration for PGM within the Stillwater complex. The company expects to make a final decision on whether to proceed with the project during 1983. Ore assays indicate a combined platinum-palladium content of 0.5 to 0.75 ounce per short ton. The palladium-to-platinum ratio is about 3.5 to 1.

Full-scale dredging operations were resumed in May at Goodnews Bay, Alaska, after a 5-year shutdown. Potentially, 10,000 troy ounces of platinum per year over a period of 50 years could be recovered from a total deposit of 500,000 troy ounces.

Refinement International, Inc., announced plans to develop a collection network for recovering PGM from scrapped automotive catalytic converters. The spent catalyst will be shipped to the company's Woonsocket, R.I., refinery for processing.

United Smelting & Refining Co. began operation of its expanded precious metals smelting facility at Franklin Park, Ill., in June 1981. Capacity was increased to 50,000 pounds per day of precious metals, principally from industrial scrap.

CONSUMPTION AND USES

Reported sales of PGM in 1981 decreased from the 1980 level, primarily as a result of decreased sales to the automotive, chemical, and petroleum industries. Sales of PGM to both the electrical and dental industries changed little in 1981. The automotive industry remained the largest purchaser of PGM, accounting for 32% of sales in 1981.

U.S. automobile production of 6.3 million automobiles was the lowest in 20 years in 1981, according to Ward's automotive reports. Lower automotive production and a continuing trend towards downsizing automobiles reduced demand for PGM in auto-

Table 2.—Platinum-group metals refined in the United States

(Troy ounces)

Year	Platinum	Palladium	Iridium	Osmium	Rhodium	Ruthenium	Total
PRIMARY METAL							
Nontoll-refined:							
1977	831	4,300	52	9	6	1	5,199
1978	1,081	7,222	--	--	--	--	8,303
1979	1,980	6,412	--	--	--	--	8,392
1980	535	1,765	--	--	--	--	2,300
1981	1,005	4,602	--	--	--	--	5,607
Toll-refined:							
1977	466	610	4	--	3	--	1,083
1978	177	1,177	--	--	--	--	1,354
1979	56	420	--	--	--	--	476
1980	128	673	--	--	--	--	801
1981	235	934	--	--	--	--	1,169
SECONDARY METAL							
Nontoll-refined:							
1977	50,838	134,086	1,442	12	5,011	3,830	195,219
1978	75,585	166,371	1,565	3	8,266	5,401	257,191
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
Toll-refined:							
1977	620,848	327,450	4,970	1,955	42,178	6,539	1,003,940
1978	630,961	344,022	6,599	667	35,914	3,797	1,021,960
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
1980 TOTALS							
Total primary	663	2,438	--	--	--	--	3,101
Total secondary	687,176	661,313	8,119	1,384	43,468	8,475	1,409,935
Grand total	687,839	663,751	8,119	1,384	43,468	8,475	1,413,036
1981 TOTALS							
Total primary	1,240	5,536	--	--	--	--	6,776
Total secondary	708,600	793,161	11,144	1,929	46,187	21,762	1,582,783
Grand total	709,840	798,697	11,144	1,929	46,187	21,762	1,589,559

mobile catalysts.

The principal domestic uses of PGM in 1981 were as catalysts to control automobile exhaust emissions, reforming catalysts to upgrade the octane rating of gasolines, catalysts to produce acids and organic chemicals, electrical contacts and relays primarily for use in telephone systems, bushings for glass fiber manufacture, and dental alloys for orthodontic and prosthodontic uses.

Uses of platinum and palladium in 1981 are shown in figure 1. Catalytic uses include automotive, chemical, and petroleum end uses. Corrosion-resistant uses include dental, medical, and glass end uses.

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
1977	789,819	700,469	13,456	911	55,216	32,406	1,592,277
1978	1,196,341	917,928	16,839	817	69,640	57,993	2,259,558
1979	1,408,925	1,132,621	17,301	974	83,470	112,730	2,756,021
1980:							
Automotive	517,143	176,518	--	--	37,012	674	731,347
Chemical	118,956	119,905	4,134	321	5,273	35,972	284,561
Dental and medical	25,831	244,279	495	498	45	508	271,656
Electrical	150,060	312,778	11,273	--	14,818	37,224	526,153
Glass	52,897	1,155	50	--	8,581	--	62,683
Jewelry and decorative	50,998	13,491	3,092	--	5,434	560	73,575
Petroleum	144,039	22,013	4,058	--	662	--	170,772
Miscellaneous	58,307	21,828	482	--	1,703	2,843	85,163
Total	1,118,231	911,967	23,584	819	73,528	77,781	2,205,910

See footnotes at end of table.

Table 3.—Platinum-group metals[1] sold to consuming industries in the United States —Continued

(Troy ounces)

Year and industry	Platinum	Palladium	Iridium	Osmium	Rhodium	Ruthenium	Total
1981:							
Automotive	446,677	129,214	83	--	30,009	1,300	607,283
Chemical	78,134	90,272	999	413	8,899	51,843	230,560
Dental and medical	18,739	255,114	173	250	35	233	274,544
Electrical	111,697	345,365	3,551	--	12,050	27,323	499,986
Glass	29,272	2,922	--	--	3,950	--	36,144
Jewelry and decorative	27,604	14,772	558	--	3,618	700	47,252
Petroleum	88,314	20,877	1,874	--	--	170	111,235
Miscellaneous	72,202	30,650	1,178	--	3,549	6,089	113,668
Total	872,639	889,186	8,416	663	62,110	87,658	1,920,672

[1]Comprises primary and nontoll-refined secondary metals.

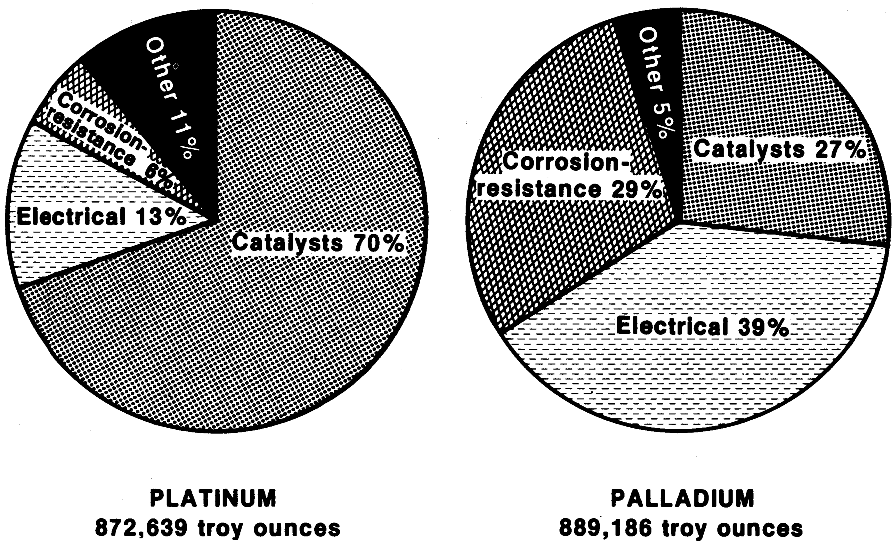

Figure 1.—Uses of platinum and palladium in 1981.

STOCKS

Stocks of platinum decreased and stocks of palladium increased as a result of changes in inventories held by the New York Mercantile Exchange (NYME). Stock data in table 4 are partial stocks because the Bureau of Mines does not collect inventory data from end users of PGM, some of whom may hold sizable inventories. In addition, there were Government inventories of platinum, palladium, and iridium.

The NYME upgraded the minimum quality standard platinum contract from 99.5% to 99.9% pure platinum. The amended contract trading was opened in August and was effective beginning for the January and April 1983 contract months.

Table 4.—Refiner, importer, and dealer stocks of platinum-group metals in the United States, December 31[1]

Year	Platinum	Palladium	Iridium	Osmium	Rhodium	Ruthenium	Total
1977	438,045	475,358	15,689	420	48,392	34,908	1,012,812
1978	369,823	369,937	16,264	708	51,322	53,357	861,411
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	429,830	399,083	16,819	37	43,355	57,645	946,769

[1]Includes metal in depositories of the New York Mercantile Exchange; on Dec. 31, 1981, this comprised 195,350 troy ounces of platinum and 98,400 troy ounces of palladium.

PRICES

All PGM prices declined sharply in 1981.

Table 5.—Monthly 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: Average	352	445	113	120	733	770	257	280	45	32	150	130
1980:												
January	420	820	155	231	800	839	350	351	45	34	150	130
February	420	889	188	271	800	833	381	461	45	36	150	130
March	420	699	225	239	800	801	419	557	45	36	150	130
April	420	600	225	195	800	761	500	624	45	36	150	130
May	420	564	225	160	800	733	500	702	45	36	150	130
June	420	648	225	170	800	749	500	769	45	35	150	130
July	420	664	225	199	800	727	500	769	45	35	150	130
August	433	650	225	205	787	705	513	752	45	35	150	130
September	475	707	225	213	700	652	600	750	45	35	150	130
October	475	671	225	201	700	652	600	767	45	35	150	130
November	475	634	225	183	700	661	600	750	45	35	150	130
December	475	580	200	151	700	634	600	735	45	35	150	130
Average	439	677	214	201	766	729	505	666	45	35	150	130
1981:												
January	475	522	200	128	700	609	600	689	45	33	150	130
February	475	480	170	112	700	581	600	670	45	33	150	130
March	475	496	140	119	700	567	600	643	45	33	150	130
April	475	478	140	107	700	547	600	589	45	33	150	130
May	475	462	134	103	687	527	600	530	45	33	150	130
June	475	440	110	92	600	497	600	508	45	32	150	130
July	475	408	110	85	600	472	600	483	45	32	150	130
August	475	423	110	86	600	467	600	463	45	32	150	130
September	475	434	110	87	600	462	600	450	45	32	150	130
October	475	419	110	78	600	436	600	453	45	32	150	130
November	475	393	110	69	600	419	600	444	45	31	150	130
December	475	397	110	70	600	392	600	421	45	31	150	130
Average	475	446	130	95	641	498	600	529	45	32	150	130

[1]Average prices calculated at the low end of the ranges of weekly averages and rounded to the nearest dollar.

Source: Metals Week.

FOREIGN TRADE

Exports of PGM increased to 863,000 troy ounces valued at over $300 million in 1981. Principal recipients were Japan, the United Kingdom, Switzerland, and Canada. Principal import sources were from the Republic of South Africa, the U.S.S.R., and the United Kingdom.

Table 6.—U.S. exports of platinum-group metals, by year and country

Year and country	Ores and concentrates (troy ounces)	Waste, scrap, and sweepings (troy ounces)	Metal not rolled (troy ounces)			Metal rolled (troy ounces)		Total	
			Platinum	Palladium	Other platinum group	Platinum	Other platinum group	Troy ounces	Value (thousands)
1980:									
Argentina	--	--	--	200	707	29	--	936	$230
Australia	--	--	57	--	701	5	36	799	267
Belgium-Luxembourg	--	27,662	30	2,451	1,093	19	1,028	32,283	12,166
Brazil	--	--	53	2,214	--	774	1,593	4,634	915
Canada	344	27,781	6,187	20,060	17,047	307	673	72,399	27,796
Finland	--	--	--	20	4,664	--	--	4,684	2,908
France	--	358	2,065	4,634	4,149	614	18	11,838	3,878
Germany, Federal Republic of	1,472	14,001	43,264	26,873	23,184	732	1,649	111,175	57,596
Greece	--	--	--	2,304	511	--	--	2,815	279
Hong Kong	--	--	--	825	139	--	20	984	281
India	--	4	800	19	8	50	--	881	527
Ireland	--	--	--	581	--	--	--	581	52
Italy	15	12	1,667	983	2,805	844	67	6,393	2,514
Japan	289	--	97,949	83,073	23,715	29,655	3,282	237,963	108,493
Korea, Republic of	--	--	124	780	--	--	198	1,102	131
Mexico	--	6	253	323	5,044	497	21	6,144	2,126
Netherlands	--	--	(1)	9,347	1,115	1,106	218	11,786	2,934
Norway	--	--	--	3	3,929	--	35	3,967	2,293
Singapore	--	--	--	211	361	--	--	572	100
South Africa, Republic of	--	--	1,000	40	1,897	--	315	3,252	1,950
Sweden	17	69	--	1,286	2,551	--	326	4,249	1,835
Switzerland	80	4	48,649	8,032	10,367	13	49	67,194	38,862
United Kingdom	387	100,106	52,101	13,945	4,060	275	2,867	173,741	71,723
Venezuela	30	--	14	452	--	4	21	521	52
Other	163	253	282	1,030	1,464	35	844	4,071	1,296
Total	2,797	170,256	254,495	179,686	109,511	34,959	13,260	764,964	[2]341,206
1981:									
Argentina	157	52	474	321	121	--	279	1,404	263
Australia	--	--	47	--	816	--	50	913	382
Belgium-Luxembourg	--	38,891	--	1,096	3,764	854	848	45,453	13,447
Brazil	217	--	352	--	890	99	93	1,651	326

Canada	190	48,197	5,441	12,066	19,989	484	1,261	87,628	32,327
China	3,215	--	--	--	--	--	--	3,215	107
Finland	--	--	--	--	3,343	--	--	3,343	1,226
France	--	175	730	2,606	1,971	21	410	5,913	1,925
Germany, Federal Republic of	1,100	5,259	30,344	22,437	4,886	243	2,951	67,220	22,031
Greece	--	--	12	3,471	640	--	43	4,166	319
Hong Kong	--	--	2	1,589	372	2,399	1	4,363	1,388
India	222	--	662	32	15	--	--	931	477
Italy	--	--	1,500	559	1,929	164	187	4,339	1,493
Japan	1,655	1,300	178,179	73,299	19,837	56,123	9,589	339,982	130,074
Korea, Republic of	--	--	326	1,471	11	--	2	1,810	214
Mexico	588	--	67	161	1,165	273	168	2,422	769
Netherlands	--	--	628	1,388	257	202	1,819	4,294	916
Norway	--	--	--	6	5,312	--	166	5,484	2,459
South Africa, Republic of	--	--	96	--	2,355	387	4	2,842	1,052
Sweden	--	308	151	--	2,473	1,940	138	5,010	1,641
Switzerland	--	--	96,967	2,819	7,998	380	40	108,204	48,618
United Kingdom	677	109,889	6,089	22,468	1,526	60	8,799	149,508	36,514
Other	225	109	5,261	4,005	2,178	237	1,255	13,270	3,922
Total	8,246	204,180	327,328	149,794	81,848	63,866	28,103	863,365	301,890

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

Table 7.—U.S. imports for consumption of platinum-group metals, by year and country

Year and country	Unwrought (troy ounces): Platinum grains and nuggets	Platinum sponge	Palladium	Iridium	Osmium	Osmiridium	Rhodium	Ruthenium	Unspecified combinations	Platinum-group metals from precious metal ores	Sweepings, waste, and scrap
1980	15,427	1,191,803	1,202,342	26,090	440	10,388	109,591	98,488	110,951	675	376,500
1981:											
Australia	--	24	--	--	--	--	--	--	--	--	25,695
Belgium-Luxembourg	267	13,034	85,029	--	--	--	148	--	--	--	41,000
Canada	63	5,760	23,812	--	--	--	213	250	57	--	43,518
Colombia	--	1,200	--	--	--	--	--	--	--	--	3,102
Costa Rica	--	1,424	402	--	--	--	--	368	--	--	7,650
Finland	--	--	--	--	--	--	--	--	--	--	3,079
Germany, Federal Republic of	--	10,038	6,370	--	--	433	1,492	--	11	--	--
Hong Kong	--	--	--	--	--	--	--	52,499	--	--	--
Italy	--	2,817	--	194	--	--	--	--	--	--	--
Japan	--	--	--	--	--	--	100	--	582	--	--
Mexico	--	--	--	--	--	--	--	--	--	--	78,591
Netherlands	--	6,850	24,032	100	--	--	535	3,000	--	--	2,299
Norway	--	14,247	13,200	--	--	--	798	--	--	--	4,138
Panama	--	--	--	--	--	--	--	--	--	--	5,920
Peru	--	--	--	--	--	--	--	10,695	804	--	--
South Africa, Republic of	--	759,845	562,051	9,304	--	--	52,623	96,437	497	1,442	9,988
Spain	--	--	9,017	--	--	--	--	--	--	--	--
Sweden	--	--	960	250	--	--	--	--	--	--	5,262
Switzerland	10	5,100	10,315	--	--	--	200	50	10,381	--	--
U.S.S.R.	1,000	9,115	296,432	--	--	--	6,196	--	14,197	--	--
United Kingdom	251	57,451	81,528	1,262	850	8,876	9,929	17,139	6,207	--	3,055
Other	300	2,090	1,165	--	--	--	1,504	--	--	--	2,082
Total	1,891	888,995	1,114,313	11,110	850	9,309	73,738	180,438	32,736	1,442	235,379

	Semimanufactured (troy ounces)					Platinum-group metals in materials not elsewhere specified (troy ounces)	Total	
	Platinum	Palladium	Iridium	Rhodium	Unspecified combinations		Troy ounces	Value (thousands)
1980	230,344	114,246	73	686	744	12,994	3,501,782	$1,176,747
1981:								
Australia	--	--	--	--	--	--	25,719	2,341
Belgium-Luxembourg	--	--	--	917	--	--	140,395	36,591
Canada	3,134	--	--	--	--	1,563	78,370	20,031
Colombia	--	--	--	43	--	--	4,345	2,145
Costa Rica	--	--	--	--	--	--	9,844	2,748
Finland	--	--	--	--	--	--	3,079	1,578
Germany, Federal Republic of	387	22	48	--	--	--	18,801	6,959
Hong Kong	--	2	--	--	--	--	52,501	650
Italy	--	--	--	--	--	--	3,011	1,524
Japan	--	--	--	--	--	--	682	361
Mexico	--	--	--	--	--	--	78,591	4,096
Netherlands	--	4,498	200	--	--	--	41,514	7,726
Norway	--	321	--	114	--	--	32,818	10,284
Panama	--	--	--	--	--	--	5,920	2,700
Peru	--	--	--	--	--	--	11,499	1,188
South Africa, Republic of	108,277	19,784	--	289	--	--	1,620,537	539,536
Spain	100	--	--	--	--	--	9,117	828
Sweden	--	--	--	--	--	--	6,472	2,742
Switzerland	6,597	3,925	--	--	--	--	36,578	12,348
U.S.S.R.	5,283	27,239	--	--	--	--	359,462	50,327
United Kingdom	55,543	60,577	--	370	1	--	303,039	90,449
Other	--	180	--	--	2	--	7,323	3,104
Total	179,321	116,548	248	1,733	3	1,563	2,849,617	800,256

Table 8.—Imports of platinum-group metals, by year and country

(Percent of total imports)

Year and country	Platinum	Palladium	Iridium	Osmium	Rhodium	Ruthenium	Total imports
1980:							
South Africa, Republic of	66	40	46	2	70	78	54
U.S.S.R.	1	21	--	--	7	--	11
United Kingdom	16	13	29	98	13	10	14
Other	17	26	25	--	10	12	21
1981:							
South Africa, Republic of	75	42	61	2	67	53	57
U.S.S.R.	2	24	--	--	7	--	13
United Kingdom	10	10	8	98	13	9	10
Other	13	24	31	--	13	38	20

WORLD REVIEW

World production of PGM in 1981 was estimated at 6.8 million troy ounces. The U.S.S.R. and the Republic of South Africa remained the leading producers. Byproduct production of PGM from nickel-copper ores in Canada, the third largest PGM producer, declined slightly in 1981.

Lower economic activity in the United States and abroad resulted in less demand for PGM. Owing to high interest rates and relatively low inflation in the United States in 1981, most investors and speculators avoided purchases of precious metals.

A review and outlook for platinum and palladium was published by J. Aron Commodities Corp.[2] Included in the review was a discussion of supply and demand, investment demand, the U.S. strategic stockpile, and the future outlook.

Canada.—Inco Ltd. and Falconbridge Nickel Mines Ltd. decreased mine production levels in 1981 as nickel demand decreased. Both companies recovered PGM as byproducts of nickel and copper production. Inco processed the concentrate at its refinery in Acton, England, and Falconbridge recovered PGM from nickel-copper matte at its refinery in Kristiansand, Norway. Inco tested a proprietary process for refining precious metals.[3] If the process proves successful, Inco could build a $30 million to $50 million refinery that would upgrade refining of PGM at Sudbury. The process would still require shipment of PGM concentrate to Acton for final refining.

Japan.—Imports of PGM by Japan increased 22% to 2.2 million troy ounces, roughly equivalent to Japanese consumption of PGM in 1981.[4] The Republic of South Africa remained the primary supplier of platinum, the U.S.S.R. remained the primary supplier of palladium, and the United Kingdom was the primary supplier of rhodium. Over 500,000 troy ounces of platinum were consumed by the jewelry industry alone in Japan in 1981. About 200,000 troy ounces of palladium were consumed by the dental industry. Two Japanese automobile manufacturers signed contracts with Johnson Matthey Public Ltd. Co. for supply of automobile catalysts.

South Africa, Republic of.—The Republic of South Africa continued to be the world's largest producer of platinum, ruthenium, and possibly rhodium and osmium. Virtually all of the country's production was mined from the Merensky Reef of the Bushveld complex in Transvaal by three companies. Osmiridium also was recovered as a byproduct of gold mining.

RPM, a subsidiary of Rustenburg Platinum Holdings Ltd. (RPH), continued to operate three major mines for the production of platinum-group metals from the Merensky Reef. ATOK Platinum Mines (Pty.) Ltd., a subsidiary of RPH, continued to operate a mine at the eastern end of the Merensky Reef.

RPM's mine output was refined at two plants, one of which was in the Republic of South Africa, and the other in the United Kingdom. The plants were operated and owned by Matthey Rustenburg Refiners (Pty.) Ltd., which was jointly owned by RPM and Johnson Matthey Public. All PGM products were marketed exclusively by Johnson Matthey Public.

Impala operated four mines in Bophuthatswana for the production of PGM. Ore was concentrated into a nickel-copper matte containing small quantities of PGM. Nickel, copper, and PGM were produced at two refineries in Springs, the Republic of South Africa.

Western Platinum Ltd. mined ore in the Merensky Reef and produced a copper, nickel, and cobalt matte containing PGM. Matte was shipped to the Falconbridge refinery at Kristiansand, Norway, where it was processed to obtain refined copper, nickel, and cobalt. The precious metal sludge byproduct was sent back to the Republic of South Africa for final processing and extraction of PGM.

Western Platinum continued development work on the UG-2 Reef, which underlies the Merensky Reef. Mining of UG-2 is scheduled to begin in 1982.

In response to lower world demand for PGM in 1981, the two leading world PGM producers, RPM and Impala, announced plans to reduce production. Impala reduced its production by 10% to 15%, and RPM deferred plans to expand its Amandelbult Mine.

United Kingdom.—Matthey Rustenburg Refiners approved construction of a $33 million to $36 million PGM refinery at Royston, about 60 miles north of London. The facilities will process both South African concentrates and secondary materials using a new solvent extraction process. The refinery is scheduled for completion by yearend 1982.

Table 9.—Platinum-group metals: World production, by country[1]

(Troy ounces)

Country[2]	1977	1978	1979	1980[p]	1981[e]
Australia, metal recovered domestically from nickel ore:[3]					
Palladium, metal content, from nickel ore	9,581	7,395	6,880	7,100	7,000
Platinum, metal content, from nickel ore	3,697	[r]12,958	2,765	2,500	2,400
Ruthenium	225	[e]300	[e]200	150	140
Canada: Platinum-group metals from nickel ore	465,371	346,213	197,943	410,757	400,000
Colombia: Placer platinum	[r]17,315	13,939	12,933	14,345	15,000
Ethiopia: Placer platinum	[e]100	123	108	113	125
Finland: Platinum-group metals from copper ore[e]	[r]640	[r]640	720	700	700
Japan, metal recovered from nickel and copper ores:[4]					
Palladium	22,716	24,221	22,495	28,968	25,600
Platinum	9,737	10,176	12,142	12,366	10,400
South Africa, Republic of: Platinum-group metals from platinum ores[e] [5]	2,870,000	2,860,000	3,017,000	3,100,000	3,000,000
U.S.S.R.: Placer platinum and platinum-group metals recovered from nickel-copper ores[e]	3,100,000	[r]3,150,000	3,200,000	3,250,000	3,350,000
United States: Placer platinum and platinum-group metals from gold and copper ores	5,545	8,246	7,300	3,348	6,150
Yugoslavia:					
Palladium	4,951	5,562	5,241	5,150	5,100
Platinum	739	417	675	640	650
Total	[r]6,510,617	[r]6,440,190	6,486,402	6,836,137	6,823,265

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

[1]Table includes data available through May 12, 1982. Platinum-group metal production by the Federal Republic of Germany, Norway, and the United Kingdom is not included in this table because the production is derived wholly from imported metallurgical products and to include it would result in double counting.

[2]In addition to the countries listed, China, Indonesia, Papua New Guinea, and the Philippines are believed to produce platinum-group metals, and several other countries may also do so, but output is not reported quantitatively, and there is no reliable basis for the formulation of estimates of output levels. However, a part of this output not specifically reported by country is presumably included in this table credited to Japan. (See footnote 4.)

[3]Partial figure; excludes platinum-group metals recovered in other countries from nickel ore of Australian origin; however, a part of this output may be credited to Japan. (See footnote 4.)

[4]Japanese figures do not refer to Japanese mine production, but rather represent Japanese smelter-refinery recovery from ores originating in a number of countries; this output cannot be credited to the country of origin because of a lack of data. Countries producing and exporting such ores to Japan include (but are not necessarily limited to) Australia, Canada, Indonesia, Papua New Guinea, and the Philippines. Output from ores of Australian, Indonesian, Papua New Guinea, and Philippine origin are not duplicative, but output from Canadian material might duplicate a part of reported Canadian production.

[5]Includes osmiridium produced in gold mines.

TECHNOLOGY

The Bureau of Mines investigated the concentration of PGM ore from the Stillwater complex in Montana.[5] Best results were obtained with a flotation scheme utilizing a mercaptobenzothiazole collector and sulfuric acid.

The Bureau of Mines tested ore from four potential platinum deposits in Alaska.[6] An attempt was made to concentrate PGM with primary minerals such as chromite, copper sulfide, or magnetite. A high-grade sample from the Salt Chuck copper sulfide deposit yielded the best PGM concentrate; the maximum grade attained was 0.04 ounce platinum and 1.5 ounce palladium per ton of high-grade copper sulfide concentrate.

Johnson Matthey Public continued to investigate technologies for reducing automobile emissions.[7] Progressively tighter emission standards in the United States have necessitated the use of rhodium-platinum three-way catalyst systems by automobile manufacturers. Three-way catalysts are capable of removing the three major exhaust pollutants: Hydrocarbons, carbon monoxide, and nitrogen oxides. In order for a three-way catalyst to work at maximum efficiency, the air-to-fuel ratio must be carefully controlled by using a method such as electronic air injection.

As an alternative to the single three-way catalyst, Johnson Matthey Public studied the use of a dual catalyst system consisting of a rhodium-platinum three-way reduction catalyst and an oxidation catalyst.[8] After exhaust gases pass through the reduction catalyst, most of the nitrogen oxides and some of the hydrocarbons and carbon monoxides are removed. Air is added to the exhaust gases after the gases leave the reduction catalyst but before the gases enter the oxidation catalyst. After passing through the oxidation catalyst, the remainder of the hydrocarbons and carbon monoxide are removed.

Johnson Matthey Public researched the protection of gas turbine blades from corrosive environments using platinum aluminide diffusion coatings.[9] According to the report, gas turbine engines operating in marine environments often ingest salt-laden air. The combination of corrosive salt and the high operating temperatures causes premature destruction of internal engine components. Conventional aluminide coatings are widely used for corrosion protection, but platinum aluminides provide better corrosion resistance.

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[1]Physical scientist, Division of Nonferrous Metals.

[2]J. Aron Commodities Corp. Annual Platinum-Palladium Review and Outlook. May 1981, 111 pp.

[3]American Metal Market. Testing of Inco Process Could Lead to Refinery. V. 89, No. 3, Jan. 7, 1981, p. 8.

[4]Japan Metal Journal. Imports of Precious Metals in Entire 1981 and Jan. 1982. V. 12, No. 10, Mar. 8, 1982, pp. 8-9.

[5]Bennetts, J., E. Morrice, and M. M. Wong. Preparation of Platinum-Palladium Flotation Concentrate From Stillwater Complex Ore. BuMines RI 8500, 1981, 18 pp.

[6]Dahlin, D. C., A. R. Rule, and L. L. Brown. Beneficiation of Potential Platinum Resources From Southeastern Alaska. BuMines RI 8553, 1981, 14 pp.

[7]Harrison, B., B. J. Copper, and A. J. J. Wilkins. Control of Nitrogen Oxide Emissions From Automobile Engines. Platinum Met. Rev., v. 25, No. 1, January 1981, pp. 14-21.

[8]Work cited in footnote 7.

[9]Wing, R. G., and I. R. McGill. The Protection of Gas Turbine Blades. Platinum Met. Rev., v. 25, No. 3, July 1981, pp. 94-105.

Potash

By James P. Searls[1]

U.S. potash production declined 4% while apparent consumption fell 2% with the decline occurring primarily in the second half of the year. Domestic sales fell 14%. Exports from the United States also fell sharply in the second half of the year. Stocks at the producers' plants had risen strongly by yearend. Domestic producers discounted prices in response to lower demand and foreign discounting with delay-of-payment schedules.

Worldwide potash supply appeared to be in general balance with demand in the first half of the year, but larger than demand in the second half of the year. Brazilian demand for potash fell owing to lack of foreign reserves for purchasing imports of any sort. Brazilian authorities allocated their imports of potash at a lower-than-historical level as part of their effort to achieve a positive balance-of-payments position at the end of the year. Polish demand for potash also declined owing to the social unrest, which forced its usual suppliers, the U.S.S.R. and the German Democratic Republic, to look to the international market with their unsold product. Additionally, the U.S.S.R. apparently brought new production capacity into the market. The U.S.S.R. was also in need of hard currencies to support its client country economies and to purchase foodstuffs to supplement their poor 1981 harvest. The U.S.S.R.'s efforts to sell potash by price cutting appeared to be part of a larger effort that involved gold, petroleum products, and other commodities moving out of the U.S.S.R. All this, plus the strengthening U.S. dollar, caused U.S. potash exports to fall sharply in the second half of the year.

In the United States, the full year average prices, as measured at the plant, for muriate (standard, coarse, and granular) increased from $133 per metric ton, K_2O equivalent,[2] in 1980 to $137 per ton, f.o.b. mine, in 1981. The sulfate of potash price increased from $299 per ton in 1980 to $349 per ton, f.o.b. mine, in 1981.

Société Nationale Elf Aquitaine, a French national oil and chemical company, took control of Texasgulf, Inc., a U.S. potash producer, by buying 87% of its stock. Texasgulf's Canadian holdings were split and came under Canadian control. In the United States, Texasgulf had about 5% of the U.S. potash capacity.

Legislation and Government Programs.—In late March, the U.S. International Trade Commission determined that the domestic potash industry would not be materially injured if the 1969 antidumping order was modified or revoked.

The Department of Energy Waste Isolation Pilot Plant, which is east of and borders the Duval Corp.'s Nash-Draw langbeinite mine and includes some Duval and International Minerals & Chemical Corp. leases, met a new difficulty when an exploratory drill hole penetrated a brine pocket. This brine pocket is about 1,460 feet from the nearest point of the proposed storage galleries and about 850 feet below the gallery level. The implications of this find are not presently clear.

Table 1.—Salient potash statistics[1]

(Thousand metric tons and thousand dollars unless otherwise specified)

	1977	1978	1979	1980	1981
United States:					
Production	4,241	4,326	4,271	4,315	4,153
K_2O equivalent	2,229	2,253	2,225	2,239	2,156
Sales by producers	4,241	4,358	4,549	4,265	3,670
K_2O equivalent	2,232	2,307	2,388	2,217	1,908
Value[2]	$206,900	$226,500	$279,200	$353,900	$328,900
Average value per ton of product ------ dollars	$48.78	$51.97	$61.38	$82.98	$89.62
Average value per ton of K_2O equivalent --do	$92.68	$98.16	$116.92	$159.63	$172.40
Exports[3]	1,497	1,431	1,119	[r]1,584	887
K_2O equivalent	845	809	635	[r]840	491
Value[4]	$90,200	$88,600	$79,500	[r]$179,830	$107,950
Imports for consumption[3] [5]	7,608	7,762	8,505	8,193	7,903
K_2O equivalent	4,605	4,707	5,165	4,972	4,796
Customs value	$374,000	$399,000	$520,800	$648,000	$750,400
Apparent consumption[6]	10,352	10,689	11,935	[r]10,874	10,686
K_2O equivalent	5,992	6,205	6,918	[r]6,349	6,213
Yearend producers' stocks, K_2O equivalent	467	414	251	273	520
World: Production, marketable K_2O equivalent	[r]25,252	[r]26,113	[r]25,677	[p]27,673	[e]27,357

[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.

DOMESTIC PRODUCTION

Domestic production declined about 4% from the 1980 level. In 1981, 79% of all production was potassium chloride—muriate of potash (standard, coarse, or granular)—and 9% was potassium sulfate—sulfate of potash. The remaining production comprised manure salts, soluble and chemical grades of muriate of potash, and potassium magnesium sulfate. The New Mexico potash producers accounted for 83% of the total domestic potash production. New Mexico mine production in 1981 was 18.5 million tons of 13.1% K_2O equivalent crude salts. This was down from 13.6% K_2O in 1980. Production in other States was from brines or a solution mine, so no comparable ore grade is available.

Seven companies produced potash in New Mexico in 1981 from underground, bedded deposits east of Carlsbad. The companies were AMAX Chemical Corp. of AMAX Inc.; Duval of Pennzoil Co., Inc.; International Minerals & Chemical; Kerr-McGee Chemical Corp. of Kerr-McGee Corp.; Mississippi Chemical Corp.; National Potash Co. of Freeport-McMoRan; and Potash Co. of America of Ideal Basic Industries, Inc. Sylvinite ores were mined to produce potassium chloride. Langbeinite ores were mined to produce potassium magnesium sulfate. One company reacted potassium chloride and potassium magnesium sulfate to produce potassium sulfate. Potassium sulfate was also produced by three plants in Texas that treated potassium chloride with sulfuric acid. These plants were operated by AMAX Chemical Corp., Stauffer Chemical Co., and Dorchem, Inc., of Dorchester Gas Corp. The Dorchem plant was sold in 1981 to a private investor group operating under the name of Permian Chemical Corp.

In April, Ideal Basic Industries, parent to Potash Co. of America, rejected a takeover bid from an unidentified company. In May, Standard Oil Co. of California abandoned a merger attempt with AMAX Inc., parent company of AMAX Chemical Corp. The AMAX potash plant was closed for a week in September because of an electrical fire in the refining plant. Superfos of Denmark has acquired shares of stock in Mississippi Chemical. Superfos plans to invest in Mississippi Chemical's planned Carlsbad potash expansion for a portion of the new production. National Potash laid off 75 employees in October owing to fall sales slowdown.

Methane was found in gas samples from

roof relief holes in two potash mines. The Hobbs Mine of Kerr-McGee Chemical and Mississippi Chemical mine were operating under variances because the methane level was above 0.25% in the samples. The underground potash industry was threatened with being declared "gassy" and having to invest in new nonsparking equipment. Most or all of the companies felt that they could not support the additional investment.

There were three potash producers in Utah in 1981. Great Salt Lake Minerals & Chemicals Corp., a subsidiary of Gulf Resources and Chemical Corp., produced potassium sulfate as a coproduct from the Great Salt Lake brines. Kaiser Aluminum & Chemical Corp. of Kaiser Industries Corp. produced potassium chloride from natural near-surface brines at the west end of the Bonneville Salt Flats near Wendover, Utah. Texasgulf produced potassium chloride from underground mines near Moab, Utah, using solution mining techniques. On June 26, 1981, the French oil company Société Nationale Elf Aquitaine started a successful takeover of Texasgulf. The Canadian Development Corp. (CDC) which held 37% of Texasgulf because of Texasgulf's Canadian investments, sold its Texasgulf holdings to Elf Aquitaine for Texasgulf's Canadian property and the Elf Aquitaine Canadian property and about $500 million.

In California, in 1981, Kerr-McGee Chemical produced both potassium chloride and potassium sulfate as coproducts along with other products from underground brines at Searles Lake. The labor strike in 1981 at the Searles Lake complex did not involve the potash production plant.

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	
	1980	1981	1980	1981	1980	1981	1980	1981	1980	1981	1980	1981	1980	1981
January-June:														
Muriate of potash, 60% K_2O minimum:														
Standard	701	709	426	432	702	683	427	415	51,400	58,200	169	193	102	117
Coarse	281	242	172	148	274	231	168	141	22,500	20,400	58	79	35	48
Granular	468	416	283	252	463	398	281	241	37,200	34,300	68	92	41	56
Chemical	30	29	19	18	30	28	19	18	W	W	4	2	3	1
Potassium sulfate	222	205	114	105	202	190	104	97	29,700	33,600	62	62	32	32
Other potassium salts[2]	528	492	132	119	523	469	127	115	W	W	243	284	58	65
Total[3]	2,230	2,094	1,145	1,073	2,194	1,998	1,125	1,027	172,600	181,300	603	712	271	318
July-December:														
Muriate of potash, 60% K_2O minimum:														
Standard	729	809	443	492	731	605	445	368	59,500	48,800	167	397	101	240
Coarse	271	215	166	131	262	176	160	108	23,100	14,800	67	118	41	72
Granular	447	409	271	248	441	372	267	226	38,700	29,500	74	128	45	78
Chemical	32	26	20	17	35	28	22	18	W	W	1	(4)	1	(4)
Potassium sulfate	175	185	90	95	190	156	97	80	30,400	28,400	47	90	24	46
Other potassium salts[2]	431	415	105	100	412	333	101	81	W	W	262	366	61	84
Total[3]	2,086	2,059	1,094	1,083	2,071	1,672	1,092	881	181,300	147,600	618	1,099	273	520
Grand total[3]	4,315	4,153	2,239	2,156	4,265	3,670	2,217	1,908	353,900	328,900	XX	XX	XX	XX

W Withheld to avoid disclosing company proprietary data included in "Total." XX Not applicable.
[1]F.o.b. mine.
[2]Includes soluble muriate, manure salts, and potassium magnesium sulfate.
[3]Data may not add to totals shown because of independent rounding.
[4]Less than 1/2 unit.

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]
1980:							
January-June	8,985	1,232	1,872	945	1,889	952	143,600
July-December	9,046	1,222	1,788	926	1,756	916	145,400
Total	18,031	2,454	3,660	1,871	3,645	[3]1,869	289,000
1981:							
January-June	9,129	1,186	1,786	904	1,732	881	147,600
July-December	9,361	1,234	1,726	894	1,386	720	113,700
Total	18,490	2,420	[3]3,513	1,798	3,118	1,601	261,300

[1]Sylvinite and langbeinite.
[2]F.o.b. mine.
[3]Data do not add to total shown because of independent rounding.

Table 4.—Salient sulfate of potash statistics[1] in the United States

(Thousand metric tons of K_2O equivalent and thousand dollars)

	1977	1978	1979	1980	1981
Production	221	205	205	203	200
Sales by producers	221	222	204	201	178
Value[2]	$42,400	$45,300	$46,230	$60,080	$61,993
Exports[3]	84	83	81	[r]70	40
Value[4]	NA	NA	NA	$23,113	$16,095
Imports[5]	34	29	10	22	18
Value[6]	$6,800	$6,230	$2,710	$7,111	$7,380
Apparent consumption[7]	171	169	133	[r]153	156
Yearend producers' stocks	38	21	22	24	46

[r]Revised. NA Not available.
[1]Excluding potassium magnesium sulfate.
[2]F.o.b. mine.
[3]Export data supplied by Potash & Phosphate Institute (1977-79) and the U.S. Bureau of the Census (1980-81).
[4]F.a.s. U.S. port.
[5]U.S. Bureau of the Census.
[6]C.i.f. to U.S. port.
[7]Sales plus imports minus exports, independent rounding.

CONSUMPTION AND USES

Apparent domestic consumption of all forms of potash was down in 1981. Spring sales were nearly normal despite a winter drought and spring rains during planting season. The fall harvest was quite large, and with high interest rates and low crop prices, the farmers had little money available for fertilizer purchases in late 1981. Prices declined in the fall as Brazil slowed its buying of fertilizers and the potash started to build up at the producers' warehouses worldwide. The relative strength of the U.S. dollar intensified this producers' stockpile buildup for domestic producers. Discounts were not enough to reduce the producers' stocks.

According to the Potash & Phosphate Institute, which reports only the sales of United States and Canadian producers, the consumption of muriate of potash for agricultural uses declined as follows: Standard grade fell 8% to less than 900,000 tons, coarse grade fell 7% to 2.1 million tons, granular grade fell 8% to 1.5 million tons, and sulfates (both potassium sulfate and potassium magnesium sulfate) fell 11% to 217,000 tons.

The Potash & Phosphate Institute reported that U.S. domestic agricultural sales by United States and Canadian producers were, by K_2O content, 40% coarse muriate, 30% granular muriate, 17% standard muriate, 9% soluble muriate, and 4% sulfates. These fractions are unchanged from those of 1980. Of these fractions, potash from the U.S. mines was 45% of the standard muriate, 8% of the coarse muriate, 24% of the granular muriate, 4% of the soluble muriate, and 100% of the sulfates.

In addition, the Potash & Phosphate Institute reported that 383,000 tons of potash was sold for nonagricultural (chemical) uses. Standard muriate was 68% of the total, soluble muriate was 31%, and sulfates were 1%. Nonagricultural use of potash is primarily for caustic potash-chlorine plants.

Caustic potash (potassium hydroxide) was used as the major pathway to the other potassium chemicals as well as for a caustic chemical. Caustic potash has slightly different properties in comparison to caustic soda and competes with caustic soda on price and availability. Caustic potash supplies were also hindered by the excess of byproduct chlorine on the market in 1981. Some muriate was also used in petroleum well drilling muds for shale stabilization and in petroleum well stimulation by massive fracturing where the potassium ion inhibits clay particle expansion.

According to the Potash & Phosphate Institute, the top six States for agricultural potash consumption were Illinois, Iowa, Ohio, Minnesota, Indiana, and Wisconsin. These six States consumed 54% of the agricultural potash from United States and Canadian producers. The top six States for agricultural consumption using domestically produced potash were Mississippi, Texas, Florida, Missouri, Georgia, and California. These six States consumed 52% of the agricultural potash from U.S. producers. The top six States for agricultural consumption using domestically produced sulfates of potash were Florida, Kentucky, Georgia, California, North Carolina, and Texas. These six States consumed 61% of the domestically produced sulfates of potash.

Table 5.—Sales of North American potash, by State of destination

(Metric tons of K_2O equivalent)

State	Agricultural potash		Nonagricultural potash	
	1980	1981	1980	1981
Alabama	112,613	109,345	54,893	52,287
Alaska	--	--	88	--
Arizona	1,266	4,092	2,746	344
Arkansas	54,526	54,281	486	1,381
California	62,078	55,943	10,955	12,738
Colorado	29,332	30,633	291	258
Connecticut	5,713	4,634	1	--
Delaware	30,596	22,277	28,275	26,988
Florida	183,035	137,473	944	1,060
Georgia	202,651	171,482	181	1,559
Hawaii	22,697	14,939	--	--
Idaho	13,236	15,716	19	151
Illinois	843,752	698,789	29,782	29,085
Indiana	448,642	364,045	5,620	4,835
Iowa	528,721	513,411	443	1,100
Kansas	40,593	36,091	3,543	4,187
Kentucky	143,689	138,063	15,131	13,990
Louisiana	47,111	55,725	3,830	4,358
Maine	9,570	8,324	68	45
Maryland	33,770	25,113	1,468	1,121
Massachusetts	4,198	2,325	631	583
Michigan	197,546	158,646	2,645	2,665
Minnesota	415,802	404,039	57	171
Mississippi	248,918	217,987	6,808	9,984
Missouri	272,853	238,920	3,885	5,831
Montana	7,196	10,293	13	40
Nebraska	52,522	53,275	211	1,624
Nevada	--	54	629	625
New Hampshire	435	455	--	--
New Jersey	8,532	7,951	608	904
New Mexico	5,600	3,378	12,558	33,957
New York	53,319	86,625	44,269	41,014
North Carolina	126,006	115,707	634	1,739

Table 5.—Sales of North American potash, by State of destination —Continued

(Metric tons of K_2O equivalent)

State	Agricultural potash 1980	Agricultural potash 1981	Nonagricultural potash 1980	Nonagricultural potash 1981
North Dakota	15,556	21,788	78	93
Ohio	482,688	470,391	46,524	46,495
Oklahoma	26,583	24,345	12,266	14,396
Oregon	20,477	20,801	1,774	1,399
Pennsylvania	54,437	44,401	3,835	3,674
Rhode Island	2,209	1,643	161	132
South Carolina	80,653	74,387	318	450
South Dakota	10,470	12,531	--	--
Tennessee	125,948	133,854	79	337
Texas	117,123	131,356	52,209	53,060
Utah	1,142	913	1,288	2,109
Vermont	5,566	4,462	--	--
Virginia	59,083	52,585	1,087	1,404
Washington	29,210	35,152	2,937	2,602
West Virginia	4,720	5,217	--	28
Wisconsin	308,973	347,121	166	454
Wyoming	4,060	3,049	931	1,469
Total	5,555,416	5,144,027	355,365	382,726

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	1978	1979	1980	1981
Agricultural:				
Standard	954	1,067	948	873
Coarse	2,305	2,459	2,228	2,070
Granular	1,747	1,952	1,687	1,549
Soluble	387	522	447	435
Total	5,393	6,000	5,310	4,927
Nonagricultural:				
Soluble	103	118	108	118
Other	191	237	242	260
Total	294	355	350	378
Grand total	5,687	6,355	5,660	5,305

Source: Potash & Phosphate Institute.

STOCKS

Yearend 1981 producers' stocks of potash were 91% higher than 1980's comparable quantity and were equal to 24% of 1981 production by K_2O content. Yearend 1980 stocks were about 1.5 months of average production while yearend 1981 stocks were 2.9 months of average production. All types of potash stocks increased except for chemical muriate.

TRANSPORTATION

Potash Corp. of Saskatchewan (PCS) opened its fourth warehouse for receiving unit train shipments in Danville, Ill. The first three are in Seneca, Ill.; Waterloo, Iowa; and Springfield, Ill. A fifth center is planned for Fort Dodge, Iowa, in 1982. PCS formed a separate division to handle the transportation of its potash.

Shipments of Canadian potash through the Thunder Bay harbor on Lake Superior to sites on the southern shores of Lake Michigan and Lake Erie commenced this year. There were some railroad tariff reductions to meet these lower shipping costs.

Across the United States, rural fertilizer dealers on lightly used railroad spurs were facing railroad abandonment as railroad management sought to reduce its losses. This increased costs of fertilizers to some farmers.

PRICES

The average value, f.o.b. mine, of U.S. potash production of all types and grades in 1981 was $172.40 per ton. The average value, f.o.b. mine, during the first half of the year was $176 per ton, and the average value for the second half was $168 per ton. The average value per ton of the three major muriate grades was $137 for the year. The individual average year prices for the three muriates were standard, $137; coarse, $142; and granular, $137. The average value per ton for sulfate of potash for 1981 was $349.

Table 7.—Prices[1] of U.S. potash, by type and grade

(Dollars per metric ton of K_2O equivalent)

Type and grade	1979 January-June	1979 July-December	1980 January-June	1980 July-December	1981 January-June	1981 July-December
Muriate, 60% K_2O minimum:						
Standard	81.33	93.70	120.30	133.82	140.18	132.45
Coarse	96.63	106.26	134.28	144.69	144.92	137.28
Granular	96.79	107.53	132.48	145.10	142.42	130.94
All muriate[2]	89.75	100.66	126.88	139.27	141.70	132.71
Sulfate, 50% K_2O minimum	218.87	234.61	285.75	313.06	344.84	354.55

[1]Average prices, f.o.b. mine, based on sales.
[2]Excluding soluble and chemical muriates.

FOREIGN TRADE

Total U.S. potash exports in 1981 decreased 42% from that of 1980 owing to a worldwide excess of potash. Three factors appear to have caused this. Because of a trade imbalance, the Brazilians started to limit their total imports to rescue their foreign currency reserves. The German Democratic Republic and the U.S.S.R. apparently put more potash on the world market because one of their customers, Poland, was unable to take its usual quantity owing to political unrest. Finally, a relatively strong U.S. dollar put U.S. potash exports at a disadvantage relative to other suppliers. Potash exports to Latin America and Asia fell 51% and 33%, respectively, on a product tonnage basis.

Total U.S. imports of potash decreased 4% in 1981 from that of 1980, with only mixed potassium-sodium nitrate increasing. Muriate from Canada declined 4% but was 94% of all muriate imported and 93% (by K_2O equivalents) of all potash imports. Israel was the second largest source of imports with an increase of 31% to 5% of total muriate imports and 5% of all potash imports because it supplies both muriate and potassium nitrate.

Table 8.—U.S. exports of potash

	Approximate average K_2O content (percent)	1980[r] Quantity (metric tons) Product	1980[r] Quantity (metric tons) K_2O equivalent	1980[r] Value[1] (thousands)	1981 Quantity (metric tons) Product	1981 Quantity (metric tons) K_2O equivalent	1981 Value[1] (thousands)
Potassium chloride, all grades	61	1,160,640	708,000	$131,180	700,420	427,300	$80,680
Potassium sulfates, all grades[2]	([3])	423,640	132,400	48,650	186,470	63,300	27,270
Total	XX	1,584,280	840,400	179,830	886,890	490,600	107,950

[r]Revised. XX Not applicable.
[1]Export values are f.a.s. U.S. port.
[2]This includes potassium magnesium sulfate.
[3]Varies from year to year according to relative quantities of the two types of sulfates exported.

Source: U.S. Bureau of the Census.

Table 9.—U.S. exports of potash, by continent and country

Continent and country	Metric tons of product: Potassium chloride 1980	Potassium chloride 1981	Potassium sulfates, all grades[1] 1980	Potassium sulfates, all grades[1] 1981	Total[2] 1980	Total[2] 1981	Total value[2] [3] (thousands) 1980	Total value[2] [3] (thousands) 1981
Latin America:								
Argentina	--	720	[r]5,200	5,170	[r]5,200	5,890	[r]$490	$700
Belize	--	--	[r]630	--	630	--	120	--
Brazil	509,300	211,210	[r]34,910	16,200	[r]544,210	227,410	[r]68,330	27,330
Chile	40	--	[r]16,660	11,750	[r]16,700	11,750	[r]2,820	2,130
Colombia	43,800	32,340	[r]5,360	--	[r]49,160	32,340	[r]4,940	4,100
Costa Rica	[r]13,130	6,950	[r]13,750	10,180	[r]26,880	17,130	[r]3,100	1,790
Dominican Republic	[r]50,350	26,830	440	2,100	[r]50,790	28,930	[r]6,590	4,000
Ecuador	17,090	17,350	[r]1,280	1,550	[r]18,370	18,900	[r]2,310	2,090
French West Indies	--	4,200	--	3,150	--	7,350	--	950
Guatemala	10,920	8,000	[r]9,350	--	[r]20,270	8,000	[r]2,760	1,150
Guyana	--	--	[r]1,540	--	[r]1,540	--	[r]210	--
Honduras	--	--	[r]15	1,370	15	1,370	1	390
Jamaica	5,800	4,470	--	--	5,800	4,470	690	560
Mexico	63,180	25,610	[r]37,260	21,740	[r]100,440	47,350	[r]9,300	5,820
Nicaragua	6,510	--	--	5,060	6,510	5,060	880	490
Panama	[r]1,450	5,050	[r]270	160	1,720	5,210	240	600
Peru	13,760	10,500	[r]4,080	2,900	[r]17,840	13,400	[r]2,280	1,770
Uruguay	6,420	5,100	[r]6,000	1,500	[r]12,420	6,600	[r]1,280	790
Venezuela	14,110	--	3,410	--	17,520	--	[r]2,380	--
Total[2]	[r]755,850	358,330	[r]140,160	82,830	[r]896,010	441,160	[r]108,700	54,700
Oceania:								
Australia	[r]25,220	60,990	[r]5,340	5,580	[r]30,560	66,570	[r]$3,750	8,400
Canada	[r]33,630	--	[r]87,460	40,880	[r]121,090	40,880	[r]14,710	5,640
New Zealand	[r]141,640	98,630	[r]750	350	[r]142,390	98,980	12,800	10,920
Total[2]	[r]200,490	159,620	[r]93,550	46,810	[r]294,040	206,430	31,260	24,960
Asia:								
India	--	44,950	--	--	--	44,950	--	4,490
Indonesia	21,000	--	--	--	21,000	--	2,740	--
Japan	91,460	79,690	[r]98,510	22,000	[r]189,970	101,690	[r]21,270	12,820
Korea, Republic of	--	--	[r]180	60	[r]180	60	15	14
Malaysia	--	--	[r]52,940	19,100	[r]52,940	19,100	[r]4,300	1,630
Philippines	[r]5,000	--	[r]3,650	1,650	[r]8,650	1,650	[r]1,110	380

See footnotes at end of table.

Table 9.—U.S. exports of potash, by continent and country —Continued

Continent and country	Metric tons of product						Total value[2] [3] (thousands)	
	Potassium chloride		Potassium sulfates, all grades[1]		Total[2]			
	1980	1981	1980	1981	1980	1981	1980	1981
Asia —Continued								
Saudi Arabia	--	160	[r]70	--	70	160	$13	$15
Singapore	10,500	--	--	--	10,500	--	1,270	--
Taiwan	30,270	41,060	--	200	30,270	41,260	3,160	4,310
Thailand	--	--	4,000	5,000	4,000	5,000	310	490
Other	--	--	[r]40	70	[r]40	70	[r]8	10
Total[2]	[r]158,230	165,860	[r]159,390	48,080	[r]317,620	213,940	[r]34,196	24,160
Europe:								
Denmark	44,800	16,640	[r]30,500	--	[r]75,300	16,640	[r]5,650	1,730
Greece	350	--	--	--	350	--	40	--
Sweden	870	--	--	450	870	450	170	100
Other	--	--	--	280	--	280	--	30
Total[2]	[r]46,020	16,640	[r]30,500	730	[r]76,520	17,370	[r]5,860	1,860
Africa:								
Zambia	--	--	--	7,990	--	7,990	--	2,290
Other	[r]50	--	[r]40	--	[r]90	--	[r]8	--
Total[2]	[r]50	--	[r]40	7,990	[r]90	7,990	[r]8	2,290
Grand total[2]	[r]1,160,640	700,420	[r]423,640	186,470	[r]1,584,280	886,890	[r]179,820	107,950

[r]Revised.
[1]This includes potassium magnesium sulfate.
[2]Data may not add to totals shown because of independent rounding.
[3]F.a.s. U.S. port.

Source: U.S. 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.
1980					
Potassium chloride	61	8,080,000	4,929,000	$628,700	$753,800
Potassium sulfate	50	44,800	22,400	6,550	7,110
Potassium nitrate	45	35,600	16,000	8,620	9,600
Potassium sodium nitrate mixtures	14	32,500	4,550	4,050	4,880
Total[1]	XX	8,193,000	4,972,000	648,000	775,300
1981					
Potassium chloride	61	7,800,000	4,758,000	729,540	811,150
Potassium sulfate	50	36,600	18,300	6,860	7,380
Potassium nitrate	45	32,800	14,760	9,340	10,360
Potassium sodium nitrate mixtures	14	33,900	4,740	4,650	5,180
Total[1]	XX	7,903,300	4,796,000	750,400	834,100

[e]Estimated. XX Not applicable.
[1]Data may not add to totals shown because of independent rounding.

Source: U.S. 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.	
	1980	1981	1980	1981	1980	1981	1980	1981	1980	1981	1980	1981	1980	1981
Belgium-Luxembourg	--	--	14,800	11,600	--	--	--	--	14,800	11,600	$2,040	$2,040	$2,250	$2,290
Canada	7,642,200	7,304,600	--	--	--	--	--	--	7,642,200	7,304,600	587,600	677,400	706,700	753,770
Chile	5,900	--	--	--	--	--	32,400	33,900	38,300	33,900	4,430	4,650	5,280	5,180
German Democratic Republic	57,300	62,900	--	--	--	--	--	--	57,300	62,900	4,410	5,200	6,500	6,740
Germany, Federal Republic of	10,030	2,700	29,970	25,100	--	--	--	--	40,000	27,800	5,450	5,100	6,200	5,370
Israel	312,100	407,800	--	--	35,600	32,800	--	--	347,700	440,600	40,260	53,900	43,600	58,500
Japan	--	--	--	--	--	--	130	--	130	--	26	--	40	--
Netherlands	3,150	--	--	--	--	--	--	--	3,150	--	330	--	420	--
Spain	11,000	22,000	--	--	--	--	--	--	11,000	22,000	920	2,070	1,040	2,260
U.S.S.R	38,400	--	--	--	--	--	--	--	38,400	--	2,400	--	3,350	--
Total[1]	8,080,000	7,800,000	44,800	36,600	35,600	32,800	32,500	33,900	8,193,000	7,903,300	648,000	750,400	775,300	834,100

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

Source: U.S. Bureau of the Census.

WORLD REVIEW

For 1981, the total world potash production was estimated at 27.4 million tons, down 1% from that of 1980. Of this, the U.S.S.R. and the German Democratic Republic produced an estimated 11.8 million tons or 43%. North America produced 9.0 million tons or 33% of the world total. Western Europe produced 5.7 million tons or 21% of the world total.

Brazil.—The released plans for the potash mine at Sergipe revealed an initial plant capacity of 60,000 metric tons per year from reserves of 5 million metric tons grading 16% to 22% K_2O, with a capital cost of $160 million. Capacity could be increased to 315,000 metric tons per year. Brazil also revealed a discovery of unknown size in the Amazon Basin.

Canada.—PCS, a provincial crown corporation, announced completion of the Rocanville Phase II site expansion in late October. This effort, both underground and in the mill, added 330,000 tons per year capacity to the site to reach a 975,000-ton-per-year capacity. PCS announced its withdrawal of participation in Canpotex Ltd. as of June 30, 1982; Potash Corp. of Saskatchewan International Ltd. will handle all offshore business excluding Canada and the United States from that date forward.

International Minerals & Chemical Corp. (Canada) Ltd. (IMCC) and PCS were given approval by the Saskatchewan provincial government for an 800,000-ton capacity increase at the Esterhazy Mines. In-place capacity was 2,560,000 tons per year. The Viscount potash mine and mill (Central Canadian Potash Co. Ltd.) owned by Noranda Mines Ltd. was denied permission to expand its capacity by 300,000 tons per year because of the other capacity expansions already in progress. Brascade Resources, Inc., owned 70% by Brascan Resources Ltd. and 30% by Caissi de Depot et Placement du Quebec (the Quebec government's pension fund manager), became the largest single shareholder, at 37%, of Noranda Mines Ltd. during the fall.

In a complex trading arrangement, the 40% of the Allan potash mine owned by Texasgulf was transferred to CDC. Société Nationale Elf Aquitaine purchased Texasgulf and sold its Canadian properties to CDC for $994 million. CDC exchanged its shares (37%) of Texasgulf for the Texasgulf properties in Canada plus about $400 million. The Allan potash mine is now owned 60% by PCS and 40% by CDC.

Potash Co. of America and Denison-Potacan continued development of their respective mine sites in New Brunswick. Denison-Potacan Potash Co. reportedly had some problems with water-bearing strata while sinking its first shaft. This site is reported to be problematic owing to extensive folding of the ore body. A bulk loading dock was in the planning stages at the Port of Saint John, New Brunswick, only 46 miles from the PCS potash site and 31 miles from the Denison-Potacan site.

In Manitoba, IMCC signed a Memorandum of Agreement to develop a mine and mill near McAuley, about 40 miles northwest of Virden. The signers, including IMCC and the Manitoba government as Manitoba Mineral Resources Ltd. (MMR), agreed to form a company to be called the Manitoba Potash Co. IMCC will initially own 75% of the company, but MMR has the option to increase its equity from 25% to 40% within 5 years of start of production.

There have been sylvinite showings in southwest Newfoundland and Nova Scotia; continued exploration was planned for both locations.

Both Canadian railroads are considering rail-capacity increases for routes between the Province of Alberta and the west coast. Besides planned potash export increases, there will be more coal and grain moving to the ports, and the present rail system is near capacity.

Table 12.—Salient Canadian potash statistics

(Thousand metric tons of K_2O equivalent)

	1978	1979	1980	1981
Production[1]	6,124	6,715	7,300	7,175
Domestic sales by domestic producers[1]	370	379	378	332
Exports:				
United States[1]	4,498	4,931	4,563	4,182
Overseas[1]	1,596	1,846	2,170	1,823
Imports for consumption[2]	39	29	33	11
Domestic consumption[3]	409	408	411	343
Yearend producers' stocks[1]	832	378	564	1,308

[1]Data supplied by the Potash & Phosphate Institute.
[2]From U.S. 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.

Finland.—There are indications that Kemira Oy has entered the potassium sulfate market in the German Democratic Republic and the Pacific Basin. It buys muriate of potash from the German Democratic Republic, the U.S.S.R., and the Federal Republic of Germany for conversion to sulfate of potash at its Kokhola Works. Kemira Oy is investigating the recovery of potassium ions from mica found in the Siilinjarvi apatite deposit. This would reduce its need to import muriate of potash.

France.—The French members of the Rhine Salt Convention have agreed, although the French legislature has not ratified the agreement, to reduce the release of chloride ions into the Rhine River from 120 to 100 kilograms per second. Fourteen kilograms per second of chloride ions have been targeted for underground injection and 6 kilograms per second of chloride ions have been targeted for a sodium chloride plant. The French Government's nationalization policy will not have an effect on Enterprise Minière et Chemique since it is already a state-owned operation, except to possibly transfer its animal feeds business to another company.

Germany, Federal Republic of.—Kali Chemie AG, a subsidiary of Deutsche Solvay-Werke GmbH, sold its potash mine, Friedrichshall, near Hannover, to Kali und Salz AG, a subsidiary of BASF. The mine had production problems and the new owner expects to reduce employment levels from 600 to 400 workers when the facility returns to production. The facility was inactive at the end of the year.

Israel.—The Israeli Government has proposed canaling Mediterranean Sea water to the Dead Sea to establish needed additional electrical generation capacity through hydropower. The Dead Sea water level is 400 meters below the Mediterranean water level, which would provide an excellent head for the water turbines. It is not clear if the threat is the greatest from changing the chemical composition of the Dead Sea, from disturbing the stratification of the water layers by turbulent mixing, or from the threat to Dead Sea Works Ltd. dikes from a rise in the Dead Sea water level. The Jordanians have also proposed a similar plan for hydropower using a canal from Akaba. The Dead Sea Works of Israel Chemical Ltd. completed its latest expansion on July 1, adding 285,000 tons of capacity.

Mexico.—Fertilizantes Mexicanos S.A. signed a contract for a plant to recover muriate and other salts from the brine of the Cerro Prieto geothermal electricity generating plant. Cerro Prieto is about 25 miles south of Mexicali and the California border. Targeted production is 46,000 tons per year. Estimated cost was $25 million for the complex.

Spain.—In November 1980, Spain's National Institute for Industry revealed that it was considering closing the publicly-owned Pamplona Mine, which is operated by Potasas de Navarra. The mine had operating losses for several years. By midyear 1981, the labor unions and the Spanish Government had agreed on a program to keep the mine operating. The agreement included improved production methods, searching for new mining sites, and "a general diversification of activities."

Thailand.—Development of Thailand's large deposit of carnallite and sylvinite is under consideration. A joint venture of Duval Corp. and C.R.A. Exploration Pty. Ltd. (a unit of Conzinc Riotinto of Australia Ltd.) was awarded an exploration concession in northeast Thailand in the Khon Kaen Province. AMAX Exploration, Inc., was negotiating for an exploration concession in the Sakon Nakhon Province, and Agrico Chemical Co. was negotiating for an exploration concession a little further south in the Khorat Basin. The problem in Thailand is to find a lens of sylvinite large enough to justify development costs. As a backup effort, the Thai Government has arranged a loan from the World Bank of $8.9 million to investigate the mining and beneficiation of the much more abundant, high-grade carnallite. French and German experts are advising on this effort. There were also efforts to improve the Nation's railways and seaports.

Tunisia.—A state-controlled company is considering a small production facility to produce potassium sulfate from the brackish waters of the Chott El Djeria with help from Mines de Potasse d' Alsace.

U.S.S.R.—A new potash find was announced this year in the Irkutsk Oblast, which is north of Mongolia, on the new Trans-Siberian or Baykal-Amur railway. Reserves are estimated at 70 million tons. Lurgi Umwelt und Chemotechnik GmbH of the Federal Republic of Germany won a contract to build a 1.2-million-ton-per-year crystallization, compaction, and granulation plant at the Berezniki site. The U.S.S.R. designed and built crushing, grinding, and beneficiation facilities will be upstream of the Lurgi plant. The Lurgi contract is valued at about $70 million.

The Soligorsk No. 4, first stage, apparently produced some product after starting up in 1979. This was the first stage of three planned stages that have been under construction since 1971. The stage apparently consists of 1.8 million tons of product capacity of 41.6% K_2O or 750,000 tons K_2O per year. The seam is about 3,300 feet underground, 6 feet thick, and about 17% K_2O sylvinite. Longwall mining has been ascribed to this mine. Beneficiation appears to be by the "halurgic" method, probably a dissolution recrystallization process, for higher sylvinite recovery. The technology was provided by PEC Engineering of France. This stage has started the trial operation of a compacting line, to produce granular products, with a capacity of 450,000 tons or 190,000 tons K_2O per year. The authorities wish to compact the complete 1.8 million tons of product of this stage, which would add 750,000 tons K_2O of granular potash to the world market.

Solikamsk No. 2, which entered startup sometime in the 1971-75 period, had continuous problems including complete stoppage for 104 days in 1979. In 1980, it apparently reached normal operation.

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

(Thousand metric tons of K_2O equivalent)

Country	1977	1978	1979	1980[p]	1981[e]
Canada (sales)[2]	5,764	6,340	7,074	7,532	[3]6,815
Chile	11	15	15	15	15
China	18	21	16	12	11
Congo	136	--	--	--	--
France	1,580	1,795	1,850	1,735	[3]1,969
German Democratic Republic	3,229	3,323	3,395	3,422	3,490
Germany, Federal Republic of	2,341	2,470	2,616	2,737	[3]2,591
Israel	[r]730	[r]744	737	797	850
Italy	[r]224	196	182	156	155
Spain	562	[r]613	668	658	705
U.S.S.R	8,347	8,193	6,635	8,064	8,350
United Kingdom	81	150	264	306	250
United States	2,229	2,253	2,225	2,239	2,156
Total	[r]25,252	[r]26,113	25,677	27,673	27,357

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through Apr. 21, 1982.
[2]Official Government figures. Potash & Phosphate Institute production data are given in table 12.
[3]Reported figure.

TECHNOLOGY

The Bureau of Mines Salt Lake City Research Center continued with studies of potash recovery from low-grade resources. The project is divided into (1) potash recovery from carnallite ore and (2) potash recovery from plant process and waste brines by solar evaporation. The Bureau of Mines Denver Research Center continued an investigation of mining evaporate deposits (trona, salt, and potash). The effort was aimed at identifying strata conditions that affect mining methods and layout. Long-term mine passage stability and exclusion of water are the desired results. The U.S. Geological Survey (USGS) continued studies of developing new potash ore-finding techniques. Parallel with the Thailand potash development, USGS is using modern geophysical techniques and a deposition model to investigate new methods of sensing non-exposed ore bodies.

The University of Saskatchewan (Canada) is investigating the use of waste (sodium chloride and slime) from the potash refinery to backfill the potash mines. This would provide roof support and allow a recovery of ore greater than the 35% presently practiced in the deep Saskatchewan mines.[3]

The New Mexico Bureau of Mines and Mineral Resources along with the University of Texas at Dallas initiated a study to identify a microorganism that will accelerate the clay settlement from potash refinery wastes.[4]

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[1]Physical scientist, Division of Industrial Minerals.
[2]All quantities in this report are in metric tons, K_2O equivalent, unless otherwise noted.
[3]Canadian Mining Journal (Ontario). Salt as Backfill in Potash Mines May up Recovery. V. 102, No. 11, November 1981, p. 12.
[4]Science News (Washington, D.C.). Helping Clay Return. V. 119, No. 12, Mar. 21, 1981, p. 184.

Pumice and Pumicite

By Arthur C. Meisinger[1]

Data on U.S. production and consumption of volcanic cinder and scoria from 1953 through 1980 were included with pumice and pumicite. Beginning with 1981 data, volcanic cinder and scoria were to be incorporated with crushed stone (in the Minerals Yearbook chapter on Stone) because of their similar use and price patterns in the domestic market.

In 1981, domestic production of pumice and pumicite was 499,000 tons valued at $4.3 million, a decrease of 8% in quantity, but an increase of 1% in value compared with that of 1980. U.S. output came from 22 operations in 8 States, of which 4 States together accounted for more than 90% of the national total. Apparent consumption of pumice and pumicite declined 20%, owing largely to a slowdown in construction activity during 1981. Pumice imports, used primarily for concrete masonry products, decreased by 53%. The average value of pumice and pumicite produced domestically was $8.64 per ton, an increase of 10% over that of 1980.

Table 1.—Salient pumice and pumicite statistics

(Thousand short tons and thousand dollars unless otherwise specified)

	1977	1978	1979	1980	1981
United States: Sold and used by producers:					
Pumice and pumicite	1,178	1,208	1,172	543	499
Value (f.o.b. mine and/or mill)	$4,625	$4,836	$4,864	$4,267	$4,311
Average value per ton	$3.93	$4.00	r$4.15	$7.86	$8.64
Exports	2	e2	e2	e1	e1
Imports for consumption	253	216	62	194	92
Apparent consumption[1]	1,429	1,422	1,232	736	590
World: Production, pumice and related volcanic materials	r15,375	r15,650	14,786	p14,021	e14,084

eEstimated. pPreliminary. rRevised.
[1]Quantity sold or used, plus imports, minus exports.

DOMESTIC PRODUCTION

Domestic production of pumice and pumicite (volcanic ash) in 1981 declined 8% in quantity (499,000 tons) from that of 1980, but value showed a slight increase (1%) to $4.3 million. Domestic output came from 22 operations in 8 States: Arizona, California, Hawaii, Idaho, Kansas, New Mexico, Oklahoma, and Oregon. Four States, California, Idaho, New Mexico, and Oregon, together accounted for more than 90% of 1981 production.

The principal producers of pumice and/or pumicite, as in 1980, were American Pumice Products, Inc., Littlelake, Calif.; Amcor, Inc., Idaho Falls, Idaho; Central Oregon Pumice Co., Bend, Oreg.; Copar Pumice Co., Inc., Espanola, N. Mex.; General Pumice Corp., Santa Fe, N. Mex.; Graystone Corp. - Cascade Pumice Co., Bend, Oreg.; Hess Pumice Products, Malad City, Idaho; Tionesta Aggregates Co., Tulelake, Calif.; U.S. Pumice Co., Burbank, Calif.; and Volcanite, Ltd., Kailua Kona, Hawaii. Together, these 10 companies in 1981 accounted for 92% of the tonnage and 85% 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	1980[1]		1981	
	Quantity	Value	Quantity	Value
Arizona	9	13	1	3
California	58	1,340	98	1,501
Kansas	(2)	W	W	W
New Mexico	84	814	93	919
Oklahoma	1	W	1	W
Oregon	219	1,318	W	W
Other[3]	172	782	306	1,888
Total	543	4,267	499	4,311

W Witheld to avoid disclosing company proprietary data; included with "Other."
[1]Revised to exclude volcanic cinder and scoria.
[2]Less than 1/2 unit.
[3]Hawaii, Idaho, and items indicated by symbol W.

CONSUMPTION AND USES

U.S. apparent consumption of pumice and pumicite (table 1) was 590,000 tons in 1981, a decrease of 20% from that of 1980. The decreased activity in domestic construction during the year was largely responsible for the continuing decline in consumption.

Consumption of domestically produced pumice and pumicite (table 3) was 8% lower than that of 1980. Abrasive uses and concrete aggregate (including admixtures) uses were down 30% and 12%, respectively, compared with those of 1980; however, pumice used for landscaping increased 79% over that of 1980, and other uses of pumice and pumicite increased 11% in quantity, compared with that of the previous year.

Table 3.—Pumice and pumicite sold and used by producers in the United States, by use

(Thousand short tons and thousand dollars)

Use	1980		1981	
	Quantity	Value	Quantity	Value
Abrasives (includes cleaning and scouring compounds)	27	568	19	486
Concrete admixture and concrete aggregate	459	2,515	404	2,469
Landscaping	19	249	34	370
Other[1]	38	935	42	986
Total	543	4,267	499	4,311

[1]Includes decorative building block, heat-or-cold insulating medium, pesticide carriers, road construction material, roofing granules, and miscellaneous uses.

PRICES

Prices quoted in Chemical and Marketing Reporter for pumice from domestic and foreign sources were as follows at yearend 1981: Domestic grades, bagged in 1-ton lots, $205 per ton for fine (4F-0); $225 per ton for medium (0-1/2, 1-1/2); and $205 per ton for coarse (2-extra coarse). Yearend quoted prices on imported (Italian) pumice, f.o.b. east coast, bagged in 1-ton lots, were $200 per ton for fine; $285 per ton for medium, a $5-per-ton increase during the year; and $250 per ton for coarse.

The average value, f.o.b. mine and/or mill, for pumice and pumicite sold or used by domestic producers in 1981 was $8.64 per ton, an increase of 10% over the 1980 average value. Average values in 1981 for pumice and pumicite used in abrasives and as concrete aggregate, including admixture, increased from 1980 values by 22% and 11%, respectively. However, pumice used for landscaping decreased 17% in value compared with that of 1980. The average value for other uses of pumice and pumicite also declined, but by only 5% compared with that of the previous year.

FOREIGN TRADE

The total quantity of pumice imported for domestic consumption in 1981 was 92,283 tons, a substantial decrease (53%) from the total imported in 1980. Pumice specifically imported for use in the manufacture of concrete masonry products also decreased by 53%, to 89,252 tons, compared with that of 1980. The quantity of pumice and pumicite exported was estimated at 1,000 tons, the same as in 1980.

[1]Industry economist, Division of Industrial Minerals.

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)
1980:							
Greece	2,345	$27	--	--	171,630	$953	--
Italy	2,273	106	323	$37	17,747	95	$27
Other[1]	--	--	--	--	--	--	65
Total	4,618	133	323	37	189,377	1,048	92
1981:							
Germany, Federal Republic of	1	([2])	--	--	--	--	23
Greece	2,543	36	--	--	89,252	586	--
Italy	343	32	77	14	--	--	51
Japan	66	1	--	--	--	--	6
Mexico	1	1	--	--	--	--	--
United Kingdom	--	--	([2])	1	--	--	7
Other[3]	--	--	--	--	--	--	39
Total	2,954	70	77	15	89,252	586	126

[1]Austria, Belgium, Canada, China, the Federal Republic of Germany, Japan, Mexico, Taiwan, and the United Kingdom.
[2]Less than 1/2 unit.
[3]Austria, Belgium, Canada, China, Denmark, Hong Kong, India, the Netherlands, the Republic of Korea, and Taiwan.

Table 5.—Pumice and related volcanic materials: World production, by country[1]

(Thousand short tons)

Country[2]	1977	1978	1979	1980[p]	1981[e]
Argentina[3]	72	24	51	40	44
Austria: Pozzolan	10	10	9	9	9
Cape Verde Islands: Pozzolan[e]	17	17	18	18	18
Chile: Pozzolan	175	201	242	275	265
Costa Rica[e]	1	2	[r]1	1	1
Dominica: Pumice and volcanic ash[e]	120	120	120	120	120
France: Pozzolan and lapilli	[r]987	[e]648	[e]650	[e]660	660
Germany, Federal Republic of:					
Pumice (marketable)	1,928	[r]2,301	1,579	890	880
Pozzolan	131	192	215	220	220
Greece:					
Pumice	626	827	692	695	690
Pozzolan	1,385	1,565	1,235	[e]1,650	1,650
Guadeloupe: Pozzolan	209	220	220	220	220
Guatemala:					
Pumice	NA	21	20	20	17
Volcanic ash	29	39	41	14	11
Iceland	[4]8	9	27	40	40
Italy:					
Pumice and pumiceous lapilli[e]	825	860	940	990	880
Pozzolan[e]	6,300	6,400	6,500	6,600	6,600

See footnotes at end of table.

Table 5.—Pumice and related volcanic materials: World production, by country[1] —Continued

(Thousand short tons)

Country[2]	1977	1978	1979	1980[p]	1981[e]
Martinique: Pumice	316	183	172	141	145
New Zealand	31	44	28	15	15
Spain[5]	1,027	759	854	860	1,100
United States (sold or used by producers):	1,178	1,208	1,172	543	[6]499
Total	[r]15,375	[r]15,650	14,786	14,021	14,084

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available.
[1]Table includes data available through Apr. 14, 1982.
[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]Data represents exports.
[5]Includes Canary Islands.
[6]Reported figure.

Rare-Earth Minerals and Metals

By James B. Hedrick[1]

Domestic mine production of ores containing bastnasite and monazite decreased slightly in 1981. Production of domestic rare-earth concentrates, however, showed an increase. Molycorp, Inc., and Associated Minerals Ltd., Inc. (AMC), were the only domestic producers. Molycorp and W. R. Grace & Co. remained the principal processors of rare earths in the United States. Major end uses were in petroleum catalysis and metallurgical applications.

Legislation and Government Programs.—Shipments of previously sold rare earths by the General Services Administration from the National Defense Stockpile totaled 802 metric tons[2] of contained rare-earth oxides (REO) in 1981. No Government stocks of rare earths were sold in 1981. Government stocks of rare earths at year-end 1981 were 443 (dry) tons REO in sodium sulfate. The stockpile of yttrium oxide remained unchanged throughout 1981 at 108 kilograms.

Lower tariffs for imported rare earths, resulting from the 1979 Tokyo Round of negotiations, continued for nations having most-favored-nation status. The tariffs for these countries will decline annually through January 1, 1987. The new rare-earth schedule is shown in table 1.

DOMESTIC PRODUCTION

Concentrate.—Domestic mine production of REO contained in bastnasite and monazite concentrates increased 7.6% above the 1980 level. Bastnasite continued to be the major domestic source of rare earths. Less than 5% was produced from monazite.

Molycorp produced bastnasite concentrates at its Mountain Pass Mine in California. According to the annual report of the Union Oil Co. of California, the parent company of Molycorp, production of REO contained in bastnasite concentrates was 17,082 tons.

Associated Minerals was the only domestic producer of monazite. AMC's mine at Green Cove Springs, Fla., recovered monazite as a byproduct of minerals sands processing. Planned improvements at the processing operations were replacement of sluice concentrators and Humphrey spirals with Wright spirals, installation of a bucketwheel excavator in place of the suction dredge, relocation of the caustic scrub operation, and a reduction of process water usage. A new horizontal undercutting mining system was also initiated to provide a more uniform feed grade.

Compounds and Metals.—Molycorp completed construction of a $15 million separation plant at Mountain Pass, Calif., to supplement existing separation facilities. Separation circuits at the new plant will initially produce samarium oxide and gadolinium oxide. Startup of the plant began at the end of 1981 with production scheduled for the first quarter of 1982. Molycorp also completed construction of a samarium metal plant in Washington, Pa. The new facility has the capacity to produce 36 tons of samarium metal per year using controlled-atmosphere induction furnaces.

Rhône-Poulenc Inc. announced the completion and startup of its rare-earth separation plant at Freeport, Tex. The first phase of the $50 million project has a production capacity of 4,000 tons per year of rare-earth

Table 1.—U.S. import duties for rare earths

TSUS No.	Item	Most favored nation (MFN)			Non-MFN	
		Jan. 1, 1981	Jan. 1, 1982	Jan. 1, 1987	Jan. 1, 1981	Jan. 1, 1982
601.12, 601.45	Ore and concentrate[1]	Free	Free	Free	Free	Free.
418.40, 418.42, 418.44	Cerium chloride, oxide, compounds	13.1% ad valorem	12.1% ad valorem	7.2% ad valorem	35% ad valorem	35% ad valorem.
423.0030	Rare-earth oxides except cerium oxide	4.7% ad valorem	4.5% 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).	45 cents per pound.	43 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.	42 cents per pound plus 5.1% ad valorem.	38 cents per pound plus 5.1% 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.	43 cents per pound plus 5.1% ad valorem.	39 cents per pound plus 4.7% ad valorem.	22 cents per pound plus 2.6% ad valorem.	do	Do.

[1]Crude or concentrated by crushing, flotation, washing, or by other physical or mechanical processes which do not involve substantial chemical change.

oxides. Rare-earth products were available from the plant at the end of 1981.

W. R. Grace's Davison Chemical Div. began operation of a new 25,000-ton-per-year plant at Curtis Bay, Md., to produce rare-earth-containing fluid cracking catalysts. In response to increased demand from the petroleum industry, W. R. Grace planned expansion of catalyst production at three U.S. locations: Curtis Bay, Md., Lake Charles, La., and South Gate, Calif.

Katalistics International, a joint venture of Catalyst Recovery Inc., and EAB of Göteburg, Sweden, planned to build a $30 million fluid cracking catalyst facility in Savannah, Ga. The new plant will reportedly produce 50,000 tons per year of catalysts containing rare earths. Construction was begun in 1981 with completion scheduled for 1983.

Ronson Metals Corp. increased mischmetal capacity at its Newark, N.J., facilities 20% during the year.

Reactive Metals & Alloys Corp. (Remacor) planned to install a new $4 million submerged-arc furnace at its West Pittsburg, Pa., facilities. The new furnace reportedly will be used to produce three new specialty silicon alloys and triple production of rare-earth silicide. Completion is scheduled for the first quarter of 1982. Additional arc furnaces are planned for 1983 and 1985.

Producers of concentrates and mixed rare-earth compounds were Molycorp, W. R. Grace, and Associated Minerals, with Rhône-Poulenc starting production at the end of 1981. All categories of concentrate production increased during the year. Production of both mixed and purified rare-earth compounds also increased. Purified rare earths were produced by Molycorp, Research Chemicals, W. R. Grace, and Transelco Div. of Ferro Corp.

Metallurgical demand for rare earths during 1981 was stronger than in other sectors. Mischmetal, rare-earth silicide, and other rare-earth alloy production was 15% higher in response to demand. Mischmetal was produced by Remacor and Ronson Metals. Other rare-earth alloys were produced by Foote Mineral Co. and Cabot Corp. Producers of rare-earth silicide were Globe Div. of Interlake Inc., American Metallurgical Products Co., Foote Mineral, and Remacor.

High-purity rare-earth metal production was double that of 1980. Research Chemicals and Molycorp were the major producers.

CONSUMPTION AND USES

Domestic rare-earth processors consumed an estimated 21,100 tons of REO contained in raw materials in 1981, reflecting an 11% increase from the 18,900 tons consumed in 1980. Compared with that of 1980, bastnasite consumption was 15% higher. Monazite consumption was virtually unchanged. Shipments of rare-earth and yttrium products from primary processing plants to consumers were about 18,100 tons of contained REO, essentially the same as that of 1980.

The approximate distribution of rare earths by end use, based on information supplied by primary processors and certain consumers, was as follows: Petroleum cracking catalysts, 43%; metallurgical uses (including iron and steel, alloys, and mischmetal), 34%; ceramics and glass, 21%; and miscellaneous (including nuclear, electrical, phosphors, lighting, and research), 2%.

Consumption of mixed rare-earth compounds during 1981 by primary processors increased 7% because of increased rare-earth chloride use in catalyst and metallurgical applications. Consumption of purified rare-earth compounds was slightly lower.

The primary producers of mischmetal, rare-earth silicide, and other rare-earth alloys consumed 30% more REO in 1981 than in 1980. Shipments of these rare-earth metals to other consumers increased 34%. High-purity rare-earth metal consumption also increased.

In the glass industry, purified oxides and compounds were used as colorants and decolorizers, color stabilizers, polishing agents, dopants in laser glass, absorbers of ultraviolet light, additives to increase refractive indices and decrease dispersion, and color correctors in incandescent and fluorescent lighting.

Activated phosphors containing rare earths were used in color television tubes, X-ray intensifying screens, radar screens, avionics displays, thermometers, low- and high-pressure mercury vapor lamps, and trichromatic fluorescent lights.

Gadolinium was used in nuclear applications, phosphors, high refractive index glass, and gadolinium-gallium-garnet (GGG) substrates for magnetic bubble memory systems in computers.

The ceramic industry used purified rare earths in pigments, heating elements, dielectric and conductive ceramics, and as principal constituents and stabilizers in high-temperature ceramics and glazes. Purified rare-earth compounds were also used in gas mantles, electronic components, and synthetic gem stones.

Rare-earth permanent magnets were used in various electric motors, alternators, generators, line printers, disk-drive actuators, proton linear accelerators, earring and necklace clasps, medical and dental applications, traveling wave tubes, aerospace applications, and in speakers, microphones, and headphones.

Metallurgical applications of rare earths included alloys and additives in high-strength, low-alloy steels; gray and ductile iron; stainless and carbon steels; high-temperature and corrosion-resistant metals; hydrogen storage alloys; lighter flints; armaments; permanent magnets; nuclear control rods; and welding materials.

STOCKS

Stocks of rare earths in all forms held by 16 producing, processing, and consuming companies decreased 13% during 1981.

Bastnasite concentrate stocks held by the principal producer and four other processors decreased about 31%. Yearend inventories of monazite and other rare-earth concentrates also decreased.

Stocks of mixed rare-earth compounds increased from 1,897 tons of contained REO at yearend 1980 to 2,590 tons at yearend 1981. Inventories of purified rare-earth compounds were 354 tons of REO in 1980 compared with 356 tons in 1981. Yearend stocks of mischmetal, rare-earth silicide, and alloys containing rare earths decreased 25%. High-purity rare-earth metal inventories were 64% higher.

PRICES

The average declared value of imported monazite increased during 1981 to $423 per ton, an increase of $64 per ton over the 1980 value. The price of Australian monazite (minimum 60% REO including thoria, f.o.b./f.i.d.), as quoted in Metal Bulletin (London), increased from $403-$460 (A$350-A$400) per ton at yearend 1980 to $437-$495 (A$380-A$430) per ton by yearend 1981. Industrial Minerals quoted yearend prices for yttrium concentrate (60% Y_2O_3, f.o.b. Malaysia) at $46 per kilogram.

Prices quoted from Molycorp of unleached, leached, and calcined bastnasite containing 60%, 70%, and 85% REO increased from $0.85, $0.90, and $1.05 per pound of contained REO, respectively, at yearend 1980 to $0.92, $0.97, and $1.12 per pound of contained REO at yearend 1981. The price of cerium concentrate quoted by American Metal Market increased from $1.15 per pound REO at yearend 1980 to $1.32 per pound REO at yearend 1981. Lanthanum concentrate also increased from $0.90 per pound REO at yearend 1980 to $1.02 per pound REO at yearend 1981.

Mischmetal (99.8%, 50- to 100-pound lots, f.o.b. Newark, N.J.) prices, quoted in American Metal Market, remained at the yearend 1980 level of $5.60 per pound throughout 1981. Molycorp listed prices of Sm-Co_5 and mischmetal-Co_5 permanent magnet alloys (99%, f.o.b. Washington, Pa.) at $55 and $40 per pound, respectively.

Rhône-Poulenc quoted rare-earth prices, per kilogram, net 30 days, f.o.b. New Brunswick, N.J., or duty paid at point of entry, effective January 1, 1981, as follows:

Product[1] (oxide)	Percent purity	Quantity (kilograms)	Price per kilogram
Ceric	98	20	$14.30
Erbium	96	50	196.00
Gadolinium	99.99	50	142.50
Lanthanum	99.9	50	14.60
Neodymium	95	20	8.45
Praseodymium	96	50	43.40
Samarium	96	50	51.50
Terbium	99.9	20	1,140.00
Yttrium	99.9	50	86.00

[1]Dysprosium, europium, holmium, lutetium, thulium, and ytterbium oxide prices on request.

Nominal prices for various rare-earth materials were also quoted by Research Chemicals, net 30 days, f.o.b. Phoenix, Ariz., effective January 12, 1981:

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.

Molycorp quoted prices for rare-earth oxides, net 30 days, f.o.b. Louviers, Colo., Mountain Pass, Calif., or York, Pa., effective September 1, 1981:

Product (oxide)	Percent purity	Quantity (pounds)	Price per pound
Cerium	99.9	1-199	$8.75
Europium	99.99	1-24	900.00
Gadolinium	99.99	1-69	65.00
Lanthanum	99.99	1-299	7.00
Neodymium	99.99	1-49	60.00
Praseodymium	95.0	1-299	17.50
Terbium	99.99	1-49	575.00
Yttrium	99.99	1-49	50.00

Prices for rare-earth metals were also quoted by Molycorp, net 30 days, f.o.b. Washington, Pa., effective May 5, 1980, and throughout 1981:

Product (metal)	Percent purity	Quantity (pounds)	Price per pound
Cerium	99	10-100	$35
Gadolinium	99	<10	210
Lanthanum	99	10-100	35
Neodymium	99	<10	100
Praseodymium	99	10-100	65
Samarium	99	10-100	70
Yttrium	99	10-100	170

FOREIGN TRADE

Exports of ferrocerium and other pyrophoric alloys containing rare earths totaled 9,935 kilograms in 1981, a 36% decrease from that of 1980. Major destinations were Canada (30%), the Federal Republic of Germany (18%), and Australia (11%).

Exports of rare-earth metal ores, excluding monazite, increased 5% from the 1980 total of 9,114,773 kilograms to a total of 9,586,505 kilograms in 1981. Shipments in 1981 were valued at $19,107,983. Major destinations were Japan (44%), the Federal Republic of Germany (29%), and Austria (9%).

Exports of thorium ore, including monazite, in 1981 increased fortyfold. France received all of the reported total of 129,405 kilograms valued at $146,421.

Imports for consumption of monazite (table 2) showed a substantial increase in 1981. U.S. receipts of monazite totaled more than one-half of Australia's 1981 monazite production.

Rare-earth oxide, metal, and alloy imports are shown in table 3. Imports increased only in the cerium oxide and ferrocerium categories. France remained the largest source of imported rare-earth oxides. Brazil was the leading supplier of metals and alloys.

Table 2.—U.S. imports for consumption of monazite, by country

Country	1977		1978		1979		1980		1981	
	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	2,857	$491	5,018	$1,154	5,686	$1,501	4,933	$1,749	7,469	$3,158
Liberia	--	--	53	<1	--	--	--	--	--	--
Malaysia	2,114	409	1,157	255	561	161	215	101	--	--
South Africa, Republic of	--	--	--	--	3	2	--	--	--	--
Thailand	--	--	767	193	37	13	--	--	--	--
Total	4,971	900	6,995	1,603	6,287	1,677	5,148	1,850	7,469	3,158
REO content[e]	2,734	XX	3,847	XX	3,458	XX	2,831	XX	4,108	XX

[e]Estimated. XX Not applicable.

Table 3.—U.S. imports for consumption of rare earths, by country

Country	1979 Quantity (kilograms)	1979 Value	1980 Quantity (kilograms)	1980 Value	1981 Quantity (kilograms)	1981 Value
Cerium oxide:						
Austria	100	$1,002	--	--	--	--
Belgium	1,000	14,150	--	--	--	--
France	2,649	40,519	2,180	$26,896	7,450	$51,644
Germany, Federal Republic of	5	1,624	4	1,975	--	--
Switzerland	44	4,769	10	1,095	--	--
United Kingdom	2,402	53,788	3,636	71,524	127	1,068
Total	6,200	115,852	5,830	101,490	7,577	52,712
Rare-earth oxide, excluding cerium oxide:						
Austria	--	--	50	1,372	100	1,339
Belgium	1,000	49,492	--	--	4,097	466,781
Brazil	50	880	205,498	3,890,000	NA	299
Canada	--	--	34,192	6,123	1	950
China	--	--	2	1,229	--	--
France	242,776	7,660,675	245,950	11,199,793	147,256	8,169,455
Germany, Federal Republic of	62,019	3,276,152	967	126,314	10,808	1,947,385
Italy	--	--	715	34,540	--	--
Japan	19,971	1,298,004	168	125,002	14,736	1,154,744
Malaysia	16,000	152,232	--	--	--	--
Norway	3,846	282,976	2,067	166,609	3,984	419,193
U.S.S.R.	38,871	2,417,062	33,465	2,256,545	11,728	895,932
United Kingdom	150	15,996	1,031	147,480	3,443	121,927
Total	384,683	15,153,469	524,105	17,955,007	196,153	13,178,005
Rare-earth metals (alloys):						
Brazil	20,000	159,070	314,034	2,747,765	179,998	1,518,469
France	549	14,331	4,000	113,428	37	833
Germany, Federal Republic of	160	2,728	50	826	950	8,157
Japan	10,000	63,626	--	--	--	--
United Kingdom	35,000	337,407	230	55,597	555	123,503
Total	65,709	577,162	318,314	2,917,616	181,540	1,650,962
Rare-earth metals, including scandium and yttrium:						
France	1,850	52,129	--	--	200	11,568
Germany, Federal Republic of	--	--	--	--	15	1,415
Japan	--	--	--	--	3	9,329
U.S.S.R.	2,001	104,592	3,715	252,225	1,000	34,638
United Kingdom	219	29,277	126	54,459	483	110,940
Total	4,070	185,998	3,841	306,684	1,701	167,890
Other rare-earth metals:						
Brazil	--	--	8,000	71,616	--	--
Germany, Federal Republic of	([1])	261	11	900	168	10,848
United Kingdom	--	--	2	454	25	2,874
Total	([1])	261	8,013	72,970	193	13,722
Ferrocerium and other pyrophoric alloys:						
Austria	188	3,821	--	--	840	13,314
Belgium	--	--	208	1,400	--	--
Brazil	189	750	--	--	6,725	102,818
France	41,786	518,935	43,283	633,108	50,443	745,169
Germany, Federal Republic of	34	1,663	--	--	100	1,854
Japan	13,154	143,810	21,319	255,248	23,741	332,733
Switzerland	2	352	--	--	--	--
United Kingdom	538	10,281	507	12,054	1,310	53,287
Total	55,891	679,612	65,317	901,810	83,159	1,249,175

NA Not available.
[1]Less than 1 unit.

WORLD REVIEW

Australia.—Mining royalties on minerals sands in Western Australia reportedly will be raised 0.5%. Starting December 1, 1981, the royalties were to be assessed at 2.5% of the realized value of the concentrates, including monazite.

It was estimated that 45% (11,000 tons REO in monazite) of Australia's east coast minerals sands reserves are excluded from mining because of environmental concerns. The Minerals Sands Producers' Association (MSPA) considers the restrictions to be excessive in view of improved environmental controls and rehabilitation programs. The MSPA also noted that the government of New South Wales has ordered the sands mining companies to cease operations by 1982 in newly created national parks, although the parks were created after the minerals sands operations had been established.

The Queensland government decided it would allow mining for monazite and other minerals sands on Moreton Island, off the coast of Brisbane. However, mining will be restricted to less than 7% of the island on the northeast coastline.

Murphyores Pty. Ltd. planned to finance exploration and development of minerals sands, including monazite, at Gladstone, Shoalwater Bay, Curtis Island, and Moreton Island. Murphyores properties on Fraser Island remained closed because of a Government ban on mining based on environmental concerns.

Westralian Sands Ltd. completed an agreement to sell certain heavy minerals sands leases in the Eneabba area to Allied Eneabba Pty. Ltd. In exchange for the leases, Westralian Sands will reportedly receive 27,500 tons of zircon over a 3-year period and an option to purchase 50,000 tons of ilmenite per year over a 10-year period. Monazite production by Westralian Sands was about 1,900 tons in 1981.

Consolidated Goldfields Australia Ltd. (United Kingdom) reorganized, allotting themselves a 49% share and the public (Australia) a 51% share in a new holding company, Renison Goldfields Consolidated Ltd. (RGC). Under the new structuring, Associated Minerals Consolidated Ltd. will become a wholly owned subsidiary of RGC. The new restructuring will be in line with the Australian Government's foreign investment policy of having controlling interest held by Australians.

Allied Eneabba acquired 56 heavy minerals sands claims containing monazite, north of the town of Eneabba, Western Australia. As a result its total ore reserves increased 66% over that of 1980 to 13,328,000 tons. Allied Eneabba reported monazite production for 1981 at 7,603 tons.

Joint venture partners Western Mining Corp. Ltd. (51%) and BP Australia Ltd. (49%) planned additional feasibility studies at the Olympic Dam copper-uranium-gold-rare earth deposit near Roxby Downs, South Australia.

Brazil.—Brazilian rare-earth production in kilograms was as follows:

Year	Carbonate	Chloride	Oxide
1976	3,351	2,036,000	3,320
1977	7,210	2,527,455	16,926
1978	7,000	2,799,000	21,000
1979	14,000	2,725,000	16,000
1980	5,750	2,071,000	11,716

China.—The Chinese Rare Earth Co. (CREC) estimated 1980 rare-earth chloride production at 5,600 tons. Japan imported 2,035 tons of Chinese rare-earth chlorides during 1980, an increase from the 1,037 tons imported in 1979. CREC also reportedly signed a 3-year contract to supply 2,000 tons of chlorides per year to a U.S. company. In 1981 the Bayan Obo mining district accounted for over 20% of the country's rare-earth chloride production.

Rare-earth localities, reported in various news releases and publications, include Nei Monggol Province (Bayan Obo Mine), Jiangxi Province, Henan Province (xenotime), Guangdong Province, Hunan Province, and an undisclosed producing bastnasite deposit. Additional discoveries of rare earths were found in minerals sands near Xiamen, within the coastal Province of Fujian.

Mitsui Mining and Smelting Co., Ltd. (Japan), was contracted by China to build two rare-earth plants in Baotou, Inner Mongolia. The plants would process and smelt ore from the Bayan Obo Mine. Production capacities of 2,000 tons (smelter) and 5,000 tons (ore dressing) were planned. Other rare-earth extraction and smelting operations are the Shanghai Yaolong Chemical Plant and the No. 1 Smelting Plant (Gansu Province).

Total rare-earth reserves for China were reported at 36 million tons of contained

REO.[3]

China now has two mineral trading firms handling rare earths. Both firms, MINMETALS, under the Ministry of Foreign Trade, and the China Metallurgical Import and Export Corp., under the Ministry of Metallurgical Industry, exported rare earths in 1981.

Egypt.—Minerals sands near Rosetta contain 4.28% heavy minerals, including 0.5% monazite. Total economic reserves at Rosetta were calculated at 1.9 million tons.

France.—In 1981, nationalization was the major issue facing France's industrial sector. The Government announced at midyear that it would begin nationalizing several chemical and metal producers including Rhône-Poulenc and the Pechíney Ugine Kuhlmann Group (PUK). The new Socialist government planned to purchase all shares owned by French shareholders, with foreign investors having the option to sell or retain their interests. The nationalization of Rhône-Poulenc was expected to be finalized in the first quarter of 1982. Rhône-Poulenc did not anticipate that any operational changes would occur as a result of the takeover.

Rhône-Poulenc's U.S. subsidiary completed construction of a 4,000-ton-per-year (REO) separation plant in Freeport, Tex. (United States). The official startup for the $50 million facility was December 9, 1981. The Texas plant, in addition to the La Rochelle, France, plant, gives Rhône-Poulenc worldwide capacity of 9,000 tons per year REO.

PUK has purchased the Swiss rare earth-cobalt magnet company, Recoma, previously owned by Brown Boveri & Cie. The acquisition was to be operated through PUK's subsidiary, Aimants Ugimag.

India.—Indian Rare Earths Ltd.'s (IREL) 1980-81 fiscal year monazite production was 4,210 tons, an increase of 60% above the 1979-80 level. The higher production was attributed to the startup of the preconcentrator at Manavalakurichi, Tamil Nadu, and the modernization of the Chavara plant near Quilon, Kerala.

Continued problems at IREL's Orissa mineral sands complex has delayed completion of the project. Completion has been rescheduled for the first half of 1983.

Japan.—The Japanese Government in 1981 was considering a program to stockpile metals for its high-technology industries. The rare earths were among those minerals cited for possible acquisition.

Japanese consumption of rare earths during 1980 was reported in Topics in Japanese Newer Metals Industry 1980-81, as follows: Cerium oxide, 2,300 tons; europium oxide, 3 tons; gadolinium oxide, 10 tons (estimated); lanthanum oxide, 361 tons; samarium oxide, 40 tons (estimated); yttrium oxide, 90 tons; mischmetal, 550 tons; and rare-earth fluoride, 70 tons.

The report also estimated yttrium oxide consumption in Japan would be 150 tons in 1981. An estimated 54 to 58 tons of yttrium oxide was scheduled for domestic production from imported raw materials. Tight supplies and higher prices for yttrium in Japan were predicted for 1981. Santoku Metal Industries entire yttrium output for 1981 reportedly will be sold within Japan. Mitsubishi Chemical Industries (MCI), also a producer of yttrium oxide, was to use 5 to 6 tons of its output in-house and sell the remainder to Japan Yttrium and Shinetsu Chemical.

For 1980, it was estimated that 60 to 65 tons of yttrium oxide (phosphor grade) were consumed in 19,987,000 color television tubes, 18 tons as optical glass additives, and 12 to 13 tons as zirconia stabilizers. An additional 10 to 12 tons of yttrium oxide were exported to Eastern Europe and the Soviet Union for color television manufacturing.

Japan imported 6,376 tons of rare-earth raw materials (bastnasite, chlorides, and crude oxides) in 1980 containing an estimated 3,800 tons of REO. This included 35 tons of crude yttrium oxide (60% Y_2O_3). Imports in 1980 of high-purity oxides, fluorides, and mischmetal totaled 362 tons of contained REO, including 86 tons of yttrium oxide.

Japanese imports of rare earths were reported by the Japan Tariff Association. Shipments from the United States in 1980 were as follows:

Product	Quantity (kilograms)
Cerium fluoride	373
Cerium oxide	8,410
Lanthanum oxide	181
Yttrium oxide	30
Rare-earth metals including yttrium and scandium	932
Ferrocerium and other pyrophoric alloys	4,825
Crude rare-earth chloride, for manufacturing metallic compounds	575,435
Compounds of rare-earth metals including yttrium and scandium	1,051,858

Norway.—Surface investigations at Ulefloss, Telemark County, southern Norway, continued to indicate a large deposit of rare earths. Exploration drilling by Union Mineral Norway, and Fenco, a joint venture of the Norwegian companies S. D. Cappelen, Ardal og Sunndal Verk AS, Elkem Spigerverket AS, and AS Sydvaranger, is planned. S. D. Cappelen has reportedly obtained mining rights for 450 acres.

MCI Megon AS is reportedly producing about 30 tons of yttrium oxide per year. The high-purity oxides are produced from xenotime and yttrium concentrates imported from Malaysia, Australia, and the United States.

Sierra Leone.—Sierra Rutile Ltd., a joint venture of Bethlehem Steel Corp. (85%) and Nord Resources Corp. (15%), started a minerals sands operation in 1980 near Mogbwemo. Although monazite occurs in the minerals sands it is not currently being recovered.

South Africa, Republic of.—A new plant to recover monazite is planned for General Mining Union Corp. Ltd.'s Buffalo Fluorspar Mine. The 2,500- to 3,000-ton-per-year monazite plant was scheduled for commissioning in 1981. Monazite of a red brick color and lesser amounts of a yellowish-brown monazite (radioactively bombarded) is present in up to 2% of the ore.[4]

U.S.S.R.—A large apatite deposit has reportedly been discovered in Zhitomir Oblast in the Ukranian S.S.R. The deposit, which may contain rare earths, is said to be smaller than the Kola Peninsula deposits.

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

(Metric tons)

Country[2]	1977	1978	1979	1980[p]	1981[e]
Australia	9,379	14,992	16,340	13,748	13,500
Brazil	2,440	2,540	1,890	1,205	1,500
India[3]	2,734	3,303	3,254	[e]4,210	4,300
Malaysia[4]	1,977	1,263	669	400	350
Sri Lanka	5	213	213	63	60
Thailand	--	([5])	32	152	150
United States	W	W	W	W	W
Zaire	96	77	90	51	50
Total	16,631	22,388	22,488	19,829	19,910

[e]Estimated. [p]Preliminary. W Withheld to avoid disclosing company proprietary data; not included in total.
[1]Table includes data available through May 26, 1982.
[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 April 1 of that stated.
[4]Exports.
[5]Revised to zero; figure previously reported (845 short tons) was the 1978 export, and apparently was possible because of production in 1975 and before that had not been shipped when mined. Exports were not permitted in 1977.

TECHNOLOGY

Samarium-cobalt permanent magnets were used by General Electric Co. to build a high-power density direct current motor that outperforms conventional electric motors nearly tenfold. The motor weighs 14 kilograms and produces 141 horsepower at 20,000 revolutions per minute. Applications will reportedly be as lightweight starter-generators for aircraft, variable-speed drives for electric vehicles, and industrial use motors.[5]

Other samarium-cobalt research studied the biological effects of implanted permanent magnets. In experiments with rats, no unusual or harmful effects were attributed to the strong magnetic fields. The magnets have sufficient strength to be considered for use in dental prostheses and orthodontics.[6]

Researchers at General Motors Research Laboratories have achieved coercivities (resistance to demagnetization) in praseodymium-iron and neodymium-iron magnets that are the largest reported for any rare earth-iron material. A melt-spinning alloying technique with a controlled interval quench rate was used to produce the high coercivities. The new technique also reduces the conventional two steps of synthesis and magnetic hardening to a single process.[7]

General Motors laboratory also reviewed the development of rare-earth$_2$-transition metal$_{17}$ (RE_2TM_{17}) permanent magnets. A summary of the state-of-the-art technology for the RE_2TM_{17} metal is covered.[8]

An automated film characterization apparatus was developed by Quadra-Bubble Memory Technology to evaluate the magnetic parameters of bubble memory film. Using a laser and high-speed computer, the device analyzes the film in less than 1 minute, 50 times faster than conventional microscope techniques. Future applications may include quality control of epitaxial growth in rare earth-metal-garnets.[9]

Researchers at Luxtron Corp. developed a phosphor-fiberoptic temperature measurement system that operates in electrically, thermally, and chemically harsh environments. An optical fiber tipped with europium doped oxysulfide phosphor was used to measure temperatures from -50° C to 250° C within $\pm 0.1°$ C. Future development of a disposable, sterilizable sensor would be useful in clinical and food processing applications.[10]

A research safety vehicle (RSV) built by Calspan Corp. and Chrysler Corp. was designed for 40- to 50-mile-per-hour impacts. One of the major factors in making the RSV safe was the use of 146 kilograms of high-strength, low-alloy steel containing rare earths. Widespread use of this car would reportedly reduce car fatalities and injuries significantly.[11]

A new zinc-aluminum-mischmetal alloy for galvanizing steel was developed by the International Lead Zinc Research Organization. The alloy exceeded conventional galvanizing materials in corrosion resistance, ductility, weldability, and paintability. The new alloy also showed excellent edge and scratch protection.[12]

An overlay coating that reportedly extends jet engine turbine bucket life was developed by General Electric. The cobalt-chromium-aluminum-yttrium alloy was said to be resistant to hot corrosive turbine gases, have superior ductility, and excellent thermal expansion resistance.[13]

Toshiba introduced two color televisions using terbium-doped yttrium phosphors as the green coloring agent. The 20- and 26-inch screen tubes reportedly have high brightness and ultraclear definition.[14]

Researchers at Sandia Laboratories have implanted hydrogen, helium, argon, and neon ions in lead-lanthanum-zirconium-titanate (PLZT) ceramics to improve photosensitivity. Argon and neon ion coimplantation resulted in improving photosensitivity 10,000 times over that of unimplanted PLZT. Implanted ferroelectric-phase PLZT is currently the most sensitive, nonvolatile, selectively erasable image storage medium known.[15]

Bureau of Mines research on permanent magnets determined that rare earth-cobalt-copper-magnesium-iron alloys could be developed with magnetic properties approaching that of high-magnetic strength samarium-cobalt magnets. The highest magnetic strength product obtained was a lanthanum-praseodymium-cobalt-copper-magnesium alloy, although its resistance to demagnetization (coercivity) was low.

The Bureau of Mines published a report on the magnetic properties of alloys containing mischmetal-cobalt-copper-iron-magnesium.[16] Although the alloys obtained had lower magnetic strength than that of samarium-cobalt permanent magnets, coercivity values were higher.

Results of research involving the beneficiation of bastnasite and recovery of associated barite were completed by the Bureau of Mines.[17] Rare-earth concentrates were prepared with slightly higher grades using lower energy-saving pulp temperatures. Barite recovered from the tailings would reportedly require further upgrading to meet drilling mud specifications. A summary of the findings was to be published in 1982.

The Fifteenth Rare Earth Research Conference was held at the University of Missouri, Rolla, Mo., June 15-18, 1981. Proceedings of the conference will be available in 1982.

A bibliography on the use of rare earths in optical and special property glasses was completed by Molycorp.[18] A report on the discovery and commercial separation of rare earths was published by Rhône-Poulenc.[19]

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[1]Physical scientist, Division of Nonferrous Metals.

[2]All measurements are metric units unless otherwise specified.

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Rhenium

By Ivette E. Torres[1]

Rhenium was produced by two firms in 1981. One firm recovered rhenium from domestic porphyry copper ores, while the other recovered it on a toll-conversion basis. Consumption of rhenium decreased an estimated 9.6% from that of 1980, to 6,600 pounds. The major use for rhenium continued to be in bimetallic reforming catalysts to produce low-lead and lead-free high-octane gasoline. Imports of rhenium in ammonium perrhenate increased from 4,991 pounds in 1980 to 9,089 in 1981. Prices in 1981 continued to decrease. During the first quarter, the price for the metal ranged from $700 to $800 per pound, but began dropping in late summer to end the year at about $525 per pound.

Table 1.—Salient rhenium statistics

(Pounds of contained rhenium)

	1977	1978	1979	1980	1981
Mine production	--	W	W	W	W
Consumption[e]	7,300	12,500	9,500	7,300	6,600
Imports (metal)	148	449	927	513	580
Imports for consumption of ammonium perrhenate	6,111	[1]12,042	8,299	4,991	9,089
Stocks, Dec. 31	17,300	W	W	W	W

[e]Estimated. W Withheld to avoid disclosing company proprietary data.
[1]Includes 850 pounds of perrhenic acid.

DOMESTIC PRODUCTION

Kennecott Corp., near Salt Lake City, Utah, was the sole producer of rhenium from domestic porphyry copper ores in 1981.

In September, Duval Corp. announced the opening of its rhenium recovery plant at its Sierrita property near Tucson, Ariz. Production of ammonium perrhenate as a byproduct of molybdenum roasting was scheduled to begin in October, but because of problems with the grade of the material being produced, marketable ammonium perrhenate production did not begin until January 1982. Metallic rhenium and perrhenic acid will also be produced at the facility when market conditions improve.

Shattuck Chemical Co., a subsidiary of Phibro Corp., recovered rhenium from Canadian molybdenite concentrates on a toll-conversion basis, returning the rhenium to its owner for subsequent sale.

CONSUMPTION AND USES

Domestic consumption of rhenium fell an estimated 9.6% below that of 1980 to 6,600 pounds. The decrease was attributed to the decline in demand for platinum-rhenium reforming catalysts. These catalysts are used by the petroleum industry to produce low-lead and lead-free high-octane gasoline and account for about 90% of the rhenium demand. In the reforming process, bimetallic platinum-rhenium catalysts compete with conventional monometallic and other bimetallic catalysts. Platinum-rhenium's lower price, resistance towards sulfur, greater carbon tolerance, and resistance to high temperatures make it attractive and suitable for cleaning and regeneration. The regeneration of the platinum-rhenium catalysts reduces the demand for the first generation of catalytic feedstock.

Total reforming capacity decreased by 1.8% in 1981 to 3,978,180 barrels per stream day. Of this total, 80.5%, or 3,201,750 barrels per stream day, represented bimetallic reforming capacity.[2]

The three basic types of bimetallic reforming catalysts are as follows: The semiregenerative, cyclic, and other types (nonregenerative, continuous, and moving-bed systems). The semiregenerative reforming catalyst accounted for 60% of the total reforming capacity. Cyclic catalysts and other types accounted for 13% and 7%, respectively. Platinum-rhenium was used in an estimated 85% of the total bimetallic reforming capacity.

Most of the bimetallic platinum-rhenium catalysts contain 0.3% rhenium and 0.3% platinum, by weight, using alumina (Al_2O_3) as the base. The rhenium content may be as low as 0.25% and as high as 0.9%.

Platinum-rhenium catalysts are also used in the production of benzene, toluene, and xylenes.

About 10% of the total domestic consumption of rhenium in 1981 was accounted for by use in thermocouples, ionization gauges, electron tubes and targets, electrical contacts, X-ray tubes and targets, metallic coatings, semiconductors, heating elements, high-temperature nickel-based alloys, mass spectrographs, vacuum tubes, and electromagnets. For these uses, the major portion of the rhenium is contained in the tungsten-rhenium and molybdenum-rhenium alloys.

Rhenium is alloyed with other metals to improve acid and heat resistance, wear and corrosion resistance, durability, and mechanical properties.

PRICES

In 1981, the price of rhenium continued to decrease, following the trend that characterized 1980. During the first quarter, the price of rhenium powder ranged from $700 to $800 per pound, decreasing to about $550 per pound during the second quarter. Thereafter, the price stabilized and ended the year at about $525 per pound. The price of perrhenic acid was about $650 per pound during the first quarter, after which it decreased to about $460 per pound and remained at this level through the rest of the year. Gasoline oversupply was the major cause for the soft market price. The oversupply caused a lower demand for rhenium used in reforming catalysts.

FOREIGN TRADE

U.S. imports for consumption of rhenium in ammonium perrhenate increased 82% from that of 1980. The value of these imports was $3.3 million. Imports of rhenium metal increased by 13%, to 580 pounds and were valued at $0.6 million. All ammonium perrhenate originated from Chile and the Federal Republic of Germany. Over 99.5% of the rhenium metal came from the Federal Republic of Germany.

The import duty on ammonium perrhenate from countries with market economies was 3.8% ad valorem; the import duty from countries with central economies was 25% ad valorem. The duty on rhenium metal from countries with market economies was 4.7% ad valorem for unwrought metal and 8.1% ad valorem for wrought metal. The duty on wrought and unwrought metal from countries with central economies was 45% and 25% ad valorem, respectively. The duty on waste and scrap has been suspended indefinitely.

Table 2.—U.S. imports for consumption of ammonium perrhenate, by country[1]

(Rhenium content)

Country	1977		1978		1979		1980		1981	
	Quantity (pounds)	Value (thousands)	Quantity (pounds)	Value (thousands)	Quantity (pounds)	Value (thousands)	Quantity (pounds)	Value (thousands)	Quantity (pounds)	Value (thousands)
Chile	4,187	$1,087	5,855	$889	4,335	$1,380	2,049	$2,775	5,767	$2,401
Germany, Federal Republic of	1,924	533	[2]6,187	1,512	3,898	1,854	2,721	4,720	3,322	896
Poland	--	--	--	--	66	25	--	--	--	--
U.S.S.R	--	--	--	--	--	--	135	229	--	--
Yugoslavia	--	--	--	--	--	--	86	165	--	--
Total	6,111	1,620	12,042	2,401	8,299	3,259	4,991	7,889	9,089	3,297

[1]Adjusted by Bureau of Mines.
[2]Includes 850 pounds of perrhenic acid.

Table 3.—U.S. imports for consumption of rhenium metal, by country

(Gross weight)

Country	1977		1978		1979		1980		1981	
	Quantity (pounds)	Value	Quantity (pounds)	Value	Quantity (pounds)	Value	Quantity (pounds)	Value	Quantity (pounds)	Value
Belgium-Luxembourg	18	$4,120	15	$6,075	--	--	--	--	--	--
France	--	--	--	--	238	$97,836	100	$43,587	--	--
Germany, Federal Republic of	130	51,734	434	161,920	468	426,735	390	539,985	578	$573,009
U.S.S.R	--	--	--	--	220	82,594	--	--	--	--
United Kingdom	--	--	--	--	--	--	23	84,135	--	--
Other[1]	--	--	--	--	1	478	--	--	2	1,429
Total	148	55,854	449	167,995	927	607,643	513	667,707	580	574,438

[1]Includes Austria and Switzerland.

WORLD REVIEW

Rhenium was recovered from porphyry copper deposits in Canada, Chile, Peru, the U.S.S.R., and the United States. In the U.S.S.R., the majority of the rhenium was produced from the Dzhezkazgan sedimentary copper deposit. Rhenium was recovered from concentrates in Chile, the Federal Republic of Germany, France, Sweden, the United Kingdom, the U.S.S.R., and the United States.

Canada.—Rhenium production in Canada increased an estimated 10% over that of 1980 to 4,400 pounds. Rhenium in molybdenite concentrates was exported to the Federal Republic of Germany and the United States for recovery. About 60% of the rhenium was returned to Canada to be marketed. Utah International Inc., the owner of the Copper Island Mine in British Columbia, continued to be the sole producer of rhenium in Canada. The Island Copper Mine contains one of the highest concentrations of rhenium in the world.

Papua New Guinea.—Approval by the Government of Papua New Guinea for the development of the OK Tedi copper, gold, and molybdenum deposit was finalized during 1981. An international consortium named OK Tedi Co. Ltd. was formed to develop the deposit. The first phase of production, which was previously scheduled to start in early 1984, will reportedly start by yearend 1984 or the beginning of 1985. During this phase, only gold will be produced. During the second and third phases, copper and copper-molybdenum concentrates will be extracted, respectively. Rhenium concentration has been estimated at 300 parts per million in the molybdenite concentrates.

Peru.—Southern Peru Copper Corp. (SPCC), owner of the Toquepala and Cuajone Mines, did not recover any rhenium in 1981 but sent MoS_2 concentrates to be processed in the Federal Republic of Germany and the United States. The concentrates average 300 parts per million rhenium. Some of the rhenium is recovered and sold by the companies roasting the Peruvian molybdenite.

U.S.S.R.—The major source of rhenium in the Soviet Union is the Dzhezkazgan sedimentary copper deposit in Kazakhstan. In this deposit, rhenium occurs in bornite and chalcocite ores.[3] Recent reports indicate that the majority of the Soviet rhenium output comes from the Dzhezkazgan deposit and not from porphyry copper deposits as previously believed. The Dzhezkazgan copper smelting facility, in conjunction with various research institutes in the Soviet Union, has done considerable work to increase the extraction of copper, lead, rhenium, sulfur, gold, and silver from these ores.[4] To achieve better recovery, new methods have been developed to improve the handling of concentrates and the exit gases in the smelting process.

In chemical balance studies performed in 1974 and 1977, it was found that rhenium is distributed among the smelting products as follows: 70% in gases, 25% in matte, and 5% in slag.

The original design capacity of the rhenium extraction circuit of the smelter provided for a recovery of about 73%. The losses of rhenium occur in charge preparation, slag, commercial dust, and spent acid. In actual practice, rhenium recovery for the first half of 1980 averaged about 42%. This represents an increase of about fourteenfold over the 1973 recovery rate which was 3.1%.

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[1]Physical scientist, Division of Ferrous Metals.

[2]Oil and Gas Journal. V. 80, No. 12, Mar. 22, 1982, pp. 128-150.

[3]Demeshkin, S. S., G. A. Nelidova, A. A. Zubkov, K. F. Levin, and I. A. Litinskiy. Distribution of Rhenium at the Dzhezkazgan Mines and in the Concentration Products. Nonferrous Metals (U.S.S.R.), No. 3, March 1981, pp. 23-25.

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Salt

By Dennis S. Kostick[1]

Total domestic production of salt in 1981 decreased for the second consecutive year to 38.9 million short tons. The previous low production was 36.5 million tons in 1966. The decrease in salt production is attributed to the generally poor economic conditions affecting the chloralkali and agricultural sectors as well as the downturn in salt usage in certain food product industries.

Legislation and Government Programs.—The Food and Drug Administration, with the support of the U.S. Department of Health and Human Services, is investigating limiting the amount of sodium in processed food in response to public concern about the effect of salt on human health. Proposed legislation, H.R. 4031, pending before the House Health and Environment Subcommittee, would require food processing companies to specify the sodium content of foods in excess of 35 milligrams of sodium per serving. The proposed action would allow individuals the choice of increasing or decreasing the sodium level of their diets.

Many food and salt trade associations support a voluntary labeling program. Some companies are voluntarily labeling the sodium content or introducing new low-sodium products. A new product line of soups, for example, will contain between 30 to 106 milligrams of sodium per serving compared with present soups on the market that contain from 780 to more than 1,000 milligrams of sodium.[2]

In conjunction with the Solution Mining Research Institute, the Bureau of Mines is examining sinkholes in Kansas to determine the causes and mechanisms of solution cavity failures. The work will attempt to develop useful methods for monitoring surface stability over solution mining operations.[3]

Table 1.—Salient salt statistics

(Thousand short tons and thousand dollars)

	1977	1978	1979	1980	1981
United States:					
Production[1]	42,922	42,878	46,317	41,483	38,893
Sold or used by producers[1]	43,412	42,869	45,793	40,352	38,907
Value	$451,579	$499,345	$538,352	$656,164	$636,328
Exports	1,008	776	697	831	1,043
Value	$10,881	$9,795	$9,025	$12,829	$18,070
Imports for consumption	4,529	5,380	5,275	5,263	4,974
Value	$26,694	$34,247	$40,860	$44,071	$49,157
Consumption, apparent	46,933	47,473	50,371	44,784	42,695
World: Production	[r]173,107	[r]189,105	[r]191,345	[p]185,788	[e]183,106

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Excludes Puerto Rico.

DOMESTIC PRODUCTION

The total quantity of domestic salt sold or used by producers in 1981 decreased to 38.9 million short tons. In 1981, 47 companies operated 88 salt-producing plants in 16 States. Ten of the companies sold or used over 1 million tons each, accounting for

80% of the U.S. total.

The five leading States in the amount of salt sold or used follow:

State	Percent of total	
	1980	1981
Louisiana	31	32
Texas	25	22
New York	14	14
Ohio	8	9
Michigan	6	6
Total	84	83

The percentage of salt sold or used by domestic producers in 1981 by type follow:

	Percent	
	1980	1981
Salt in brine	55	53
Mined rock salt	30	31
Vacuum pan salt and grainer or open pan salt	9	10
Solar-evaporated salt	6	6
Total	100	100

Rickano Corp. purchased the abandoned salt mine of Carey Salt Co. in Lyons, Kans., with the intention of using it as a low-level radioactive waste disposal facility. An application for a State license is under review by the Kansas Legislature amid concerns by special interest groups regarding the safety of the operation.[4]

Diamond Crystal Salt Co. amended its suit against Texaco Oil Co. concerning the loss of the Jefferson Island salt mine in Louisiana in November 1980. The $219 million suit is being contested by Texaco, which cites that the flooding was caused by the salt company's negligence.[5]

Diamond Crystal closed its solar salt facility at Long Island in the Bahamas late in 1981. The operation suffered from excessive rainfall and hurricane damage through the years.[6] The company also entered into a long-term, rock salt supply agreement with Les Mines Seleine, Inc., a subsidiary of Soquem of Quebec, Canada. Diamond Crystal will receive a certain percentage of production from the new 1.5-million-ton-per-year salt mine being developed on Magdelen Island in the Gulf of St. Lawrence.[7]

CONSUMPTION AND USES

In 1981, the domestic apparent consumption of salt fell to 42.7 million short tons, the lowest recorded since 1967. Compared with those of previous years, the quantity of salt used for producing chlorine, caustic soda, and soda ash fell the sharpest of all the end uses. This decline was attributed to the slowdown in the construction and automotive industries, which use soda ash, polyvinyl chloride, and other copolymers. Rock salt for highway deicing increased 6% in 1981 despite adoption of improved deicing programs (knowing when and how much salt to use per road application, and when to substitute with alternate deicing materials), which help to reduce salt utilization.

The distribution by end use of the various types of salt sold or used by producers in the United States in 1981 is shown in table 7. Evaporated salt has been divided into vacuum pans-open pans salt and solar salt commencing with this publication in order to show a better distribution.

Production of chlorine gas, caustic soda, and metallic sodium, in thousand short tons, in 1981, as reported by the U.S. Department of Commerce, was as follows:

	1980	1981	Percent change
Chlorine gas (100%)	[r]11,190	10,559	-5.6
Sodium hydroxide, liquid (100%)	[r]11,311	10,649	-5.9
Metallic sodium	112	103	-8.0

[r]Revised.

STOCKS

Total yearend salt stocks, as reported by producers, amounted to 3.2 million tons in 1981. Most was in the form of rock and solar salt.

Table 2.—Salt sold or used by producers in the United States,[1] by recovery method

(Thousand short tons and thousand dollars)

Recovery method	1980 Quantity	1980 Value	1981 Quantity	1981 Value
Evaporated:				
Bulk:				
Open pan or grainer and vacuum pan	3,587	274,188	3,500	278,878
Solar	2,334	36,516	2,298	42,176
Pressed blocks	393	24,412	404	26,099
Total[2]	6,314	335,117	6,201	347,148
Rock:				
Bulk	11,742	172,039	11,809	162,457
Pressed blocks	65	4,502	62	4,722
Total[2]	11,806	176,541	11,871	167,178
Salt in brine (sold or used as such)	22,231	144,507	20,835	121,996
Grand total[2]	40,352	656,164	38,907	636,328

[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	1980 Quantity	1980 Value	1981 Quantity	1981 Value
Kansas[1]	1,572	64,276	1,409	62,892
Louisiana	12,662	132,182	12,565	113,190
Michigan	2,406	104,842	2,321	103,293
New York	5,509	99,395	5,597	103,668
Ohio	3,228	87,371	3,608	90,254
Texas	9,978	93,414	8,397	84,240
Utah	1,157	19,373	1,072	21,775
West Virginia	953	W	963	W
Other[2]	2,887	55,311	2,974	57,016
Total	40,352	656,164	[3]38,907	636,328
Puerto Rico[e]	27	642	8	144

[e]Estimated. W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Quantity and value of brine included with "Other."
[2]Includes Alabama, Arizona, California, Colorado, Hawaii, Kansas (brine only), Nevada, New Mexico, North Dakota, Oklahoma, and items indicated by symbol W.
[3]Data do not add to total shown because of independent rounding.

Table 4.—Evaporated salt sold or used by producers in the United States, by State

(Thousand short tons and thousand dollars)

State	1980 Quantity	1980 Value	1981 Quantity	1981 Value
Kansas	901	56,555	901	54,292
Louisiana	280	20,487	232	21,870
Michigan	1,133	90,916	1,148	89,442
New York	638	50,579	649	51,393
Utah	1,091	19,005	1,034	21,478
Other[1]	2,271	97,575	2,238	108,673
Total	6,314	335,117	[2]6,201	347,148
Puerto Rico[e]	27	642	8	144

[e]Estimated.
[1]Includes Arizona, California, Hawaii, New Mexico, North Dakota, Ohio, Oklahoma, and Texas.
[2]Data do not add to total 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
1977	14,958	136,437
1978	14,688	150,794
1979	14,891	152,192
1980	11,806	176,541
1981	11,871	167,178

Table 6.—Pressed-salt blocks sold by original producers of salt in the United States

(Thousand short tons and thousand dollars)

Year	From evaporated salt		From rock salt		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
1977	388	19,307	65	3,281	453	22,588
1978	381	20,625	58	3,041	439	23,666
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	4,722	466	30,821

Table 7.—Distribution of salt sold or used by producers in the United States in 1981, by consumer or use

(Thousand short tons)

Consumer or use	Evaporated		Rock	Brine	Total[1]
	Vacuum pans and open pans	Solar			
Chlorine, caustic soda, soda ash	45	383	1,718	19,747	21,893
All other chemicals	214	207	568	144	1,133
Textile and dyeing	152	17	51	--	220
Meatpackers, tanners, casing manufacturers	123	71	256	--	450
Dairy	72	11	8	--	91
Canning	125	35	70	--	230
Baking	87	15	7	--	109
Flour processors (including cereal)	53	13	17	--	83
Other food processing	171	27	25	--	223
Feed dealers	408	335	401	--	1,144
Feed mixers	225	107	312	--	644
Metals	42	W	228	W	294
Rubber	43	W	3	W	102
Oil	121	328	98	290	837
Paper and pulp	W	57	130	W	247
Water softener manufacturers and service companies	287	193	218	5	703
Grocery stores	760	78	179	--	1,017
Highway use	72	117	6,487	--	6,676
U.S. Government	11	54	62	(2)	127
Distributors (brokers, wholesalers, etc.)	502	W	574	W	1,431
Miscellaneous and undistributed[3]	254	553	1,010	662	1,984
Total[1]	[4]3,767	[4]2,600	[4]12,422	[4]20,849	[5]39,638

W Withheld to avoid disclosing company proprietary data; included with "Miscellaneous and undistributed."
[1]Data may not add to totals shown because of independent rounding.
[2]Less than 1/2 unit; included with "Miscellaneous and undistributed."
[3]Includes withheld figures and some exports and consumption in overseas areas administered by the United States.
[4]Differs from totals shown in tables 2, 4, and 5 because of changes in inventory.
[5]Differs from totals shown in tables 1, 2, and 3 because of changes in inventory.

Table 8.—Distribution (shipments) of evaporated and rock salt in the United States, by destination[1]

(Thousand short tons)

Destination	1980 Evaporated	1980 Rock	1981 Evaporated: Vacuum pans and open pans	1981 Evaporated: Solar	1981 Rock
Alabama	47	504	35	W	541
Alaska	16	--	W	W	--
Arizona	61	[r]5	28	40	W
Arkansas	29	68	27	W	37
California	934	1	171	841	W
Colorado	130	50	33	92	36
Connecticut	24	83	20	9	W
Delaware	47	272	4	W	270
District of Columbia	W	W	W	W	W
Florida	67	86	52	67	52
Georgia	93	90	58	W	71
Hawaii	W	--	W	--	--
Idaho	66	W	W	55	W
Illinois	360	[r]1,074	280	91	1,042
Indiana	150	[r]638	159	W	551
Iowa	205	289	168	45	231
Kansas	97	222	100	7	193
Kentucky	35	589	37	W	717
Louisiana	53	464	46	W	455
Maine	7	89	8	W	110
Maryland	39	139	50	102	96
Massachusetts	37	194	36	30	360
Michigan	170	[r]1,144	144	162	1,203
Minnesota	182	315	126	65	317
Mississippi	23	116	21	--	139
Missouri	106	353	96	30	278
Montana	69	2	29	45	W
Nebraska	125	101	78	55	96
Nevada	[r]304	W	9	W	W
New Hampshire	3	W	4	W	W
New Jersey	194	360	143	127	277
New Mexico	70	27	10	112	26
New York	[r]324	[r]1,408	218	116	1,626
North Carolina	102	152	105	W	110
North Dakota	[r]78	1	93	54	5
Ohio	[r]403	1,399	340	W	1,428
Oklahoma	63	87	53	W	77
Oregon	158	--	W	223	W
Pennsylvania	159	969	181	94	979
Rhode Island	13	W	5	W	W
South Carolina	31	17	34	W	19
South Dakota	46	41	46	24	32
Tennessee	88	498	92	--	332
Texas	233	243	153	W	231
Utah	241	W	34	217	W
Vermont	5	104	6	W	115
Virginia	103	252	100	W	168
Washington	[r]554	W	350	404	W
West Virginia	63	210	18	W	217
Wisconsin	186	[r]765	191	W	639
Wyoming	32	W	W	27	W
Other[2]	[r]1,027	[r]583	95	787	804
Total[3]	[r]7,652	[r]14,004	4,090	3,919	13,880

[r] Revised. W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Each salt type includes domestic and imported quantities.
[2]Includes shipments to overseas areas administered by the United States, Puerto Rico, exports, some shipments to unspecified destinations, and shipments to States indicated by symbol W.
[3]Data may not add to totals shown because of independent rounding.

PRICES

The average values of different classes of salt, f.o.b. works, as reported by producers follow:

	Per ton	
	1980	1981
Evaporated:		
Open pan or grainer and vacuum pan	$76.44	$79.68
Solar	15.65	18.35
Pressed blocks, all sources	63.20	66.14
Rock salt, bulk	14.65	13.76
Salt in brine	6.50	5.86

The following salt prices were quoted at yearend 1981 in Chemical Marketing Reporter:[8]

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	2.05
Bulk, same basis, per ton	50.00

FOREIGN TRADE

In 1981, exports of salt from the United States increased to 1,043,000 short tons. Approximately 97% of the salt was shipped to Canada with minor quantities being exported to Saudi Arabia, Iraq, and Mexico.

U.S. imports of salt decreased to about 5 million short tons in 1981 as a result of reduced consumption of salt in the United States. Imports from Canada and Mexico represented about 61% of the total.

Table 9.—Salt shipped to the Commonwealth of Puerto Rico and overseas areas administered by the United States

Area	1980		1981	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Puerto Rico	22,315	$4,281	70,572	$9,144
Virgin Islands	173	15	3	1

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

(Thousand short tons and thousand dollars)

Country	1980		1981	
	Quantity	Value	Quantity	Value
Angola	--	--	1	57
Bahamas	1	169	1	193
Bermuda	(1)	2	--	--
Canada	800	8,224	1,011	11,818
Costa Rica	1	157	1	78
Denmark	(1)	42	(1)	38
Germany, Federal Republic of	(1)	15	(1)	7
Hong Kong	(1)	30	(1)	26
Iraq	7	301	5	2,245
Mexico	3	326	3	399
Netherlands Antilles	(1)	68	(1)	161
Saudi Arabia	12	2,348	12	2,314
South Africa, Republic of	(1)	5	1	14
Sweden	(1)	7	--	--
Trinidad and Tobago	2	186	(1)	32
United Arab Emirates	(1)	97	1	73
United Kingdom	(1)	93	(1)	55
Venezuela	(1)	29	1	10
Other	5	730	6	550
Total	831	12,829	1,043	18,070

[1]Less than 1/2 unit.

Table 11.—U.S. imports for consumption of salt, by country

(Thousand short tons and thousand dollars)

Country	1980 Quantity	1980 Value	1981 Quantity	1981 Value
Bahamas	531	5,573	753	6,501
Brazil	62	608	28	175
Canada	[1]2,089	[1]16,515	[2]1,685	[2]16,248
Chile	341	2,689	77	554
Colombia	273	2,280	--	--
Italy	([3])	([3])	[4]30	[4]669
Mexico	1,457	10,216	1,328	20,153
Nepal	22	161	--	--
Netherlands	104	2,034	[5]746	[5]1,588
Netherlands Antilles	193	2,031	149	1,565
Spain	99	831	[6]90	[6]753
Tunisia	60	530	61	459
Yemen Arab Republic	31	163	([7])	3
Other	[8] ([7])	[8]439	27	489
Total[9]	5,263	44,071	4,974	49,157

[1]Includes salt brine through Detroit customs district, 11,490 short tons ($39,205), and Ogdensburg customs district, 20 short tons ($1,406).

[2]Includes salt brine through Portland customs district, 25 short tons ($372), and Detroit customs district, 710 short tons ($11,452); salt in bags, sacks, and barrels through 9 different customs districts amounted to 204 short tons ($1,079,143).

[3]Includes 405 pounds ($6,989) salt in bags, sacks, and barrels.

[4]Includes salt in bags, sacks, and barrels through Boston and New York customs districts, 24 pounds ($3,351).

[5] Includes salt in bags, sacks, and barrels through Philadelphia customs district, 87 pounds ($15,775).

[6]Includes salt in bags, sacks, and barrels through Portland, Boston, and Chicago customs districts, 3 short tons ($21,947).

[7]Less than 1/2 unit.

[8]Includes salt brine from Austria through New York customs district, 50 short tons ($500); from Sweden through New York customs district, 36 short tons ($727). Salt in bags, sacks, and barrels from Denmark through Boston and Cleveland customs district, 66 short tons ($28,577); from Japan through Norfolk, Los Angeles, and Anchorage customs districts, 19 short tons ($268,695).

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

Table 12.—U.S. imports for consumption of salt, by year

(Thousand short tons and thousand dollars)

Year	In bags, sacks, barrels, or other packages (dutiable)		Bulk (dutiable)	
	Quantity	Value	Quantity	Value
1979	1	1,760	[1]5,275	[1]39,099
1980	1	1,478	[2]5,263	[2]42,593
1981	27	1,483	[3]4,974	[3]47,674

[1]Includes salt brine from Canada through Detroit customs district, 239 short tons ($5,370); from the United Kingdom through Washington customs district, less than 1 short ton ($344); from Denmark through Cleveland customs district, 6 short tons ($43,410); from Finland through New York customs district, less than 1 short ton ($949); from Sweden through New York customs district, less than 1 short ton ($637).

[2]Includes salt brine from Canada through Ogdensburg customs district, 20 short tons ($1,406), and Detroit 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); from Poland through Cleveland customs district, less than 1 short ton ($300).

[3]Includes salt brine from Canada through Portland and Detroit customs districts, 25 short tons ($373) 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); from France through Los Angeles customs district, 2,012 short tons ($40,234).

Table 13.—U.S. imports for consumption of salt, by customs district

(Thousand short tons and thousand dollars)

Customs district	1980		1981	
	Quantity	Value	Quantity	Value
Anchorage, Alaska	(1)	278	2	252
Baltimore, Md	472	3,497	135	1,284
Boston, Mass	33	319	28	254
Buffalo, N.Y	64	434	136	1,155
Chicago, Ill	554	3,810	307	2,489
Cleveland, Ohio	34	600	35	434
Detroit, Mich	599	4,715	512	4,527
Duluth, Minn	179	1,434	100	1,358
Los Angeles, Calif	190	1,700	243	2,970
Milwaukee, Wis	442	2,959	334	2,774
New Orleans, La	66	463	744	752
New York, N.Y	397	5,401	155	2,347
Norfolk, Va	86	751	44	371
Ogdensburg, N.Y	58	530	63	714
Philadelphia, Pa	47	469	45	369
Portland, Maine	397	3,640	370	3,583
Portland, Oreg	513	3,158	400	4,280
Providence, R.I	--	--	83	805
St. Albans, Vt	39	590	65	1,148
San Juan, P.R	6	70	7	104
Savannah, Ga	273	2,178	344	2,388
Seattle, Wash	576	3,843	568	11,520
Tampa, Fla	51	394	88	678
Wilmington, N.C	184	2,692	166	2,569
Other	3	146	1	31
Total[2]	5,263	44,071	4,974	49,157

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

Table 14.—U.S. imports for consumption of salt, by use as reported by salt producers

(Thousand short tons)

Use	1980	1981
Government (highway use)	1,087	1,581
Chemical industry	803	829
Water-conditioning service companies	179	303
Other	260	386
Total[1]	[2]2,330	3,099

[1]Disagreement with totals in tables 1, 11, 12, and 13 is because of incomplete data on the uses of imported salt.
[2]Data do not add to total shown because of independent rounding.

WORLD REVIEW

The world production of salt, by region and by percent of total in 1980 and 1981, in million short tons, follow:

	1980	Percent of total	1981	Percent of total
Europe	r76.2	41.0	73.0	39.9
North America	r57.0	30.7	56.6	30.9
Asia	r36.0	19.4	36.8	20.1
South America	r7.5	4.0	7.7	4.2
Oceania	5.9	3.2	5.8	3.2
Africa	r3.2	1.7	3.2	1.7
Total[1]	185.8	100.0	183.1	100.0

rRevised.
[1]Data may not add to totals in table 15 because of independent rounding.

Greece.—The Messolonghi salt works plans to increase its production capacity to 450,000 tons per year by 1983. The expansion is expected to fulfill the anticipated growth in the domestic and export markets.[9]

Netherlands.—Akzo Zout Chemie Nederland B.V. is investigating the technical and economic aspects of underground salt mining near Hengelo and other locations in Western Europe. The company presently extracts salt by hot-water injection, a high energy-intensive process.[10]

Pakistan.—As part of the 1981-85 5-year plan of the Ministry of Commerce and Industry, a 10,000-ton-per-year salt plant will be built in Qurayat. About two-thirds of the production will be shipped to Ghubra where the salt will be processed into soda ash and refined sodium chloride.[11]

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

(Thousand short tons)

Country[2]	1977	1978	1979	1980[p]	1981[e]
North America:					
Bahamas	1,841	1,800	485	754	[3]1,069
Canada	6,657	7,112	7,585	7,748	8,030
Costa Rica	30	38	51	44	45
Cuba	142	144	134	137	140
Dominican Republic	38	42	42	61	70
El Salvador[e]	30	30	30	30	25
Guatemala	12	12	16	11	10
Honduras[e]	35	35	35	35	35
Leeward and Windward Islands[e]	55	55	55	55	55
Mexico	5,400	6,212	6,800	7,248	7,720
Netherlands Antilles[e]	440	440	440	440	440
Nicaragua[e]	18	20	20	22	20
Panama	23	17	21	21	25
United States, including Puerto Rico:					
Rock salt	14,958	14,688	14,891	11,806	11,871
Other salt:					
United States	28,454	28,181	30,902	28,545	27,036
Puerto Rico[e]	27	27	27	27	8
South America:					
Argentina:					
Rock salt	2	1	1	1	1
Other salt	1,263	771	682	1,106	1,205
Brazil:					
Rock salt	323	631	759	877	885
Marine salt	2,735	3,006	3,159	3,353	3,530
Chile	467	434	650	486	440
Colombia:					
Rock salt	[r]383	[r]416	422	383	[3]348
Other salt	[r]655	[r]507	407	541	[3]440
Peru	[r]350	[r]384	440	504	550
Venezuela	266	174	[e]170	268	275
Europe:					
Albania[e]	55	55	70	75	75
Austria:					
Rock salt	1	1	1	1	1
Evaporated salt	[r]366	354	419	452	465
Salt in brine	160	172	229	243	250
Bulgaria	96	96	95	96	95
Czechoslovakia	280	284	299	305	300
Denmark[4]	346	358	419	[e]420	420
France:					
Rock salt	316	505	631	331	[3]328
Brine salt	1,120	1,215	1,310	1,227	1,204
Marine salt	1,087	952	1,986	[e]1,405	[3]1,517
Salt in solution	3,844	4,254	4,955	4,867	[3]4,266
German Democratic Republic:					
Rock salt	2,855	2,963	3,304	3,391	3,420
Marine salt	58	58	60	57	60
Germany, Federal Republic of:					
Marketable:					
Rock salt	7,860	7,546	9,876	[e]7,600	7,450
Marine salt and other salt	5,723	6,407	6,757	[e]6,700	6,065
Greece	209	147	149	133	130
Iceland	--	--	--	([5])	([5])
Italy:					
Rock salt and brine salt	3,969	4,102	4,949	4,406	4,000
Marine salt	[r]1,123	1,334	[e]1,300	1,400	1,400
Malta	1	1	[e]1	1	1
Netherlands	3,429	3,240	4,355	3,818	3,860
Poland:					
Rock salt	1,722	1,582	1,607	1,615	1,200
Other salt	3,081	3,261	3,275	3,383	2,535
Portugal:					
Rock salt	387	360	450	442	440
Marine salt	164	165	[e]155	140	130
Romania:					
Rock salt	NA	1,827	1,819	1,950	1,875
Other salt	NA	3,397	3,384	3,622	3,640
Spain:					
Rock salt	[r]2,095	[r]2,306	2,411	2,622	2,650
Marine salt and other evaporated salt[6]	1,323	1,408	1,389	1,245	1,325
Switzerland	403	431	430	406	410

See footnotes at end of table.

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

(Thousand short tons)

Country[2]	1977	1978	1979	1980[p]	1981[e]
Europe —Continued					
U.S.S.R.[e]	15,760	15,980	15,760	16,000	16,000
United Kingdom:					
Rock salt	998	1,445	1,752	1,925	1,765
Brine salt[7]	2,062	1,940	2,111	1,773	1,740
Other salt[7]	5,981	4,673	4,756	4,190	4,000
Yugoslavia:					
Rock salt	94	94	151	NA	NA
Marine salt	23	23	23	NA	NA
Salt from brine	207	212	212	NA	NA
Africa:					
Algeria	162	189	[e]182	187	200
Angola[e]	55	55	55	55	55
Benin	(5)	(5)	(5)	(5)	(5)
Egypt	658	832	679	701	720
Ethiopia:[8]					
Rock salt[e]	6	11	17	17	20
Marine salt	[e]85	55	182	110	110
Ghana[e]	55	55	55	55	55
Kenya:					
Crude	44	22	24	27	30
Refined	14	[e]13	[e]13	22	23
Libya[e]	11	17	11	11	11
Madagascar	29	33	[e]33	[e]33	35
Mali[e]	5	5	5	5	5
Mauritania[e]	1	1	1	1	--
Mauritius	7	7	[e]7	7	10
Morocco	14	38	112	74	80
Mozambique[e]	31	31	31	31	30
Namibia (marine salt)[e]	250	250	250	250	250
Niger[e]	1	1	3	3	3
Senegal	154	154	154	154	154
Sierra Leone[e]	200	200	200	200	200
Somalia	[r]2	[r]2	33	33	30
South Africa, Republic of	267	540	594	625	580
Sudan	101	79	90	90	90
Tanzania	31	[r]32	41	44	45
Togo	--	1	1	1	1
Tunisia	446	469	440	481	[3]467
Uganda[e]	1	1	1	1	20
Asia:					
Afghanistan	86	89	22	[e]6	10
Bangladesh[8]	381	866	743	772	770
Burma	254	336	284	296	300
China	18,850	21,528	16,281	19,048	20,200
Cyprus	--	[r]3,659	6	8	8
India:					
Rock salt	4	[r]4	4	6	4
Marine salt	5,873	7,381	7,751	[e]8,000	8,000
Indonesia	867	259	779	761	770
Iran[9]	770	770	770	660	660
Iraq	90	90	100	100	90
Israel	[e]110	134	118	130	130
Japan[10]	1,164	1,183	1,202	1,215	1,100
Jordan	33	33	33	33	30
Kampuchea[e]	33	13	29	33	30
Korea, North[e]	600	600	600	630	630
Korea, Republic of	875	717	551	502	500
Kuwait	18	21	21	22	20
Laos[e]	11	17	20	22	20
Lebanon[e]	39	13	11	[e]13	10
Mongolia[e]	17	17	17	17	20
Pakistan:					
Rock salt[8]	424	455	564	446	550
Other salt	126	250	212	220	220
Philippines	[r]220	249	355	382	390
Sri Lanka	57	165	134	126	120
Syria	117	[e]120	83	99	100
Taiwan	547	375	404	796	400
Thailand:					
Rock salt	14	13	12	18	20
Other salt[e]	180	180	180	180	180
Turkey	857	1,024	1,246	690	770
Vietnam[e]	640	585	580	570	550
Yemen Arab Republic	80	30	100	70	70
Yemen, People's Democratic Republic of[e]	83	83	83	90	80

See footnotes at end of table.

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

(Thousand short tons)

Country[2]	1977	1978	1979	1980[p]	1981[e]
Oceania:					
Australia (marine salt and brine salt)	5,197	6,356	5,701	5,859	5,840
New Zealand	58	72	61	[11]6	NA
Total	[r]173,107	[r]189,105	191,345	185,788	183,106

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available.
[1]Table includes data available through June 8, 1982.
[2]Salt is produced in many other countries, but quantities are relatively insignificant and reliable production data are not available.
[3]Reported figure.
[4]Data represents sales.
[5]Less than 1/2 unit.
[6]Includes production in the Canary Islands (Spanish Provinces of Las Palmes and Santa Cruz de Tenerife) totaling 17,434 short tons in 1977, 15,766 short tons in 1978, 8,685 short tons in 1979, and 24,208 short tons in 1980 (1981, not available).
[7]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.
[8]Year ending June 30 of that stated.
[9]Year beginning Mar. 21 of that stated.
[10]Includes Ryukyu Islands.
[11]Production of 5,500 tons (312,123 New Zealand dollars), as per Department of State Airgram A-46, Dec. 4, 1981.

TECHNOLOGY

Researchers at the Iowa Department of Transportation developed a deicing material that could substitute for rock salt. The method uses sand that is coated with calcium magnesium acetate, obtained by reacting powdered limestone with acetic acid. Although, at the present time, the price of calcium magnesium acetate is high, using the new deicer would reduce the deterioration of steel in highway structures, be environmentally safe, and be formulated to work at temperatures below 20° F.[12]

The Franklin Institute Research Laboratory, Inc., and the Philadelphia Electric Co. began tests on a process that destroys polychlorinated biphenyls (PCB). The process involves mixing modified sodium salts of polyethylene glycol with PCB-contaminated oil. The mixture is then stirred and heated to slightly above 212° F. In the reaction, the sodium strips the chlorine from the PCB to form usable sodium chloride, and the remaining oil can be reused.[13]

The Bureau of Mines is engaged in a research project involving the occurrence and distribution of methane in salt mines in the Louisiana gulf coast salt domes. One objective of the project is to predict regions of high-methane buildup in salt domes by correlating the lithographic-structural relationships of the salt with the gas content.[14]

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Sand and Gravel

By Valentin V. Tepordei[1]

A total of 755 million tons of sand and gravel valued at $2.3 billion, f.o.b. plant, was estimated to have been produced in the United States in 1981. This tonnage is the lowest production reported in the last 20 years, 24% below the record high production of 1978. Of the 1981 total, about 96% was construction sand and gravel and 4% was industrial sand and gravel.

Preliminary production estimates for construction sand and gravel indicate a decrease of 5% in 1981, reflecting the impact of the recession on the construction industry. Production of industrial sand and gravel remained about the same as that of 1980. Exports of sand and gravel in 1981 decreased minimally, and imports decreased 38% to 338,000 tons. Domestic apparent consumption of total sand and gravel (construction and industrial) was 753 million tons.

Table 1.—Salient sand and gravel statistics in the United States[1]

(Thousand short tons and thousand dollars)

	1977	1978	1979	1980	1981
Sold or used:					
Construction:					
Sand:					
Quantity	439,400	489,800	455,000	[r]373,400	NA
Value	$848,200	$989,200	$974,100	[r]$925,400	NA
Gravel:					
Quantity	458,400	473,500	490,500	[r]389,700	NA
Value	$968,700	$1,064,000	$1,170,000	[r]$1,071,000	NA
Total construction:[2]					
Quantity	897,900	963,300	945,500	[r]763,100	[p]724,800
Value	$1,817,000	$2,053,000	$2,144,000	[r]$1,996,000	[p]$1,958,000
Industrial:					
Sand:					
Quantity	29,610	31,810	32,120	[r]28,711	29,250
Value	$201,900	$243,200	$275,200	[r]$286,500	$326,300
Gravel:					
Quantity	1,745	1,041	1,391	865	728
Value	$8,704	$5,554	$8,574	$6,458	$5,997
Total industrial:[2]					
Quantity	31,360	32,850	33,510	[r]29,600	29,980
Value	$210,600	$248,800	$283,800	[r]$293,100	$332,300
Grand total:[2]					
Quantity	929,200	996,200	979,000	[r]792,700	754,800
Value	$2,028,000	$2,302,000	$2,427,000	[r]$2,289,000	$2,290,000
Exports:					
Quantity	3,689	4,260	2,076	2,451	2,397
Value	$21,515	$29,270	$32,440	$40,660	$36,736
Imports:					
Quantity	386	625	423	541	338
Value	$1,278	$2,084	[r]$2,321	$2,718	$2,608

[p]Preliminary. [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.

Legislation and Government Programs.—In August 1981, the Economic Recovery Tax Act became Public Law 97-34. This law provides accelerated cost recovery system incentives for plant, equipment, and real property placed in service after 1980.

Despite the introduction of several bills in both houses of the 97th Congress favoring transfer of regulatory responsibility for mining all surface stone and sand and gravel from the Mine Safety and Health Administration (MSHA) to the Occupational Safety and Health Administration (OSHA), no final decision was made on this matter. A temporary restraint of MSHA's enforcement of safety rules in the surface mining of sand and gravel and stone operations was achieved by Congress by limiting the funding of the Department of Labor through March 1982.

CONSTRUCTION SAND AND GRAVEL

To reduce the Federal Government's paperwork and costs, as well as respondents' reporting burden, in 1981 the Bureau of Mines implemented new canvassing procedures for its surveys of sand and gravel producers. Beginning with the collection of 1981 production data, the annual survey of construction sand and gravel producers will be conducted for even-numbered years only. The preliminary survey, which collects total

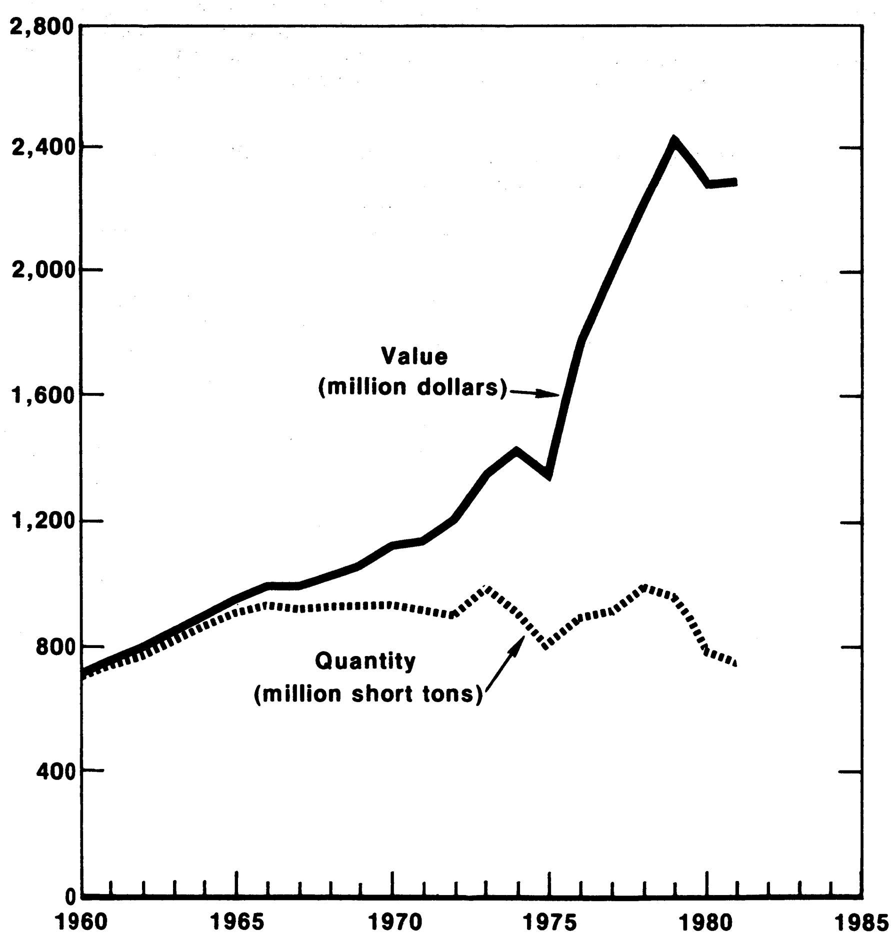

Figure 1.—Production and value of sand and gravel in the United States for 1960-81 (includes preliminary estimates for 1981 construction sand and gravel).

production data for 9 months only, is used to generate annual preliminary estimates and will continue to be conducted every year. The survey of industrial sand and gravel producers, which canvasses a much smaller number of operations, was scheduled to continue to be conducted every year. Therefore, the 1981 chapter contains only preliminary estimates for total construction sand and gravel production for the United States, geographic regions, and States, but complete data on industrial sand and gravel. It is planned to revise and finalize the preliminary estimates of the annual total production of construction sand and gravel for even-numbered years during the following year.

INDUSTRIAL SAND AND GRAVEL

DOMESTIC PRODUCTION

In 1981, the East North Central region led the Nation in the production of industrial sand and gravel with 11.9 million tons or 40% of the U.S. total. The West South Central region was next with 4.7 million tons or 16% of the total, followed by South Atlantic region with 13%. If the four major geographic regions are compared (tables 2 and 6), the North Central led the Nation in the production of industrial sand and gravel with 44% of the total, followed by the South with 33%, and the West in third place with 11%. Approximately 77% of the total U.S. industrial sand and gravel was produced in two regions, North Central and South.

A comparison of 1980 and 1981 production by regions indicates that the output of industrial sand and gravel in the North Central and South increased in 1981 by 4% and 5%, respectively, more than the national average of about 1%; in the Northeast, output decreased 14%.

Based on 1980 census data on population, U.S. per capita industrial sand and gravel production was 0.13 ton. At the regional level, per capita production was 0.22 ton in the North Central, followed by the South with 0.13 ton, the West with 0.08 ton, and Northeast with 0.07 ton.

The five leading States in the production of industrial sand and gravel in 1981, in order of decreasing volume, were Illinois, Michigan, New Jersey, Texas, and California. Their combined production represented 52% of the national total.

Compared with that of 1980, 1981 production of industrial sand and gravel increased significantly in two major producing States, Texas, 9%, and Michigan, 8%; it decreased 17% in New Jersey, and showed small changes in the rest of the top 10 States.

In 1981, a total of 91 producers of industrial sand and gravel with 141 operations was canvassed by the Bureau of Mines; actual reports were received from 121 operations that produced 82% of the total tonnage. The production for the remaining 20 operations was estimated. Some industrial sand and gravel companies also produced construction sand and gravel, but that part of their production was not surveyed this year. Most of the industrial sand and gravel produced in 1981 came from operations with an annual production larger than 300,000 tons; 40 operations representing 28% of the total number of operations produced 71% of the total tonnage. The number of active industrial sand and gravel operations in each geographic region, as well as the number and kind of processing plants, are shown in table 5.

The 10 leading producers of industrial sand and gravel in 1981 were, in descending order of tonnage: Pennsylvania Glass Sand Corp., Martin Marietta Aggregates, Ottawa Silica Co., Hardy Sand Co., Owens-Illinois Inc., Manley Brothers of Indiana, Inc., Oglebay Norton Co., Unimin Corp., Energy and Minerals Inc., and Badger Manufacturing Corp. Their combined production, from 46 operations, represented 61% of the U.S. total.

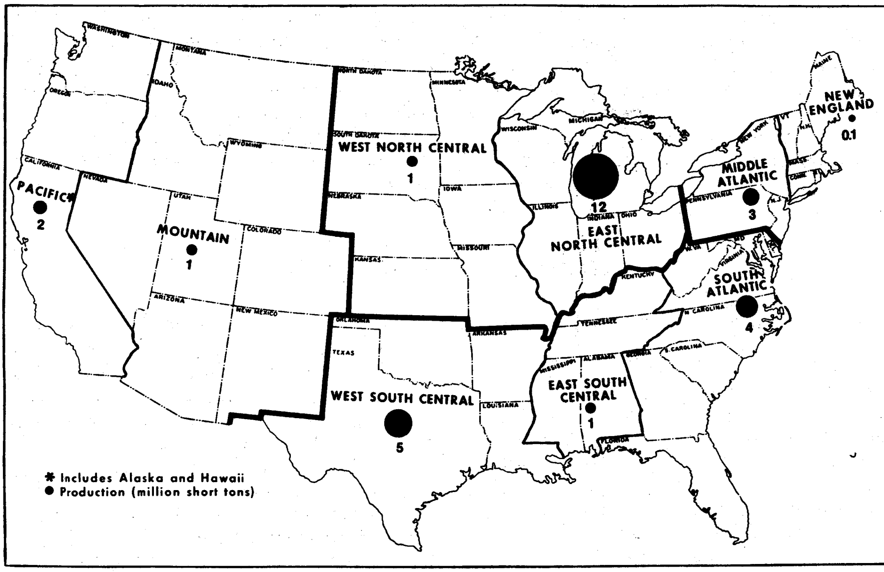

Figure 2.—Production of industrial sand and gravel by geographic region in the United States in 1981.

In 1981, Ottawa Silica Co. purchased two industrial sand operations from Dresser Industries Inc. One located in Dubberly, La., became Louisiana Industrial Sand Co., and the second, a producer of kaolin as well as industrial sand, located at Kosse, Tex., became Texas Industrial Minerals Co.

Martin Marietta Aggregates announced plans to double the capacity of its industrial sand operation at Byron, Calif., to approximately 800,000 tons per year. The operation, located about 50 miles east of San Francisco, produced high-grade silica sand for glass containers, primarily for the local wine industry and also for foundry sand and specialized uses in the construction industry.

Simplot Silica Products announced plans to expand its Overton, Nev., industrial sand operation from 380,000 tons per year to about 1 million tons per year because of increased demand for silica sand in California. Most of the industrial sand produced by this operation has been used by the glass industry for container glass and flat glass, and also by the foundry industry.

J. L. Shiely Co. of St. Paul, Minn., opened a new industrial sand operation at Jordan, Minn., to produce mostly hydraulic fracturing sand. The new operation, known as Minnesota Frac Sand Co., was expected to be onstream at the beginning of 1982.

Unimin Corp. of Stamford, Conn., initiated work at Kasota, Minn., to develop a new industrial sand operation that would produce exclusively hydraulic fracturing sand.

CONSUMPTION AND USES

The sand and gravel production reported by producers to the Bureau of Mines is material that is sold or used by companies. Stockpiled production is not reported until it is sold or consumed. Therefore, the sold or used tonnage represents the amount of production released for domestic consumption or export in a given year.

In 1981, U.S. consumption of industrial sand and gravel was about 30 million tons, valued at $332 million. About 40% of this tonnage was used as glassmaking sand, and 33% as foundry sand. Other important uses were abrasive sand, about 7% of the total, and hydraulic fracturing sand, about 5%. At the regional level, most of the glass sand was consumed in the South (37%) and the North Central (31%), while most of the foundry sand was used in the North Central (70%), and a significantly smaller amount was used in the South (20%). Of the smaller, but no less important end uses, most of the abrasive sand was used in the South (73%) and in the Northeast (15%), and most of the hydraulic fracturing sand was used in the South (55%) and the North Central (38%).

Detailed information on consumption of industrial sand by end uses and major geographic regions is shown in table 6.

Compared with that of 1980, the 1981 consumption of glassmaking sand showed a 6% drop, while foundry sand and hydraulic fracturing sand increased 10% and 20%, respectively.

PRICES

For purposes of this chapter, price means f.o.b. plant value per ton of sand and gravel, which usually is the first point of sale or self-use. This value does not include transportation from the plant, yard, or deposit to the consumer. It does, however, reflect those transportation costs needed to bring mined sand and gravel to the plant.

Based on the 1981 canvass, the average national values for industrial sand and industrial gravel were $11.16 and $8.24 per ton, respectively. Table 6 shows the average values per ton for different end uses in the four major geographic regions. Nationally, industrial sand used as fillers had the highest value per ton at $28.50, followed by ceramics at $26.54 and hydraulic fracturing sand at $23.11.

TRANSPORTATION

Of the total industrial sand and gravel produced in 1981, 57% was transported from the plant or pit to the site of the first point of sale or use by truck, 33% was transported by rail, and 6% by waterway, as shown in table 7. Because most of the producers have not kept records nor reported data regarding the distance to which industrial sand was shipped or the cost per ton-mile of the shipments, no such information has been available.

TECHNOLOGY

The 65th Annual Convention of the National Sand and Gravel Association and the 51st Annual Convention of the National Ready Mixed Concrete Association were jointly held in San Francisco, Calif., in February 1981. Federal and local regulations, including the MSHA-OSHA transfer, energy and land use, industry forecasts, and the environment were the major topics discussed.[2]

The 17th Forum on Geology of Industrial Minerals organized by the New Mexico Bureau of Mines was held in Albuquerque, N. Mex., in May 1981. About 20 papers were presented at the conference, most of them concentrating on the general theme of "Industrial Rocks and Minerals of the Southwest." Field trips to several industrial minerals operations in New Mexico were also organized for the forum's participants.[3]

A conference on "Minerals and Chemicals in Glass and Ceramics—The Next Decade" was held in Corning, N.Y., in October 1981. The major topics discussed at the conference were future prospects for the glass and ceramics industries, the impact of changes in the specifications for raw materials and glass and ceramic products on energy consumption, and the future of research and development in glass and ceramics industries.[4]

Higher oil and natural gas prices in recent years had brought a significant increase in the number of wells drilled, about 75,000 in 1981, and in the amount of hydraulic fracturing sand used in oilfields. New fracturing methods were designed (Massive Hydraulic Fracturing)[5] and new proppants (Super Sand)[6] were produced to meet more and more stringent requirements imposed by the oil industry.[7]

The American Petroleum Institute completed in 1980 a survey of the use of silica flour as a cement additive for deep oil wells. Recent research had shown that silica flour is the best additive for cements that have to be used at high temperatures (230°-400°F), while maintaining high compressive strength and low permeability.[8]

A gradual shift in glass sand specifications to finer products had occurred in the previous decade. The impact of this change on energy consumption and capital investment for new plants was an area of major concern for the industry.[9]

FOREIGN TRADE

Ninety-four percent of the 613,000 tons of construction sand and gravel exported went to Canada, and the remainder was shipped to 62 different countries. Seventy-two percent of the 1.1 million tons of industrial sand exported went to Canada, 20% to Mexico, and the remainder to 76 other countries.

Of the minor quantity of construction sand and gravel imported, 82% came from

Canada, 17% from Antigua, and the remainder from 12 other countries. The sand and gravel imported from Antigua went to the Virgin Islands, not the continental United States.

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Table 2.—Sand and gravel sold or used in the United States, by geographic region

Geographic region	Construction: Quantity (thousand short tons)	Construction: Percent of total	Construction: Value (thousands)	Construction: Percent of total	Industrial: Quantity (thousand short tons)	Industrial: Percent of total	Industrial: Value (thousands)	Industrial: Percent of total	Total[1]: Quantity (thousand short tons)	Total[1]: Percent of total	Total[1]: Value (thousands)	Total[1]: Percent of total
1980												
Northeast:												
New England	38,750	5	$93,540	5	159	1	$2,134	1	38,910	5	$95,670	4
Middle Atlantic	42,300	6	127,700	6	3,868	13	39,900	14	46,170	6	167,600	7
North Central:												
East North Central	138,000	18	339,800	17	r11,400	39	r96,360	33	r149,400	19	r436,100	19
West North Central	77,990	10	170,500	8	1,360	4	13,120	5	79,350	10	183,600	8
South:												
South Atlantic	54,700	7	151,900	8	r4,410	15	r41,350	14	r59,100	7	r193,200	8
East South Central	r38,870	5	r95,750	5	645	2	4,375	1	r39,500	5	r100,100	4
West South Central	r85,610	11	r256,500	13	r4,494	15	r53,260	18	90,110	11	r309,700	14
West:												
Mountain	93,450	12	242,300	12	877	3	12,240	4	94,330	12	254,600	11
Pacific	r193,500	25	r518,100	26	r2,378	8	r30,410	10	r195,800	25	r548,600	24
Total[1]	r763,100	100	r1,996,000	100	r29,600	100	r293,100	100	792,700	100	2,289,000	100
1981												
Northeast:												
New England	p36,200	5	p90,300	5	141	--	2,677	1	36,340	5	92,980	4
Middle Atlantic	p41,300	6	p131,100	7	3,326	11	39,790	12	44,630	6	170,900	7
North Central:												
East North Central	p126,500	17	p321,300	16	11,880	40	114,200	34	138,400	18	435,500	19
West North Central	p73,100	10	p154,600	8	1,346	4	13,870	4	74,450	10	168,500	7
South:												
South Atlantic	p52,900	7	p152,500	8	3,965	13	47,300	14	56,870	8	199,800	9
East South Central	p34,400	5	p86,900	4	1,357	5	6,891	2	35,760	5	93,790	4
West South Central	p83,500	12	p259,800	13	4,678	16	63,570	19	88,180	12	323,400	14
West:												
Mountain	p87,000	12	p228,900	12	830	3	12,380	4	87,830	12	241,300	11
Pacific	p189,900	26	p532,300	27	2,454	8	31,630	10	192,400	25	563,900	25
Total[1]	p724,800	100	p1,958,000	100	29,980	100	332,300	100	754,800	100	2,290,000	100

[p]Preliminary. [r]Revised.

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

Table 3.—Sand and gravel sold or used in the United States, by State

(Thousand short tons and thousand dollars)

State	1980						1981					
	Construction		Industrial		Total[1]		Construction		Industrial		Total[1]	
	Quantity	Value	Quantity	Value	Quantity	Value	pQuantity	pValue	Quantity	Value	Quantity	Value
Alabama	r10,714	r23,683	361	1,821	r11,076	r25,504	10,200	22,200	182	864	10,382	23,064
Alaska	44,911	85,214	--	--	44,911	85,214	46,400	87,500	--	--	46,400	87,500
Arizona	24,229	71,838	170	1,936	24,399	73,773	22,500	67,400	179	2,455	22,679	69,855
Arkansas	r12,518	r30,599	r500	r3,964	r13,017	r34,562	12,100	32,100	642	8,236	12,742	40,336
California	r112,493	r336,045	r2,169	r27,859	r114,663	r363,904	109,900	353,400	2,150	28,269	112,050	381,669
Colorado	27,433	74,452	W	W	W	W	25,700	72,300	W	W	W	W
Connecticut	7,103	18,692	W	W	W	W	6,500	18,100	W	W	W	W
Delaware	1,075	2,398	--	--	1,075	2,398	1,200	2,800	--	--	1,200	2,800
Florida	r14,412	r28,766	W	W	W	W	13,800	28,300	349	4,419	14,149	32,719
Georgia	4,858	11,898	W	W	W	W	4,700	12,000	W	W	W	W
Hawaii	1,035	2,855	--	--	1,035	2,855	1,100	2,900	--	--	1,100	2,900
Idaho	5,299	14,203	W	W	W	W	5,100	13,200	W	W	W	W
Illinois	27,094	78,510	4,631	43,822	31,725	122,332	23,900	69,800	4,646	49,186	28,546	118,986
Indiana	21,772	51,738	259	1,201	22,031	52,939	20,200	48,800	257	1,179	20,457	49,979
Iowa	12,683	32,722	W	W	W	W	12,100	32,000	W	W	W	W
Kansas	12,124	23,817	W	W	W	W	10,600	21,000	W	W	W	W
Kentucky	7,767	17,637	W	W	W	W	7,000	15,300	W	247	W	15,547
Louisiana	18,152	62,568	353	3,845	18,505	66,413	18,000	62,400	293	4,026	18,293	66,426
Maine	6,978	15,434	--	--	6,978	15,434	7,100	14,400	--	--	7,100	14,400
Maryland	10,732	33,625	--	--	10,732	33,625	10,900	35,000	--	--	10,900	35,000
Massachusetts	13,925	34,459	W	W	W	W	13,000	33,600	87	W	13,087	W
Michigan	32,536	73,166	4,062	25,188	36,597	98,354	28,500	66,000	4,393	29,787	32,893	95,787
Minnesota	25,110	49,180	W	W	W	W	23,200	46,800	W	W	W	W
Mississippi	11,710	31,606	W	W	W	W	10,400	28,800	W	W	W	W
Missouri	8,178	19,255	722	7,498	8,900	26,753	8,000	10,100	778	8,602	8,778	18,702
Montana	6,639	16,057	W	W	W	W	6,100	14,900	W	W	W	W
Nebraska	10,514	22,798	24	183	10,538	22,981	10,300	22,700	19	144	10,319	22,844
Nevada	8,439	18,360	W	W	W	W	6,000	12,800	W	W	W	W
New Hampshire	6,334	15,837	--	--	6,334	15,837	5,800	15,900	--	--	5,800	15,900
New Jersey	5,829	18,578	2,766	26,957	8,596	45,535	5,800	19,400	2,305	26,438	8,105	45,838
New Mexico	7,050	17,676	--	--	7,050	17,676	7,300	18,000	--	--	7,300	18,000
New York	21,918	53,276	W	W	W	W	21,200	56,300	55	W	21,255	W
North Carolina	7,837	20,910	1,472	7,825	9,309	28,735	7,700	22,200	1,236	10,440	8,936	32,640
North Dakota	5,173	14,457	--	--	5,173	14,457	4,900	14,100	--	--	4,900	14,100

Ohio	35,462	97,690	1,510	16,601	36,972	114,291	34,600	97,600	1,487	20,893	36,087	118,493
Oklahoma	10,294	23,395	1,587	13,767	11,881	37,162	10,200	23,800	1,500	14,317	11,700	38,117
Oregon	16,005	47,300	--	--	16,005	47,300	14,400	42,400	--	--	14,400	42,400
Pennsylvania	14,554	55,883	1,049	12,374	15,603	68,257	14,300	55,400	W	W	W	W
Rhode Island	2,506	4,945	--	--	2,506	4,945	1,900	4,100	W	W	W	W
South Carolina	4,737	13,227	819	9,628	5,556	22,855	4,500	13,000	803	10,531	5,303	23,531
South Dakota	4,209	8,243	--	--	4,209	8,243	4,000	7,900	--	--	4,000	7,900
Tennessee	8,676	22,824	244	2,106	8,921	24,930	6,800	20,600	1,142	5,610	7,942	26,210
Texas	44,651	139,892	2,054	31,684	46,704	171,576	43,200	141,500	2,242	36,992	45,442	178,492
Utah	8,906	17,234	W	W	W	W	9,100	17,900	22	286	9,122	18,186
Vermont	1,900	4,171	--	--	1,900	4,171	1,900	4,200	--	--	1,900	4,200
Virginia	8,264	29,508	W	W	W	W	7,400	27,700	W	W	W	W
Washington	19,019	46,731	W	W	W	W	18,100	46,100	304	3,358	18,404	49,458
West Virginia	2,728	11,454	W	W	W	W	2,700	11,500	W	W	W	W
Wisconsin	r21,067	r38,025	r947	r9,546	22,014	r47,571	19,300	39,100	1,100	13,180	20,400	52,280
Wyoming	5,454	12,523	W	W	W	W	5,200	12,400	--	--	5,200	12,400
Total[1]	r763,100	r1,996,000	r29,600	r293,100	r792,700	r2,289,000	724,800	1,958,000	29,980	332,300	754,800	2,290,000

pPreliminary. rRevised. W Withheld to avoid disclosing company proprietary data; included in "Total."
[1]Data may not add to totals shown because of independent rounding.

Table 4.—Industrial sand and gravel production in the United States, by size of operation

Sales and use level	1980 Number of operations	1980 Percent of total	1980 Thousand short tons	1980 Percent of total	1981 Number of operations	1981 Percent of total	1981 Thousand short tons	1981 Percent of total
Less than 25,000	34	21.8	415	1.4	25	17.7	289	1.0
25,000 to 49,999	r23	14.7	r870	2.9	17	12.1	604	2.0
50,000 to 99,999	r24	15.4	r1,715	5.8	22	15.6	1,611	5.4
100,000 to 199,999	r23	14.7	r3,204	10.8	28	19.9	4,014	13.4
200,000 to 299,999	16	10.3	3,954	13.4	9	6.4	2,200	7.3
300,000 to 399,999	r13	8.3	r4,469	15.1	17	12.1	5,909	19.7
400,000 to 499,999	r11	7.1	r4,677	15.8	8	5.7	3,611	12.0
500,000 to 599,999	3	1.9	1,631	5.5	4	2.8	2,222	7.4
600,000 to 699,999	3	1.9	1,962	6.6	2	1.4	1,203	4.0
700,000 to 799,999	--	.0	--	.0	3	2.1	2,239	7.5
800,000 to 899,999	1	.6	876	3.0	2	1.4	1,730	5.8
900,000 to 999,999	1	.6	993	3.3	1	0.7	956	3.2
1,000,000 to 1,499,999	3	1.9	3,333	11.3	3	2.1	3,393	11.3
1,500,000 to 1,999,999	r1	.6	r1,500	5.1	--	--	--	--
Total[1]	r156	100.0	r29,600	100.0	141	100	29,980	100

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

Table 5.—Number of industrial sand and gravel active operations and processing plants in the United States, in 1981, by geographic region

Geographic region	Total 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	14	12	9	1	--	--	2	2
North Central:								
East North Central	42	36	31	1	1	1	2	3
West North Central	10	9	6	1	--	--	2	--
South:								
South Atlantic	17	16	13	1	--	--	2	--
East South Central	10	6	2	--	2	1	1	1
West South Central	20	20	14	1	--	--	5	--
West:								
Mountain	11	8	5	2	1	--	--	--
Pacific	13	12	9	2	1	--	--	1
Total	141	122	91	9	5	2	15	7

[1]Based on reports submitted by individual companies.

Table 6.—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	United States: Quantity (thousand short tons)	United States: Value (thousands)	United States: Value per ton
1980															
Sand:															
Glassmaking:															
Containers	2,142	$20,690	$9.66	2,330	$17,590	$7.55	r2,772	r$22,684	$8.18	r1,617	r$19,999	r$12.37	r8,862	r$80,967	r$9.14
Flat (plate and window)	88	968	11.00	492	3,629	7.38	r927	r6,850	7.39	182	2,025	11.13	r1,689	r13,472	r7.98
Specialty	144	1,634	11.35	243	3,194	13.14	r601	r4,581	7.62	146	1,656	11.34	r1,134	r11,065	r9.76
Fiberglass (unground)	73	601	8.23	542	4,129	7.62	7	53	7.57	124	1,392	11.23	747	6,175	8.27
Fiberglass (ground)	83	762	9.18	118	1,987	16.84	268	5,138	19.17	3	51	17.00	473	7,938	16.78
Foundry:															
Molding and core	657	7,860	11.96	r6,449	r45,991	r7.13	r1,167	r8,954	7.67	r215	r2,998	r13.94	r8,488	r65,803	r7.75
Molding and core facing (ground)	67	632	9.43	57	255	4.47	26	229	8.81	4	40	10.00	153	1,156	7.56
Refractory	45	750	16.67	302	2,783	9.22	49	551	11.24	--	--	--	395	4,083	10.34
Metallurgical:															
Silicon carbide	1	15	15.00	144	1,470	10.21	2	19	9.50	9	98	10.89	156	1,603	10.28
Flux for metal smelting	--	--	--	10	29	2.90	--	--	--	r131	r1,065	r8.13	r141	r1,095	r7.77
Abrasives:															
Blasting	142	1,760	12.39	161	2,484	15.43	r1,150	r15,392	13.38	r149	r1,740	r11.68	r1,601	r21,375	r13.35
Scouring cleansers (ground)	(2)	14	--	88	1,663	18.90	75	1,374	18.32	--	--	--	163	3,051	18.72
Sawing and sanding	20	149	7.45	60	379	6.32	82	735	8.96	r2	r32	r16.00	r164	r1,294	r7.89
Chemicals (ground and unground)	73	802	10.99	211	1,802	8.54	132	1,688	12.79	40	447	11.18	456	4,739	10.39
Fillers (ground):															
Rubber, paints, putty, etc	39	1,060	27.18	82	2,693	32.84	r97	r3,107	r32.03	r7	r117	r16.71	r225	r6,977	r31.01
Ceramic (ground):															
Pottery, brick, tile, etc	11	267	24.27	88	2,853	32.42	46	963	20.93	4	53	13.25	148	4,136	27.95
Filtration	71	1,087	15.31	63	720	11.43	89	r828	r9.30	11	154	14.00	r234	r2,788	11.91
Traction (engine)	17	178	10.47	188	1,354	7.20	140	935	6.68	r58	r490	r8.45	r403	r2,958	r7.34
Coal washing	2	18	9.00	10	111	11.10	31	275	8.87	--	--	--	43	404	9.40
Roofing granules and fillers	17	266	15.65	22	201	9.14	r112	r1,564	r13.96	r52	r591	r11.37	r203	r2,623	r12.92
Hydraulic fracturing	1	11	11.00	379	6,968	18.39	688	r14,558	21.16	r109	r2,486	r22.81	r1,177	r24,023	r20.41
Other	333	2,504	7.52	648	6,446	9.95	r371	r3,548	r9.56	r328	r6,460	r19.70	r1,679	r18,958	r11.29
Total[1]	4,027	42,030	10.44	r12.680	r108,700	r8.57	r8,833	r94,030	r10.64	r3,191	r41,890	r13.13	r28,730	r286,700	r9.98

Gravel:															
Metallurgical:															
Silicon, ferrosilicon	--	--	--	75	562	7.49	605	4,465	7.38	--	--	--	680	5,027	7.39
Filtration	--	--	--	8	160	20.00	10	39	3.90	1	9	9.00	19	209	11.00
Other	--	--	--	2	23	11.50	101	452	4.48	63	747	11.86	166	1,222	7.36
Total[1]	--	--	--	85	745	8.76	716	4,957	6.92	64	756	11.81	865	6,458	7.47
Grand total[1]	4,027	42,030	10.44	r12,760	r109,500	r8.57	r9,549	r98,980	r10.37	r3,255	r42,650	r13.10	r29,600	r293,100	r9.90
1981															
Sand:															
Glass making:															
Containers	1,635	19,046	11.65	2,225	17,095	7.68	2,848	27,307	9.59	1,588	20,645	13.00	8,296	84,093	10.14
Flat (plate and window)	W	W	12.03	619	5,058	8.17	854	7,841	9.18	W	W	9.71	1,690	15,188	8.99
Specialty	W	W	12.30	227	2,691	11.85	424	4,346	10.25	W	W	12.74	937	10,628	11.34
Fiberglass (unground)	W	W	10.44	564	4,633	8.21	--	--	--	W	W	11.64	722	6,434	8.91
Fiberglass (ground)	W	W	10.32	79	1,871	23.68	293	6,551	22.36	W	W	21.00	433	9,094	21.00
Foundry:															
Molding and core	733	8,550	11.66	6,597	49,969	7.57	1,886	12,587	6.67	227	3,492	15.38	9,442	74,598	7.90
Molding and core facings (ground)	W	W	16.30	83	1,534	18.48	W	W	10.19	W	W	21.00	120	1,984	16.53
Refractory	72	1,302	18.08	278	2,539	9.13	36	470	13.06	([2])	W	W	386	4,317	11.18
Metallurgical:															
Silicon carbide	W	W	18.25	453	3,104	6.85	W	W	W	W	W	13.50	463	3,259	7.04
Flux for metal smelting	--	--	--	W	W	7.40	--	--	--	W	W	10.52	246	2,556	10.39
Abrasives:															
Blasting	114	1,943	17.04	155	2,939	18.96	1,230	19,199	15.61	106	1,455	13.73	1,605	25,536	15.91
Scouring cleansers (ground)	W	W	W	W	W	20.05	W	W	19.86	--	--	--	173	3,464	20.02
Sawing and sanding	W	W	7.69	W	W	6.84	113	970	8.58	W	W	19.50	180	1,467	8.15
Chemicals (ground and unground)	W	W	11.93	197	2,205	11.19	152	2,113	13.90	W	W	9.75	426	5,178	12.15
Fillers (ground):															
Rubber, paints, putty, etc	W	W	43.41	80	2,957	36.96	78	3,012	38.62	W	W	7.05	284	8,095	28.50
Ceramic (ground):															
Pottery, brick, tile, etc	W	W	26.07	95	2,929	30.83	64	1,369	21.39	W	W	12.60	179	4,751	26.54
Filtration	54	1,067	19.76	83	981	11.82	110	998	9.07	2	42	21.00	249	3,088	12.40

See footnotes at end of table.

Table 6.—Industrial sand and gravel sold or used by U.S. producers, by major use —Continued

Major use	North East			North Central			South			West			United States		
	Quantity (thousand short tons)	Value (thousands)	Value per ton	Quantity (thousand short tons)	Value (thousands)	Value per ton	Quantity (thousand short tons)	Value (thousands)	Value per ton	Quantity (thousand short tons)	Value (thousands)	Value per ton	Quantity (thousand short tons)	Value (thousands)	Value per ton
1981 —Continued															
Sand —Continued															
Traction (engine)	18	$212	$11.78	180	$1,496	$8.31	134	$882	$6.58	65	$661	$10.17	398	$3,252	$8.17
Coal washing	W	W	13.00	W	W	12.80	W	W	9.07	--	--	--	40	395	9.88
Roofing granules and fillers	W	W	17.33	W	W	14.92	114	1,743	15.29	14	146	10.43	162	2,448	15.11
Hydraulic fracturing	W	W	19.00	532	11,669	21.93	775	18,696	24.12	W	W	21.53	1,407	32,513	23.11
Other	369	3,380	9.16	539	11,271	20.91	158	2,762	17.48	347	6,582	18.97	1,413	23,996	16.98
Total[1]	3,467	42,462	12.25	13,163	127,598	9.69	9,400	112,898	12.01	3,222	43,375	13.46	29,252	326,333	11.16
Gravel:															
Metallurgical:															
Silicon, ferrosilicon	--	--	--	W	W	7.91	505	4,402	8.72	W	W	10.23	622	5,467	8.79
Filtration	--	--	--	W	W	3.00	W	W	8.67	W	W	8.50	6	46	7.67
Other	--	--	--	W	W	6.29	W	W	4.78	--	--	--	99	484	4.89
Total	--	--	--	66	498	7.55	600	4,868	8.11	62	631	10.18	728	5,997	8.24
Grand total[1]	3,467	42,462	12.25	13,229	128,096	9.68	10,000	117,766	11.78	3,284	44,006	13.40	29,980	332,300	11.08

[r]Revised. W Withheld to avoid disclosing company proprietary data; included in "Total."
[1]Data may not add to totals shown because of independent rounding.
[2]Less than 1/2 unit.

Table 7.—Transportation of industrial sand and gravel in the United States, in 1981, to site of first sale or use

Method	Thousand short tons	Percent of total
Truck	17,020	57
Rail	10,000	33
Waterway	1,780	6
Not shipped, used at site	1,180	4
Total	29,980	100

Table 8.—U.S. exports of construction sand, gravel, and industrial sand, by country

(Thousand short tons and thousand dollars)

Country	Construction sand		Gravel		Industrial sand	
	Quantity	F.a.s. value[1]	Quantity	F.a.s. value[1]	Quantity	F.a.s. value[1]
1980						
Bahamas	6	46	--	--	31	115
Canada	504	2,535	663	1,284	729	14,896
Costa Rica	--	--	--	--	13	194
Mexico	49	1,056	20	39	341	7,168
Panama	--	--	--	--	9	236
Peru	--	--	--	--	13	1,316
Yugoslavia	--	--	--	--	9	209
Other	28	3,024	4	157	32	8,385
Total	587	6,661	687	1,480	1,177	32,519
1981						
Bahamas	(2)	10	23	104	6	106
Canada	574	2,632	609	1,977	814	14,851
Costa Rica	--	--	(2)	4	10	157
Dominican Republic	(2)	18	--	--	3	135
Ecuador	--	--	--	--	5	70
Germany, Federal Republic of	3	157	--	--	6	1,251
Japan	(2)	95	--	--	14	1,322
Mexico	13	366	11	87	224	3,380
Panama	--	--	--	--	10	293
Peru	(2)	4	--	--	11	1,007
Saudi Arabia	4	392	1	40	2	387
United Kingdom	1	124	--	--	3	559
Venezuela	1	206	(2)	2	4	396
Other	17	2,294	8	240	20	4,070
Total	613	6,298	652	2,454	1,132	27.984

[1]Value of material at U.S. port of export; based on transaction price, including all charges incurred in placing material alongside ship.
[2]Less than 1/2 unit.

Table 9.—U.S. imports for consumption of sand and gravel, by country

(Thousand short tons and thousand dollars)

Country	Construction sand and gravel		Industrial sand	
	Quantity	C.i.f. value[1]	Quantity	C.i.f. value[1]
1980				
Australia	(2)	41	34	903
Canada	502	1,027	(2)	120
Germany, Federal Republic of	(2)	3	(2)	196
Japan	(2)	21	(2)	55
South Africa, Republic of	--	--	(2)	16
Other	--	51	5	285
Total	502	1,143	39	1,575
1981				
Antiqua	56	812	3	36
Canada	275	1,112	1	57
France	--	--	(2)	155
Germany, Federal Republic of	--	--	(2)	279
Other	(2)	63	(2)	94
Total[3]	333	1,987	5	621

[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]

Although overall production of silicon materials in 1981 changed only slightly from that of 1980, production of 56% to 95% ferrosilicon decreased 23%. Demand for miscellaneous silicon alloys, silvery pig iron, and silicon carbide was 15% to 20% lower when compared with that of the previous year. Imports of ferrosilicon materials were more than double those of 1980, with the 75% grade of ferrosilicon making up about 75% of the total. Domestic producers posted price increases in January and October. However, the price increases were mostly ineffective owing to poor market conditions and to the availability of large amounts of cheap, imported material, mainly 75% ferrosilicon.

DOMESTIC PRODUCTION

Production and shipments of silicon metal were least affected by the depressed economy, remaining essentially unchanged from 1980, while those of 50% ferrosilicon and miscellaneous silicon alloys changed by small amounts. The most pronounced decline occurred for 75% ferrosilicon (56% to 95% range) with shipments declining by 20% and production by 23%. Production decreased slightly overall for silicon materials, exclusive of silicon metal, and shipments were off 7%. Magnesium ferrosilicon constituted about four-fifths of production classified as miscellaneous alloys, the remainder in this class being calcium-silicon, silicon-manganese-zirconium, and proprietary inoculants. Producer inventories increased by about 56% for 50% ferrosilicon and silicon metal.

Union Carbide Corp. completed its sale of five ferroalloy plants in the United States and Norway to groups headed by Elkem AS of Norway. The U.S. facilities will be operated by Elkem Metals Co., Pittsburgh, Pa. The U.S. plants produce ferrosilicon, silicon metal, electrolytic manganese metal, calcium carbide, foundry inoculants, and specialty chromium products, and are located in Alloy, W. Va., and in Ashtabula and Marietta, Ohio. Union Carbide retained and is expanding its silane and silicones production facilities. In July, Ohio Ferro-Alloys Corp., Canton, Ohio, signed a letter of agreement to sell its facilities to the Fesil Group, Oslo, Norway. The plants, located in Philo and Powhatan Point, Ohio, and Montgomery, Ala., all produced silicon alloys. However, the Fesil Group subsequently withdrew its offer to buy the plants, apparently because of unfavorable economics.

SKW Alloys, Inc., temporarily ceased production of 75% ferrosilicon at its Calvert City, Ky., facility in October. In December, Foote Mineral Co. reduced production of silvery pig iron at its Keokuk, Iowa, plant and ferrosilicon at its Graham, W. Va., plant to 50% and 25% of capacity, respectively. The actions were reported to be a consequence of the depressed economy.

Domestic ferrosilicon production is directly related to demand for the material by the iron and steel industries. The high level of imported 75% ferrosilicon, priced considerably below domestic material, further eroded the domestic producers' position in the marketplace. The combined effect of weak demand by consumers and increasing imports has had a major impact on the domestic ferrosilicon industry.

Table 1.—Production, shipments, and stocks of silvery pig iron, ferrosilicon, and silicon metal in 1981

(Short tons, gross weight, unless otherwise specified)

Alloy	Silicon content (percent)		Producers' stocks as of Dec. 31, 1980	Production	Shipments	Producers' stocks as of Dec. 31, 1981
	Range	Typical				
Silvery pig iron	5-24	18	W	W	W	W
Ferrosilicon (includes briquets)	25-55	48	70,345	467,518	362,975	110,331
Do	56-95	76	24,152	92,693	87,367	23,115
Silicon metal (excluding semiconductor grades)	96-99	98	11,081	131,178	123,573	17,312
Miscellaneous silicon alloys (excluding silicomanganese)	32-65	--	15,217	70,849	65,358	13,614

W Withheld to avoid disclosing company proprietary data.

Table 2.—Producers of silicon alloys and/or silicon metal in the United States in 1981

Producer	Plant location	Product
Alabama Alloy Co., Inc	Bessemer, Ala	FeSi.
Aluminum Co. of America, Northwest Alloys, Inc	Addy, Wash	FeSi and Si.
Chromasco, Ltd., Chromium Mining & Smelting Corp. Div	Woodstock, Tenn	FeSi.
Dow Corning Corp	Springfield, Oreg	Si.
Elkem Metals Co	Alloy, W. Va	FeSi and Si.
Do	Ashtabula, Ohio	FeSi.
Foote Mineral Co., Ferroalloys Div	Graham, W.Va	Do.
Do	Keokuk, Iowa	Silvery pig iron.
Hanna Mining Co.:		
Hanna Nickel Smelting Co	Riddle, Oreg	FeSi.
Silicon Div	Wenatchee, Wash	FeSi and Si.
Interlake, Inc., Globe Metallurgical Div	Beverly, Ohio	Do.
Do	Selma, Ala	Si.
International Minerals & Chemical Corp., Industry Group, TAC Alloys Div.	Bridgeport, Ala	FeSi.
Do	Kimball, Tenn	Do.
Ohio Ferro-Alloys Corp	Montgomery, Ala	FeSi and Si.
Do	Philo, Ohio	FeSi.
Do	Powhatan Point, Ohio	Si.
Reynolds Metals Co	Sheffield, Ala	Do.
Satralloy, Inc	Steubenville, Ohio	FeSi.
SKW Alloys, Inc	Calvert City, Ky	Do.
Do	Niagara Falls, N.Y	Do.
South African Manganese Amcor, Ltd., Roane Ltd	Rockwood, Tenn	Do.
Union Carbide Corp., Metals Div.[1]	Alloy, W. Va	FeSi and Si.
Do.[1]	Ashtabula, Ohio	FeSi.
Do	Portland, Oreg	Do.

[1]Sold in July to a group led by Elkem AS of Norway.

CONSUMPTION AND USES

Reported consumption of silicon materials changed only slightly compared with that of 1980, about a 2% decline. The more significant decreases, amounting to 15% to 20%, occurred for silvery pig iron, miscellaneous silicon alloys, and silicon carbide. The greatest demand in 1981 was for the 50% and 75% ferrosilicon grades and silicon metal, followed by, on the basis of silicon content, silicon carbide, miscellaneous silicon alloys, and silvery pig iron. The end uses for silicon materials were, in decreasing order, steel, cast irons, nonferrous alloys, and silicones and silanes, with about 80% of consumption being accounted for by ferrous applications. Cast iron production consumed the largest amounts of silvery pig iron and miscellaneous silicon alloys, while steelmaking was the biggest user of 75% ferrosilicon. Iron foundries and steel plants together accounted for 93% of 50% ferrosilicon usage; 90% of silicon metal went into nonferrous alloys and silicones.

Consumption of silicon alloys is dependent mainly on iron foundries and the steel industry, both of which have been in a depressed state for about 2 years. The aluminum industry, which uses silicon metal to make castings, was confronted with an excess of supply over demand and cut back production. The reduction was in large part caused by the depressed housing and transportation market.

Consumption of silicon metal for silicones increased by 12% compared with that of 1980. All three major producers were already expanding production facilities or planning to do so. Dow Corning Corp. is more than doubling capacity for silicones at its Carrollton, Ky., facility. The $310 million expansion by the General Electric Co. of its Waterford, N.Y., silicones plant is expected to be completed in 1984. Union Carbide has started construction of a new silicones plant at South Charleston, W. Va., which is expected to begin operation in mid-1983.

Silicon metal produced by tonnage methods is used as a raw material for the manufacture of the relatively small quantity of hyperpure polycrystalline silicon for electronics and other highly specialized applications. Domestic polysilicon production was estimated at 1,500 tons. Hemlock Semiconductor Corp., a subsidiary of Dow Corning, plans to expand its polysilicon capacity by an additional 880 tons per year. The new 770-ton-per-year, semiconductor-grade silicon plant of Monsanto Co. at Spartanburg, S.C., is scheduled to begin production by 1983. Union Carbide has announced plans for a 1,100-ton-per-year polycrystalline silicon plant in Washington State. The plant will use technology developed by Komatsu Electronic Metals Ltd. of Japan to produce high-purity silicon metal from trichlorosilane. Production is slated to begin in 1984.

Table 3.—Consumption, by major end use, and stocks of silicon alloys and metal in the United States in 1981

(Short tons, gross weight, unless otherwise specified)

End use	Silvery pig iron	Ferrosilicon[1]				Silicon metal	Miscellaneous silicon alloys[2]	Silicon carbide[3]
Silicon content (percent):								
Range	5-24	25-55	56-70	71-80	81-95	96-99		63-70
Typical	18	48	65	76	85	98	50	64
Steel:								
Carbon	(4)	85,528	(4)	27,745	(4)	(4)	1,884	173
Stainless and heat-resisting	--	26,727	(4)	19,632	47	281	160	--
Full alloy	(4)	40,252	--	14,449	(4)	1,635	1,302	(4)
High-strength low-alloy	(4)	7,600	--	1,874	--	--	(4)	(4)
Electric	--	(4)	(4)	(4)	--	--	--	--
Tool	--	1,341	--	1,032	--	(4)	(4)	--
Unspecified	884	13,815	5,525	24,328	714	92	942	148
Total	884	175,263	5,525	89,060	761	2,008	4,288	321
Cast irons	39,352	125,895	3,476	27,860	545	66	27,925	25,648
Superalloys	5	141	--	38	32	40	--	--
Alloys (excluding alloy steels and superalloys)	181	6,421	--	105	24	59,248	45	4
Silicones and silanes	--	--	--	--	--	52,047	--	--
Miscellaneous and unspecified	--	15,891	--	89	--	[5]9,708	244	--
Total	40,422	323,611	9,001	117,152	1,362	123,117	32,502	25,973
Percent of 1980	85	99	113	110	103	100	86	80
Total silicon content[6]	7,276	155,333	5,850	89,036	1,158	120,654	16,251	16,623
Consumers' stocks, Dec. 31, 1981	1,740	24,586	289	10,865	180	5,233	2,434	1,365

[1]Includes briquets.
[2]Primarily magnesium-ferrosilicon but also includes other silicon alloys. Average silicon content estimated as 50%, based on 1981 production survey.
[3]Does not include silicon carbide for abrasive or refractory uses.
[4]Included with "Steel: Unspecified."
[5]Includes an estimated 9,400 tons consumed for unspecified chemicals.
[6]Estimated based on typical percent content.

PRICES

Despite weak demand by the steel and foundry industries and heavy imports, particularly of low-priced 75% ferrosilicon, domestic producers of silicon metal and alloys posted price increases in January and again in October. These increases were attributed to surging power and operating costs. However, market conditions led to domestic producer discounting.

The price of domestic lump silicon metal with 1% maximum iron and 0.07% maximum calcium increased at the beginning of 1981 from 59.5 to 64 cents per pound of contained silicon and remained at that level until October 1 when the price rose to 67.5 cents per pound of contained silicon. No further changes occurred through the remainder of the year. In May, the price of imported silicon metal increased from 58-59 cents to 62-63 cents per pound.

The price of domestic regular 75% ferrosilicon increased from 46.25 cents per pound of contained silicon to 49.5 cents per pound in January and to 53.25 cents per pound on October 1, remaining at that level the rest of the year. The f.o.b. warehouse price of imported 75% ferrosilicon, as quoted in Metals Week, began the year in the range of 37.5 to 39 cents per pound and ended the year in the range of 39 to 41 cents per pound. However, prices of this material fluctuated frequently during 1981, and the year-average price was 40.09 cents per pound. The price of regular 50% ferrosilicon also increased in January from 42 to 45 cents per pound of contained silicon and on October 1 rose to 49.25 cents per pound. Regular 5% magnesium with no cerium increased from 46.5 to 50 cents per pound of material, effective January 2, while the 9% grade went from 62 to 67 cents per pound of material. Prices of both the 5% and 9% grades rose again on October 1 to 53 cents and 72 cents per pound of material, respectively.

FOREIGN TRADE

Exports of ferrosilicon declined to their lowest level in terms of quantity and value in the last 3 years. The largest quantities were exported to Canada and Australia, 8,948 and 4,165 tons, respectively, which accounted for about 80% of both total quantity and value. Exports went to 33 countries. Silicon metal exports declined by 40% compared with that of 1980 to a total of 8,673 tons, but were still much above those of 1978 and 1979. Most of the metal was exported to Japan and Mexico, 6,979 and 1,040 tons, respectively, making up about 92% in terms of total quantity and about 47% of total value. Exports went to 22 countries.

Compared with that of 1980, imports increased 119% in volume and 89% in value for ferrosilicon overall and 36% in volume and 9% in value for silicon metal. Imports of 75% ferrosilicon were the most significant on a volume basis, nearly equaling the reported consumption.

The 75% grade (60% to 80% silicon) ferrosilicon accounted for three-fourths of ferrosilicon imports. Brazil shipped more than one-third of the total in this range while Venezuela and Norway, each with about one-fifth of the total, were the next largest sources. Imports in this class increased dramatically, about three times, compared with those of 1980. The next largest import class was calcium-silicon (60% to 80%), which comprised slightly more than one-tenth of ferrosilicon imports. The two main sources of this material were France and Norway, which accounted for 65% of the total. Average silicon content of all imported ferrosilicon in 1981 rose to 71% from 66% in 1980. Imports of silicon metal in the 96% to 99% range changed little from that of 1980. Canada and Yugoslavia were the dominant sources with 8,303 and 3,903 tons, respectively. However, imports of silicon metal in the 99% to 99.7% range increased by 105%, with Canada, the Republic of South Africa, and Portugal the principal shippers.

The marked increase in imports and the moderate decline in exports left the United States as a net importer of ferrosilicon. Net imports amounted to slightly more than 140,000 tons and a trade deficit of about $68 million. As a consequence of the increasing flow of ferrosilicon and other ferroalloy imports, the domestic ferroalloy industry, as represented by The Ferroalloys Association, petitioned the Department of Commerce for import relief under the National Security Clause (sec. 232) of the Trade

Expansion Act of 1962. The Office of Industrial Mobilization, Department of Commerce, subsequently initiated an investigation to determine whether burgeoning quantities of ferroalloy imports are a threat to the national security. Domestic producers based their complaint on unfair trade practices that placed foreign producers at an advantage in the U.S. market.

Table 4.—U.S. exports of ferrosilicon and silicon metal

Year	Quantity (short tons)	Value (thousands)
FERROSILICON		
1978	11,900	$7,871
1979	22,357	14,740
1980	27,488	18,572
1981	15,768	12,136
SILICON METAL		
1978	2,404	21,974
1979	4,987	45,752
1980	14,372	65,478
1981	8,673	57,001

Table 5.—U.S. imports for consumption of ferrosilicon and silicon metal, by grade and country

Grade and country	1980			1981		
	Quantity (short tons)		Value (thousands)	Quantity (short tons)		Value (thousands)
	Gross weight	Silicon content		Gross weight	Silicon content	
Ferrosilicon:						
Over 8% but not over 30% silicon:						
Canada	1,106	170	$85	2,783	393	$177
Germany, Federal Republic of	82	14	42	(1)	(1)	(1)
Total	1,188	184	127	2,783	393	177
Over 30% but not over 60% silicon, with over 2% magnesium:						
Brazil	2,733	1,308	1,992	2,244	1,042	1,849
Canada	527	289	1,054	1,287	580	1,079
France	1,316	651	1,287	326	162	333
Germany, Federal Republic of	393	203	530	2	1	2
Italy	307	140	204	192	88	166
Japan	--	--	--	1	(1)	1
Mexico	--	--	--	33	16	17
Norway	246	114	226	275	122	223
Total[2]	5,523	2,706	5,293	4,360	2,011	3,671
Over 30% but not over 60% silicon, not elsewhere classified:						
Brazil	154	91	180	311	167	285
Canada	6,099	2,996	1,610	7,128	3,360	2,221
France	2,569	1,485	3,187	3,772	2,184	5,279
Germany, Federal Republic of	586	328	758	826	452	1,181
Italy	37	19	34	--	--	--
Norway	1,765	1,004	582	2,205	1,288	556
South Africa, Republic of	2,898	1,047	1,272	--	--	--
Total[2]	14,107	6,971	7,621	14,242	7,451	9,522
Over 60% but not over 80% silicon, with over 3% calcium:						
Brazil	2,702	2,013	1,741	1,487	932	1,929
Canada	1,133	880	678	1,483	1,076	973
France	2,272	1,475	2,128	6,234	4,504	4,663
Germany, Federal Republic of	438	267	579	911	571	1,502
Italy	121	77	139	206	131	248
Norway	--	--	--	4,277	2,825	1,322
South Africa, Republic of	1,706	1,308	953	--	--	--
Spain	--	--	--	76	47	90
Yugoslavia	--	--	--	1,543	1,003	616
Total[2]	8,373	6,020	6,217	16,217	11,089	11,343

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	1980 Quantity (short tons) Gross weight	1980 Quantity (short tons) Silicon content	1980 Value (thousands)	1981 Quantity (short tons) Gross weight	1981 Quantity (short tons) Silicon content	1981 Value (thousands)
Ferrosilicon —Continued						
Over 60% but not over 80% silicon, not elsewhere classified:						
Argentina	--	--	--	679	511	$324
Brazil	9,233	6,962	$4,779	41,018	31,138	19,679
Canada	7,513	5,532	4,326	7,885	5,848	4,509
Chile	1,547	1,171	645	920	691	506
China	--	--	--	1	1	1
France	1,572	1,115	1,239	1,728	1,322	1,118
Germany, Federal Republic of	447	315	1,040	383	289	1,034
Iceland	4,163	3,161	2,228	12,176	9,153	6,309
Norway	10,417	7,603	4,916	23,736	17,754	10,411
South Africa, Republic of	661	502	372	1,869	1,452	969
Venezuela	6,176	4,632	3,726	23,783	17,852	8,719
Yugoslavia	--	--	--	2,599	1,953	1,340
Total[2]	41,729	30,993	23,271	116,778	87,963	54,918
Over 80% but not over 90% silicon:						
Argentina	--	--	--	1,100	936	534
Canada	42	35	34	53	44	34
Chile	55	45	21	--	--	--
Total	97	80	55	1,153	980	568
Over 90% but not over 96% silicon:						
Belgium-Luxembourg	--	--	--	39	38	36
Canada	16	14	5	--	--	--
Chile	119	110	51	--	--	--
France	--	--	--	37	35	48
Germany, Federal Republic of	--	--	--	39	38	34
Total	135	124	56	115	111	118
Grand total	71,152	47,078	42,640	155,648	109,998	80,317
Silicon metal:						
Over 96% but not over 99% silicon:						
Argentina	--	NA	--	741	NA	687
Australia	1	NA	(1)	--	NA	--
Belgium-Luxembourg	5	NA	39	168	NA	567
Brazil	--	NA	--	331	NA	352
Canada	7,927	NA	8,147	8,303	NA	8,953
France	68	NA	64	226	NA	244
Germany, Federal Republic of	57	NA	46	(1)	NA	2
Japan	(1)	NA	10	4	NA	83
Norway	888	NA	790	1,606	NA	1,503
South Africa, Republic of	4,661	NA	4,511	1,419	NA	1,504
Sweden	--	NA	--	1,074	NA	1,121
United Kingdom	(1)	NA	8	--	NA	--
Yugoslavia	2,281	NA	2,002	3,903	NA	3,470
Total[2]	15,887	NA	15,617	17,776	NA	18,485
Over 99% but not over 99.7% silicon:						
Argentina	--	--	--	385	382	361
Brazil	(1)	(1)	1	1	1	1
Canada	3,888	3,852	4,257	4,856	4,812	5,674
China	--	--	--	116	115	118
France	--	--	--	269	267	270
Germany, Federal Republic of	--	--	--	(1)	(1)	1
India	--	--	--	(1)	(1)	(1)
Japan	--	--	--	2	2	9
Norway	827	820	830	28	28	65
Portugal	--	--	--	2,205	2,185	2,160
South Africa, Republic of	543	538	574	3,109	3,080	3,461
Switzerland	--	--	--	55	55	68
United Kingdom	(1)	(1)	1	(1)	(1)	(1)
Yugoslavia	112	111	97	--	--	--
Total[2]	5,370	5,322	5,760	11,026	10,926	12,188

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	1980 Quantity (short tons) Gross weight	1980 Quantity (short tons) Silicon content	1980 Value (thousands)	1981 Quantity (short tons) Gross weight	1981 Quantity (short tons) Silicon content	1981 Value (thousands)
Silicon metal —Continued						
Over 99.7% silicon:						
Belgium-Luxembourg	11	NA	$88	(1)	NA	$2
Canada	(1)		2	48		52
China	(1)		1	9		316
Denmark	9		2,157	15		854
France	19		235	1		366
German Democratic Republic	--		--	(1)		11
Germany, Federal Republic of	429		21,538	418		19,704
India	--		--	(1)		1
Italy	104		5,737	89		4,073
Japan	4		459	39		1,307
South Africa, Republic of	--		--	94		100
Sweden	1		5	8		77
Switzerland	5		1,477	1		396
Taiwan	1		40	--		--
United Kingdom	(1)		1	(1)		5
Yugoslavia	--		--	110		97
Total[2]	582	NA	31,740	834	NA	27,361
Grand total	21,839	XX	53,117	29,636	XX	58,034

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

WORLD REVIEW

Australia.—Agnew Clough, Ltd., announced plans to build a $56.5 million silicon metal smelter at Wundowie, Western Australia. The plant will have two electric furnaces capable of producing a total of 29,700 short tons of metal per year. Production will be primarily for domestic demand with a small quantity reserved for export.[2] A $100 million silicon wafer plant is to be set up by the National Semiconductor Corp. in Canberra. The wafer plant is scheduled for completion in late 1982.[3]

Brazil.—Ferrosilicon accounted for most of the recent growth of the Brazilian ferroalloy industry. Ferrosilicon producers have increased their installed capacity to 146.2 megavolt-amperes (14 furnaces), doubling the capacity for 75% ferrosilicon. However, large quantities of the material are being exported owing to the depressed local market.[4] Brazil exported approximately 41,000 short tons of 75% ferrosilicon to the United States and about 16,900 short tons to Japan.[5]

Canada.—Cominco Ltd., Mitsui & Co., and other Japanese ferrosilicon producers are expected to announce construction of a 55,000-short-ton-per-year ferrosilicon plant in Kimberly, British Columbia. Production is scheduled for 1984.[6] Also, SKW Canada, Inc., and Sumitomo Corp. of Japan are conducting a joint study on the feasibility of producing ferrosilicon in British Columbia. Both a 27,500- and a 55,000-short-ton-per-year operation is being considered. Plant output would go mainly to the Japanese iron and steel industry.[7]

China.—China became a major exporter of ferrosilicon and silicon metal in 1981, mainly to Japan. Western European exporters were at a disadvantage since they could not compete with China in the Far East on a freight cost basis.[8] China supplied Japan with approximately 55,000 short tons of ferrosilicon and about 10,700 short tons of silicon metal in calendar year 1981[9] compared with about 680 short tons of ferrosilicon and about 220 short tons of silicon metal in calendar year 1980.[10]

Indonesia.—PT Aneka Tambang, a state-owned mining company, and Pacific Metals Co. of Japan reached an agreement to jointly build a 16,500- to 22,000-short-ton-per-year ferrosilicon plant in Celebes (Sulawesi) by 1985. Power will be available from a currently planned hydroelectric power station. Indonesian electricity rates are now about one-third those of Japan.[11]

Italy.—The Materiali Iperpuriper Elettronica S.p.A. unit of Dynamit Nobel A.G. has begun a program to expand its polysilicon capacity. Polysilicon capacity at its Merano plant will be expanded to 385 short tons by the end of 1982 from a current 308 short tons annually. A new facility to increase wafer slicing, lapping, etching, and polishing capacity next to the company headquarters in Navara is scheduled for completion in November.[12] The new Union Carbide silicones plant at Termoli is scheduled to come onstream in 1982.

Japan.—Spiraling power costs hurt domestic ferrosilicon producers, resulting in more unplanned closures in 1981. Unable to remain competitive in the face of surging, cheap imports, Kureha Seitetsu Co. Ltd. scheduled its 29,700-short-ton-per-year plant in Toyomo for shutdown in late summer. Fukuden Kogyo closed its 1,900-short-ton-per-month plant in June. Japanese production of silicon metal in 1981 was about 13,100 short tons, a 24% decrease from about 17,320 short tons in 1980.[13] However, production of polycrystalline silicon for the Japanese semiconductor industry increased to approximately 653 short tons, up 26% from about 517 short tons in 1980.[14] In 1981, ferrosilicon and silicon metal imports from China expanded rapidly and were enough to make that country the leading supplier to Japan with about 26% and 18% of the respective totals imported.[15]

Norway.—The new Orkla Industrier 42,000-ton-per-year ferrosilicon furnace at Thamshavn was started up in April as planned, expanding plant capacity to 66,000 short tons. Elkem AS cut back production at its 22,000-short-ton-per-year silicon and ferrosilicon plant in Meraker because of high inventories. Fesil-Nord was reportedly ready to close permanently owing to poor economic conditions. The ferroalloy industry has asked the Government for help in the form of a lower electricity tax and delay of pollution abatement requirements.[16]

United Kingdom.—Dow Corning is expanding its silicones plant at Barry, South Wales. The first phase of the $230 million expansion is expected to be onstream in 1983.[17]

Yugoslavia.—Dalmacija Metallurgical Industry of Dugi Rat announced plans to build an additional 16,500-short-ton-per-year ferrosilicon plant at its ferroalloy complex near Split in Croatia. The new furnace and related technology will be supplied by Elkem AS of Norway. The plant will use quartz from deposits near Sinj on the Adriatic Sea. The plant is due onstream in 1983.[18]

TECHNOLOGY

Photovoltaics (solar cells) as a commercial source of electricity have been severely limited by the high cost associated with production of high-purity, single-crystal silicon, the material from which solar cells are made. Much effort is being expended by manufacturers to overcome this obstacle. Laboratory researchers at Mobil Tyco Solar Energy Corp., Waltham, Mass., have developed a new technique in which a thin-wall, nonagonal tube of single-crystal silicon is pulled from molten silicon in a nine-sided die. Since the nine-faced tube has no outer edges, the problem of thermally induced discontinuities in width along edges of single ribbons is avoided. A laser is used to cut the tube into flat rectangles for use in solar cells.[19]

Stanford University scientists announced development of an electrolytic process for producing high-purity silicon from diatomaceous earth. The technique uses a controlled-atmosphere furnace for electrodeposition of silicon at about 1,450° C, a temperature above the melting point of silicon. Two electrodes are placed in a molten solution of silica containing barium carbonate and barium fluoride additives. Silicon is deposited at the cathode. Further purification may be required before the silicon can be used in solar cells. The main advantage over conventional processes is reported to be lower power costs.[20]

Exxon Enterprises, a division of Exxon Corp., and Elkem AS of Norway have initiated a $7 million research and development program to provide low-cost polycrystalline silicon metal (polysilicon) for solar photovoltaic cells. The Exxon-Elkem project will focus on development of a production process that avoids the costly trichlorosilane purification step used in manufacturing semiconductor-grade polysilicon. Elkem is one of the world's leading producers of ferroalloys. Exxon Enterprises has an affiliate, Solar Power Corp., that manufactures solar electric systems.[21]

Phillips Petroleum Co., Bartlesville, Okla., announced an agreement with Aerochem Laboratory Inc., Princeton, N.J., to develop Aerochem's new processes for making high-purity silicon, suitable for solar cells and semiconductors at lower costs than existing processes. The process involves the spontaneous reaction of an alkali metal and a halide in which heat, a fine spray of silicon, and a molten salt are produced.[22]

Japan Metals and Chemical Co. constructed a new closed lid furnace for ferrosilicon production at Wakagawa, Honshu Island. Use of a closed lid raises furnace temperature from 350° C-400° C to 750° C-1,000° C. As a result, electrical requirements are reduced from an average of 9.5 megawatt-hours per ton of product to 8.6 megawatt-hours per ton, while product yield improves by nearly 10%. Structural damage by the higher temperature operation is prevented by (1) use of alumina-based insulation and (2) a cooling-water jacket on the lid and other furnace parts.[23]

The Superior Graphite Co., Chicago, Ill., began testing a new process for continuous production of granular silicon carbide for metallurgical purposes. A proprietary furnace originally designed for continuous desulfurization of coke is used. Raw materials are coke and sand. The silicon carbide product is a free-flowing granular material with uniform composition. Reaction time in the furnace is much less than that required for a conventional system, with a proportional decrease in energy requirements.[24]

Research chemists at the University of Wisconsin and the University of Utah reported that they made tetramesityldisilene by photolysis (at -100° C) of 2, 2-bis(mesityl) hexamethyltrisilane, the first known stable solid compound containing a silicon-silicon double bond. In the absence of air, the bright orange-yellow crystalline solid is stable up to its melting point of 176° C. The discovery is expected to lead to a whole new field of silicon chemistry.[25]

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Silver

By Harold J. Drake[1]

U.S. mine production of silver increased and U. S. consumption decreased in 1981. The increased production was attributed to the cessation of strikes at production facilities and production from new operations. The decrease in consumption was due to the depressed economy. The United States was a net importer of silver in 1981, as imports exceeded exports by 66 million ounces.[2]

The annual average price of silver was sharply lower than the comparable price for 1980, which reflected the lack of speculative interest in silver and an increase in available supplies.

Increased consumption was reported for photography and catalysts. Official U.S. coinage use, although minor, was well above that of 1980. Uses showing decreased consumption included sterlingware, contacts and conductors, batteries, bearings, coins, medallions, commemorative objects, and others.

Refinery output rose moderately in 1981 as production from ores and concentrates increased, whereas production from old scrap fell mainly as a result of lower bullion prices which led to sharply decreased recovery from demonetized coin and a more moderate decrease in recovery from high-silver-content scrap.

Table 1.—Salient silver statistics

	1977	1978	1979	1980	1981
United States:					
Mine production ---------- thousand troy ounces--	38,166	39,385	r37,896	r32,329	40,685
Value ---------- thousands--	$176,325	$212,681	r$420,261	r667,278	$427,943
Ore (dry and siliceous) produced:					
Gold ore ---------- thousand short tons--	3,478	3,499	4,202	5,511	6,480
Gold-silver ore ---------- do----	481	738	756	872	1,006
Silver ore ---------- do----	976	1,102	1,066	r2,064	4,565
Percentage derived from:					
Dry and siliceous ores ----------	43	55	51	51	54
Base metal ores ----------	57	45	49	49	46
Refinery production[1] ---------- thousand troy ounces--	36,729	44,018	38,982	36,171	44,487
Exports[2] ---------- do----	22,394	22,400	35,563	80,851	27,903
Imports for consumption[2] ---------- do----	79,147	75,641	92,381	78,795	94,115
Stocks, Dec. 31:					
Treasury[3] ---------- million troy ounces--	39	39	39	39	39
Industry[4] ---------- thousand troy ounces--	165,343	146,902	149,131	138,053	117,456
Consumption:					
Industry and the arts ---------- do----	153,613	160,165	157,258	124,694	116,621
Coinage ---------- do----	91	45	168	72	179
Price[5] ---------- per troy ounce--	$4.62	$5.40	r$11.09	$20.63	$10.52
World:					
Production ---------- thousand troy ounces--	r331,270	r345,428	r344,630	p339,800	e364,912
Consumption:[6]					
Industry and the arts ---------- do----	433,600	442,600	419,800	349,400	363,300
Coinage ---------- do----	23,400	36,300	27,800	13,700	6,000

eEstimated. pPreliminary. rRevised.
1From domestic ores.
2Excludes coinage.
3Excludes silver in silver dollars.
4Includes silver in COMEX warehouses and silver registered in Chicago Board of Trade.
5Average New York price. Source: Handy & Harman.
6Market economies only. Source: Handy & Harman.

A major silver and base metal producer in Idaho announced the closing of its operations, and a number of base-metal companies that produce byproduct silver began cutting back operations late in 1981. A law was enacted authorizing the sale of a large portion of the silver held in the National Defense Stockpile, and another law was enacted that suspended sales from the stockpile pending further study.

Trading of silver futures on the New York Commodity Exchange (COMEX) and the Chicago Board of Trade (CBT) rose from 7.0 billion ounces in 1980 to 7.5 billion ounces in 1981. Stocks on the exchange fell to 93.1 million ounces, a net outflow of 28 million ounces. Industrial stocks were moderately higher, whereas Treasury bullion stocks were only slightly below the level of 1980. The national stockpile contained 137.5 million ounces at yearend 1981.

Legislation and Government Programs.—Two laws were enacted in 1981 that affected the 139.5 million ounces of surplus silver held in the National Defense Stockpile. Public Law 97-35, the Omnibus Budget Reconciliation Act of 1981, enacted on August 31, 1981, authorized the President to dispose of 46,537,000 ounces of silver beginning on October 1, 1981; 44,682,000 ounces beginning on October 1, 1982; and 13,900,000 ounces beginning on October 1, 1983. The fundamental reason for the sale of the excess silver was to provide funds to purchase those strategic and critical materials, such as titanium and tantalum, that are more essential to defense priorities and that are seriously short of stockpile goals. The sales were subject to certain conditions as set forth in the law and were to be conducted by the U.S. General Services Administration (GSA).

By law, GSA, when selling excess stocks, must deal responsibly in the market to protect the United States from avoidable loss, and producers, processors, and consumers against avoidable market disruptions. GSA initially planned to sell 1,250,000 ounces of silver per week beginning on October 14, 1981. Sales fell considerably short of this level in the first 4 weeks, and all bids were determined unacceptable in the sale of November 12, 1981, largely because of inadequate bid prices and their potential impact on market prices. By yearend 1981, 2 million ounces had been sold by the GSA.

Public law 97-114, the Defense Appropriation Act of 1982, enacted on December 29, 1981, suspended all sales of silver from the stockpile and required the President to redetermine by July 1, 1982, that the silver authorized for disposal was not required for national defense purposes. New studies were immediately initiated by the Federal Emergency Management Agency and the Department of the Interior to respond to the requirements of Public Law 97-114.

The Bureau of Mines awarded a contract to a private consulting firm to determine the potential supply of secondary silver in the form of scrap, coins, and privately held commercial bullion that might enter the market at various price levels and market conditions. The results of the study were expected to be available by the middle of 1982.

DOMESTIC PRODUCTION

Mine production rose to 40.7 million ounces valued at $428 million in 1981, mainly as a result of the end of strikes at copper mines producing byproduct silver and mines producing silver ore. In addition, new mines such as the Escalante in New Mexico, the Candelaria and the Taylor in Nevada, and the Troy in Montana began producing large volumes of silver for the first time.[3] The value of the silver produced was, however, 36% below that of 1980. At yearend 1981, copper mines, some of which produce significant quantities of byproduct silver, began curtailing operations as demand for copper continued to decline.

The 25 largest silver producers contributed 80% of the total output. Ten of these, the 1st, 2d, 3d, 4th, 7th, 9th, 15th, 17th, 19th, and 25th, mined silver ores; one, the 8th, mined gold-silver ores; and the others mined base-metal ores and produced byproduct silver. Eleven of the mines produced over 1 million ounces of silver each, which in the aggregate equaled 57% of total production. Domestic mine production was equivalent to 31% of consumption in 1981.

The Sunshine Mine in Idaho's Coeur d'Alene silver district regained its position as the largest silver producer in the United States. The mine, owned by Sunshine Mining Co., underwent a prolonged strike in 1980 that resulted in loss of production. Sunshine Mining Co. continued construction of its 16-to-1 Mine in Esmeralda County, Nev., and planned to open it early in 1982. Output is expected to total 1 million ounces per year for 9 years.

ASARCO Incorporated reported production of silver at 3.5 million ounces from the Galena Mine and 2.6 million ounces from the Coeur Mine, both in Idaho's Coeur d'Alene silver district.[4] The company completed development of the Troy copper-silver deposit in western Montana, and after tuneup activities were completed in September, the mine was placed in operation in December. The mine is expected to produce 4.2 million ounces of silver per year for about 16 years. Asarco's silver refinery in Amarillo, Tex., produced 34.6 million ounces of silver in 1981 compared with 27.1 million ounces in 1980. Asarco installed precious metal scrap handling facilities at the refinery and began producing silver from scrap materials in 1981.

Hecla Mining Co., Wallace, Idaho, reported production of 5.7 million ounces of silver in 1981.[5] Hecla's Lucky Friday Mine produced 2.3 million ounces, and its shares of the Sunshine Mine and the Star-Morning Mine totaled 1.05 million ounces and 0.4 million ounces, respectively. The grade of ore milled at the Lucky Friday Mine in 1981 averaged 15.3 ounces per ton. Reserves at yearend 1981 totaled 589,000 tons compared with 636,000 tons at the end of 1980. The new Silver shaft at the Lucky Friday Mine, which is expected to increase capacity at the mine 35%, reached a depth of 4,900 feet at yearend.[6] A production station is being cut at that level although production will not begin until the shaft reaches 6,100 feet. Hecla Mining is the managing partner of a joint venture to operate the mining properties of the Consolidated Silver Corp. near Osborn, Idaho. The main shaft on the property was rehabilitated, and production commenced in October 1980 but was suspended at yearend 1981. Hecla Mining also suspended production at the Sherman Tunnel Mine, Leadville, Colo. Hecla Mining merged with Day Mines Inc., thereby acquiring the Knob Hill gold-silver mine in Republic, Wash.; the Sherman Tunnel Mine, Leadville, Colo.; the Victoria copper-silver mine, Elko County, Nev.; and interests in the Coeur Mine and the Galena Mine in Idaho, in addition to other properties primarily in the Coeur d'Alene silver district in Idaho.

Homestake Mining reported production of 1.4 million ounces of silver from its Bulldog silver mine near Creede, Colo.[7] This level of production was slightly lower than that of 1980, which reflected partly the processing of lower grade ore. Ore reserves in the Bulldog Mine at yearend 1981 totaled 794,000 tons, averaging 16.3 ounces of silver per ton.

The Bunker Hill Co., a subsidiary of Gulf Resources and Chemical Corp., announced the closing of its mining-smelting-refining operation near Kellogg, Idaho.[8] Included in the facilities to be closed were the Bunker Hill and Crescent Mines, which together produced about 1.5 million ounces of silver per year, and a silver refinery with a capacity of more than 10 million ounces per year. The company had reported that considerable financial losses had been incurred from its operations, and when all efforts to sell the complex failed, the decision to close down was made.

Phelps Dodge Corp. reported that 3.2 million ounces of byproduct silver was produced from the company's domestic copper mining operations.[9] During 1981, Phelps Dodge established a Small Mines Division to acquire and develop small mining projects and to that end had put into production two small gold-silver projects in Arizona which produced 189,200 ounces of silver and 2,100 ounces of gold. The Division was evaluating a number of properties in several Western States.

The Louisiana Land and Exploration Co. reported that reserves at its 50% owned Smokey Valley Mine, Round Mountain, Nev., totaled 195 million tons containing 15 million ounces of silver and 8.4 million ounces of gold.[10]

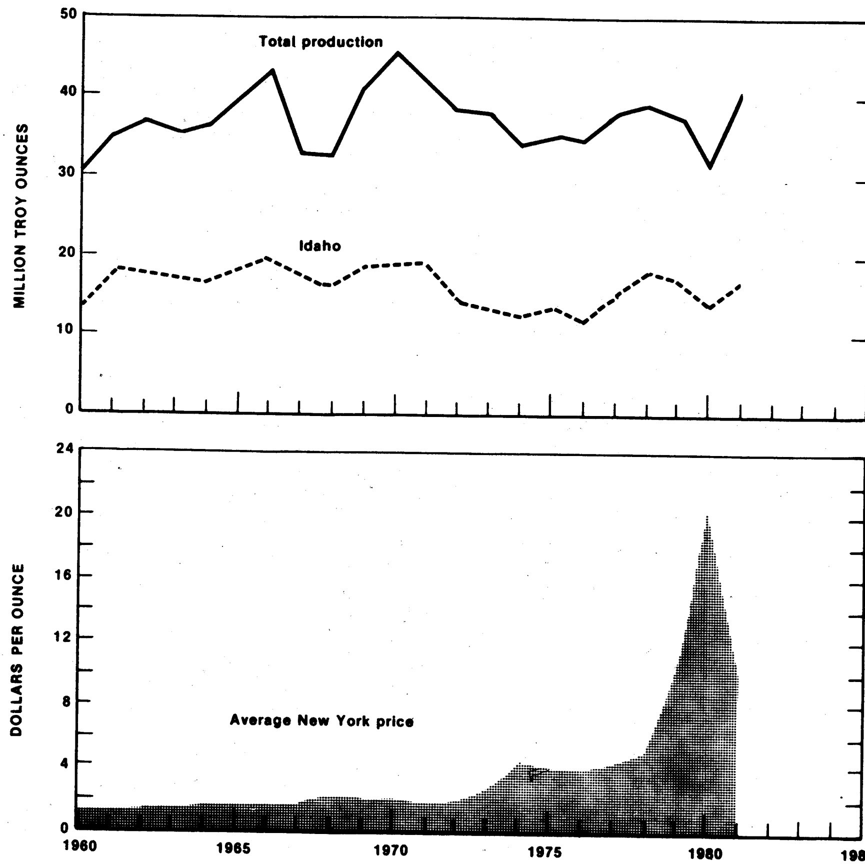

Figure 1.—Silver production in the United States and price per ounce.

CONSUMPTION AND USES

Industrial consumption of silver fell in 1981, mainly as a result of high silver prices whose effect was increased by declining business activity. The weakness in silver demand continued throughout most of the year notwithstanding the declining trend in silver prices that was prevalent during the year. Of the major uses, electroplated ware, sterlingware, jewelry, batteries, brazing alloys and solders, and contacts and conductors were most noticeably affected as demand for silver in their manufacture fell anywhere from 5% to 51%. In the aggregate, these uses accounted for 44% of total consumption in 1981 compared with 49% in 1980. Use of silver in sterlingware dropped 51%. Most other uses recorded declines in consumption during 1981. Photography and catalysts recorded increased usage.

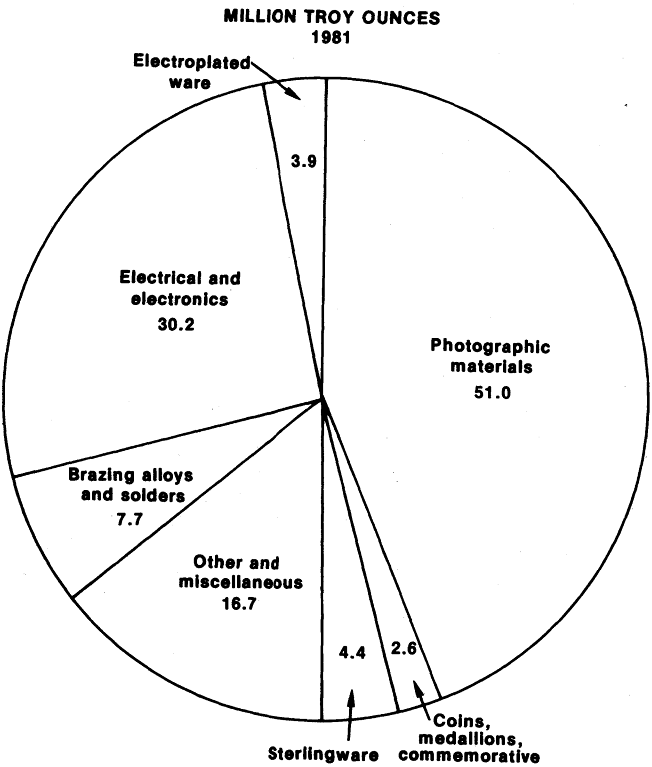

Figure 2.—Silver consumption in the United States in 1981.

STOCKS

Total accountable stocks at yearend 1981 were 296.9 million ounces, a level 24.0 million ounces below that of 1980. Refinery, fabricator, and dealer stocks rose slightly, while silver stocks in registered vaults of COMEX recorded a 9.3-million-ounce decline. Silver bullion held by the CBT fell 45%, and that of the U. S. Department of Defense fell an estimated 0.5 million ounces. The strategic stockpile contained 137.5 million ounces at yearend 1981, all of which had been declared surplus to national defense needs. Under Public Law 97-35, 2 million ounces of silver in the stockpile were sold before sales were suspended.

PRICES

The price of silver continued to fall in 1981 as speculative interest in silver metal declined and the economy in general remained in a depressed condition. The average daily price per ounce of silver, as quoted by Handy & Harman, New York, began the year at $16.35, rose to the year's high of $16.45 on January 6, and then fell to $8.30

on July 6. The price then rose moderately until the announcement in the middle of September that the Federal Government was going to sell silver in the stockpile. The price then began to fall and reached $7.85, the low for the year, on December 29.

The average daily price was $10.52 compared with $20.63 in 1980. The average monthly price, which was $14.75 for January, declined to $8.63 for July, then rose to $10.04 for September before falling to $8.44 in December. The year ended with no abatement in the downward pressure on the price.

Prices on the London Metal Exchange ranged from $16.30 on January 6 to $8.03 on November 23. The average for 1981 was $10.52.

Trading volume on the COMEX was 6.2 billion ounces during 1981, an increase of 0.9 billion ounces from 1980. The CBT trading volume was 1.3 billion ounces, a decline of 0.4 billion ounces from that of 1980.

FOREIGN TRADE

Exports of silver totaled 27.9 million ounces in 1981, a 65% decrease from the comparable figure for 1980. Refined bullion, which accounted for 54% of total exports, totaled 15.1 million ounces, a level 74% below that of 1980. Exports of waste, scrap, and sweepings decreased to 9.7 million ounces, which was equivalent to 35% of total exports. Most of the exports of waste, scrap, and sweepings occurred in the first half of 1981. Exports of doré and precipitates rose moderately. The remainder of the exports consisted of very minor quantities of silver ore and concentrates. The principal foreign markets for bullion were the United Kingdom, Canada, and Japan, and for waste, scrap, and sweepings, the United Kingdom, Belgium-Luxembourg, and Canada.

Imports for consumption of silver increased to 94.1 million ounces mainly because of increased shipments of refined bullion from Canada, Mexico, and Peru. Refined bullion, which accounted for 81% of the imports, increased 17%, while imports of ore and concentrate and waste and scrap increased slightly. Imports of doré and precipitates nearly tripled in 1981. The principal sources for imported silver in 1981 were Canada, Mexico, and Peru, which, in the aggregate, accounted for 84% of total imports and 93% of bullion imports. Chile, the other major source of bullion, accounted for 5% of total imports.

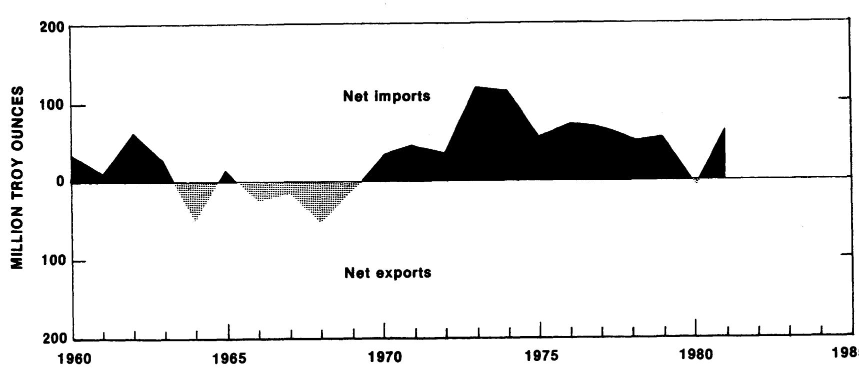

Figure 3.—Net exports or imports of silver, 1960-81.

WORLD REVIEW

World mine production of silver in 1981, including centrally planned economy countries, increased 25 million ounces to 364.9 million ounces. The United States, Canada, Mexico, and Peru accounted for 49% of world output; the U.S.S.R., 13%; Australia, 7%; and Poland, 6%. The remainder came from numerous other countries. Strikes in 1980 at mining facilities in some countries, notably the United States, Canada, and Peru, ended, and world output began to rise towards the level expected from recent expansions in capacity.

Consumption of silver in 1981 in the market economies for industrial and coinage uses totaled 369.3 million ounces compared with 363.6 million ounces in 1980.[11] A 4% increase in industrial use, which accounted for 98% of total use in 1981, was accompanied by 56% decrease in use of silver in coinage. Total consumption by market economy countries exceeded newly mined supply by 105 million ounces according to Handy & Harman estimates. Secondary production totaled 105 million ounces; outflow from Indian stocks, 33.5 million ounces; demonetized coin, 12 million ounces; and U.S. and foreign government stock withdrawals, 4.1 million ounces. Privately held bullion stocks increased by 49.3 million ounces, according to Handy & Harman.

Australia.—The Woodlawn Mine in New South Wales, which commenced operating late in 1979, produced about 1.5 million ounces of silver in 1981 after resolution of metallurgical problems. The mine is operated as a joint venture between Phelps Dodge Corp., CRA Ltd., and St. Joe International Corp., with each having an equal interest. Silver production from the Mount Isa Mine of M.I.M. Holdings Ltd., for the fiscal year ending June 30, 1981, was 11.8 million ounces.[12] Silver reserves at the Elura lead-zinc-silver deposit of EZ Industries, Ltd., total 27 million tons averaging 4.5 ounces of silver per ton. Construction of the mine continued in 1981; it is expected to be in operation by the end of 1982 with production expected to exceed 4.5 million ounces of silver per year.[13]

Canada.—Mine production of silver in 1981 by United Keno Hill Mines, Ltd., fell to 1.2 million ounces as a result of a strike during the first 5 months of the year.[14] Ore reserves of the Elsa Mining Div. decreased from 418,000 tons averaging 25.3 ounces of silver per ton to 226,800 tons averaging 27.9 ounces per ton because of increasing costs and the decrease in the price of silver. The company completed a precious metal refinery and commenced shipments of bullion in November.

Noranda Mines Ltd. reported that silver production from the No. 12 and No. 6 Mines of Brunswick Mining & Smelting Corp., Ltd., totaled 3.0 million ounces in 1981, essentially the same as in 1980.[15] Proven reserves at both mines at yearend totaled about 67 million tons containing 186 million ounces of silver. Noranda Mines has a 64.1% interest in Brunswick Mining & Smelting. Noranda's Geco Div. reported production of 1.4 million ounces of silver in 1981 from an ore reserve that contained 29.8 million ounces at yearend. Production of silver by Mattabi Mines Ltd. totaled 753,000 ounces in 1981, while ore reserves totaled 13.2 million ounces at yearend. Noranda Mines has an operating interest in this mine.

Placer Development, Ltd., with a 70% interest in Equity Mining Corp.'s silver-gold-copper property located at Houston, British Columbia, completed construction of the mine in 1980 and the leach plant in 1981.[16] The property was estimated to contain 26 million tons of ore containing 3.3 ounces of silver per ton. Production in 1981 was 7.3 million ounces of silver. Placer Development is responsible for operating the mining and processing facilities.

Chile.—St. Joe International Corp. began operating the El Indio gold-silver-copper deposit in northeastern Chile, which has a proven reserve of 3.4 million tons of ore averaging 4.3 ounces of silver per ton.[17] The mine began operating towards the end of 1981 and reportedly will produce 1.5 million ounces of silver per year.

Honduras.—Production of silver in 1981 at AMAX Inc.'s El Mochito Mine totaled 1.7 million ounces.[18] Ore reserves at yearend totaled 7.6 million tons containing 33.4 million ounces of silver in addition to gold, lead, zinc, and copper. Rate of ore production is being increased from a current 1,200 tons per day to 2,500 tons per day by 1983.

Mexico.—Mine production of silver in 1981 was 53.2 million ounces, a level below that expected from the extensive expansion of silver mines and plants of recent years. Production had been expected to increase to about 60 million ounces by the end of 1979 and to about 80 million ounces in 1982.

Lacana Mining Corp. reported production of silver at its 30% owned Torres mining complex, Guanajuato, at 4.4 million ounces.[19] The mill processed 660,000 tons of ore averaging 8.0 ounces of silver per ton from an ore body that contained 3.4 million tons averaging 8.2 ounces of silver per ton at yearend 1981. The Torres complex is composed of a centrally located 2,200-ton-per-day flotation concentrator fed with ore from four mines, the Torres-Cedros, the Peregrina-Triunvirato, the Cebada, and the Bolanitos. Other mines being developed underground were Sirena, Melladitos, Los Viejitos, and La Luz.

Lacana owns 40% of Encantada Mining Group, Coahuila, which is composed of a 1,320-ton-per-day flotation concentrator fed by three mines, the Encantada, the Los Angeles, and the Plomo. Silver production in 1981 totaled 1.5 million ounces from deposits containing 1.7 million tons averaging 9.3 ounces of silver per ton.

Subsidiary companies of Lacana continued to explore numerous silver prospects in Mexico. Diamond drilling of the Guiterra vein at the Temascaltepec silver-gold prospect encountered high-grade mineralization, which was being explored by underground methods at yearend 1981. Tres Amigos, another silver-gold prospect, gave indications of a multimillion-ton potential, which Lacana planned to explore by diamond drilling in 1982. The Preciosa silver-gold property was being explored by underground methods, which gave indications that a considerable body of ore existed, averaging 8 ounces of silver per ton. Other properties being explored by Lacana included the La Olla, silver, and the Tecolote, silver-lead.

Papua New Guinea.—Bougainville Copper Ltd. reported production of 1.4 million ounces of silver in concentrates from its open pit copper-gold-silver mine near Panguna.[20] Ore reserves at the mine at yearend 1981 totaled 880 million tons containing approximately 40 million ounces of silver.

Peru.—Southern Peru Copper Corp. reported silver production from its Toquepala and Cuajone copper mines totaled 2.1 million ounces in 1981.[21]

South Africa, Republic of.—Black Mountain Mineral Development Co., Ltd., continued to develop the Black Mountain Mine ore body, one of the three large contiguous lead, zinc, copper, and silver deposits located near Aggeneys, northwestern Cape Province.[22] In the aggregate, the three deposits contain about 600 million ounces of silver. The property came onstream early in 1980 and produced 4.7 million ounces of silver in 1981. Gold Fields of South Africa, Ltd., the manager of the project, owns a 51% interest, and Phelps Dodge Corp. of the United States owns 49%.

Spain.—The Aznalcollar open pit mine of Andaluza de Piritas SA reportedly was operating at about 4 million tons per year and producing approximately 1.5 million ounces of silver in addition to copper, lead, and zinc.[23] Ore reserves at the mine total 90 million tons containing about 108 million ounces of silver.

TECHNOLOGY

Research scientists at the Bureau of Mines Reno (Nev.) Research Center conducted studies in 1981 to recover silver from low-grade resources.[24] The research investigated particle agglomeration techniques as a means for improving the flow of leaching solutions through heaps of low-grade ores. The research resulted in markedly enhanced percolation rates and increased silver recovery. Silver leaching production and problems were reviewed by Bureau scientists at the Twin Cities Research Center, Minneapolis, Minn.[25] Various aspects of leaching operations using dilute alkaline cyanide on gold-silver ores were reviewed.[26] Key factors include extent of ore preparation and delivery, method of applying and recovering the leach solution, recovery of the precious metals from the leach solutions, and others. Low-cost methods outlined should stimulate development of gold and silver operations notwithstanding the current low price of these precious metals.

The Federal Government's program for precious metal recovery from surplus military items was described.[27] The two principal aspects of the program are the identification of kinds and amounts of precious metals in items supplied to the military services and their recovery from the mass of heterogeneous materials used by the military. Construction and operations of the tailings dam at the Pueblo Viejo gold-silver mine in the Dominican Republic were discussed.[28] Climatic conditions and a local agricultural industry required careful planning to assure a strong dam and a highly efficient and safe system of tailings disposal and cyanide solution reclamation.

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[22]Work cited in footnote 9.
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Table 2.—Mine production of recoverable silver in the United States, by month

(Thousand troy ounces)

Month	1979[r]	1980[r]	1981
January	3,252	3,271	3,062
February	3,055	3,365	3,404
March	3,310	3,280	3,408
April	3,228	3,335	3,314
May	3,341	3,006	3,151
June	3,240	3,163	3,315
July	3,198	1,993	3,577
August	3,482	1,741	3,408
September	2,897	1,776	3,503
October	3,057	2,074	3,797
November	2,888	2,144	3,354
December	2,948	3,181	3,392
Total	37,896	32,329	40,685

[r]Revised.

Table 3.—Twenty-five leading silver-producing mines in the United States in 1981, in order of output

Rank	Mine	County and State	Operator	Source of silver
1	Sunshine	Shoshone, Idaho	Sunshine Mining Co	Silver ore.
2	Galena	do	ASARCO Incorporated	Do.
3	Coeur	do	do	Do.
4	Lucky Friday	do	Hecla Mining Co	Do.
5	Utah Copper	Salt Lake, Utah	Kennecott Corp	Copper ore.
6	Berkeley Pit	Silver Bow, Mont	The Anaconda Company	Do.
7	Candelaria	Mineral, Nev	Candelaria Partners	Silver ore.
8	Delamar	Owyhee, Idaho	Earth Resources Co	Gold-silver ore.
9	Bulldog Mountain	Mineral, Colo	Homestake Mining Co	Silver ore.
10	Twin Buttes	Pima, Ariz	Anamax Mining Co	Copper ore.
11	Tyrone	Grant, N. Mex	Phelps Dodge Corp	Do.
12	Bunker Hill	Shoshone, Idaho	The Bunker Hill Co	Lead-zinc ore.
13	Star Unit	do	Hecla Mining Co	Do.
14	Sierrita	Pima, Ariz	Duval Corp	Copper ore.
15	Troy Unit	Lincoln, Mont	ASARCO Incorporated	Silver ore.
16	Morenci	Greenlee, Ariz	Phelps Dodge Corp	Copper ore.
17	Sherman Tunnel	Lake, Colo	Hecla Mining Co	Silver ore.
18	Eisenhower	Pima, Ariz	Eisenhower Mining Co	Copper ore.
19	Taylor	White Pine, Nev	Silver King Mines, Inc	Silver ore.
20	Magma	Pinal, Ariz	Magma Copper Co	Copper ore.
21	Buick	Iron, Mo	Amax Lead Co. of Missouri	Lead ore.
22	San Manuel	Pinal, Ariz	Magma Copper Co	Copper ore.
23	Mission	Pima, Ariz	ASARCO Incorporated	Do.
24	Bagdad	Yavapai, Ariz	Cyprus Bagdad Copper Co	Do.
25	Crescent	Shoshone, Idaho	The Bunker Hill Co	Silver ore.

Table 4.—Silver produced in the United States, by State, type of mine, and class of ore yielding silver, in terms of recoverable metal

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: Total	431	[r]4,201,963	[r]677,819	756,221	2,152,845	1,065,591	16,766,967
1980: Total	467	5,510,745	749,785	872,019	1,953,874	[r]2,064,191	13,699,057
1981:							
Alaska	1,704	301	227	--	--	14	441
Arizona	--	W	W	W	W	122,597	203,601
California	135	22,955	3,923	1,445	10,447	257	1,851
Colorado	--	W	W	W	W	335,500	2,408,280
Idaho	--	W	W	W	W	955,927	13,161,698
Missouri	--	--	--	--	--	--	--
Montana	--	593,984	105,671	W	W	586,837	833,084
Nevada	--	2,938,928	282,451	48,120	252,057	2,540,598	2,484,636
New York	--	--	--	--	--	--	--
South Dakota	--	1,848,303	55,792	--	--	--	--
Washington	--	56,308	67,390	--	--	--	--
Other[1]	--	1,019,253	247,419	956,556	1,905,357	22,970	88,659
Total	1,839	6,480,032	762,873	1,006,121	2,167,861	4,564,700	19,182,250
Percent of total silver	([2])	XX	2	XX	5	XX	47

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: Total	[r]267,313,440	[r]13,877,531	9,122,812	2,278,603	672,292	12,984
1980: Total	[r]220,293,487	[r]11,135,824	10,080,986	2,534,828	370,702	20,956
1981:						
Alaska	--	--	--	--	--	--
Arizona	197,106,146	7,565,368	3,937	1,907	--	--
California	--	--	--	--	--	--
Colorado	--	--	--	--	--	--
Idaho	W	W	W	W	W	W
Missouri	--	--	8,520,094	1,837,011	--	--
Montana	15,134,477	2,029,438	W	W	--	--
Nevada	57,856	8,586	--	--	--	--
New York	--	--	--	--	561,957	28,829
South Dakota	--	--	--	--	--	--
Washington	--	--	--	--	--	--
Other[1]	69,649,785	4,349,446	14	280	439,054	2,178
Total	281,948,264	13,952,838	8,524,045	1,839,198	1,001,011	31,007
Percent of total silver	XX	34	XX	5	XX	([2])

See footnotes at end of table.

Table 4.—Silver produced in the United States, by State, type of mine, and class of ore yielding silver, in terms of recoverable metal—Continued

State	Lode: Copper-lead, lead-zinc, copper-zinc, and copper-lead-zinc ores		Lode: Old tailings, etc.		Total[3]	
	Short tons	Troy ounces of silver	Short tons	Troy ounces of silver	Short tons	Troy ounces of silver
1979: Total	3,103,669	2,055,561	42,493	72,783	r286,278,481	r37,895,524
1980: Total	3,256,562	2,112,419	67,623	122,163	r242,516,315	r32,329,373
1981:						
Alaska	--	--	--	--	315	2,372
Arizona	--	--	94,948	173,507	197,344,162	8,055,231
California	W	W	W	W	25,459	53,286
Colorado	W	W	W	W	910,823	3,008,994
Idaho	932,091	1,836,133	2,741	6,028	2,774,457	16,545,648
Missouri	--	--	--	--	8,520,094	1,837,011
Montana	--	--	W	W	16,328,835	2,988,810
Nevada	--	--	111,935	11,750	5,697,437	3,039,480
New York	--	--	--	--	561,957	28,829
South Dakota	--	--	--	--	1,848,303	55,792
Washington	--	--	--	--	56,308	67,390
Other[1]	2,254,897	533,652	76,795	[4]186,381	72,929,430	5,002,474
Total	3,186,988	2,369,785	286,419	377,666	306,997,580	40,685,317
Percent of total silver	XX	6	XX	1	XX	100

rRevised. W Withheld to avoid disclosing company proprietary data; included in "Other." XX Not applicable.
[1]Includes Illinois, Michigan, New Mexico, Oregon, South Carolina, Tennessee, Utah, Virginia, States indicated by symbol W, and a small amount of silver recovered from tailings, not distinguishable as to State origin.
[2]Less than 1/2 unit.
[3]Data may not add to State totals because of items withheld to avoid disclosing company proprietary data.
[4]Includes byproduct silver recovered from tungsten ore in California and fluorspar in Illinois.

Table 5.—Mine production of recoverable silver in the United States, by State

(Troy ounces)

State	1977	1978	1979	1980	1981
Alaska	1,725	2,052	W	8,354	2,372
Arizona	6,828,145	6,637,838	7,478,942	r6,267,588	8,055,231
California	57,891	58,014	64,185	49,257	53,286
Colorado	4,663,496	4,217,181	2,808,934	2,987,058	3,008,994
Idaho	15,291,964	18,379,417	17,144,209	13,694,902	16,545,648
Michigan	335,479	W	W	W	W
Missouri	2,362,752	2,056,053	2,201,112	2,357,236	1,837,011
Montana	3,367,442	2,918,317	3,301,928	2,023,893	2,988,810
Nevada	738,402	803,887	560,435	r939,997	3,039,480
New Mexico	918,155	894,833	W	W	1,632,346
New York	56,353	20,911	10,538	20,702	28,829
Oregon	7,134	1,714	1,572	841	7,487
South Dakota	68,717	53,099	57,973	51,257	55,792
Tennessee	60,246	W	W	W	W
Utah	3,283,323	2,885,065	2,454,136	r2,203,289	2,882,671
Washington	120,582	W	W	W	67,390
Other	3,897	456,989	r1,811,560	r1,724,999	479,970
Total	38,165,703	39,385,370	r37,895,524	r32,329,373	40,685,317

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

Table 6.—Silver produced in the United States from ore, old tailings, etc., by State and method of recovery, in terms of recoverable metal

State	Total ore, old tailings, etc. treated[1] [2] (thousand short tons)	Ore and old tailings to mills					Crude ore, old tailings, etc., to smelters[1]	
		Thousand short tons[1] [2]	Recoverable in bullion		Concentrates smelted and recoverable metal			
			Amalgamation (troy ounces)	Cyanidation (troy ounces)	Concentrates (short tons)	Troy ounces	Thousand short tons	Troy ounces
1979: Total	[r]329,174	[r]328,354	170	[r]2,374,767	[r]6,282,071	[r]34,184,240	[r]821	1,335,916
1980: Total	[r]274,015	[r]273,270	1,502	[r]2,637,809	[r]6,068,875	[r]28,643,779	[r]746	1,045,816
1981:								
Alaska	(3)	(3)	--	--	4	227	(3)	441
Arizona	[4]217,231	[4]216,846	--	1,592	3,801,815	7,694,911	385	358,728
California	[4]30	[4]29	6	44	3,293	49,635	1	3,466
Colorado	1,207	1,199	--	--	60,598	2,757,910	8	251,084
Idaho	2,774	2,769	--	1,494,251	147,035	14,994,849	6	56,548
Missouri	8,520	8,520	--	--	701,476	1,837,011	--	--
Montana	[4]16,342	[4]16,321	--	105,185	260,995	2,818,002	21	65,623
Nevada	[4] [5]11,861	[4] [5]11,859	--	2,961,954	5,149	64,680	2	12,846
New Mexico	25,767	25,671	--	7,848	840,440	1,533,229	96	91,269
New York	562	562	--	--	72,941	28,829	--	--
Oregon	27	27	--	--	2,924	6,900	(3)	587
South Dakota	1,848	1,848	--	55,792	--	--	--	--
Utah	[4]40,629	[4]40,474	--	1,000	824,169	2,483,786	156	397,885
Washington	56	56	--	--	116	67,361	(3)	29
Other[6]	11,535	11,535	--	--	477,053	479,970	--	--
Total[7]	338,392	337,717	6	4,627,666	7,198,008	34,817,300	675	1,238,506

[r]Revised.
[1]Includes some nonsilver-bearing ore not separable.
[2]Excludes tonnages of fluorspar and tungsten ores from which silver was recovered as a byproduct.
[3]Less than 1/2 unit.
[4]Includes ore from which silver was recovered by heap leaching.
[5]Includes ore from which silver was recovered by vat leaching.
[6]Includes Illinois, Michigan, South Carolina, Tennessee, Virginia, and small amounts of silver recovered from tailings, not distinguishable as to State origin.
[7]Data may not add to totals shown because of independent rounding.

Table 7.—Silver produced at amalgamation and cyanidation mills in the United States and percentage of silver recoverable from all sources, by year

Year	Bullion and precipitates recoverable (troy ounces)		Silver recoverable from all sources (percent)			
	Amalgamation	Cyanidation	Amalgamation	Cyanidation	Smelting[1]	Placers
1977	16,720	1,308,209	0.04	3.43	96.52	0.01
1978	654	2,600,357	(2)	6.60	93.39	.01
1979	170	2,374,767	(2)	[r]6.27	[r]93.73	(2)
1980	1,502	[r]2,637,809	[r](2)	[r]8.16	[r]91.84	(2)
1981	6	4,267,666	(2)	11.37	88.62	.01

[r]Revised.
[1]Crude ores and concentrates.
[2]Less than 0.005%.

Table 8.—Silver produced at refineries in the United States, by source

(Thousand troy ounces)

Source	1980	1981
Concentrates and ores:		
Domestic	36,171	44,487
Foreign	3,182	2,520
Total	39,353	47,007
Old scrap:		
Coins	12,089	1,118
Other	41,043	37,949
Total	[1]53,131	39,067
Total net production	92,484	86,074
New scrap	65,642	44,738
Grand total	[1]158,127	130,812

[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]	1980	1981
Electroplated ware	4,350	3,904
Sterlingware	9,082	4,407
Jewelry	5,893	5,368
Photographic materials	49,825	51,025
Dental and medical supplies	2,212	1,709
Mirrors	672	581
Brazing alloys and solders	8,508	7,718
Electrical and electronic products:		
Batteries	5,976	3,803
Contacts and conductors	27,796	26,411
Bearings	649	248
Catalysts	3,035	3,830
Coins, medallions, commemorative objects	4,693	2,622
Miscellaneous[2]	2,005	4,995
Total net industrial consumption	[3]124,694	116,621
Coinage	72	179
Total consumption	[3]124,766	116,800

[1]End use as reported by converters of refined silver.
[2]Includes silver-bearing copper, silver-bearing lead anodes, ceramics, paints, etc.
[3]Data do not add to total shown because of independent rounding.

Table 10.—Value of silver exported from and imported into the United States, by year

(Thousand dollars)

Year	Exports	Imports
1979	471,162	961,761
1980	1,909,733	1,606,010
1981	332,470	1,028,450

Table 11.—U.S. exports of silver in 1981, by country

Country	Ore and concentrates		Waste and sweepings		Doré and precipitates		Refined bullion		Total[1]	
	Thousand troy ounces	Value (thousands)	Thousand troy ounces	Value (thousands)	Thousand troy ounces	Value (thousands)	Thousand troy ounces	Value (thousands)	Thousand troy ounces	Value (thousands)
Belgium-Luxembourg	6	$192	1,238	$13,497	1,206	$12,242	152	$1,900	2,602	$27,831
Canada	108	849	2,412	27,243	1,014	12,931	6,982	77,248	10,516	118,271
France	40	279	54	937	6	58	36	372	136	1,646
Germany, Federal Republic of	35	70	127	2,021	124	1,769	1	9	287	3,869
Japan	--	--	322	5,339	271	4,512	3,452	37,693	4,045	47,544
Spain	--	--	785	9,445	--	--	--	--	785	9,445
United Kingdom	7	14	4,728	55,555	158	2,514	3,784	54,397	8,677	112,480
Other	17	106	82	1,069	34	447	724	9,761	857	11,383
Total[1]	213	1,510	9,746	115,106	2,813	34,474	15,131	181,380	27,903	332,470

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

Table 12.—U.S. imports for consumption of silver in 1981, by country

Country	Ore and concentrates		Waste and sweepings		Doré and precipitates		Refined bullion		Total[1]	
	Thousand troy ounces	Value (thousands)	Thousand troy ounces	Value (thousands)	Thousand troy ounces	Value (thousands)	Thousand troy ounces	Value (thousands)	Thousand troy ounces	Value (thousands)
Brazil	109	$1,549	--	--	--	--	66	$625	175	$2,174
Canada	681	7,865	833	$9,439	119	$1,539	32,361	355,967	33,994	374,810
Chile	680	8	--	--	2,414	26,387	1,220	14,489	4,314	40,884
Dominican Republic	--	--	5	70	1,026	10,879	1	21	1,032	10,970
France	--	--	10	170	(2)	2	504	6,322	514	6,494
Germany, Federal Republic of	1	7	2	20	300	4,035	201	2,816	504	6,878
Honduras	1,523	15,638	(2)	4	--	--	--	--	1,523	15,642
Hong Kong	--	--	281	2,345	569	8,436	848	8,920	1,693	19,701
Japan	--	--	--	--	10	91	274	3,074	284	3,165
Korea, Republic of	210	2,312	--	--	97	1,332	904	10,073	1,211	13,717
Mexico	2,255	23,133	77	707	554	6,514	19,271	197,576	22,157	227,930
Peru	2,938	35,998	73	964	1,173	13,824	18,859	221,817	23,043	272,603
United Kingdom	616	6,842	571	1,084	12	213	226	2,767	1,425	10,908
Yugoslavia	--	--	--	--	--	--	837	8,377	837	8,377
Other	755	7,071	199	1,612	99	1,185	354	4,329	1,407	14,197
Total[1]	9,769	100,422	2,051	16,414	6,374	74,439	75,921	837,174	94,115	1,028,450

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

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

(Thousand troy ounces)

Country[2]	1977	1978	1979	1980[p]	1981[e]
North and Central America:					
Canada	42,236	40,733	36,874	33,340	37,418
Costa Rica[e]	1	2	2	2	2
Dominican Republic	1,852	1,848	2,276	1,623	2,062
El Salvador	112	185	152	146	110
Guatemala	NA	10	10	10	8
Honduras	2,819	2,788	2,434	1,766	[3]2,400
Mexico	47,030	50,779	49,408	47,344	53,204
Nicaragua	167	482	389	164	150
United States	38,166	39,385	37,896	32,329	[3]40,685
South America:					
Argentina	[r]2,450	[r]2,164	2,209	2,305	2,300
Bolivia	5,813	6,285	5,742	6,099	6,602
Brazil[4]	372	506	1,065	837	800
Chile	8,461	8,210	8,740	9,598	10,000
Colombia[5]	91	[r]77	99	152	[3]143
Ecuador	57	29	[e]44	45	44
Peru	[r]39,731	[r]37,022	39,248	42,989	46,940
Europe:					
Bulgaria[e]	840	900	920	930	930
Czechoslovakia[e]	1,192	1,300	1,300	1,300	1,300
Finland	813	[r]1,069	1,028	1,430	1,215
France	3,004	[r]2,755	2,408	2,373	2,400
German Democratic Republic[e]	1,600	1,600	1,550	1,510	1,600
Germany, Federal Republic of	1,061	799	1,039	1,038	1,038
Greece	1,070	1,360	1,752	1,672	1,600
Greenland	521	559	765	771	720
Hungary[e]	39	[r]32	32	33	33
Ireland	936	631	1,059	771	700
Italy[5 6]	1,222	890	1,065	1,366	1,600
Poland[e]	[r]10,708	21,900	22,600	24,665	22,690
Portugal	26	23	[e]31	19	18
Romania[e]	1,125	1,030	965	900	850
Spain	[r]2,966	[r]2,924	3,168	4,526	4,800
Sweden	5,438	[r]5,007	5,649	5,112	5,100
U.S.S.R.[e 5]	45,000	46,000	46,000	46,000	46,500
Yugoslavia[5]	4,679	[r]5,125	5,214	4,790	[3]4,437
Africa:					
Algeria[e]	40	75	100	100	110
Ghana	NA	19	20	[e]20	20
Mauritania	[e]26	19	--	--	--
Morocco	[r]2,820	[r]3,131	3,283	3,154	2,500
Namibia	[r]1,758	[r]1,866	2,106	2,172	3,258
South Africa, Republic of	[r]3,135	[r]3,110	3,240	5,500	7,568
Tunisia	236	281	231	235	230
Zaire	2,730	4,391	3,892	2,733	2,100
Zambia	[e]1,450	1,069	914	764	750
Zimbabwe	207	1,109	978	954	730
Asia:					
Burma	355	377	340	587	590
China[e]	1,000	1,500	2,000	2,500	2,500
India[5]	425	388	370	366	555
Indonesia	790	826	662	693	753
Japan	9,604	9,664	8,680	8,930	8,982
Korea, North[e]	1,600	1,600	1,600	1,600	1,600
Korea, Republic of	2,106	1,385	2,278	2,292	3,148
Malaysia (Sabah)	[r]410	[r]459	433	432	430
Philippines	1,621	[r]1,640	1,838	1,952	1,900
Solomon Islands	NA	NA	(7)	(7)	(7)
Taiwan	68	75	85	95	215
Turkey	[e]220	219	250	200	200
Oceania:					
Australia	27,525	26,123	26,756	25,375	25,000
Fiji	15	10	11	10	10
New Zealand	8	2	2	1	1
Papua New Guinea	1,523	[r]1,681	1,428	1,180	1,363
Total	[r]331,270	[r]345,428	344,630	339,800	364,912

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

[1]Recoverable content of ores and concentrates produced unless otherwise noted. Table includes data available through June 30, 1982.

[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, as follows in troy ounces: 1977—14,339; 1978—21,348; 1979—14,725; 1980—15,657; 1981—not available; and that recovered from treatment of lead, as follows in troy ounces: 1977—358,002; 1978—484,157; 1979—1,050,717; 1980—721,205; 1981—not available.

[5]Smelter and/or refinery production.

[6]Includes production from imported ores.

[7]Less than 1/2 unit.

Sodium Compounds

By Dennis S. Kostick[1]

The 1981 total domestic production of soda ash was 8,281,000 short tons. Domestic apparent consumption declined slightly to 7,112,000 short tons from the 1980 level of 7,134,000 short tons. Although exports of soda ash were stronger in the second half of 1981, total exports of 1,051,000 short tons were still slightly less than the 1980 record high of 1,094,000 short tons.

Production of natural and synthetic sodium sulfate increased from 1,139,000 short tons in 1980 to 1,143,000 short tons in 1981. The domestic apparent consumption of sodium sulfate was 1,262,000 short tons, a slight increase compared with the 1980 level of 1,236,000 short tons.

Legislation and Government Programs.—The Bureau of Land Management (BLM) of the U.S. Department of the Interior issued an Environment Assessment draft that contained various sodium leasing options within the Known Sodium Leasing Area in the Green River Basin of Wyoming. For the past several years, only lease applications were accepted by the BLM; however, no applications were approved. The U.S. Department of the Interior is also examining the issue of increasing the Federal royalty rate on sodium minerals from 5% to 8%.

Table 1.—Salient sodium compound statistics

(Thousand short tons and thousand dollars)

	Soda ash		Sodium sulfate	
	1980	1981	1980	1981
United States:				
Production[1]	8,275	8,281	1,139	1,143
Value[2]	$768,168	$787,469	$71,096	$81,187
Exports	1,094	1,051	129	124
Value	$121,945	$121,107	$12,740	$12,980
Imports for consumption	18	12	230	275
Value	$2,389	$1,625	$13,242	$19,135
Stocks, producer	133	[3]263	[4]33	[4]66
Consumption, apparent	7,134	7,112	1,236	1,262
World: Production	[p]31,442	[e]31,214	[p]4,791	[e]4,848

[e]Estimated. [p]Preliminary.
[1]Includes natural and synthetic.
[2]The value for soda ash includes synthetic soda ash. The value for synthetic sodium sulfate is based upon the average value for natural sodium sulfate.
[3]Includes synthetic soda ash.
[4]Natural only.

DOMESTIC PRODUCTION

Production of natural and synthetic soda ash in 1981 increased slightly over the total recorded for 1980 (table 1). The entire soda ash industry worked at 88% of total nameplate capacity. Domestic production of sodium sulfate in 1981 increased slightly compared with that of the previous year. Production of natural sodium sulfate by three domestic producers represented 53% of the total output. Synthetic sodium sulfate production, as reported by the U.S. Bureau of the Census, decreased slightly from 556,000 short tons in 1980 to 535,000 short tons in 1981.

FMC Corp. introduced a new longwall unit in March to its mining operation in Wyoming. The unit, modified with slab plates to minimize the slabbing problems associated with trona, is expected to increase the ore extraction ratio to about 75% compared with an ore extraction ratio of 45% for continuous and conventional techniques.

Texasgulf Chemicals Co., with a soda ash plant at Granger, Wyo., was acquired at midyear by the French Government-controlled Société Nationale Elf Aquitaine. A concurrent expansion to increase nameplate capacity to 2 million tons per year was indefinitely delayed because of economic conditions rather than the sale of the company.

A small sodium carbonate mining facility owned by Lake Minerals Corp. at Owens Lake in California was sold in the third quarter to Cominco American Incorporated. The new owner will continue to mine crude sodium carbonate but may expand operations in the future to produce commercial-grade soda ash.

Allied Chemical Co. announced that it will downrate its Syracuse, N.Y., synthetic soda ash plant to 700,000 short tons per year from its present annual capacity of 900,000 short tons effective January 1, 1982. The cutback is in response to poor market conditions, particularly in the glass sector, in the Northeast.

The U.S. soda ash industry is contemplating forming a Soda Ash Export Trading Association under the provisions of the Webb-Pomerene Act of 1918. One benefit of forming the association would be to obtain favorable transportation rates for larger unit shipments to foreign markets. Two areas for increased export potential are the Far East and Western Europe.

Table 2.—Producers of soda ash and natural sodium sulfate in 1981

Product and company	Plant nameplate capacity (thousand short tons)	Plant location	Source of sodium
Soda ash, natural:			
Allied Chemical Co	2,200	Green River, Wyo.	Underground trona.
FMC Corp	2,850	do	Do.
Kerr-McGee Chemical Corp	1,300	Argus, Calif	Dry lake brine.
Do	150	Westend, Calif	Do.
Stauffer Chemical Co. of Wyoming	1,960	Green River, Wyo.	Underground trona.
Texasgulf Chemicals Co	1,000	Granger, Wyo	Do.
Soda ash, synthetic:			
Allied Chemical Co	900	Syracuse, N.Y	Ammonia-soda process.
Sodium sulfate:			
Great Salt Lake Minerals & Chemical Corp	40	Ogden, Utah	Salt lake brine.
Kerr-McGee Chemical Corp	225	Trona, Calif	Dry lake brine.
Do	225	Westend, Calif	Do.
Ozark-Mahoning Co	70	Brownfield, Tex.	Subterranean brine.
Do	100	Seagraves, Tex	Do.

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	
1977	1,812	6,228	337,516	8,040
1978	[e]1,500	6,790	370,147	8,290
1979	W	W	[4]543,812	8,253
1980	W	W	[4]768,168	8,275
1981	W	W	[4]787,469	8,281

[e]Estimated. W Withheld to avoid disclosing company proprietary data.
[1]Current Industrial Reports, Inorganic Chemicals, U.S. Bureau of the Census. Bureau of Mines responsible for data compilation after January 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.—Source of U.S. soda ash

(Thousand short tons)

Year	Solvay		Natural	
	Production	Percent of total	Production	Percent of total
1977	1,812	22.5	6,228	77.5
1978	[e]1,500	18.1	6,790	81.9
1979	W	W	W	W
1980	W	W	W	W
1981	W	W	W	W

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

Table 5.—Manufactured and natural sodium sulfate produced in the United States[1]

(Thousand short tons and thousand dollars)

Year	Manufactured and natural[2]			Natural only	
	Lower purity[3] (99% or less)	High purity	Total[4]	Quantity	Value
1977	[r]677	[r]522	1,199	636	29,313
1978	[r]660	[r]509	[r]1,169	605	27,865
1979	[r]612	[r]509	[r]1,121	533	29,689
1980	[r]676	[r]464	[r]1,139	583	[r]36,389
1981	690	453	1,143	608	43,186

[r]Revised.
[1]All quantities converted to 100% Na_2SO_4 basis.
[2]Current Industrial Reports, Inorganic Chemicals, U.S. Bureau of the Census.
[3]Includes Glauber's salt.
[4]Data may not add to totals shown because of independent rounding.

CONSUMPTION AND USES

Unfavorable economic conditions resulted in a decrease in the apparent domestic consumption of soda ash during 1981. The third consecutive year of declining soda ash usage was due to slowdowns in the construction and automotive industries, both large users of glass, which is the largest consumer of soda ash.

Polyethylene terephthalate (PET) soft drink bottles continue to displace glass containers, which are made with soda ash. After capturing the lead in the 1- and 2-liter-size soft drink bottles, PET bottle manufacturers are concentrating their efforts toward the smaller 16.9-ounce soft drink bottles. The U.S. bottle industry consumed over 275,000 tons of PET resin in 1981, an increase of 25% over that of the previous year. The advantages of PET bottles, which retain carbonation better than other plastics, over glass are that they have no adverse effect on the taste of the beverage, are safer, and are very easy to recycle because they are made completely of polyester.[2]

The total U.S. primary demand for soda ash in 1981 was 7,112,000 short tons. The estimated consumption of soda ash in each of the end uses is shown in table 6.

Apparent consumption of sodium sulfate increased 2% in 1981 to 1,262,000 short tons. The major end uses of sodium sulfate include pulp and paper, 48%; detergents, 39%; and glass and miscellaneous, 13%.

Table 6.—Estimated consumption of soda ash in 1981, by end use

(Thousand short tons)

Glass:	
Bottle and container	2,627
Flat	555
Fiber	260
Other	258
Total	3,700
Chemical	1,420
Soaps and detergents	500
Pulp and paper	210
Water treatment	250
Other[1]	1,032
Total	3,412
Grand total	7,112

[1]Includes soda ash used in petroleum and metal refining, leather tanning, enamels, etc.

STOCKS

Depressed economic conditions in 1981 affected total sales of soda ash. As a result, producer inventories increased compared with those of previous years. In order to better analyze the domestic supply and demand balance of soda ash, effective June 1981, the Bureau of Mines started canvassing to obtain data on soda ash inventories stored on teamtracks, in terminals, and in warehouses in addition to the monthly survey of producers' plant stocks. Synthetic soda ash stocks were also canvassed for the first time as well. As a result, these yearend stocks, as reported by most of the producers, rose to 263,000 short tons. Yearend stocks of natural sodium sulfate were 66,000 short tons.

PRICES

The average value of bulk natural soda ash, f.o.b. Green River, Wyo., and Searles Valley, Calif., in 1981 was $91.19 per short ton, a slight increase over the 1980 average value of $89.85 per short ton. The f.o.b. price of dense, bulk soda ash of the four Wyoming producers increased from $86 per ton to $92 per ton effective July 1, 1981. Kerr-McGee Chemical Corp. raised its f.o.b. price of dense, bulk soda ash on July 15, 1981, from $103.25 to $106.25.

The average value of bulk natural sodium sulfate, f.o.b. mine or plant, of the three producers was $71.03 per short ton, an increase of 13.8% over the revised 1980 average value of $62.42 per short ton. Kerr-McGee increased its price of fine, standard, and coarse grades of bulk sodium sulfate from $82 to $85 per ton. The price for special coarse grade sodium sulfate increased $3 to $85 per ton and for pulp and paper grades of sodium sulfate, $4 to $79 per ton.

Yearend 1981 quoted prices of sodium carbonate and sodium sulfate are shown in table 7.

Table 7.—Sodium compounds yearend prices

	1980	1981
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	112.00
Dense, bulk, carlots, works do	86.00	92.00
Sodium sulfate (100% Na_2SO_4):		
Technical detergent, rayon-grade, bags, carlots do	$70.00- 72.00	$70.00- 72.00
Sodium sulfate, bulk, carlots, works[1] do	78.00	78.00
Domestic salt cake, bulk, works[1] do	47.00- 52.00	47.00- 52.00
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. 218, No. 26, Dec. 29, 1980, p. 34; v. 220, No. 26, Dec. 28, 1981, p. 36.

FOREIGN TRADE

The United States produced over one-fourth of the world's soda ash in 1981 and exported a total of 1,051,000 short tons to 58 countries. The distribution of exports on a regional basis was North America, 27.2%; South America, 23.7%; Asia, 20.6%; Africa, 14.7%; Europe, 7.6%; Oceania, 3.1%; Central America, 1.9%; and the Caribbean, 1.2%.

Table 8.—U.S. exports of sodium carbonate and sodium sulfate

(Thousand short tons and thousand dollars)

Year	Sodium carbonate		Sodium sulfate	
	Quantity	Value	Quantity	Value
1978	779	61,454	84	5,475
1979	997	86,663	102	8,516
1980	1,094	121,945	129	12,740
1981	1,051	121,107	124	12,980

Table 9.—U.S. imports for consumption of sodium sulfate

(Thousand short tons and thousand dollars)

Year	Crude (salt cake)[1]		Anhydrous		Total[1]	
	Quantity	Value	Quantity	Value	Quantity	Value
1978	41	1,701	96	4,890	[2]136	[2]6,590
1979	85	3,763	104	5,748	[2]188	9,511
1980	97	4,872	133	8,370	230	13,242
1981	136	8,038	139	11,097	275	19,135

[1]Includes Glauber's salt as follows: 1978, 1 ton ($1,157); 1979, 926 tons ($24,854); 1980, 1,418 tons ($37,372); 1981, 30 tons ($13,800).
[2]Crude and anhydrous quantities may not add to totals shown because of independent rounding.

Table 10.—U.S. imports for consumption of sodium carbonate and bicarbonate

(Thousand short tons and thousand dollars)

	1980		1981	
	Quantity	Value	Quantity	Value
Sodium carbonate	18	2,389	12	1,625
Sodium bicarbonate	2	425	3	680
Total	20	2,814	15	2,305

WORLD REVIEW

Bulgaria.—The European Economic Community (EEC) Commission imposed an antidumping duty of $26.07 per metric ton ($23.65 per short ton) on imports of Bulgarian light soda ash into Western Europe. Bulgaria and other centrally controlled economies were found guilty of similar violations in 1978. All countries except Bulgaria consented to raise their prices of soda ash to meet the established price level of $105.10 per metric ton ($95.35 per short ton). Bulgarian authorities filed a protest with the EEC Commission, stating that the antidumping allegation was unjustified and would cause severe hardships to the Bulgarian soda ash industry.[3]

Canada.—The Quebec government is considering a synthetic soda ash plant at Beconcour, midway between Montreal and Ontario, in order to reduce imports of soda ash from the United States. Asahi Glass Co., Ltd., one of the major Japanese soda ash producers, was commissioned to determine if the project would be competitive with the U.S. soda ash industry. If the project is accepted, Asahi Glass would probably supply the technology and may form a joint venture with the Canadians.[4]

Netherlands.—In an effort to comply with revised environmental and safety legislation, Akzo Zout Chemie Nederland B.V. announced it will spend $35 million to modernize its 450,000-ton-per-year capacity soda ash plant at Delfzijl. The work is scheduled to start early in 1982.[5]

Poland.—Labor strikes affected the Polish coal industry and resulted in coal shortages at the Janikowo soda ash plant. The plant began operation in 1978 with an annual capacity of about 450,000 tons. Approximately 100,000 tons of additional soda ash was to be produced for export in 1981; however, total production fell short of the estimated goal because of political and social problems.[6]

Spain.—The sodium sulfate mine of Criaderos Minerales y Derivados S.A. in Burgos Province resumed production in April 1981 after violence and protests prompted the mine closure several months earlier. Shortages of sodium sulfate in the detergent and paper industries necessitated the lifting of import tariffs by the Spanish Ministry of Commerce. The duties ranged from 9.9% for imports from the EEC countries to 13.2% for other countries. The tariffs were reinstated after production resumed at the mine.[7]

Table 11.—Sodium carbonate: World production, by country[1]

(Thousand short tons)

Country	1977	1978	1979	1980[p]	1981[e]
Albania[e]	25	[r]26	26	28	28
Australia[e]	175	180	180	200	210
Austria[e]	185	190	190	190	190
Belgium	487	471	[e]480	480	440
Brazil	155	133	131	143	140
Bulgaria	1,343	1,426	1,651	1,630	1,619
Canada[e]	500	500	500	500	500
Chad[2]	12	12	12	9	6
Chile[e]	11	12	12	12	11
China	[e]1,200	1,465	1,638	1,778	1,900
Colombia	155	184	147	137	140
Czechoslovakia	130	133	131	135	135
Denmark[3]	1	2	3	([4])	--
Egypt	NA	4	4	5	5
France	1,505	[r]1,491	1,708	[e]1,800	1,650
German Democratic Republic	925	939	948	955	960
Germany, Federal Republic of	1,489	1,356	1,544	1,555	1,540
Greece[e]	1	1	1	1	1
India	626	650	[e]670	660	660
Italy[e]	[r]105	[r]105	105	105	100
Japan	1,300	[r]1,281	1,493	1,494	1,430
Kenya[2]	[r]122	168	247	226	280
Korea, Republic of	[r]187	194	225	245	220
Mexico[5]	[e]460	456	463	[e]500	500
Netherlands	304	[r]315	[e]460	[e]460	460
Norway[e]	27	29	30	--	--
Pakistan	[r]94	[r]120	125	129	130
Poland	740	[r]806	754	840	770
Portugal	143	[r]144	202	193	187
Romania	949	991	984	1,033	1,070
Spain	[e]350	550	[e]550	555	550
Sweden[e]	1	1	1	1	1

See footnotes at end of table.

Table 11.—Sodium carbonate: World production, by country[1] —Continued

(Thousand short tons)

Country	1977	1978	1979	1980[p]	1981[e]
Switzerland[e]	50	50	50	50	50
Taiwan	88	85	89	102	82
Turkey[e]	65	70	75	65	65
U.S.S.R	5,375	5,355	5,271	5,269	5,290
United Kingdom[e]	1,650	1,760	1,550	1,500	1,433
United States[5]	8,040	8,290	8,253	8,275	[6]8,281
Yugoslavia	173	183	181	182	180
Total	[r]29,148	[r]30,128	31,084	31,442	31,214

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available.
[1]Table includes data available through May 12, 1982. Synthetic unless otherwise specified.
[2]Natural only.
[3]Production for sale only; excludes output consumed by producers.
[4]Less than 1/2 unit.
[5]Includes natural and synthetic.
[6]Reported figure.

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

(Thousand short tons)

Country[2]	1977	1978	1979	1980[p]	1981[e]
Natural:					
Argentina	40	45	40	21	28
Canada	435	415	488	547	610
Chile[3]	15	4	2	6	6
Egypt	6	3	4	4	3
Iran	44	39	[e]25	10	22
Mexico[4]	[r]120	[r]365	400	440	400
Spain	200	229	229	150	[5]176
Turkey	80	71	53	53	55
U.S.S.R.[e 6]	350	365	375	385	385
United States[7]	636	605	533	[3]583	[3]608
Total	[r]1,926	[r]2,141	2,149	2,199	2,293
Synthetic:					
Austria[e]	60	60	60	60	60
Belgium[e]	275	275	275	275	275
Chile[8]	33	48	76	66	66
Finland[e]	50	55	50	50	50
France	131	138	168	165	165
German Democratic Republic	[r]151	144	140	140	140
Germany, Federal Republic of	267	233	233	209	210
Greece[e]	7	7	8	12	12
Hungary[e]	11	11	11	11	11
Italy[e]	[r]10	[r]10	10	10	10
Japan	357	353	373	342	330
Netherlands	55	55	[e]55	55	55
Portugal	51	56	[e]50	57	55
Spain[9]	192	134	193	193	190
Sweden	116	116	116	116	116
U.S.S.R.[e 6]	250	265	265	275	275
United States[10]	[r]563	[r]564	[r]588	556	535
Total	[r]2,579	[r]2,524	[r]2,671	2,592	2,555

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through May 12, 1982.
[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 inadequate 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]Series revised to reflect output reported by Mexico's principal producer, Industrias Peñoles, S.A. In 1979, and probably in other years, an additional 20,000 tons (estimated) of natural sodium sulfate was produced by a smaller producer.
[5]Reported figures.
[6]Conjectural estimates based on 1968 information on natural sodium sulfate and general economic conditions.
[7]Sold or used by producers.
[8]Byproduct of nitrate industry.
[9]Quantities of synthetic sodium sulfate credited to Spain are reported in official sources in such a way 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.
[10]Derived approximate figure; data presented are the difference between reported total sodium sulfate production (natural and synthetic, undifferentiated) and reported natural sodium sulfate sold or used by producers (reported under "Natural" in this table).

TECHNOLOGY

A feasibility study was prepared under contract with the U.S Department of Energy detailing the use of soda ash in an experimental peat biogasification project. The abundant peat resources of the United States could be used as an alternate energy source. Soda ash would be used to solubilize the peat before oxidation and fermentation reactions convert the peat to methane. Preliminary data indicate that about 1 ton of soda ash would be needed for every 3 tons of peat converted. The major advantage of this biogasification process is that wet peat can be used without the need for predrying for treatment.[8]

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[1]Physical scientist, Division of Industrial Minerals.

[2]Chemical Week. PET Makes It Big in World Bottle Markets. V. 130, No. 8, Feb. 24, 1982, pp. 55-56.

[3]European Chemical News. EEC Slaps Antidumping Duty on Imports of Bulgarian Soda Ash. V. 37, No. 997, Sept. 7, 1981, p. 15.

[4]Chemical Week. Quebec Considers Soda Ash Production. V. 129, No. 16, Oct. 14, 1981, p. 27.

[5]European Chemical News. Akzo Invests Dfl. 45m. in Soda Ash Modernization. V. 37, No. 1009, Nov. 30, 1981, p. 29.

[6]Chemical Age. Coal Hitch Hits Polish Soda Ash. May 15, 1981, p. 12.

[7]Chemical Week. Spain Lifts the Duty on Sodium Sulfate. V. 128, No. 5, Feb. 4, 1981, p. 25.

[8]Dynatech R/D Co. Peat Biogasification Development Program. U.S. Dept. of Energy. Contract No. ACO1-79ET14696, Apr. 21, 1981, 150 pp.

Stone

By Harold A. Taylor, Jr.[1] and Valentin V. Tepordei[1]

A total of 873 million tons of crushed stone valued at $3.1 billion, f.o.b. plant, was reported produced in the United States in 1981. This tonnage is the lowest production reported in 11 years, 11% less than that of 1980 and 21% below the record high production of 1979, reflecting mainly the impact of the recession on the construction industry. About three-quarters of crushed stone production continued to be limestone, followed by granite, traprock, sandstone, shell, marl, volcanic cinder, marble, and slate, in order of volume.

Production of dimension stone totaled 1.33 million tons valued at $150.5 million in 1981, little changed in tonnage from the last 5 years. One-half of the dimension stone produced was granite, followed by limestone and sandstone.

The Bureau of Mines canvass of dimension stone does not include processors of purchased rough stone. All producers are covered; if the producer sells rough stone to a processor, it is tabulated as rough stone; if the producer processes finished stone, only the finished stone is tabulated, and the rough stone is deducted. The Bureau of Mines generally accepts the stone classification reported by producers.

Granite usually includes all coarser-grained igneous rocks. Limestone may be pure calcium carbonate or may be bituminous, dolomitic, or siliceous. The term "traprock" pertains to all dense, dark, fine-grained igneous rocks. Marble may include calcareous rock that will polish. Sandstone may be calcareous, quartz or quartzite, or a conglomerate. Quartzite may be described as any siliceous-cemented sandstone. Quartzite that has been comminuted to sand is included in the sand and gravel chapter.

Exports of crushed stone in 1981 increased 17% to 3.6 million tons, and imports decreased 7%. Ninety-two percent of the exported and 62% of the imported crushed stone was limestone. Domestic apparent consumption of crushed stone in 1981 was 873 million tons.

Although exports of dimension stone increased 29% in 1981, the quantity was still relatively minor. Imports of dimension stone value increased 48% to $131 million, equivalent to 87% of the value of domestic production. World production of dimension stone was about the same.

Table 1.—Salient stone statistics in the United States

(Thousand short tons and thousand dollars)

	1977	1978	1979	1980	1981
Sold or used by producers:					
Dimension stone	1,416	1,394	1,350	1,315	1,331
Value	$103,900	$113,100	$122,800	$138,900	$150,500
Crushed stone[1]	954,000	1,049,600	r1,099,500	r983,500	873,000
Value	$2,353,000	$2,773,000	r$3,275,900	r$3,265,800	$3,126,500
Total stone[2]	955,400	1,051,000	r1,100,850	r984,815	874,400
Total value[3]	$2,457,000	$2,886,000	r$3,398,700	r$3,404,700	$3,277,000
Exports (value)	$22,600	$31,400	$40,200	$36,400	$43,800
Imports for consumption (value):					
Dimension stone	$37,900	$51,700	$65,800	r$88,900	$131,400
Crushed stone	$10,700	$13,100	$16,000	$13,900	$13,900

rRevised.
[1]Includes volcanic cinder and scoria in 1979-81.
[2]Does not include American Samoa, Guam, Puerto Rico, and Virgin Islands.
[3]Data may not add to totals shown because of independent rounding.

Legislation and Government Programs.—In August 1981, the Economic Recovery Tax Act became Public Law 97-34. This law provides accelerated cost recovery system incentives for plant, equipment, and real property placed in service after 1980.

Despite the introduction of several bills in both houses of the 97th Congress favoring transfer of regulatory responsibility for mining all surface stone and sand and gravel from the Mine Safety and Health Administration (MSHA) to the Occupational Safety and Health Administration (OSHA), no final decision was made on this matter. A temporary restraint of MSHA's enforcement of safety rules in the surface mining of stone and sand and gravel operations was achieved by Congress by limiting the funding of the U.S. Department of Labor through March 1982.

Following a decision of the Federal Mine Safety and Health Review Commission, in April 1981, new guidelines were issued to MSHA inspectors regarding changes in their practice of designating "significant and substantial" violations of safety and health rules by the mine operators. A comparative analysis of the Mine Safety and Health Act and the Occupational Safety and Health Act was presented during the National Crushed Stone Association and National Sand and Gravel Association Government Affairs Conference in Washington, D.C., in April 1981.[2]

CRUSHED STONE[3]

DOMESTIC PRODUCTION

Of the total 873 million tons of crushed stone[4] produced in the United States in 1981, 646 million tons or 74% was limestone, 101 million tons or 12% was granite, and 71 million tons or 8% was traprock. Total quantities and values of crushed stone by kind produced in the United States in 1980 and 1981, as well as the approximate number of quarries producing each kind of stone are shown in table 2.

In 1981, the South Atlantic region led the Nation in the production of crushed stone with 206 million tons or 24% of the U.S. total. Next was the East North Central region with 152 million tons or 17% of the total, followed by West South Central with 124 million tons or 14%. If the four major geographic regions are compared, the South led the Nation in the production of crushed stone with 48% of the total, followed by the North Central with 28%, and the Northeast with 13%. Approximately 76% of the total U.S. crushed stone was produced in two major geographic regions, South and North Central.

A comparison of 1980 and 1981 production by regions indicates that, except for New England, output of crushed stone decreased in all regions in 1981 between 2% and 16%. The largest decrease in production was recorded in the West North Central region, 16%, significantly more than the national average of about 11%. In New England, production of crushed stone increased by 1% (table 4).

Based on 1980 census data on population, per capita crushed stone production in 1981 was 3.85 tons, a decrease of 11% from 1980. At the regional level, per capita production was 5.6 tons in the South, followed by the North Central with 4.1 tons, and the North East, and West with 2.3 tons each.

Crushed stone was produced in every State except Delaware and North Dakota. The 10 leading States in the production of crushed stone in 1981, in order of volume, were Texas, Florida, Pennsylvania, Illinois, Missouri, Virginia, Ohio, Georgia, California, and Tennessee. Their combined production represented 52% of the national total.

Production of crushed stone decreased in most States in 1981, including all of the top 10. The only States that showed an increase in production were Alaska, Arizona, Colorado, Maine, Massachusetts, New Hampshire, New Mexico, and Oklahoma, all small producers of crushed stone, except Oklahoma (table 3).

In 1981, a total of 1,809 producers of crushed stone with 5,137 quarries were canvassed by the Bureau of Mines; actual reports were received from 2,620 operations that produced about 75% of the total tonnage. Production for about 1,200 quarries was estimated. Most of the crushed stone produced in 1981 came from quarries with an annual output larger than 300,000 tons; 837 quarries, representing 22% of the total number of active quarries, produced 74% of the total tonnage. The number of crushed stone quarries by size, and their output, is shown in table 5. The 10 leading producers of crushed stone in 1981 were, in descending order of tonnage: Vulcan Materials Co.; Martin Marietta Aggregates; Koppers Co. Inc.; Lone Star Industries, Inc.; U.S. Forest

Service; Dolese Brothers Co.; General Dynamics Corp.; Genstar Ltd.; Florida Rock Industries, Inc.; and the United States Steel Corp.

In 1981, Vulcan Materials Co., the largest commercial producer of crushed stone in the world, bought 10 limestone operations: 5 quarries in Alabama from Trinity Quarries of Decatur, Ala., and 5 quarries in Illinois from Pontiac Stone Co. of Pontiac, Ill. It now operates a total of 84 quarries in the United States. Genstar Ltd. bought from Flintkote Stone Products Co. several limestone quarries located in Maryland, Virginia, New York, Arizona, and California. The quarries were being managed by a new subsidiary company, Genstar Stone Products. Amoco Minerals Co., a subsidiary of Standard Oil Co. of Indiana, bought a limestone quarry in Kentucky from Harbest Corp. Acadian Sand & Limestone Inc. of Abbeville, La., changed its name to Ingram Aggregates Inc. to reflect its relationship with the parent company, Ingram Industries Inc. of Nashville, Tenn.

A specific kind of stone—volcanic cinder and scoria—is included in this chapter for the first time. It had been included in prior years in the Pumice and Volcanic Cinder chapter.

Limestone.—Limestone includes dolomite. Compared with that of 1980, 1981 output of crushed limestone decreased 11% in tonnage and 4% in value to 646 million tons and $2,227 million. Limestone was produced by 1,238 companies at 2,673 quarries in 46 States. Leading States, in order of tonnage, were Texas, Florida, Illinois, Pennsylvania, and Missouri; these five States accounted for 40% of the total U.S. output. The 1981 production of crushed limestone decreased in most of the States, including the top five, by 2% to 17%. Leading U.S. producers were, in order of volume, Vulcan Materials Co., Martin Marietta Aggregates, and Lone Star Industries, Inc. These three companies accounted for 10% of total U.S. output (table 7).

Granite.—Compared with that of 1980, 1981 output of crushed granite decreased 14% in tonnage and 8% in value to 101 million tons and $386 million. Granite was produced by 132 companies at 361 quarries in 29 States. Leading States continued to be, in order of tonnage, Georgia, North Carolina, Virginia, and South Carolina; these four States accounted for 73% of U.S. output. The 1981 production of crushed granite decreased in most of the States, including the top four; the decrease was between 11% and 21%. Leading U.S. producers, in order of tonnage, were Vulcan Materials Co., Martin Marietta Aggregates, and Koppers Co. Inc.; their combined production repre-

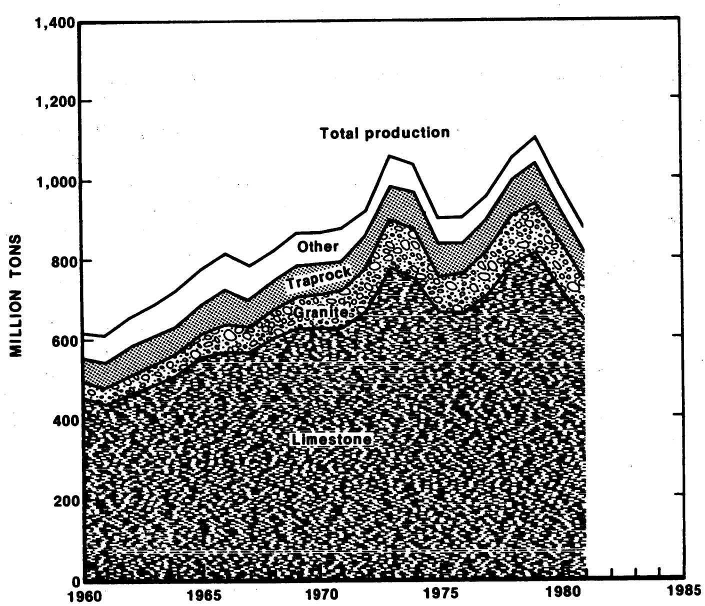

Figure 1.—Crushed stone sold or used by producers in the United States, by kind.

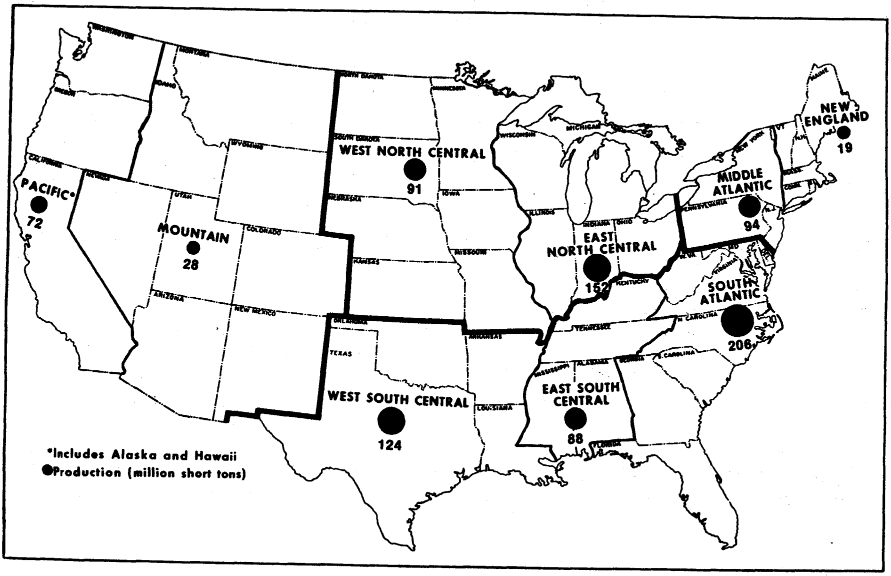

Figure 2.—Production of crushed stone by geographic region in 1981.

sented 46% of the U.S. total (table 8).

Traprock.—Compared with that of 1980, 1981 production of crushed traprock decreased 13% in tonnage and 6% in value to 71 million tons and $282 million. Traprock was produced by 293 companies at 514 quarries in 23 States. Leading States, in order of total tonnage were Oregon, New Jersey, and Washington; these three States accounted for 42% of U.S. output.

The 1981 production of crushed traprock decreased in most of the States, including the top three; the decrease was between 10% and 15%. Leading U.S. producers, in order of tonnage, were U.S. Forest Service, Tilcon Inc., and Koppers Co. Inc. Their combined production accounted for 25% of total U.S. output (table 9).

Sandstone.—Compared with that of 1980, 1981 output of crushed sandstone decreased 21% in tonnage and 18% in value to 23 million tons and $84 million. Crushed sandstone was produced by 150 companies at 319 quarries in 27 States. Leading States, in order of volume, were Arkansas, Pennsylvania, and California; these three States accounted for 40% of U.S. output. Leading producers of sandstone, in order of tonnage, were Martin Marietta Aggregates, East Bay Excavating Co. Inc., and U.S. Forest Service; their combined production represented 16% of the U.S. total (table 10).

Shell.—Shell is mainly fossil reefs of oyster shell. Compared with that of 1980, 1981 output of crushed shell decreased 1% to 10.8 million tons valued at $50 million. Crushed shell was produced by 13 companies at 21 quarries in 6 States. Louisiana accounted for 67% of U.S. output. The other major producing States, in order of volume, were Florida, Texas, and Alabama. Leading producers, in order of tonnage, were Radcliff Materials Inc. (a subsidiary of Dravo Corp.), Pontchartrain Dredging Corp., and Parker

Brothers & Co., Inc.; their combined production represented 69% of U.S. output.

Marble.—Compared with that of 1980, 1981 production of crushed marble decreased 21% to 1.1 million tons, valued at $22.5 million. Crushed marble was produced by 9 companies at 18 quarries in 6 States. Leading States, in order of tonnage, were Alabama, Georgia, and Texas. Alabama alone accounted for 49% of the U.S. total. Leading producers of crushed marble, in order of tonnage, were Georgia Marble Co., Standard Oil Co. of Indiana, and Moretti-Harrah Marble Co.; their combined production represented 87% of the total U.S. output (table 13).

Calcareous Marl.—Compared with that of 1980, 1981 output of marl showed a small increase of 3% to 3.8 million tons valued at $8.0 million. Marl was produced by 25 companies at 26 quarries in 9 States. South Carolina accounted for 71% of total U.S. output, followed by Texas and Mississippi. Leading producers, in order of tonnage, were Dundee Cement Co., Gifford-Hill & Co., Inc., and Giant Portland Cement Co.; their combined output accounted for 71% of the total U.S. production. These three leading producers of marl were also manufacturers of portland cement (table 11).

Volcanic Cinder and Scoria.—Compared with that of 1980, 1981 production of volcanic cinder and scoria increased 13% in tonnage and 19% in value to 3.7 million tons and $13.4 million. Volcanic cinder and scoria was produced by 50 companies from 199 operations in 8 States. Leading States, in order of volume, were Arizona, Oregon, California, and New Mexico; their combined production accounted for 84% of the total U.S. output. Leading producers, in order of tonnage, were U.S. Forest Service, Twin Mountain Rock Co., and Apache City Highway Department. These top three producers accounted for 67% of U.S. output (table 12).

Slate.—Compared with that of 1980, 1981 output of crushed slate decreased by 51% to 521,000 tons valued at $7.7 million. Crushed slate was produced by eight companies at nine quarries in six States. Leading States, in order of tonnage, were Virginia, Georgia, and Arkansas; their combined production accounted for 96% of U.S. output. Leading producers, in order of tonnage, were Galite Corp., Arvonia-Buckingham Slate Co., and Amlite Corp. The top three producers accounted for 79% of U.S. output.

Miscellaneous Stone.—Compared with that of 1980, 1981 output of miscellaneous crushed stone increased 6% in tonnage and 30% in value to 12.6 million tons and $45 million (table 14).

CONSUMPTION AND USES

The crushed stone production reported to the Bureau of Mines by producers is material "sold or used" by the producers. Stockpiled production is not reported until it is sold or used. Therefore, the sold or used tonnage represents the amount of production released for domestic consumption or export in a given year.

In 1981, U.S. consumption of crushed stone decreased 11% to 873 million tons valued at $3.1 billion. About 70% of this tonnage was used as construction aggregates, mostly for highway and road construction and maintenance, 14% was for cement and lime manufacturing, 4% was for agricultural purposes, and 2% was for metallurgical processes (table 15).

Limestone.—Of the 646 million tons of crushed limestone consumed in 1981, 67% was used as construction aggregates, 19% was for cement and lime manufacturing, and 5% was for agricultural purposes (table 16). No significant changes occurred in the use patterns of crushed limestone at the national level. At the State level, consumption of crushed limestone as construction aggregates decreased significantly in most of the top producing States, from 7% in Texas to between 13% and 20% in Pennsylvania, Ohio, Tennessee, Missouri, and Illinois, and 29% in Wisconsin. The only State that showed an increase in consumption of construction aggregates was Oklahoma, 12%.

Consumption of crushed limestone for lime manufacturing decreased between 13% and 35% in Ohio, Texas, and Alabama, but increased in Missouri, 7%, and Michigan, 10%. Consumption of aglime decreased significantly in Illinois, 16%, in Iowa and Missouri, 24% each, and in Florida, 27%. Also notable during 1981 were significant increases in the consumption of flux stone in Kentucky and riprap in New Mexico. The consumption of riprap in Illinois and railroad ballast in New York showed significant decreases (table 17).

Granite.—Of the 101 million tons of crushed granite consumed in 1981, 81% was used as construction aggregates, and 13% was used as railroad ballast. Compared with that of 1980, consumption of construction aggregates in 1981 decreased 16%, filter stone decreased 73%, and railroad ballast increased 6% (table 18).

Traprock.—Of the 71 million tons of crushed traprock consumed in 1981, 91% was used as construction aggregates, and 5% was used as railroad ballast (table 19).

Sandstone.—Of the 23 million tons of crushed sandstone consumed in 1981, 77% was used as construction aggregates, and 6% was used as railroad ballast (table 20).

Shell.—Of the 11 million tons of crushed shell consumed in 1981, 75% was used as construction aggregates, mostly for roads, and 11% was used for cement manufacturing. No significant changes in the use pattern occurred (table 21).

Calcareous Marl.—Of the 3.8 million tons of marl consumed in 1981, 92% was for cement manufacturing, and 7% was for agricultural purposes. No significant changes in the use pattern occurred.

Volcanic Cinder and Scoria.—Of the 3.7 million tons of volcanic cinder and scoria consumed in 1981, 92% was used as construction aggregates, mainly for road construction and maintenance (table 22). This was the only use that showed an increase.

Marble.—No significant changes in end-use patterns of crushed marble occurred in 1981 (table 23).

Slate.—Of the 521,000 tons of crushed slate consumed in 1981, 83% was used as construction aggregates, and 9% as slate flour. No significant changes occurred in the consumption pattern.

Miscellaneous Stone.—Of the 13 million tons of miscellaneous crushed stone consumed in 1981, 96% was used as construction aggregates, mainly for road construction and maintenance (table 24).

PRICES

Compared with that of 1980, the 1981 average unit price of crushed stone increased 8%, to $3.58 per ton. By kind of stone, the average unit prices showed increases from 4% for sandstone, 5% for volcanic cinder, and 8% for limestone, granite, and traprock, 19% for marble, 25% for shell, and 31% for slate. Crushed marl was the only kind of stone that showed a very small decrease in average unit price (table 2).

All unit prices by end use showed increases except for a significant decrease in unit price, 19%, for slate flour.

TRANSPORTATION

Of the total crushed stone produced in 1981, 83% was transported by truck from the plant or quarry to the site of the first point of sale or use, 8% was transported by rail, and 5% by waterway, as shown in table 6. Because most of the producers have not kept records or reported data regarding the distance to which crushed stone was shipped or the cost per ton per mile of the shipments, no transportation cost data have been available.

FOREIGN TRADE

Exports.—Exports of crushed stone, increased 17% to 3.6 million tons, and 22% in value to $25.9 million. Ninety-two percent of the crushed stone exported in 1981 was limestone and 91% of it was exported to Canada. Exports of quartzite also increased significantly to a total value of $2.5 million (table 25).

Imports.—Imports of crushed stone decreased 7% in 1981 to 3.4 million tons valued at $9.3 million. Approximately 62% of this tonnage was limestone, 93% of which came from Canada. Imports of quartzite, over 99% from Canada, more than quadrupled to 71,000 tons valued at $761,000.

Imports of calcium carbonate fines decreased 8% to 270,000 tons valued at $4.6 million; of this, aragonite from the Bahamas accounted for 90% on a tonnage basis but only 8% on a value basis. Imports of chalk whiting, 95% from France, increased 100% to 16,000 tons. About 10,000 tons of precipitated calcium carbonate was imported in 1981; of this, 41% came from France, 37% came from the United Kingdom, and 20% was imported from Japan (table 26).

WORLD REVIEW

The estimated world annual production of crushed stone in 1981, excluding centrally planned economy countries, was about 2.7 billion tons, a decrease of about 10% from the 1980 production. Of this total, the United States produced about one-third.

Canada.—Preliminary estimations of crushed stone production indicate a decrease of 8% in 1981 to 95 million tons, valued at $289 million. The estimated average unit price increased by 11% to $3.04 per ton. The Province of Quebec was the largest producer of crushed stone with over 50% of the total, followed by Ontario with about 30%.

TECHNOLOGY

The 64th annual convention of the National Crushed Stone Association was held in January 1981 in New Orleans, La. Energy conservation, use of computers in the crushed stone industry, improvements in quarry production, optimization of productivity in stone operations, and ground vibration and air blast were among the major topics discussed at the convention.[5]

The 36th annual convention of the National Limestone Institute was held in January 1981 in Washington, D.C. Mine safety regulations, including MSHA-OSHA transfer, transportation, and use of limestone for agricultural purposes were discussed at the convention.[6]

ConExpo'81, the largest heavy equipment exhibit ever organized in the Western Hemisphere, was held in February 1981 in Houston, Tex. Several new models of heavy mining and construction equipment were presented at the show as well as improvements on existing machinery.[7]

A special water-resistant concrete has been developed in Japan, for use in underwater construction projects, such as bridge or dam foundations. The concrete, called "hydrocrete," is made of cement, sand, and crushed stone and has strong adhesive properties that make it stable in water. The strength of the concrete can be controlled by changing the ratio of its components.[8]

A new process that will enable industrial boilers to burn high-sulfur coal cleanly was patented by Conoco Coal Development Co. and Stone & Webster Engineering Co. called "Solids Circulation Fluidized-Bed Combustion." The process consists of mixing coal with crushed limestone which reacts with the sulfur dioxide combustion product of the coal. Conoco planned to construct a commercial-size demonstration plant with a capacity of 50,000 pounds of steam per hour at its Lake Charles, La., chemical complex.[9]

High-quality mineral textile fibers with tensile strengths averaging 500,000 pounds per square inch, good chemical resistance, and high-temperature insulation characteristics was produced from basaltic waste by the Michigan Technological University at Houghton, Mich. Some of its possible applications include fabrics used in harsh chemical environments, concrete reinforcement, and as sound and thermal insulation. Basaltic fiber production has proven to be economically feasible, and a number of basalt fiber plants have been developed in Western Europe and the U.S.S.R.

Several articles dealing with crushed stone plant design,[10] plant operation and efficiency,[11] energy,[12] recycling of waste material,[13] blasting, drilling,[14] and transportation,[15] were discussed in several articles published during 1981.

Table 2.—Crushed stone sold or used by producers in the United States, by kind

Kind	1980				1981			
	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value
Limestone	2,806	723,166	$2,315,511	$3.20	2,673	646,168	$2,227,474	$3.45
Granite	406	117,949	417,985	3.54	361	101,073	386,322	3.82
Traprock	579	81,396	300,198	3.69	514	70,577	282,367	4.00
Sandstone	317	28,874	102,497	3.55	319	22,811	84,016	3.68
Shell	15	10,914	40,060	3.67	21	10,769	49,541	4.60
Marl	26	3,719	7,901	2.12	26	3,824	8,016	2.10
Volcanic cinder	199	r3,236	r11,258	r3.48	199	3,667	13,400	3.65
Marble	27	1,348	23,732	17.61	18	1,071	22,519	21.03
Slate	11	1,057	12,014	11.37	9	521	7,740	14.86
Miscellaneous	234	11,882	34,674	2.92	190	12,568	45,110	3.59
Total[1]	--	r983,542	r3,265,830	r3.32	--	873,050	3,126,504	3.58

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

Table 3.—Crushed stone sold or used by producers in the United States, by State[1]

(Thousand short tons and thousand dollars)

State	1980		1981	
	Quantity	Value	Quantity	Value
Alabama	23,433	82,270	20,706	88,377
Alaska	3,990	19,978	5,359	26,855
Arizona	[r]6,205	[r]24,780	6,315	26,263
Arkansas	20,666	61,399	13,834	47,260
California	[r]37,760	[r]118,140	34,560	118,698
Colorado	6,277	20,068	6,969	24,083
Connecticut	7,977	40,283	7,247	38,115
Florida	66,209	215,972	65,067	226,192
Georgia	40,884	162,642	35,730	153,751
Hawaii	6,341	30,634	6,036	31,403
Idaho	2,007	7,240	1,437	6,206
Illinois	53,309	180,656	44,159	165,218
Indiana	30,910	92,106	25,349	79,910
Iowa	26,542	92,603	22,424	82,891
Kansas	17,398	54,731	14,143	45,738
Kentucky	W	W	32,433	108,257
Louisiana	W	W	[2]7,228	[2]34,566
Maine	1,130	3,969	1,375	5,532
Maryland	18,945	77,431	16,485	74,289
Massachusetts	7,316	36,804	7,997	41,037
Michigan	32,121	91,727	30,013	94,324
Minnesota	8,606	21,731	6,995	18,438
Mississippi	W	W	[3]1,984	[3]5,451
Missouri	48,296	130,254	40,910	116,297
Montana	1,962	6,302	1,582	5,137
Nebraska	3,775	16,301	3,139	14,024
Nevada	1,809	7,407	1,343	5,664
New Hampshire	590	2,281	665	2,599
New Jersey	11,830	61,886	10,434	57,819
New Mexico	[r]2,581	[r]9,473	4,162	12,485
New York	34,483	120,764	30,681	117,689
North Carolina	34,764	125,019	28,833	117,092
Ohio	42,441	136,929	36,950	125,588
Oklahoma	28,173	76,267	29,930	83,407
Oregon	[r]19,251	[r]49,606	16,482	46,055
Pennsylvania	61,143	218,231	53,258	207,821
Rhode Island	203	1,208	141	1,116
South Carolina	16,107	49,207	14,825	49,830
South Dakota	3,151	8,942	2,985	9,085
Tennessee	38,584	126,993	[4]32,497	[4]113,729
Texas	76,483	220,265	72,454	219,086
Utah	[r]2,954	[r]12,123	2,840	12,157
Vermont	1,320	4,787	1,319	5,144
Virginia	44,615	167,839	37,071	152,630
Washington	[r]11,085	29,024	9,516	25,619
West Virginia	9,766	36,305	7,885	28,399
Wisconsin	20,603	49,245	15,189	39,962
Wyoming	4,374	14,835	3,224	9,858
Other	[r]45,172	[r]149,171	891	5,358
Total[5]	[r]983,542	[r]3,265,830	873,050	3,126,504
American Samoa	W	167	6	127
Guam	529	2,163	332	W
Puerto Rico	23,917	101,908	20,473	96,223
Virgin Islands	W	W	W	W

[r]Revised. W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes volcanic cinder and scoria.
[2]Does not include miscellaneous stone, to avoid disclosing company proprietary data; included with "Other."
[3]Does not include marl, to avoid disclosing company proprietary data; included with "Other."
[4]Does not include marble, to avoid disclosing company proprietary data; included with "Other."
[5]Data may not add to totals shown because of independent rounding.

Table 4.—Crushed stone sold or used in the United States, by region[1]

(Thousand short tons and thousand dollars)

Region	1980		1981	
	Quantity	Value	Quantity	Value
Northeast:				
New England	18,536	89,332	18,744	93,543
Middle Atlantic	107,456	400,881	94,374	383,329
North Central:				
East North Central	179,384	550,663	151,660	505,002
West North Central	107,768	324,562	90,596	286,472
South:				
South Atlantic	231,290	834,415	205,895	802,184
East South Central	98,886	324,567	87,943	316,346
West South Central	133,171	389,550	124,014	389,146
West:				
Mountain	r28,333	r103,249	27,872	101,852
Pacific	r78,715	r248,609	71,952	248,631
Total[2]	r983,542	r3,265,830	873,050	3,126,504

rRevised.
[1]Includes volcanic cinder and scoria.
[2]Data may not add to totals shown because of independent rounding.

Table 5.—Crushed stone[1] sold or used by producers in the United States, by size of operation

(Thousand short tons)

Size range	1980			1981		
	Number of operations	Quantity	Percent	Number of operations	Quantity	Percent
0 to 25	r1,264	r10,485	1	1,136	10,799	1
25 to 50	r628	r22,868	2	560	20,804	2
50 to 75	r291	r17,937	2	262	16,032	2
75 to 100	r219	r19,075	2	355	29,680	3
100 to 200	r662	r90,118	9	542	77,776	9
200 to 300	r352	r86,138	9	326	79,892	9
300 to 400	207	71,490	7	205	71,219	8
400 to 500	185	81,846	8	157	70,105	8
500 to 600	149	63,540	6	115	62,792	7
600 to 700	105	68,134	7	88	56,688	7
700 to 800	76	56,921	6	50	37,109	4
800 to 900	56	47,686	5	49	41,665	5
900 to 999	30	28,543	3	30	28,359	3
1,000 and over	171	318,760	33	144	270,130	32
Total[2]	r4,395	r983,542	100	4,019	873,050	100

rRevised.
[1]Volcanic cinder and scoria data included.
[2]Data may not add to totals shown because of independent rounding.

Table 6.—Crushed stone sold or used by producers in the United States, by method of transportation[1]

(Thousand short tons)

Method	1980		1981	
	Quantity	Percent	Quantity	Percent
Truck	805,418	82	719,109	83
Rail	81,838	9	70,940	8
Water	51,642	5	45,478	5
Other	41,407	4	33,855	4
Total	980,305	100	[2]869,383	100

[1]Volcanic cinder and scoria not included.
[2]Data do not add to total shown because of independent rounding.

Table 7.—Crushed limestone sold or used by producers in the United States, by State

(Thousand short tons and thousand dollars)

State	1980 Quantity	1980 Value	1981 Quantity	1981 Value
Alabama	21,412	65,948	19,159	72,620
Alaska	2,848	13,811	3,022	15,985
Arizona	4,580	19,017	4,520	18,949
Arkansas	8,737	24,215	6,116	18,888
California	17,359	61,054	16,108	58,968
Colorado	4,052	13,608	4,090	13,864
Florida	65,252	213,760	63,394	222,041
Georgia	6,143	23,738	5,618	24,277
Idaho	420	1,063	379	1,006
Illinois	53,309	180,656	44,159	165,218
Indiana	30,896	92,079	25,343	79,897
Iowa	26,542	92,603	22,424	82,891
Kansas	16,949	52,370	13,783	43,938
Kentucky	33,687	105,207	31,900	105,407
Maine	900	2,964	944	3,622
Maryland	12,018	50,659	10,801	49,440
Massachusetts	W	W	681	10,692
Michigan	32,056	91,629	29,568	92,909
Minnesota	5,797	14,314	4,918	13,295
Mississippi	1,996	4,667	1,984	5,451
Missouri	46,248	125,987	38,618	111,217
Montana	1,400	4,648	1,118	3,834
Nebraska	3,775	16,301	3,138	14,023
Nevada	1,208	5,485	1,043	4,351
New Mexico	1,273	4,396	1,728	6,353
New York	30,894	103,404	27,942	102,986
North Carolina	4,592	17,736	4,276	17,941
Ohio	41,938	134,923	36,667	124,004
Oklahoma	27,091	72,684	28,591	79,673
Pennsylvania	47,620	171,358	42,226	167,005
South Carolina	3,185	9,470	2,677	10,196
South Dakota	2,237	5,428	2,048	5,278
Tennessee	38,580	126,827	32,497	113,729
Texas	72,956	202,517	69,965	206,913
Utah	2,712	11,246	2,653	11,828
Vermont	1,123	4,036	1,093	4,230
Virginia	18,496	62,704	16,387	62,197
Washington	1,380	3,630	1,398	3,583
West Virginia	8,277	30,506	6,782	24,563
Wisconsin	16,957	39,405	12,148	30,759
Wyoming	2,646	9,524	1,750	5,924
Other[1]	3,624	29,931	2,510	17,528
Total[2]	723,166	2,315,511	646,168	2,227,474
Guam	529	2,163	332	W
Puerto Rico	20,981	91,214	18,462	87,788

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes Connecticut, Hawaii, New Jersey, Oregon, and Rhode Island.
[2]Data may not add to totals shown because of independent rounding.

Table 8.—Crushed granite sold or used by producers in the United States, by State

(Thousand short tons and thousand dollars)

State	1980 Quantity	1980 Value	1981 Quantity	1981 Value
Alabama	251	1,048	W	W
Alaska	767	4,142	929	5,275
Arizona	396	1,031	246	623
Arkansas	6,754	19,466	4,170	14,991
California	5,847	17,665	5,758	18,106
Colorado	1,935	5,205	2,394	7,906
Georgia	32,581	121,002	27,959	111,380
Idaho	368	1,458	W	W
Maryland	W	W	1,691	7,438
Massachusetts	756	2,848	1,093	4,168
Minnesota	2,591	6,582	1,913	4,516
Montana	8	16	W	W
Nevada	W	W	69	138
New Mexico	57	287	W	W
North Carolina	26,792	94,418	21,691	86,226
Oklahoma	W	144	W	W
South Carolina	10,614	35,173	9,424	34,140
Texas	23	528	--	--
Utah	1	2	--	--
Virginia	18,238	72,578	14,336	62,936
Washington	W	W	98	253
Wisconsin	W	W	462	1,227
Wyoming	1,703	4,754	1,474	3,934
Other[1]	8,267	29,640	7,365	23,065
Total[2]	117,949	417,985	101,073	386,322
Puerto Rico	W	W	W	W

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes Connecticut, Missouri, New Hampshire, New Jersey, Oregon, Pennsylvania, Rhode Island, and Vermont.
[2]Data may not add to totals shown because of independent rounding.

Table 9.—Crushed traprock sold or used by producers in the United States, by State

(Thousand short tons and thousand dollars)

State	1980 Quantity	1980 Value	1981 Quantity	1981 Value
Alaska	268	1,703	931	3,623
California	6,440	19,077	6,240	23,193
Colorado	84	271	W	W
Connecticut	7,346	35,653	6,927	35,359
Hawaii	4,944	24,326	4,471	23,741
Idaho	795	2,086	532	1,980
Maryland	3,728	14,311	W	W
Massachusetts	5,790	22,949	6,223	26,177
Michigan	37	44	1	2
Montana	123	290	W	W
New Jersey	8,936	42,511	8,023	41,012
New Mexico	178	426	W	W
New York	2,746	14,530	2,050	11,602
North Carolina	3,128	11,805	2,587	11,639
Oregon	16,781	43,051	14,331	40,179
Pennsylvania	3,493	12,374	3,216	11,975
Texas	52	220	W	W
Utah	160	399	--	--
Virginia	5,866	24,052	4,376	19,467
Washington	8,287	21,735	7,368	20,030
Wisconsin	1,402	5,278	1,031	4,242
Wyoming	10	21	--	--
Other[1]	803	3,086	2,270	8,146
Total[2]	81,396	300,198	70,577	282,367
American Samoa	W	167	6	127
Puerto Rico	2,146	6,657	1,177	4,143
Virgin Islands	W	W	290	2,565

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes Maine, Minnesota, Nevada (1980), and New Hampshire.
[2]Data may not add to totals shown because of independent rounding.

Table 10.—Crushed sandstone sold or used by producers in the United States, by State

(Thousand short tons and thousand dollars)

State	1980		1981	
	Quantity	Value	Quantity	Value
Arizona	194	758	261	1,524
Arkansas	5,053	15,215	3,432	11,375
California	4,131	9,482	2,504	6,231
Colorado	206	984	234	1,192
Idaho	421	2,623	371	2,833
Kansas	449	2,361	360	1,800
Kentucky	W	W	533	2,850
Maryland	271	2,191	139	691
Montana	430	1,348	316	1,068
Nebraska	--	--	1	2
New Mexico	710	2,149	W	W
New York	833	2,744	678	3,010
Ohio	503	2,006	283	1,584
Oklahoma	950	3,170	736	2,370
Oregon	708	2,508	577	2,126
Pennsylvania	3,850	17,059	3,137	13,634
South Dakota	914	3,515	937	3,807
Texas	1,613	7,437	1,069	4,261
Utah	W	W	187	329
Virginia	1,154	3,707	1,621	6,040
Washington	695	1,854	636	1,578
West Virginia	1,489	5,799	1,103	3,836
Wisconsin	W	W	1,548	3,734
Other[1]	4,302	15,587	2,151	8,142
Total[2]	28,874	102,497	22,811	84,016

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes Alabama (1980), Georgia, Maine, Minnesota, Missouri, and North Carolina (1981).
[2]Data may not add to totals shown because of independent rounding.

Table 11.—Crushed calcareous marl sold or used by producers in the United States, by State

(Thousand short tons and thousand dollars)

State	1980		1981	
	Quantity	Value	Quantity	Value
Florida	W	W	11	15
Indiana	13	27	6	13
Michigan	27	54	43	112
North Carolina	252	1,046	249	1,173
South Carolina	2,308	4,564	2,724	5,495
Virginia	5	10	3	7
Other[1]	1,113	2,200	787	1,201
Total[2]	3,719	7,901	3,824	8,016

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes Maine, Mississippi, and Texas.
[2]Data may not add to totals shown because of independent rounding.

Table 12.—Volcanic cinder and scoria sold or used by producers in the United States, by State

(Thousand short tons and thousand dollars)

State	1980		1981	
	Quantity	Value	Quantity	Value
Arizona	981	3,215	1,087	3,186
California	510	1,819	672	2,961
Colorado	W	W	107	615
Hawaii	W	W	373	1,364
New Mexico	364	2,214	445	2,891
Oregon	871	1,416	878	1,547
Utah	35	347	--	--
Other[1]	r475	r2,247	104	836
Total	r3,236	r11,258	[2]3,667	13,400
American Samoa	3	32	--	--

rRevised. W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes Nevada and Washington.
[2]Data do not add to total shown because of independent rounding.

Table 13.—Crushed marble sold or used by producers in the United States, by State

(Thousand short tons and thousand dollars)

State	1980		1981	
	Quantity	Value	Quantity	Value
Alabama	766	12,544	522	11,419
Arizona	54	758	32	611
Missouri	4	197	W	W
Tennessee	4	166	W	W
Texas	112	2,117	79	1,891
Wyoming	15	536	--	--
Other[1]	393	7,413	439	8,598
Total	1,348	[2]23,732	[2]1,071	22,519
Puerto Rico	W	W	W	W

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes Georgia, Utah (1980) and Washington (1980).
[2]Data do not add to total shown because of independent rounding.

Table 14.—Crushed miscellaneous stone sold or used by producers in the United States, by State

(Thousand short tons and thousand dollars)

State	1980		1981	
	Quantity	Value	Quantity	Value
Alaska	107	322	477	1,972
Arizona	--	--	169	1,369
California	3,455	8,569	3,259	8,665
Idaho	3	10	154	384
Maryland	466	1,327	2,525	10,523
Michigan	--	--	400	1,300
Nevada	187	529	143	514
Oklahoma	W	270	W	W
Oregon	273	620	73	130
Virginia	160	391	W	W
Washington	626	1,626	--	--
Other[1]	6,604	21,009	5,368	20,252
Total[2]	11,882	34,674	12,568	45,110

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes Arkansas, Colorado (1981), Hawaii, Louisiana, Massachusetts (1980), Pennsylvania, Rhode Island, and Vermont.
[2]Data may not add to totals shown because of independent rounding.

Table 15.—Crushed stone sold or used by producers in the United States, by use

(Thousand short tons and thousand dollars)

Use	1980 Quantity	1980 Value	1981 Quantity	1981 Value
Agricultural limestone	33,262	130,272	29,028	127,075
Agricultural marl and other soil conditioners	r683	r3,288	738	3,884
Poultry grit and mineral food	2,621	21,826	2,182	19,388
Concrete aggregate (coarse)	r127,243	r456,788	114,935	450,819
Bituminous aggregate	r90,513	r339,415	80,589	326,398
Macadam aggregate	25,131	79,515	19,138	63,901
Dense-graded road base stone	r221,614	r653,799	192,456	612,416
Surface treatment aggregate	45,294	156,303	34,798	132,127
Other construction aggregate and road stone	180,717	566,012	158,252	528,805
Riprap and jetty stone	23,650	75,808	19,080	68,632
Railroad ballast	r30,319	r91,663	28,351	91,021
Filter stone	5,656	19,453	4,390	15,565
Manufactured fine aggregate (stone sand)	20,241	80,078	18,085	73,174
Terrazzo and exposed aggregate	r1,340	r15,519	904	11,082
Cement manufacture	99,106	234,576	96,482	247,222
Lime manufacture	30,261	95,051	29,421	100,955
Dead-burned dolomite	2,001	6,329	2,391	7,498
Ferrosilicon	133	965	143	1,016
Flux stone	16,123	60,133	14,550	61,577
Refractory stone (including ganister)	1,012	4,749	93	470
Chemical stone for alkali works	1,852	5,739	1,548	5,801
Abrasives	68	680	78	975
Mine dusting	1,331	10,412	1,161	10,541
Asphalt filler	948	7,141	1,400	11,107
Whiting or whiting substitute	969	23,286	861	26,912
Other fillers or extenders	3,730	50,511	3,518	48,984
Building materials	90	262	64	218
Chemicals	W	W	665	1,880
Bedding materials	308	1,118	--	--
Drain fields	72	150	W	W
Fill	r3,853	r8,269	6,724	16,124
Slate flour	54	1,067	45	709
Glass manufacture	2,134	15,841	2,021	16,284
Lightweight aggregate	503	8,053	238	4,892
Paper manufacture	89	397	W	W
Roofing granules	r4,488	r17,556	4,485	18,094
Sugar refining	1,518	7,433	1,220	6,704
Waste materials	53	145	43	133
Sulfur removal from stack gases	667	2,129	563	1,550
Other[1]	3,893	r14,096	2,407	12,568
Total[2]	r983,542	r3,265,830	873,050	3,126,504

rRevised to include volcanic cinder and scoria. W Withheld to avoid disclosing company proprietary data; included with "Other."

[1]Includes acid neutralization, carbon dioxide, and other uses.

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

Table 16.—Crushed limestone sold or used by producers in the United States, by use

(Thousand short tons and thousand dollars)

Use	1980 Quantity	1980 Value	1981 Quantity	1981 Value
Agricultural limestone	33,262	130,272	29,028	127,075
Agricultural marl and other soil conditioners	391	2,167	448	2,573
Poultry grit and mineral food	2,335	20,664	2,002	18,274
Concrete aggregate	98,158	336,576	86,367	319,405
Bituminous aggregate	57,835	204,794	49,252	191,533
Macadam aggregate	19,897	59,719	15,978	51,166
Dense-graded road base stone	151,869	418,500	132,305	392,535
Surface treatment aggregate	36,445	126,260	28,853	107,848
Other construction aggregate and road stone	116,622	355,856	105,814	340,892
Riprap and jetty stone	15,321	46,709	12,812	42,651
Railroad ballast	12,966	38,631	10,628	37,003
Filter stone	3,497	11,308	3,544	12,287
Manufactured fine aggregate (stone sand)	15,204	58,716	13,345	51,994
Terrazzo and exposed aggregate	577	6,091	473	5,129
Cement manufacture	94,009	222,167	91,222	233,675
Lime manufacture	29,662	93,629	28,847	98,776
Dead-burned dolomite	2,001	6,329	2,391	7,498
Flux stone	15,313	55,885	13,870	57,157
Refractory stone	880	2,001	66	241
Chemical stone for alkali works	1,852	5,739	1,548	5,801
Abrasives	49	526	77	967
Mine dusting	1,307	10,349	1,133	10,462
Asphalt filler	761	6,048	997	8,136
Whiting or whiting substitute	666	20,742	628	21,160
Other filler or extenders	2,808	32,964	2,682	33,818
Building products	88	258	W	W
Other chemicals	W	W	665	1,880
Fill	2,092	4,804	5,835	14,094
Glass manufacture	2,134	15,841	2,021	16,284
Paper manufacture	89	397	W	W
Roofing granules	476	3,589	485	3,718
Sugar refining	1,518	7,433	1,220	6,704
Waste material	53	145	43	133
Sulfur removal from stack gases	667	2,129	563	1,550
Other[1]	2,362	8,275	1,025	5,055
Total[2]	723,166	2,315,511	646,168	2,227,474

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes acid neutralization, bedding material (1980), carbon dioxide, drain fields, and other uses.
[2]Data may not add to totals shown because of independent rounding.

Table 17.—Crushed limestone sold or used by producers

(Thousand short tons

State	Aggregates		Cement		Aglime		Lime	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	11,103	41,374	3,375	8,896	1,150	6,153	1,694	7,626
Alaska	3,022	15,985	--	--	--	--	--	--
Arizona	1,125	3,382	W	W	--	--	1,088	4,910
Arkansas	2,347	7,483	1,726	3,887	371	1,484	W	W
California	2,313	7,464	12,205	36,425	W	W	W	W
Colorado	682	2,059	2,745	9,090	3	11	49	171
Connecticut	W	W	37	76	80	651	22	42
Florida	52,670	185,867	2,432	7,816	1,264	7,064	387	1,062
Georgia	2,723	12,206	W	W	718	3,042	--	--
Hawaii	454	3,664	696	2,394	W	W	W	W
Idaho	4	10	W	W	35	104	--	--
Illinois	33,186	118,124	2,759	6,093	4,351	16,207	W	W
Indiana	19,478	61,381	2,461	5,472	1,975	6,929	--	--
Iowa	15,959	60,403	2,631	5,168	2,323	8,757	204	686
Kansas	9,736	34,415	3,150	6,915	385	1,167	--	--
Kentucky	23,765	78,931	W	W	1,963	7,203	1,621	3,913
Maine	211	755	W	W	W	W	--	--
Maryland	8,851	30,966	1,055	2,379	W	W	17	64
Massachusetts	W	W	--	--	128	1,568	W	W
Michigan	6,769	20,593	6,357	14,251	248	948	8,450	28,166
Minnesota	3,791	10,151	--	--	599	1,691	--	--
Mississippi	332	852	W	W	799	3,042	--	--
Missouri	23,129	70,439	5,037	11,063	3,051	9,363	3,107	6,116
Montana	--	--	W	W	--	--	--	--
Nebraska	1,845	8,955	W	W	186	801	W	83
Nevada	--	--	W	W	--	--	W	W
New Mexico	927	2,439	W	W	--	--	W	W
New York	20,446	82,317	5,187	10,798	255	1,697	W	W
North Carolina	3,111	13,139	W	W	21	96	--	--
Ohio	24,655	82,012	2,394	8,365	1,612	6,938	2,768	7,298
Oklahoma	23,013	62,677	2,514	4,759	602	1,300	W	W
Pennsylvania	25,969	96,328	6,770	17,295	1,687	13,012	2,886	12,127
South Carolina	2,246	7,808	--	--	271	1,917	--	--
South Dakota	1,134	3,493	W	W	W	W	179	359
Tennessee	26,573	89,509	1,564	5,195	1,702	5,562	235	1,076
Texas	53,401	160,201	10,507	21,077	407	1,554	1,979	6,782
Utah	W	W	820	3,381	127	945	338	1,518
Vermont	698	2,212	--	--	147	1,013	--	--
Virginia	10,568	36,325	1,365	2,616	1,581	10,244	1,475	5,701
Washington	129	228	W	W	24	362	--	--
West Virginia	4,562	18,664	W	W	24	190	W	W
Wisconsin	11,018	25,921	--	--	696	2,589	W	W
Wyoming	623	2,431	336	W	--	--	W	W
Total (excluding withheld)[1]	432,568	1,461,163	78,124	193,412	28,785	123,605	26,500	87,700
Total withheld[2]	304	3,055	13,098	40,265	244	3,467	2,348	11,078
Guam	317	W	--	--	--	--	--	--
Puerto Rico	W	W	W	W	W	W	--	--

W Withheld to avoid disclosing company proprietary data; included with "Total withheld" and "Other uses."
[1]Data may not add to totals shown because of independent rounding.
[2]Includes New Jersey, Oregon, and Rhode Island.

in the United States in 1981, by State and use

and thousand dollars)

Flux stone		Riprap		Railroad ballast		Other uses		Total[1]	
Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
360	1,100	983	3,908	W	W	494	3,564	19,159	72,620
--	--	--	--	--	--	--	--	3,022	15,985
151	625	17	83	--	--	2,140	9,950	4,520	18,949
W	W	325	1,028	426	1,331	922	3,676	6,116	18,888
70	364	69	175	--	--	1,451	14,540	16,108	58,968
394	W	W	W	--	--	217	2,533	4,090	13,864
W	W	--	--	--	--	W	W	W	W
--	--	256	687	--	--	6,385	19,545	63,394	222,041
--	--	75	220	W	W	2,102	8,809	5,618	24,277
--	--	--	--	--	--	W	W	W	W
--	--	23	61	--	--	318	831	379	1,006
619	2,869	388	1,403	943	4,768	1,914	15,754	44,159	165,218
W	W	285	1,067	738	2,304	406	2,744	25,343	79,897
W	W	232	1,221	639	2,231	437	4,425	22,424	82,891
--	--	136	394	46	208	331	838	13,783	43,938
47	164	2,263	6,809	482	1,631	1,759	6,756	31,900	105,407
--	--	W	W	W	W	733	2,867	944	3,622
--	--	155	760	95	295	627	14,976	10,801	49,440
W	W	W	W	--	--	553	9,123	681	10,692
6,537	25,055	W	W	378	1,081	829	2,815	29,568	92,909
--	--	257	681	W	W	270	772	4,918	13,295
--	--	139	397	W	W	714	1,161	1,984	5,451
W	W	2,948	7,672	163	389	1,183	6,175	38,618	111,217
38	W	3	8	--	--	1,077	3,826	1,118	3,834
16	81	115	686	W	W	976	3,417	3,138	14,023
--	--	--	--	--	--	1,043	4,351	1,043	4,351
28	W	67	279	W	W	705	3,635	1,728	6,353
W	W	454	2,215	229	628	1,371	5,331	27,942	102,986
--	--	W	W	W	W	1,144	4,707	4,276	17,941
1,911	5,784	448	1,573	1,084	3,302	1,795	8,732	36,667	124,004
--	--	729	2,067	1,216	5,039	516	3,830	28,591	79,673
2,157	11,615	411	1,677	859	3,165	1,486	11,785	42,226	167,005
--	--	W	W	W	W	160	471	2,676	10,196
--	--	W	W	56	135	679	1,291	2,048	5,278
58	290	495	1,648	215	723	1,655	9,726	32,497	113,729
635	2,105	237	1,064	823	2,818	1,976	11,312	69,965	206,913
W	W	W	W	W	W	1,368	5,984	2,653	11,828
--	--	W	W	W	W	247	1,006	1,093	4,230
73	226	67	289	384	1,135	874	5,663	16,387	62,197
--	--	W	W	--	--	1,245	2,992	1,398	3,583
--	--	37	175	480	1,346	1,678	4,189	6,782	24,563
W	W	346	1,877	W	W	89	371	12,148	30,759
--	--	W	W	W	W	790	3,492	1,750	5,924
13,095	50,278	11,960	40,124	9,256	32,529	44,656	227,965	643,655	2,209,945
777	6,881	855	2,529	1,371	4,476	1,221	10,700	2,510	17,528
--	--	3	7	--	--	12	28	332	W
--	--	W	W	--	--	W	W	W	W

Table 18.—Crushed granite sold or used by producers in the United States, by use

(Thousand short tons and thousand dollars)

Use	1980 Quantity	1980 Value	1981 Quantity	1981 Value
Poultry grit and mineral food	36	422	16	166
Concrete aggregate	18,144	70,435	18,777	81,431
Bituminous aggregate	16,694	66,583	14,424	61,139
Macadam aggregate	1,863	7,564	1,076	4,274
Dense-graded road base stone	32,228	109,432	26,909	99,998
Surface treatment aggregate	3,422	12,408	2,612	10,795
Other construction aggregate and road stone	22,718	77,636	16,160	61,236
Riprap and jetty stone	2,836	11,074	2,011	8,462
Railroad ballast	12,278	35,231	13,003	36,914
Filter stone	1,458	5,574	396	1,338
Manufactured fine aggregate (stone sand)	3,026	10,101	2,985	10,773
Terrazzo and exposed aggregate	206	1,393	107	569
Asphalt filler	144	810	134	839
Fill	322	630	231	479
Roofing granules	1,599	4,594	1,636	5,250
Other[1]	975	4,097	595	2,659
Total[2]	117,949	417,985	101,073	386,322

[1]Includes bedding material (1980), and other uses.
[2]Data may not add to totals shown because of independent rounding.

Table 19.—Crushed traprock sold or used by producers in the United States, by use

(Thousand short tons and thousand dollars)

Use	1980 Quantity	1980 Value	1981 Quantity	1981 Value
Concrete aggregate	7,685	35,144	6,950	35,750
Bituminous aggregate	11,633	52,384	12,622	56,661
Macadam aggregate	2,579	9,429	1,957	8,044
Dense-graded road base stone	20,222	69,769	17,556	66,342
Surface treatment aggregate	3,925	11,729	1,903	6,923
Other construction aggregate and road stone	25,074	82,106	20,479	68,206
Riprap and jetty stone	3,665	11,577	2,699	11,927
Railroad ballast	3,397	13,041	3,271	13,060
Filter stone	409	1,479	227	970
Manufactured fine aggregate (stone sand)	986	7,041	839	6,088
Terrazzo and exposed aggregate	10	56	2	13
Mine dusting	24	63	28	79
Other filler	22	117	W	W
Building products	2	4	2	4
Bedding materials	W	19	--	--
Drain fields	1	2	--	--
Fill	W	W	79	170
Roofing granules	1,526	5,138	1,548	5,105
Other[1]	285	1,099	417	3,026
Total[2]	81,396	300,198	70,577	282,367

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes asphalt filler and other uses.
[2]Data may not add to totals shown because of independent rounding.

Table 20.—Crushed sandstone sold or used by producers in the United States, by use

(Thousand short tons and thousand dollars)

Use	1980 Quantity	1980 Value	1981 Quantity	1981 Value
Concrete aggregate	2,393	10,096	2,141	9,580
Bituminous aggregate	3,699	13,332	3,475	13,883
Macadam aggregate	228	1,084	112	371
Dense-graded road base stone	7,123	21,062	4,826	15,553
Surface treatment aggregate	1,219	5,101	880	3,636
Other construction aggregate and road stone	7,373	22,986	5,399	17,390
Riprap and jetty stone	1,143	4,371	731	3,042
Railroad ballast	1,448	4,075	1,320	3,593
Filter stone	227	971	198	904
Manufactured fine aggregate (stone sand)	934	3,815	772	3,134
Terrazzo and exposed aggregate	100	1,446	15	265
Cement manufacture	669	2,382	611	2,191
Ferrosilicon	87	848	143	1,016
Flux stone	810	4,248	680	4,420
Refractory stone	133	2,749	27	230
Abrasives	18	155	W	W
Drain fields	67	131	W	W
Fill	205	261	391	719
Roofing granules	751	1,876	697	1,868
Other[1]	247	1,508	393	2,222
Total	28,874	102,497	22,811	84,016

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes poultry grit, other fillers or extenders, and other uses.

Table 21.—Crushed shell sold or used by producers in the United States, by use

(Thousand short tons and thousand dollars)

Use	1980 Quantity	1980 Value	1981 Quantity	1981 Value
Agricultural marl and other soil conditioners	--	--	9	20
Poultry grit and mineral food	228	547	145	743
Dense-graded road base stone	2,652	13,871	3,515	16,641
Surface treatment aggregate	--	--	369	2,352
Other construction aggregate and road stone	5,001	16,881	4,235	18,403
Cement manufacture	1,200	3,751	1,133	4,588
Fill	W	1,039	77	180
Other[1]	1,834	3,969	1,286	6,613
Total[2]	10,914	40,060	10,769	49,541

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes bituminous aggregate, riprap, lime manufacture, and other uses.
[2]Data may not add to totals shown because of independent rounding.

Table 22.—Volcanic cinder and scoria sold or used by producers in the United States, by use

(Thousand short tons and thousand dollars)

Use	1980 Quantity	1980 Value	1981 Quantity	1981 Value
Concrete admixture and aggregate[1]	514	3,316	534	4,020
Landscaping	209	2,513	184	2,568
Railroad ballast	140	377	31	50
Road construction and maintenance	[r]2,292	[r]4,628	2,856	6,230
Other[2]	82	426	63	532
Total[3]	[r]3,236	11,258	3,667	13,400

[r]Revised.
[1]Includes cinder block.
[2]Includes asphalt mix, horticultural uses, roofing granules, drain fill, fill, and miscellaneous uses.
[3]Data may not add to totals shown because of independent rounding.

Table 23.—Crushed marble sold or used by producers in the United States, by use

(Thousand short tons and thousand dollars)

Use	1980		1981	
	Quantity	Value	Quantity	Value
Poultry grit and mineral food	15	166	13	177
Surface treatment aggregate	--	--	39	167
Manufactured fine aggregate (stone sand)	14	267	9	229
Terrazzo and exposed aggregate	169	3,840	91	2,345
Whiting or whiting substitute	W	W	233	5,753
Roofing granules	W	W	4	96
Other[1]	1,150	19,459	682	13,752
Total	1,348	23,732	1,071	22,519

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes concrete aggregate, riprap, and other fillers or extenders (1980).

Table 24.—Crushed miscellaneous stone sold or used by producers in the United States, by use

(Thousand short tons and thousand dollars)

Use	1980		1981	
	Quantity	Value	Quantity	Value
Concrete aggregate	372	995	144	411
Bituminous aggregate	579	2,132	575	2,417
Macadam aggregate	563	1,719	14	47
Dense-graded road base stone	5,074	16,133	4,451	14,990
Surface treatment aggregate	283	808	141	407
Other construction aggregate and road stone	3,529	9,477	6,017	22,252
Riprap and jetty stone	592	1,395	735	1,865
Railroad ballast	90	308	99	401
Terrazzo and exposed aggregate	70	180	32	194
Other fillers	5	30	59	W
Fill	556	1,113	94	339
Roofing granules	W	W	26	140
Other[1]	168	384	181	1,647
Total	[2]11,882	34,674	12,568	45,110

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes filter stone, manufactured fine aggregate (stone sand), cement manufacture (1981), and other uses.
[2]Data do not add to total shown because of independent rounding.

Table 25.—Exports of crushed stone, by destination

(Thousand short tons)

Destination	Quartzite 1980	Quartzite 1981	Limestone[1] 1980	Limestone[1] 1981	Other 1980	Other 1981	Total 1980	Total 1981
North America:								
Bahamas	--	--	(2)	(2)	57	12	57	12
Canada	4	4	2,647	3,273	r123	3166	r2,774	3,443
Mexico	(2)	(2)	(2)	1	10	32	10	33
Other	(2)	(2)	8	2	7	4	15	6
Total	4	4	2,655	3,276	r197	214	2,856	3,494
South America:								
Venezuela	--	(2)	68	31	23	1	91	32
Other	(2)	--	18	1	5	1	23	2
Total	(2)	(2)	86	32	28	2	114	34
Europe:								
France	(2)	3	--	--	18	15	18	18
Netherlands	1	3	--	--	--	(2)	1	3
Other	43	51	2	1	11	13	16	15
Total	4	7	2	1	r29	28	35	36
Asia:								
Japan	2	1	--	--	r58	2	60	3
Other	(2)	1	(2)	(2)	8	1	8	2
Total	2	2	(2)	(2)	r66	3	68	5
Oceania	--	(2)	1	1	9	22	10	23
Middle East and Africa[6]	(2)	(2)	(2)	1	1	5	1	6
Grand total	10	13	2,744	3,311	r330	274	3,084	3,598
Total value (thousands)	$1,707	$2,494	$13,699	$15,982	$5,833	$7,473	$21,239	$25,949

rRevised.
[1]Includes ground limestone.
[2]Less than 1/2 unit.
[3]Includes an estimated 7,000 tons of slate waste and powder exported to Canada.
[4]Includes the Federal Republic of Germany and Belgium in order of volume.
[5]Includes the Federal Republic of Germany, Switzerland, and the United Kingdom in order of volume.
[6]Includes Libya.

Table 26.—U.S. imports of crushed stone and stone fines, by type

Type	1980 Quantity	1980 Customs value (thousands)	1981 Quantity	1981 Customs value (thousands)
Crushed stone and chips:				
Limestone thousand short tons	2,375	$6,966	2,092	$5,166
Marble, breccia, onyx short tons	2,109	113	8,838	482
Quartzite thousand short tons	r15	r211	71	761
Slate short tons	--	--	541	4
Other thousand short tons	1,198	3,286	1,183	2,887
Total do	r3,590	r10,576	13,355	9,300
Calcium carbonate fines:				
Chalk, natural crude do	280	369	244	344
Chalk, whiting do	8	858	16	1,694
Precipitated do	6	2,021	10	2,539
Total do	294	3,248	2270	4,577
Grand total do	r3,884	r13,824	3,625	13,877

rRevised.
[1]Includes Canada, 95%, and the Dominican Republic (limestone), 5%.
[2]Includes the Bahamas (natural crude chalk), 90%; France (chalk whiting and precipitated calcium carbonate), 7%; the United Kingdom (mostly precipitated calcium carbonate), 2%; and Japan (precipitated calcium carbonate), 1%.

DIMENSION STONE[16]

DOMESTIC PRODUCTION

Dimension stone was produced by 254 companies at 437 quarries in 38 States. Leading States, in order of tonnage, were Georgia, Vermont, and Indiana, producing, together, 47% of the Nation's total. Notable in 1981 was a 16% increase in output from Georgia and a 22% increase from Vermont. Of the total U.S. production; 51% was granite, 21% was limestone, 13% was sandstone, 9% was slate, and 4% was marble. A 33% increase in slate production occurred in 1981. Leading companies were, in 1981, Rock of Ages Corp. in Vermont and Cold Spring Granite Co., principally in California, Minnesota, South Dakota, and Texas.

Granite.—Compared with that of 1980, 1981 output of dimension granite increased 3% in tonnage and 4% in value to 681,550 tons and $82.9 million. Dimension granite was produced by 85 companies at 119 quarries in 20 States. Georgia continued to be the leading State producing 37% of the U.S. total, followed by Vermont and New Hampshire. These three States together produced 63% of the U.S. total. Notable were a 25% production increase in Georgia and a 14% decrease in New Hampshire. Leading companies were Rock of Ages Corp. and Cold Spring Granite Co. It was estimated that the three leading companies produced 31% of U.S. output.

Limestone.—Compared with that of 1980, 1981 output of dimension limestone decreased 5% in tonnage and increased 3% in value to 279,700 tons and $22.0 million. Dimension limestone was produced by 58 companies at 68 quarries in 18 States. Indiana continued to be the leading State, followed by Wisconsin. The top two producers, in order of value, were Indiana Limestone Co. and Elliott Stone Corp., Inc., both in Indiana.

Sandstone.—Compared with that of 1980, 1981 output of dimension sandstone increased 5% in tonnage and 53% in value to 178,300 tons and $11.8 million. Dimension sandstone was produced by 65 companies at 184 quarries in 24 States. Leading States continued to be, in order of volume, Ohio, Pennsylvania, and New York; these three States accounted for 52% of U.S. output. Notable were a 43% increase in production in Ohio and a 19% decrease in Pennsylvania. Leading producers were, in order of tonnage, Delaware Quarries Inc. in Pennsylvania and Standard Slag Co. in Ohio. The top three producers accounted for 28% of U.S. production, compared with 32% (revised) in 1980.

Slate.—Compared with that of 1980, 1981 output of dimension slate increased 33% to 120,000 tons valued at $19.6 million. Dimension slate was produced by 28 companies at 37 quarries in 6 States. The two leading States, Vermont and Pennsylvania, in order of volume, accounted for 93% of U.S. output. The top three producers accounted for an estimated 65% of U.S. output.

Marble.—Dimension marble included crystalline marble, certain hard limestones, and any other calcareous stone capable of accepting a polish. Output of dimension marble decreased 3% to 58,500 tons valued at $13.8 million. Total value did not change significantly compared with that of 1980. Dimension marble was produced by 11 companies at 18 quarries in 12 States. Vermont, Georgia, and Texas, in order of tonnage, were the three leading States, accounting for almost three-quarters of U.S. output. Leading producers were, in order of tonnage, Georgia Marble Co. and Vermont Marble Co. The top three companies accounted for 81% of U.S. output.

Traprock.—Compared with that of 1980, 1981 output of dimension traprock decreased 91% to 1,355 tons valued at $38,000. Washington was the leading State, producing 620 tons valued at $29,500, with Hawaii and Oregon accounting for the balance.

Miscellaneous Stone.—Compared with that of 1980, 1981 output of miscellaneous dimension stone decreased 47% to 11,700 tons valued at $433,000.

CONSUMPTION AND USES

Dimension stone was marketed over wide areas. Stockpiles were not monitored and output during the year was assumed to equal consumption.

Compared with that of 1980, 1981 consumption of dimension stone increased slightly to 1.33 million tons valued at $150.5 million. Consumption of stone for monuments decreased 11% to 279,000 tons, 21% of total dimension stone tonnage and 34% of total value. Notable during 1981 was a 62% increase in flooring slate to 45,500 tons valued at $9.5 million.

Industry sources indicated that dimension stone is displacing other materials as building facing.

Granite.—Notable during 1981 was a 142% increase in rubble. Use of granite in monuments showed an 11% decrease in tonnage. The use breakdown in 1981 was monumental, 39%; rubble, 16%; and other construction the balance.

Limestone.—Notable during 1981 were a 442% increase in irregular shapes to 43,300 tons valued at $1.0 million; and a 36% decrease in sawed stone to 34,000 tons valued at $3.9 million.

Sandstone.—Notable during 1981 were a 57% decrease in house stone veneer to 6,234 tons valued at $378,000 and a 109% increase in dressed flagging to 9,387 tons valued at $960,000. The large increase in other dressed stone reflects production from an operation that was idle in 1980.

Slate.—Notable during 1981 was a 64% increase in flagging to 60,042 tons valued at $2.8 million and a 62% increase in flooring slate to 45,490 tons valued at $9.5 million. The large decrease in tonnage of other slate reflects a major decrease in production of unprocessed blocks.

Marble.—No significant change in the end-use pattern was apparent during 1981.

Traprock.—Flagging accounted for somewhat under one-half of dimension traprock use in 1981; rubble accounted for almost all of the remainder.

Miscellaneous Stone.—Miscellaneous types of dimension stone were used in 1981 primarily as irregular shapes (66%).

PRICES

Compared with that of 1980, the average 1981 price of dimension stone increased 7% to $113.04 per ton. The price of dimension sandstone increased 46% to $66 per ton, accompanied by a 5% increase in tonnage sales.

The 62% increase in flooring slate tonnage was accompanied by a 10% increase in price.

The prices of imported stone increased significantly.

FOREIGN TRADE

Exports.—Exports of dimension stone in 1981, mostly granite and limestone, increased 29% in quantity to 227,000 tons, and 18% in value to $17.9 million. Most of the increase was in rough limestone blocks sent to Venezuela and Canada. Exports to Canada increased 8% and accounted for 46% of total exports in 1981. Exports of rough granite blocks to Japan increased by 67% to 35,000 tons valued at $4.5 million.

Imports.—Value of imports of dimension stone increased 48% in 1981 to $131 million; of this, 71% came from Italy, 10% came from Canada, and 3% came from Mexico. On a value basis, marble accounted for 38% of imports (76% from Italy) followed by granite, 35% (59% from Italy and 28% from Canada); travertine, 14% (91% from Italy), and slate, 8% (87% from Italy). Notable was a doubling of the total value of imported granite. On a value basis, imports accounted for 50% of U.S. consumption.

WORLD REVIEW

World production of dimension stone in 1981 was about the same as in 1980. Italy probably produced about one-half of the world total. Imports from Italy accounted for about 40% of U.S. dimension stone supply in 1981.

Canada.—Annual domestic supply of dimension stone in 1980-81, including stone later exported, was about 320,000 tons, of which 80% was limestone, 15% was granite, and the balance was sandstone. In terms of use, 85% of the total was rough building stone, 7% was monumental and ornamental stone, and the balance was other (flagstone, curbstone, paving blocks, etc.). The limestone was almost all used as rough building stone and the granite was mostly used as monumental and ornamental stone. Ontario supplied most of the limestone and Quebec supplied almost all of the granite. The industry operated at a little better than one-half capacity.

India.—Tamil Nadu Minerals Ltd. planned to purchase equipment for a new cutting and polishing unit that would be capable of contour cutting and polishing, in addition to the more conventional stone dressing techniques. The dimension stone produced was to be black granite and gray granite destined for export markets. The facility was expected to be located near Madras and to cost $1.7 million, part of which might be provided by some Japanese companies.[17]

Mysore Minerals Ltd. planned to construct an export-oriented plant for finishing and polishing a local black granite, for an estimated plant cost of $1.1 million. The company had received a few trial orders from Europe and Japan.[18]

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[1]Physical scientist, Division of Industrial Minerals.

[2]Mining Safety and Health Administration and Occupational Saftey and Health Administration. A Comparative Analysis. Stone News, July 1981, pp. 8-10.

[3]Prepared by Valentin V. Tepordei.

[4]Volcanic cinder and scoria is included in the crushed stone chapter in 1981 for the first time.

[5]Herod, S. Productivity is Theme of NCSA Convention. Pit & Quarry, March 1981, pp. 69-70, 101, 117.

Stearn, E. W. Highlights of NCSA Meeting. Rock Prod., March 1981, pp. 89-94.

[6]Herod, S. NLI's 1981 Convention Covers Key Problem Areas. Pit & Quarry, March 1981, pp. 78-80, 138.
[7]Huhta, R. S. The Sights & Sounds of ConExpo 81. Rock Prod., March 1981, pp. 76-78.
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[8]Japan Chemical Week. July 1981, p. 6.
[9]Chemical Marketing Reporter. November 1981, p. 41.
[10]Robertson, J. L. Dream Plant Designed for Less Labor, Easy Upkeep. Rock Prod., May 1981, pp. 53-56.
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[12]Rock Products. Energy Briefs. August 1981, pp. 40-60.
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[14]Levine, S. Blast Vibration Analysis Provides Damage Control. Pit & Quarry, April 1981, pp. 77-80.
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[15]Robertson, J. L. Expansion Doubles Capacity With No Loss in Production. Rock Prod., September 1981, pp. 42-45.
[16]Prepared by Harold A. Taylor, Jr.
[17]Industrial Minerals (London). New Dimension Stone Capacity Slated. No. 166, July 1981, p. 12.
[18]———.Mysore Plans Polishing Units. No. 171, December 1981, p. 14.

Table 27.—Dimension stone sold or used by producers in the United States, by State

State	1980			1981		
	Short tons	Cubic feet (thousands)	Value (thousands)	Short tons	Cubic feet (thousands)	Value (thousands)
Alabama	10,812	133	$2,259	7,425	94	$2,130
Arizona	W	W	45	W	W	578
Arkansas	8,104	101	355	6,770	85	411
California	36,103	443	1,967	29,431	359	1,909
Colorado	6,124	78	259	761	9	64
Connecticut	15,397	175	723	19,440	225	910
Georgia	231,496	2,374	17,466	267,871	2,773	17,894
Hawaii	W	W	11	432	5	4
Illinois	2,238	26	103	1,712	20	85
Indiana	160,791	2,173	14,046	144,876	1,965	13,672
Iowa	9,645	113	509	W	W	W
Kansas	18,435	248	937	14,067	187	605
Maryland	14,659	183	612	33,894	415	1,002
Massachusetts	51,458	616	7,018	49,659	710	8,616
Michigan	6,805	85	144	6,064	75	129
Minnesota	44,464	534	14,189	41,196	494	14,298
New Hampshire	103,039	1,216	7,167	88,902	1,050	6,889
New Mexico	17,750	244	91	26,230	361	173
New York	25,022	294	2,414	21,457	251	2,291
North Carolina	55,365	682	4,536	29,906	365	2,773
Ohio	34,809	476	1,558	W	W	W
Oklahoma	15,984	221	678	18,233	220	738
Oregon	14,556	171	231	327	4	5
Pennsylvania	65,399	780	6,397	50,830	607	7,193
South Carolina	11,660	141	703	17,550	213	1,109
South Dakota	42,315	489	15,035	50,188	557	17,543
Tennessee	10,318	125	883	10,921	130	1,063
Texas	36,887	454	7,095	41,883	529	5,543
Utah	3,450	44	272	3,116	40	280
Vermont	169,276	1,782	23,649	206,819	2,209	30,756
Virginia	27,439	327	2,287	4,201	58	1,130
Washington	5,686	70	248	14,663	183	2,378
Wisconsin	45,431	559	4,501	40,343	498	4,259
Other[1]	13,615	165	521	81,940	1,081	4,030
Total[2]	1,314,532	15,523	138,907	1,331,107	15,773	150,463
Puerto Rico	129,288	1,724	2,271	104,628	1,395	2,040

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes Idaho, Missouri, Montana, New Jersey, and Rhode Island.
[2]Data may not add to totals shown because of independent rounding.

Table 28.—Dimension granite sold or used by producers in the United States, by State

State	1980			1981		
	Short tons	Cubic feet (thousands)	Value (thousands)	Short tons	Cubic feet (thousands)	Value (thousands)
California	9,670	119	$1,180	8,133	99	$1,045
Connecticut	8,480	87	413	10,234	107	438
Georgia	199,249	1,987	9,646	249,192	2,514	11,217
Maryland	--	--	--	28,997	354	779
Massachusetts	49,719	598	W	48,557	699	8,504
Minnesota	32,359	384	11,917	29,450	347	11,540
New Hampshire	103,039	1,216	7,167	88,902	1,050	6,889
North Carolina	49,169	608	3,849	24,233	297	2,130
Oklahoma	7,292	84	559	5,954	67	569
South Carolina	11,660	141	703	17,550	213	1,109
South Dakota	42,315	489	15,035	50,188	557	17,543
Texas	21,521	259	6,399	17,458	209	3,796
Vermont	94,565	958	11,780	91,371	925	13,420
Other[1]	32,521	372	11,283	11,331	117	3,893
Total[2]	661,559	7,303	79,930	681,550	7,557	82,870

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes Colorado, New York, Pennsylvania, Rhode Island, Virginia, Washington, and Wisconsin.
[2]Data may not add to totals shown because of independent rounding.

Table 29.—Dimension limestone sold or used by producers in the United States, by State

State	1980			1981		
	Short tons	Cubic feet (thousands)	Value (thousands)	Short tons	Cubic feet (thousands)	Value (thousands)
Alabama	7,596	101	$970	4,250	57	$665
California	15,800	198	492	12,331	154	552
Illinois	2,238	26	103	1,712	20	85
Indiana	158,135	2,133	W	W	W	W
Iowa	9,645	113	509	W	W	W
Kansas	18,435	248	937	14,067	187	605
Maryland	--	--	--	420	5	21
Michigan	442	5	30	W	W	W
Minnesota	10,339	128	2,239	9,976	124	2,721
Ohio	1,646	19	79	W	W	W
Texas	6,926	96	240	16,115	222	1,268
Virginia	1,213	15	W	1,481	28	W
Wisconsin	40,677	510	1,464	35,867	450	1,528
Other[1]	22,293	327	14,218	183,492	2,465	14,525
Total[2]	295,385	3,920	21,281	279,711	3,712	21,971
Puerto Rico	129,288	1,724	2,271	104,628	1,395	2,040

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes Colorado, Oklahoma, New Mexico, Rhode Island, Utah (1980), and Washington.
[2]Data may not add to totals shown because of independent rounding.

Table 30.—Dimension sandstone sold or used by producers in the United States, by State

State	1980			1981		
	Short tons	Cubic feet (thousands)	Value (thousands)	Short tons	Cubic feet (thousands)	Value (thousands)
Arizona	W	W	(1)	W	W	$557
Arkansas	8,085	101	$353	6,770	85	411
Colorado	5,629	72	182	370	5	10
Connecticut	6,917	89	310	9,206	118	472
Indiana	2,656	40	148	W	W	W
Maryland	5,767	72	242	4,477	56	203
Michigan	6,363	80	114	W	W	W
Minnesota	1,766	22	34	1,770	22	36
Missouri	200	3	W	210	3	W
New York	19,378	231	1,768	16,538	197	1,647
North Carolina	4,133	52	206	3,473	43	132
Ohio	33,163	456	1,479	47,447	654	2,980
Oregon	1,450	17	42	23	(1)	1
Pennsylvania	34,809	446	1,107	28,099	360	1,259
Utah	3,320	43	266	3,116	40	280
Virginia	192	2	8	--	--	--
Washington	864	11	40	12,713	159	2,295
Other[2]	35,266	451	1,382	44,089	576	1,468
Total[3]	169,958	2,187	7,681	178,301	2,318	11,752

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Less than 1/2 unit.
[2]Includes Alabama (1981), California, Georgia, Idaho, New Jersey, Oklahoma, Tennessee, and Wisconsin.
[3]Data may not add to totals shown because of independent rounding.

Table 31.—Dimension marble sold or used by producers in the United States, by State

State	1980			1981		
	Short tons	Cubic feet (thousands)	Value (thousands)	Short tons	Cubic feet (thousands)	Value (thousands)
Alabama	3,216	32	$1,288	W	W	W
Arizona	2,544	30	45	W	W	$20
Massachusetts	1,739	17	W	1,102	11	112
North Carolina	W	W	W	200	2	109
Texas	8,440	99	456	8,310	98	479
Vermont	18,055	201	4,111	17,941	211	4,503
Other[1]	26,417	299	8,283	30,967	391	8,581
Total[2]	60,411	679	14,184	58,520	713	13,804

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes Georgia, Idaho, Missouri, Montana, New Mexico, Tennessee, and Washington (1980).
[2]Data may not add to totals shown because of independent rounding.

Table 32.—Dimension stone sold or used by producers in the United States, by use

Use	1980 Short tons	1980 Cubic feet (thousands)	1980 Value (thousands)	1981 Short tons	1981 Cubic feet (thousands)	1981 Value (thousands)
Rough stone:						
Rough blocks	198,708	2,439	$7,871	207,033	2,530	$9,509
Irregular-shaped stone	112,108	1,386	4,234	155,660	1,948	5,148
Rubble	114,989	1,375	2,052	157,153	1,725	5,242
Monumental	246,521	2,504	20,912	216,146	2,203	21,624
Flagging	53,220	662	2,229	37,732	518	2,087
Other rough stone	2,276	28	58	2,751	33	81
Dressed stone:						
Cut stone	144,565	1,817	30,026	129,225	1,648	31,032
Sawed stone	71,820	949	8,690	61,196	803	7,580
House stone veneer	62,147	792	3,795	39,980	514	2,723
Construction	19,103	230	2,186	12,187	147	1,592
Monumental	66,022	767	29,117	62,491	714	28,791
Curbing	116,859	1,393	10,519	96,667	1,257	10,388
Flagging	42,712	477	2,399	71,881	816	3,884
Paving block	3,232	39	336	3,293	40	373
Roofing slate, standard	7,478	82	3,447	5,962	66	2,942
Roofing slate, architectural	140	2	60	99	1	47
Structural shapes	8,736	96	3,421	6,310	69	3,883
Flooring slate	28,114	309	5,345	45,490	500	9,502
Other dressed stone[1]	15,782	176	2,208	19,851	240	4,036
Total[2]	1,314,532	15,523	138,907	1,331,107	15,773	150,463

[1]Includes blackboards, billiard table tops, and other uses.
[2]Data may not add to totals shown because of independent rounding.

Table 33.—Dimension granite sold or used by producers in the United States, by use

Use	1980 Short tons	1980 Cubic feet (thousands)	1980 Value (thousands)	1981 Short tons	1981 Cubic feet (thousands)	1981 Value (thousands)
Rough stone:						
Rough blocks	84,591	948	$3,504	84,110	925	$4,628
Irregular-shaped stone	26,464	303	1,002	40,573	476	1,273
Rubble	45,091	469	782	108,979	1,105	3,653
Monumental	245,406	2,492	20,832	214,990	2,189	21,535
Flagging	154	2	9	456	6	21
Other rough stone	350	4	17	209	2	12
Dressed stone:						
Cut stone	65,214	785	16,740	58,144	704	16,306
Sawed stone	1,172	14	217	9,927	118	767
House stone veneer	5,425	66	220	4,627	56	169
Construction	8,398	103	1,265	3,871	47	673
Monumental	56,215	653	23,639	52,650	599	22,468
Curbing	116,340	1,386	10,473	96,117	1,250	10,336
Flagging	61	1	3	1,338	17	92
Paving block	3,232	39	336	3,293	40	373
Other	3,446	38	890	2,266	25	566
Total[1]	661,559	7,303	79,930	681,550	7,557	82,870

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

Table 34.—Dimension limestone sold or used by producers in the United States, by use

Use	1980 Short tons	1980 Cubic feet (thousands)	1980 Value (thousands)	1981 Short tons	1981 Cubic feet (thousands)	1981 Value (thousands)
Rough stone:						
Rough blocks	89,477	1,179	$3,483	92,919	1,229	$3,786
Irregular-shaped stone	7,987	128	335	43,278	573	981
Rubble	37,845	492	587	18,160	233	418
Flagging	18,667	249	358	16,697	222	338
Other rough stone	56	1	2	34	([1])	1
Dressed stone:						
Cut stone	42,074	564	8,302	42,155	573	10,441
Sawed stone	52,955	719	5,317	33,955	466	3,908
House stone veneer	38,851	498	2,432	26,818	347	1,755
Construction	5,493	66	223	4,254	51	173
Curbing	196	2	12	W	W	W
Flagging	1,510	19	106	1,064	13	78
Other[2]	274	3	125	377	5	92
Total	295,385	3,920	[3]21,281	279,711	3,712	21,971

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Less than 1/2 unit.
[2]Includes Other uses.
[3]Data do not add to total shown because of independent rounding.

Table 35.—Dimension sandstone sold or used by producers in the United States, by use

Use	1980 Short tons	1980 Cubic feet (thousands)	1980 Value (thousands)	1981 Short tons	1981 Cubic feet (thousands)	1981 Value (thousands)
Rough stone:						
Rough blocks	17,343	232	$424	18,447	249	$614
Irregular-shaped stone	43,600	556	1,344	47,176	612	1,599
Rubble	26,590	348	552	28,692	372	1,141
Flagging	20,104	244	1,610	18,738	228	1,678
Other rough stone	1,776	22	34	1,770	22	36
Dressed stone:						
Cut stone	30,339	389	1,972	24,455	320	2,326
Sawed stone	8,120	112	488	8,676	120	559
House stone veneer	14,560	191	713	6,234	85	378
Construction	2,226	28	61	1,313	16	26
Flagging	4,488	55	335	9,387	126	960
Other dressed stone[1]	812	11	148	13,413	168	2,433
Total[2]	169,958	2,187	7,681	178,301	2,318	11,752

[1]Includes monumental, curbing, and other uses.
[2]Data may not add to totals shown because of independent rounding.

Table 36.—Dimension slate sold or used by producers in the United States, by use

(Thousand short tons and thousand dollars)

Use	1980 Quantity	1980 Value	1981 Quantity	1981 Value
Flagging	36,599	1,953	60,042	2,752
Roofing slate, standard	7,478	3,447	5,962	2,942
Roofing slate, architectural	140	60	99	47
Structural and sanitary	8,736	3,421	6,310	3,883
Flooring slate	28,114	5,345	45,490	9,502
Other[1]	9,295	593	2,049	469
Total	90,362	[2]14,820	119,952	19,595

[1]Includes house stone veneer, blackboards, bulletin boards, school slates, billiard table tops, and other uses.
[2]Data do not add to total shown because of independent rounding.

Table 37.—Dimension marble sold or used by producers in the United States, by use

Use	1980 Short tons	1980 Cubic feet (thousands)	1980 Value (thousands)	1981 Short tons	1981 Cubic feet (thousands)	1981 Value (thousands)
Rough stone:						
Rough blocks	5,765	61	$413	11,525	127	$478
Irregular-shaped stone	20,390	235	1,066	16,868	196	1,032
Monumental stone	1,115	12	80	1,156	14	90
Dressed stone:						
Cut stone	6,083	69	2,961	3,686	42	1,911
Sawed stone	9,573	104	2,668	8,638	100	2,345
House stone veneer	3,198	36	426	W	W	W
Construction stone	1,286	13	562	W	W	W
Monumental stone	9,801	113	5,477	9,835	115	6,322
Other dressed stone[1]	3,200	36	531	6,812	119	1,625
Total	60,411	679	14,184	58,520	713	[2]13,804

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes flagging and other uses.
[2]Data do not add to total shown because of independent rounding.

Table 38.—Miscellaneous dimension stone sold or used by producers in the United States, by use

Use	1980 Short tons	1980 Cubic feet (thousands)	1980 Value (thousands)	1981 Short tons	1981 Cubic feet (thousands)	1981 Value (thousands)
Rough stone:						
Rough blocks	1,500	19	$44	--	--	--
Irregular-shaped stone	13,658	164	487	7,749	91	$262
Rubble	3,756	46	106	764	9	23
Flagging	610	7	21	--	--	--
Dressed stone:						
House stone veneer	31	([1])	1	--	--	--
Flagging	50	1	1	50	1	1
Other[2]	2,555	30	125	3,155	37	147
Total[3]	22,160	268	786	11,718	138	433

[1]Less than 1/2 unit.
[2]Includes other rough stone (1981), cut stone, and dressed construction stone.
[3]Data may not add to totals shown because of independent rounding.

Table 39.—Unit values of domestic and imported dimension stone

(Dollars per ton)

Stone	1980 Domestic	1980 Imported	1981 Domestic	1981 Imported
Granite	121	350	122	478
Limestone	72	144	79	257
Marble	235	[e]270	236	[e]300
Sandstone	45	--	66	--
Slate	164	--	163	--

[e]Estimated.

Table 40.—Exports of dimension stone, by type[1]

(Thousand short tons and thousand dollars)

Type	Canada 1980	Canada 1981	Japan 1980	Japan 1981	Other 1980	Other 1981	Total quantity 1980	Total quantity 1981	Total value 1980	Total value 1981
Granite:										
Rough blocks	42	38	21	35	16	4	79	77	4,759	6,365
Other[2]	4	5	(3)	1	5	5	9	11	1,169	1,515
Total	46	43	21	36	21	9	88	[4]88	5,928	7,880
Limestone:										
Rough blocks	6	11	--	--	1	[5]42	7	53	360	719
Other	16	22	(3)	--	1	3	17	25	333	463
Total	22	33	(3)	--	2	45	24	78	693	1,182
Marble[2]	r12	12	1	(3)	r11	[6]8	r24	21	3,038	2,673
Slate[2]	5	6	(3)	(3)	8	[7]5	13	11	2,303	2,180
Other:										
Rough blocks	7	8	5	7	5	[8]5	17	20	1,601	1,788
Other including alabaster[2]	4	2	1	1	5	[9]6	10	9	1,606	2,164
Total[7]	11	10	6	8	10	11	27	29	3,207	3,952
Grand total[10]	r96	104	28	45	r52	78	r176	227	15,170	17,867

rRevised.
[1]Partly estimated from reported values.
[2]Tonnage data estimated from value data.
[3]Less than 1/2 unit.
[4]Includes Italy, the United Kingdom, and Mexico in order of volume.
[5]Venezuela accounted for 99%.
[6]Includes Saudi Arabia, the Bahamas, and Mexico in order of volume.
[7]Includes Saudi Arabia and the Bahamas in order of volume.
[8]Includes Switzerland.
[9]Includes Switzerland, Saudi Arabia, France, and Taiwan in order of volume.
[10]Data may not add to totals shown because of independent rounding.

Table 41.—U.S. imports of dimension stone, by type

Type	1980 Quantity	1980 Customs value (thousands)	1981 Quantity	1981 Customs value (thousands)
Granite:				
Rough blocks thousand cubic feet	260	$2,958	334	[1]$6,696
Dressed including monumental do	456	18,383	691	[2]33,522
Other, n.s.p.f.	(3)	1,427	(3)	[4]5,333
Total	XX	22,768	XX	45,551
Marble, breccia, onyx:				
In block, rough, or squared[5] thousand cubic feet	16	346	21	[6]285
Slabs and tiles thousand square feet	9,332	23,725	11,912	[7]30,971
Other, n.s.p.f.	(3)	15,504	(3)	[8]19,243
Total	XX	39,575	XX	50,499
Travertine stone:				
Rough, unmanufactured thousand cubic feet	36	164	11	69
Dressed, suitable for monumental and other uses short tons	29,997	12,206	46,453	17,541
Other, n.s.p.f.	(3)	1,133	(3)	1,334
Total	XX	13,503	XX	[9]18,944
Alabaster and jet	(3)	2,009	(3)	[10]1,169
Limestone:				
Rough blocks thousand cubic feet	16	29	12	28
Dressed manufactured short tons	471	214	626	385
Other, n.s.p.f.	(3)	129	(3)	39
Total	XX	372	XX	[11]452
Slate:				
Roofing thousand square feet	80	38	140	[12]116
Other, n.s.p.f.	(3)	7,484	(3)	10,665
Total	XX	7,522	XX	[13]10,781
Stone and articles of stone, n.s.p.f.:				
Statuary and sculptures	(3)	384	(3)	[14]705
Rough, unmanufactured short tons	[r]11,585	[r]267	17,889	[15]297
Building stone, dressed do	1,030	183	664	[16]278
Other, n.s.p.f.	(3)	2,365	(3)	[17]2,735
Total	XX	[r]3,199	XX	4,015
Grand total	XX	88,948	XX	[18]131,416

[r]Revised. XX Not applicable.
[1]Includes Canada, 64%; the Republic of South Africa, 17%; Italy, 14%; and other, 5%.
[2]Includes Italy, 74%; Canada, 14; Brazil, 4%; the Republic of South Africa, 2%; and other, 6%.
[3]Quantity not reported.
[4]Includes Canada, 70%; Italy, 18%; Ireland, 7%; and other, 5%.
[5]Includes sawed or dressed, over 2-inches thick.
[6]Includes Mexico, 42%; Italy, 24%; and other, 13%.
[7]Includes Italy, 84%; Portugal, 5%; Spain, 3%; the Philippines, 2%; Mexico, 1%; and other, 5%.
[8]Includes Italy, 64%; Taiwan, 14%; Mexico, 9%; and other, 13%.
[9]Includes Italy, 91%; Mexico, 7%; Canada, 1%; and other, 1%.
[10]Includes Italy, 70%; Spain, 16%; Taiwan, 9%; and other 5%.
[11]Includes Italy, 42%; Mexico, 20%; the Federal Republic of Germany, 19%; Canada, 5%; the Republic of South Africa, 4%; and other, 10%.
[12]Includes Spain, 47%; France, 22%; the Republic of South Africa, 18%; the United Kingdom, 11%; and other, 2%.
[13]Includes Italy, 87%; the United Kingdom, 7%; and other, 6%.
[14]Includes Peru, 46%; Italy, 37%; and other, 17%.
[15]Includes Mexico, 67%; Canada, 13%; the Republic of South Africa, 11%; and other, 9%.
[16]Includes Mexico, 43%; Italy, 26%; India, 13%; the United Kingdom, 11%; and other, 7%.
[17]Includes Mexico, 22%; India, 16%; China, 11%; Italy, 9%; Taiwan, 7%; the Federal Republic of Germany, 6%; the United Kingdom, 6%; and other, 23%.
[18]Data do not add to total shown because of independent rounding.

Sulfur

By David E. Morse and John E. Shelton[1]

The net shipment value, f.o.b. mine or plant, for elemental sulfur was $1.3 billion in 1981, up 14% more than that of 1980. In 1981, production and stocks of elemental sulfur increased. Shipments, apparent consumption, and exports decreased in 1981. Imports were essentially the same as those of 1980. The average net shipment value, f.o.b. mine or plant, for Frasch and recovered elemental sulfur increased from $89.06 per metric ton in 1980 to $111.48 per metric ton in 1981. The 1981 yearend quoted price for Frasch sulfur was $138.77 per metric ton, Texas and Louisiana gulf ports, and $145.17 per metric ton, exterminal Tampa, Fla.

Production of sulfur in all forms was up 2% in 1981. For the sixth year, domestic production was less than apparent domestic consumption. Production of elemental sulfur was concentrated in Texas and Louisiana. Together, these two States accounted for 64% of the total output in 1981. Shipments of sulfur in all forms by U.S. produc-

Table 1.—Salient sulfur statistics

(Thousand metric tons, sulfur content, and thousand dollars unless otherwise specified)

	1977	1978	1979	1980	1981
United States:					
Production:					
Frasch	5,915	5,648	6,357	6,390	6,348
Recovered elemental	3,624	4,062	4,070	r4,073	4,259
Other forms	1,188	1,465	1,674	1,403	1,538
Total	10,727	11,175	12,101	r11,866	12,145
Shipments:					
Frasch	6,030	5,736	7,507	7,400	5,910
Recovered elemental	3,627	4,088	4,108	r4,115	4,207
Other forms	1,188	1,465	1,674	1,403	1,538
Total	10,845	11,289	13,289	r12,918	11,655
Imports, elemental and pyrites	2,009	2,177	2,494	2,523	2,522
Exports, crude and refined[1]	1,088	827	1,963	1,673	1,392
Consumption, apparent, all forms[2]	11,657	12,600	13,739	r13,659	12,785
Stocks, Dec. 31: Producer, Frasch and recovered elemental	5,557	5,345	4,239	r3,094	3,634
Value:					
Shipments, f.o.b. mine or plant:					
Frasch	$294,733	$279,918	$449,433	$720,511	$715,683
Recovered elemental	133,849	163,799	198,137	r305,046	412,115
Other forms	57,304	68,295	89,643	84,332	140,618
Total	485,886	512,012	737,213	r1,109,889	1,268,416
Imports, elemental[3]	$65,154	$75,671	$94,147	$138,852	$209,766
Exports, crude and refined[3] [4]	$52,111	$34,667	$142,966	$185,866	$187,407
Price, elemental, dollars per metric ton, f.o.b. mine or plant	$44.38	$45.17	$55.75	r$89.06	$111.48
World: Production, all forms (including pyrites)	r52,341	r53,687	r54,745	p56,635	e55,669

eEstimated. pPreliminary. rRevised.
[1]Excludes exports from the Virgin Islands to foreign countries, except for 1981.
[2]Measured by shipments, plus imports, minus exports.
[3]Declared customs valuation.
[4]Excludes value of exports from the Virgin Islands to foreign countries, except for 1981.

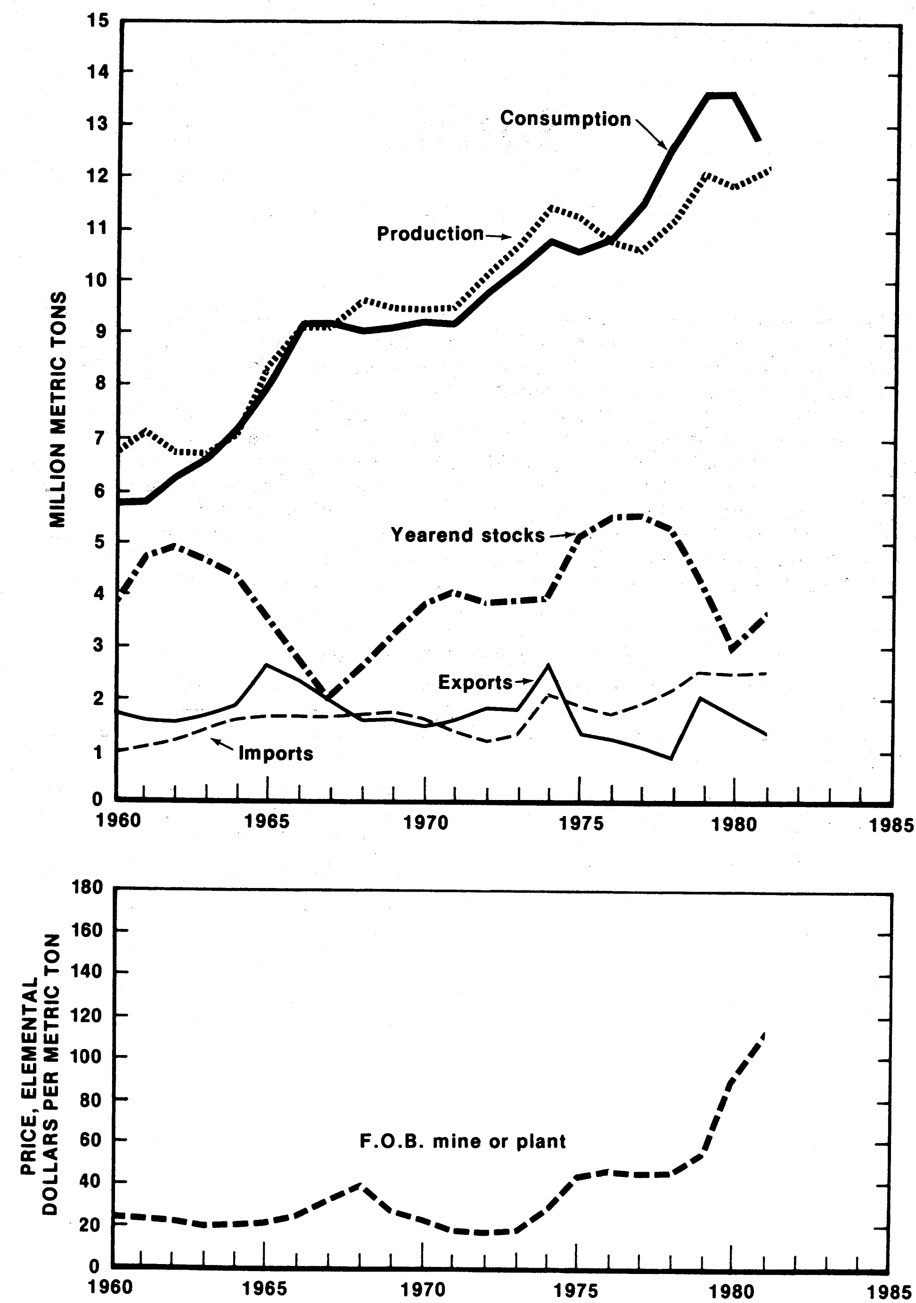

Figure 1.—Trends in the sulfur industry in the United States.

ers to domestic and export markets were 11.7 million metric tons, a decrease of 10% compared with that of 1980. The total value of shipments, f.o.b. mine or plant, was $1.3 billion in 1981, up from $1.1 billion in 1980. The apparent domestic consumption of sulfur in all forms declined to 12.8 million tons in 1981; the United States was a net importer again in 1981.

Legislation and Government Programs.—A report, in four volumes, evaluating the sources of sulfur and the impact of byproduct sulfur on the Frasch mining industry of Texas and Louisiana was prepared by the University of Arizona under contract with the Federal Bureau of Mines. The reports OFR 94(1)—(4)-81 are available for reading at the Bureau of Mines facilities at Tuscaloosa, Ala.; Denver, Colo.; Boulder City, Nev.; Pittsburgh, Pa.; and Spokane, Wash.; and at the Bureau of Mines and the Department of the Interior libraries in Washington, D.C. The reports are available for purchase from the National Technical Information Service, 5285 Port Royal Rd., Springfield, VA 22161. Order numbers for the four volumes are PB 81-222796, PB 81-222804, PB 81-222812, and PB 81-222820, or, as a set, PB 81-222788.

An administrative review of imports of sulfur from Mexico resulted in a determination that shipments of sulfur to the United States by Azufrera Panamericana, S.A., and Compañia Exploradora del Istmo, S.A., would require no cash deposits, whereas shipments by Agrico Centro, S.A., would require a cash deposit of 33% of entered value.[2]

DOMESTIC PRODUCTION

Frasch.—In 1981, there were 10 Frasch mines, all in Louisiana and Texas. Mines in Louisiana were Freeport Minerals Co. at Garden Island Bay, Grand Isle, and Caillou Island. Producers' mines in Texas were Farmland Industries, Inc., at Fort Stockton; Duval Corp. at Culberson and Phillips Ranch; Jefferson Lake Sulfur Co. at Long Point Dome; and Texasgulf, Inc., at Boling Dome, Moss Bluff Dome, and Comanche Creek. The eight mines operated by Duval, Freeport Minerals, and Texasgulf accounted for most of the Frasch sulfur production. A relatively small portion of the output was from the other two producers operating one mine each.

Of producers' shipments of Frasch sulfur, about 24% were for export. The value of Frasch sulfur shipments in 1981 declined to $716 million. Reported stocks after inventory adjustments increased by 488,000 tons to 3.4 million metric tons.

Recovered.—Production in 1981 of recovered elemental sulfur, a nondiscretionary byproduct from natural gas and petroleum refinery operations, electric utilities, and coking plants, increased to 4.3 million tons. This type of sulfur was produced by 61 companies at 165 plants in 29 States, 2 plants in Puerto Rico, and 1 plant in the Virgin Islands. Most of the plants were of relatively small size, with only six reporting an annual production exceeding 100,000 tons. The 10 largest plants accounted for 42% of the output. By source, 54% was produced by 45 companies at 92 refineries or satellite plants treating refinery gases, 3 coking operations, and 1 utility plant, and 46% was produced by 27 companies at 69 natural gas treatment plants. The five largest recovered elemental sulfur producers were Chevron U.S.A., Inc.; Exxon Co., U.S.A.; Pursue Gas Processing and Petrochemical Co.; Shell Oil Co.; and Standard Oil Co. (Indiana). Together, their 41 plants accounted for 57% of recovered elemental sulfur production in 1981.

The leading States in production of recovered elemental sulfur were Texas, Mississippi, California, Alabama, and Florida. Together these States contributed 70% of the total 1981 output. The total value of shipments of recovered elemental sulfur in 1981 was an alltime high of $412 million.

Table 2.—Production of sulfur and sulfur-containing raw materials in the United States

(Thousand metric tons)

	1980		1981	
	Gross weight	Sulfur content	Gross weight	Sulfur content
Frasch sulfur	6,390	6,390	6,348	6,348
Recovered elemental sulfur	r4,073	r4,073	4,259	4,259
Byproduct sulfuric acid (100% basis) produced at copper, lead, molybdenum, and zinc plants	3,069	1,003	3,546	1,159
Pyrites	847	322	797	307
Other forms[1]	124	78	119	72
Total	XX	r11,866	XX	12,145

rRevised. XX Not applicable.
[1]Hydrogen sulfide and liquid sulfur dioxide.

Table 3.—Sulfur produced and shipped from Frasch mines in the United States

(Thousand metric tons and thousand dollars)

Year	Production Texas	Production Louisiana	Production Total	Shipments Quantity	Shipments Value[1]
1977	3,454	2,461	5,915	6,030	294,733
1978	3,720	1,928	5,648	5,736	279,918
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

[1]F.o.b. mine.

Table 4.—Recovered sulfur produced and shipped in the United States

(Thousand metric tons and thousand dollars)

Year	Production Natural gas plants	Production Petroleum refineries[1]	Production Total	Shipments Quantity	Shipments Value[2]
1977	1,426	2,198	3,624	3,627	133,849
1978	1,753	[3]2,309	4,062	4,088	163,799
1979	1,760	[3]2,310	4,070	4,108	198,137
1980	[r]1,757	[3]2,316	[r]4,073	[r]4,115	[r]305,046
1981	1,971	[3]2,288	4,259	4,207	412,115

[r]Revised.
[1]Includes a small quantity from a coking operation.
[2]F.o.b. plant.
[3]Includes a small quantity from utility plants.

Table 5.—Recovered sulfur produced and shipped in the United States, by State

(Thousand metric tons and thousand dollars)

State	1980 Production (quantity)	1980 Shipments Quantity	1980 Shipments Value	1981 Production (quantity)	1981 Shipments Quantity	1981 Shipments Value
Alabama	376	374	32,010	403	404	41,224
California	480	480	17,616	477	465	31,393
Florida	303	304	W	243	243	W
Illinois	207	208	[r]13,031	216	216	19,739
Indiana	68	68	2,089	W	W	W
Kansas	21	21	1,337	20	20	1,716
Louisiana	209	209	17,382	239	239	26,606
Michigan and Minnesota	79	81	3,085	77	77	5,600
Mississippi	534	[r]593	[r]60,404	698	677	78,871
New Jersey	120	118	7,273	119	120	13,581
New Mexico	61	62	4,264	69	69	5,991
Ohio	21	21	1,377	31	31	2,155
Oklahoma	8	8	586	W	W	W
Pennsylvania	58	57	3,403	56	56	4,654
Texas	1,111	1,104	87,986	1,144	1,136	115,252
Wisconsin	1	1	23	([1])	([1])	19
Wyoming	47	46	1,506	46	47	2,568
Other[2]	[r]373	361	51,676	418	405	62,745
Total[3]	[r]4,073	[r]4,115	[r]305,046	4,259	4,207	412,115

[r]Revised. W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Less than 1/2 unit.
[2]Arkansas, Colorado, Delaware, Kentucky, Missouri, Montana, New York, North Dakota, Utah, Virginia, Washington, the Virgin Islands, and Puerto Rico combined to avoid disclosing company proprietary data and data indicated by symbol W.
[3]Data may not add to totals shown because of independent rounding.

Byproduct Sulfuric Acid.—Production of byproduct sulfuric acid at copper, lead, molybdenum, and zinc smelters and roasters was by 11 companies at 26 plants in 14 States. Twelve acid plants operated in conjunction with copper smelters and 14 plants were accessories to lead, molybdenum, and zinc roasting and smelting operations. The five largest acid plants accounted for 52% of the output, and production in five States was 81% of the total. The five largest producers of byproduct sulfuric acid were

ASARCO Incorporated, Magma Copper Co., Kennecott Copper Corp., Phelps Dodge Corp., and AMAX Inc., whose 18 plants produced 79% of the byproduct sulfuric acid in 1981.

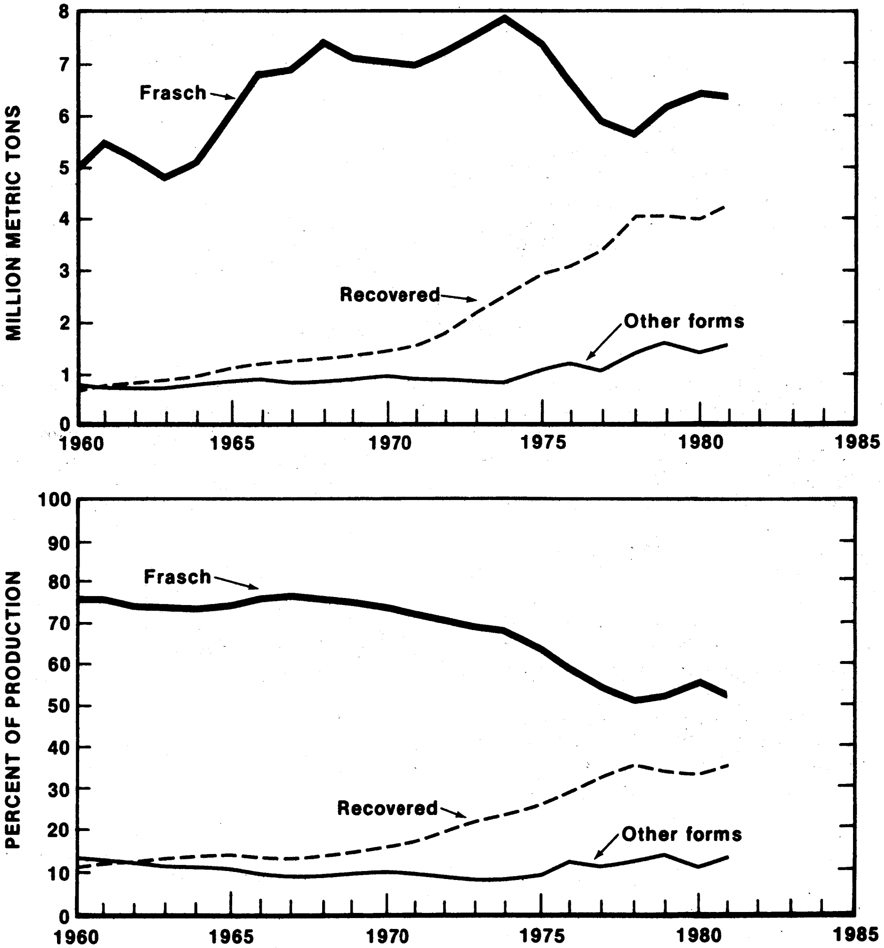

Figure 2.—Trends in the production of sulfur in the United States.

Table 6.—Byproduct sulfuric acid[1] (sulfur content) shipments in the United States

(Thousand metric tons and thousand dollars)

Year	Copper plants[2]	Lead and zinc plants[3]	Zinc plants[3]	Lead and molybdenum plants[3]	Total	Value
1977	699	261	--	--	960	46,236
1978	812	291	--	--	1,103	49,848
1979	821	346	--	--	1,167	51,815
1980	686	--	183	134	1,003	55,897
1981	848	--	179	132	1,159	75,657

[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.—Pyrites was produced by three companies at three mines in three States; hydrogen sulfide by three companies at four plants in three States; and sulfur dioxide by three companies at five plants in five States. The three largest producers of these products were Cities Service Co. (pyrites and sulfur dioxide), Stauffer Chemical Co. (sulfur dioxide), and Tosco Corp. (hydrogen sulfide). These companies combined, at one mine and five plants, accounted for 92% of the contained sulfur produced in the form of these products. Total contained sulfur produced in the form of these three products represented 3% of all sulfur produced domestically.

Table 7.—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
1977	169	59	(1)	228	11,068
1978	301	61	(1)	362	18,447
1979	400	35	72	507	37,828
1980	322	36	42	400	28,435
1981	307	28	44	379	64,961

[1]Included with "Hydrogen sulfide."

CONSUMPTION AND USES

In 1981, apparent domestic consumption of sulfur in all forms was nearly 12.8 million tons, a 6% decrease from that of 1980. Eighty percent of the sulfur for domestic consumption was obtained from domestic sources compared with 82% in 1980. The supply sources of sulfur were domestic Frasch sulfur, 35%; domestic recovered elemental sulfur, 33%; and combined domestic byproduct sulfuric acid, pyrites, hydrogen sulfide, and sulfur dioxide, 12%. The remaining 20% of the sulfur was from imports of Frasch and recovered elemental sulfur.

The Bureau of Mines collected data on the end uses of sulfur and sulfuric acid by Standard Industrial Classification of industrial activities. Shipments by end use of elemental sulfur were reported by 67 companies, and shipments by end use of sulfuric acid were reported by 69 companies. Sixteen companies reported shipments of both elemental sulfur and sulfuric acid.

Companies responding to the canvass reported shipments of 11.7 million metric tons of sulfur in 1981. Of these reported shipments, 856,000 tons was for export. The largest sulfur use, sulfuric acid production, represented 85% of shipments for domestic consumption. Some identified end uses were tabulated in unidentified uses because data were proprietary. Data collected from some companies that did not identify shipments by end use were also tabulated as unidentified.

Reported shipments of 100% sulfuric acid totaled 37.6 million metric tons in 1981, a 7% decrease from shipments reported in 1980. Shipments of sulfuric acid for phosphatic fertilizers, the largest end use, declined 9% to 23.7 million tons in 1981 from 26.0 million tons in 1980. Shipments of sulfuric acid for petroleum refining and other petroleum and coal products, the second largest end use of sulfuric acid, were 3.2 million tons.

Usage of sulfuric acid for copper ore leaching decreased from 1.4 million tons in 1980 to 942,000 tons in 1981; shipments of sulfuric acid for copper ore leaching were 2.1 million tons in 1979. Shipments of sulfuric acid for other end-use categories are shown in table 10.

According to the reports received, receipts of spent sulfuric acid for reclaiming totaled 1.97 million metric tons in 1981. The largest source of spent acid was from petroleum refining and petroleum and coal products, which accounted for 72% of the spent acid returned. The petroleum refining industry was a net user of about 1.75 million tons of sulfuric acid.

According to the reports received, about 373,000 tons or 19% of the spent acid was returned for reclaiming from the organic chemical industry. The remaining reclaimed acid was returned from phosphatic fertilizers, soap and detergents, explosives, steel pickling, paints and pigments, inorganic chemicals, and some unidentified sources.

Table 11 shows the domestic uses of sulfur including the sulfur contained in sulfuric acid. The largest identified end use for sulfur (as sulfuric acid) was for phosphatic fertilizers, which accounted for 56% of the total use of sulfur in 1981.

Table 8.—Apparent consumption of sulfur in the United States[1]

(Thousand metric tons)

	1977	1978	1979	1980	1981
Frasch:					
Shipments	6,030	5,736	7,507	7,400	5,910
Imports	781	993	1,229	990	856
Exports	1,088	827	1,963	1,673	[2]1,392
Total	5,723	5,902	6,773	6,717	5,374
Recovered:					
Shipments	3,627	4,088	4,108	r4,115	4,207
Imports	1,228	1,185	1,265	1,533	1,666
Exports from the Virgin Islands	109	39	81	109	--
Total	4,746	5,234	5,292	r5,539	5,873
Pyrites, shipments	169	301	400	322	307
Byproduct sulfuric acid, shipments	960	1,103	1,167	1,003	1,159
Other forms, shipments[3]	59	61	107	78	72
Total, all forms	11,657	[4]12,600	13,739	r13,659	12,785

rRevised.
[1]Crude sulfur or sulfur content.
[2]Total exports, includes exports from the Virgin Islands.
[3]Includes consumption of hydrogen sulfide and liquid sulfur dioxide.
[4]Data do not add to total shown because of independent rounding.

Table 9.—Elemental sulfur sold or used in the United States, by end use

(Thousand metric tons)

SIC	Use	1980	1981
20	Food and kindred products	W	W
26, 261	Pulp and paper products	94	30
282, 2822	Synthetic rubber and other plastic products	W	W
287	Agricultural chemicals	280	348
28, 285, 286	Paints and allied products, industrial organic chemicals, and other chemical products	125	77
29, 291	Petroleum refining and petroleum and coal products	159	193
295	Paving and roofing materials	W	3
281	Other industrial inorganic chemicals	181	157
30	Rubber and miscellaneous plastic products	W	W
	Sulfuric acid:		
	Domestic sulfur	8,741	7,733
	Imported sulfur	1,516	1,460
	Total	10,257	9,193
	Unidentified	910	820
	Total domestic uses	12,006	10,821
	Exports	1,277	856
	Grand total	13,283	11,677

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

Table 10.—Sulfuric acid sold or used in the United States, by end use

(Thousand metric tons of 100% H_2SO_4)

SIC	Use	Quantity 1980	Quantity 1981
102	Copper ores	1,352	942
1094	Uranium and vanadium ores	616	652
10	Other ores	40	165
261	Pulpmills	510	739
26	Other paper products	266	94
285, 2816	Inorganic pigments and paints and allied products	693	449
281	Other inorganic chemicals	1,059	839
282, 2822	Synthetic rubber and other plastic materials and synthetics	616	590
2823	Cellulosic fibers including rayon	311	193
283	Drugs	94	54
284	Soaps and detergents	397	392
286	Industrial organic chemicals	978	1,725
2873	Nitrogenous fertilizers	668	634
2874	Phosphatic fertilizers	25,999	23,700
2879	Pesticides	138	113
287	Other agricultural chemicals	277	204
2892	Explosives	40	42
2899	Water-treating compounds	299	461
28	Other chemical products	673	199
29, 291	Petroleum refining and other petroleum and coal products	2,644	3,171
30	Rubber and miscellaneous plastic products	W	29
331	Steel pickling	316	268
333	Nonferrous metals	64	75
33	Other primary metals	31	81
3691	Storage batteries/acid	105	173
	Unidentified	1,905	1,418
	Total domestic	40,091	37,402
	Exports	248	210
	Grand total	40,339	37,612

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

Table 11.—Sulfur and sulfuric acid sold or used in the United States, by end use

(Thousand metric tons, sulfur content)

SIC	Use	Elemental sulfur[1] 1980	Elemental sulfur[1] 1981	Sulfuric acid (sulfur equivalent) 1980	Sulfuric acid (sulfur equivalent) 1981	Total 1980	Total 1981
102	Copper ores	--	--	442	308	442	308
1094	Uranium and vanadium ores	--	--	201	213	201	213
10	Other ores	--	--	13	54	13	54
20	Food and kindred products	W	W	--	--	W	W
261, 26	Pulpmills and paper products	94	30	254	272	348	302
2816, 285, 28, 286	Inorganic pigments, paints and allied products, industrial organic chemicals, and other chemical products	125	77	227	146	352	223
281	Other inorganic chemicals	181	157	346	274	527	431
2822, 2823, 282	Synthetic rubber, cellulosic fibers, other plastic materials and synthetics	W	W	303	255	303	255
283	Drugs	--	--	31	18	31	18
284	Soaps and detergents	--	--	130	128	130	128
286	Industrial organic chemicals	--	--	320	564	320	564
2873	Nitrogenous fertilizers	--	--	218	207	218	207
2874	Phosphatic fertilizers	--	--	8,499	7,748	8,499	7,748
2879	Pesticides	--	--	45	37	45	37
287	Other agricultural chemicals	280	348	91	67	371	415
2892	Explosives	--	--	13	14	13	14
2899	Water-treating compounds	--	--	98	151	98	151
28	Other chemical products	--	--	220	65	220	65
291, 29	Petroleum refining and other petroleum and coal products	159	193	864	1,037	1,023	1,230
295	Paving and roofing materials	W	3	--	--	W	3
30	Rubber and miscellaneous plastic products	W	W	W	9	W	9
331	Steel pickling	--	--	103	88	103	88
333	Nonferrous metals	--	--	21	25	21	25
33	Other primary metals	--	--	10	26	10	26
3691	Storage batteries/acid	--	--	34	57	34	57
	Exported sulfuric acid	--	--	81	68	81	68
	Total identified	839	808	12,564	11,831	13,403	12,639
	Unidentified	910	820	623	464	1,533	1,284
	Grand total	1,749	1,628	13,187	12,295	14,936	13,923

W Withheld to avoid disclosing company proprietary data; included with "Unidentified."
[1]Does not include elemental sulfur used for production of sulfuric acid.

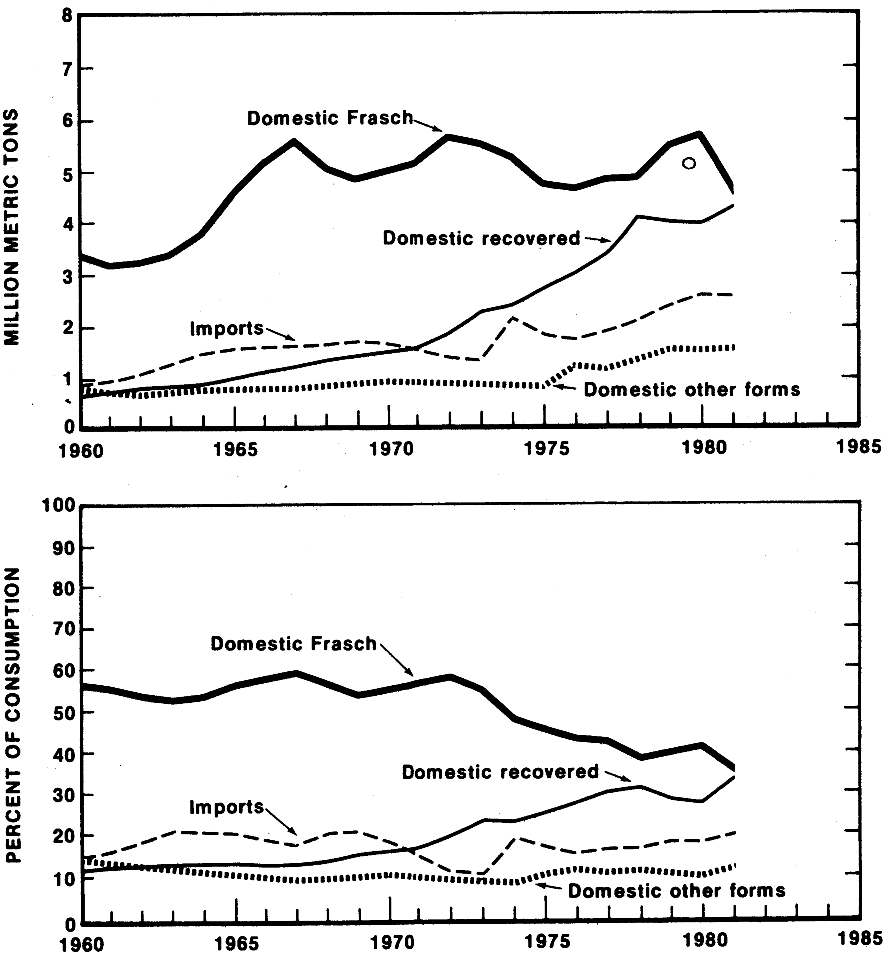

Figure 3.—Trends in the consumption of sulfur in the United States.

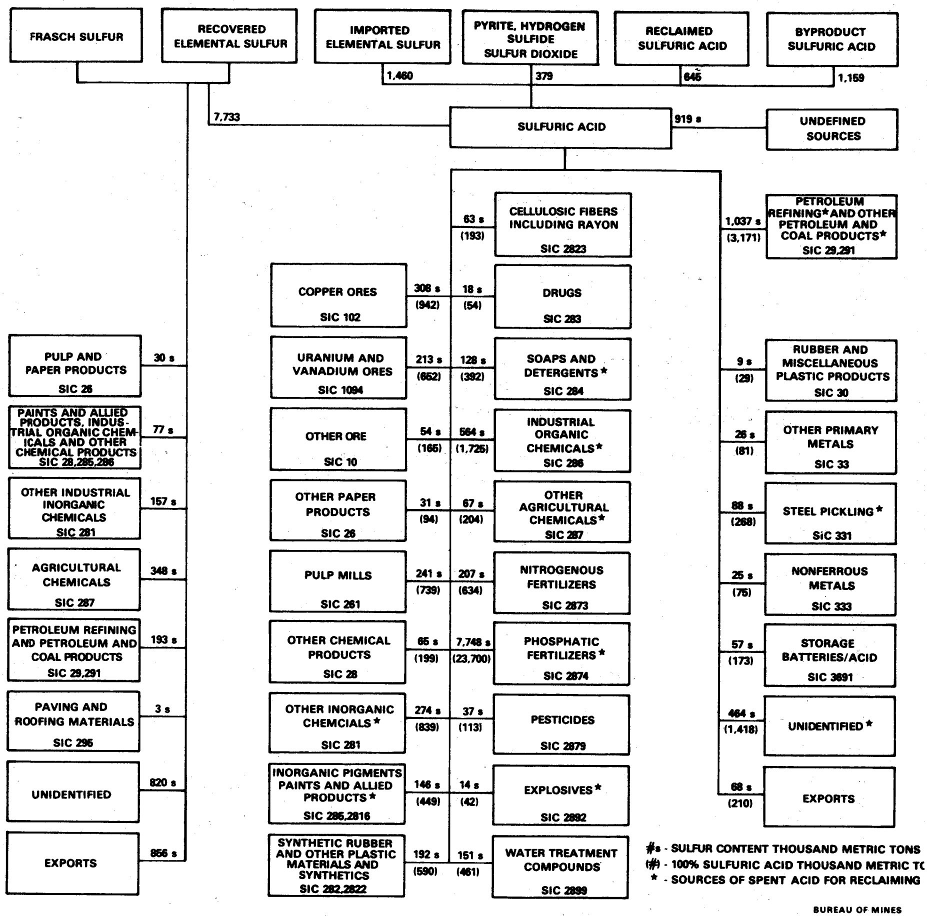

Figure 4.—Sulfur-sulfuric acid supply and end-use relationship in 1981.

STOCKS

Yearend 1981 producers' inventory of Frasch sulfur increased 17% as Frasch producers began rebuilding stocks that were drawn down in 1979 and 1980 to supply domestic needs and world markets. Combined yearend stocks amounted to approximately 4 months' supply based on 1981 domestic and export demands for domestically produced Frasch and recovered elemental sulfur.

Table 12.—Producers' yearend stocks

(Thousand metric tons)

Year	Frasch	Recovered	Total
1977	5,288	269	5,557
1978	5,123	222	5,345
1979	4,058	181	4,239
1980	2,954	r140	r3,094
1981	3,442	192	3,634

rRevised.

PRICES

The quoted price for liquid sulfur was $138.77 per metric ton, Texas and Louisiana gulf ports, and $145.17 per metric ton, exterminal Tampa, Fla., at yearend 1981.

On the basis of shipments and total value reported to the Bureau of Mines, the average value of shipments of Frasch sulfur, f.o.b. mine, for combined domestic consumption and exports during 1981 rose sharply to $121.11 per metric ton from $97.36 per ton in 1980. Shipment values for recovered elemental sulfur varied widely in different regions: Lowest in the West, somewhat higher in the midcontinent, and near the values for Frasch sulfur in the East and South. Overall, the reported unit shipment sulfur value for recovered elemental sulfur, f.o.b. plant, in 1981 was $97.97 per metric ton compared with $74.13 per ton in 1980. In 1981, the average price per ton of sulfur contained in byproduct sulfuric acid increased from $56 in 1980 to $65. The average unit value for sulfur contained in pyrites, hydrogen sulfide, and sulfur dioxide, combined, increased to $171 per ton.

Table 13.—Reported sales values of shipments of elemental sulfur, f.o.b. mine or plant

(Dollars per metric ton)

Year	Frasch	Recovered	Total
1977	48.88	36.91	44.38
1978	48.80	40.07	45.17
1979	59.87	48.23	55.75
1980	97.36	[r]74.13	[r]89.06
1981	121.11	97.97	111.48

[r]Revised.

FOREIGN TRADE

The United States was a net importer of sulfur in 1981 for the seventh year. Exports from the United States, including the Virgin Islands in 1981, were down 22% from those of 1980 to about 1.4 million tons. Imports in the form of elemental sulfur were 2.5 million tons in 1981, the same as in 1980.

Exports from the United States were almost entirely in the form of Frasch sulfur. The total value of exports, including the Virgin Islands, in 1981 decreased 6% from that of 1980. The reported average export value was $134.64 per ton in 1981. Exports to Belgium-Luxembourg and the Netherlands were 52% of the total in 1981.

Imports of Frasch sulfur from Mexico were 856,000 tons in 1981. Imports of recovered elemental sulfur, mostly from Canada, totaled 1.7 million tons in 1981. The unit value of imports of sulfur from Canada increased from $34.20 in 1980 to $60.94 in 1981, and the value of imports from Mexico increased from $86.18 in 1980 to $126.43 in 1981.

Table 14.—U.S. exports of crude and refined sulfur, by country

(Thousand metric tons and thousand dollars)

Country	1980[1] Quantity	1980[1] Value	1981 Quantity	1981 Value
Argentina	23	3,040	7	1,063
Australia	33	4,415	1	500
Belgium-Luxembourg	604	58,888	453	67,028
Brazil	124	15,825	51	7,267
Bulgaria	--	--	14	1,775
Canada	3	447	11	796
Chile	50	5,810	16	1,699
Colombia	15	1,942	(2)	173
Egypt	51	7,214	54	7,400
Finland	--	--	29	4,061
France	24	2,552	(2)	18
Greece	(2)	25	15	1,962
India	49	7,061	161	20,726
Mexico	33	2,187	56	3,235
Morocco	128	16,372	--	--
Netherlands	251	22,479	261	29,820
Nigeria	--	--	16	1,438
Romania	59	7,156	169	22,069
South Africa, Republic of	92	10,519	16	1,710
Spain	4	452	6	630
Tunisia	35	4,127	--	--
Turkey	--	--	14	1,778
United Kingdom	62	6,645	1	28
Uruguay	20	2,523	9	1,171
Other	14	6,189	36	11,060
Total[3]	1,673	185,866	1,392	187,407

[1]In 1980, excluded exports from the Virgin Islands to foreign countries which totaled 108,802 metric tons ($12,887,185).
[2]Less than 1/2 unit.
[3]Data may not add to totals shown because of independent rounding.

Table 15.—U.S. imports of elemental sulfur, by country

(Thousand metric tons and thousand dollars)

Country	1980 Quantity	1980 Value	1981 Quantity	1981 Value
Canada	1,517	51,875	1,666	101,518
Germany, Federal Republic of	(1)	40	(1)	27
Mexico	990	85,316	856	108,221
Trinidad	16	1,620	--	--
Other[2]	(1)	1	(1)	1
Total	2,523	138,852	2,522	[3]209,766

[1]Less than 1/2 unit.
[2]1980—Japan; 1981—United Kingdom.
[3]Data do not add to total shown because of independent rounding.

WORLD REVIEW

Although shipments of sulfur from Iran, Iraq, and Poland continued to be curtailed, Western World demand for sulfur in 1981 was met by shipments of newly produced sulfur and withdrawal from producer inventories. Demand was high during the first half of the year, but was lower in the last half of the year as demand for agricultural purposes declined.

Canada.—Shipments of sulfur in all forms were about 9.0 million tons in 1981. Recovered elemental, which represents about 90% of total output, was produced at 60 sour natural gas plants: 57 in Alberta and 3 in British Columbia. Production of byproduct sulfur from smelter gases was about 720,000 tons in 1981. Canadian sulfur exports were a record high 7.3 million tons, most of which were shipped through the Port of Vancouver.[3]

In Alberta, production of sulfur in 1981 was about 5.7 million tons. About 250,000 tons of the 1981 total was from tar sands. Of the total shipments from Alberta of 7.7 million tons, 5.33 million tons was exported to overseas markets, 1.53 million tons was exported to the United States, and 840,000 tons was for consumption in Canada. Producers' stocks declined from 18.9 million tons at the end of 1980 to 16.7 million tons at the end of 1981. The overall average market value for shipments of sulfur, f.o.b. plant, in December 1981 was $64.03 per metric ton—$53.31 for North American deliveries and $69.17[4] for offshore deliveries—compared with the overall average of $60.77 per metric ton in December 1980.[5]

Facilities are adequate for overseas export of sulfur from natural gas production operations in Alberta. Two railroad lines and two deepwater ports can move the volume of sulfur exported in 1981.[6]

Iraq.—Production of sulfur in Iraq is expected to be 700,000 to 800,000 metric tons until 1985 when it is expected to rise to 900,000 tons.[7]

Italy.—The Campiano Boccheggiano pyrite mine with reserves of 30 million metric tons was opened. Current output of 800,000 metric tons per year is expected to rise to 1 million tons by 1983.[8]

Japan.—Recovery of sulfur at petroleum refineries in 1981 was about 1.0 million tons.

Mexico.—Frasch sulfur production in 1981 was about 1.7 million tons, essentially the same as in 1980. Sulfur reserves have been estimated at 80 million tons. Production of recovered elemental sulfur was about 350,000 tons. Exports of Frasch and recovered elemental sulfur totaled 1.2 million tons. Domestic sales were almost 900,000 tons.

Poland.—Plans are being developed to open a new mine at Skopanie, adjacent to the Jeziorko Mine, using Frasch mining methods. Exports of sulfur were about 3.8 million tons.

Saudi Arabia.—Three sulfur recovery plants are currently in operation. The plant at Berri is producing about 800 tons per day. The Shedgum has four modules with total design capacity of 1,700 tons per day. The first of three modules with total design capacity of 1,100 tons per day was started in the last half of 1981 at Uthmaniyah.[9]

Table 16.—Sulfur: World production in all forms, by country and source[1]

(Thousand metric tons)

Country[2] and source[3]	1977	1978	1979	1980[p]	1981[e]
Algeria: Byproduct, petroleum and natural gas	10	15	15	14	15
Argentina:					
Native (from caliche)	27	18	--	--	--
Byproduct, all sources[e]	20	20	20	NA	NA
Total	47	38	20	NA	NA
Australia:[4]					
Pyrites[5]	108	93	29	29	30
Byproduct:					
Metallurgy[6]	[r]121	[r]140	[e]140	140	140
Petroleum	11	10	11	11	11
Total	[r]240	[r]243	180	180	181
Austria:					
Byproduct:					
Metallurgy	8	9	10	9	9
Petroleum and natural gas	25	22	24	19	19
Gypsum	27	27	27	23	24
Total	60	58	61	51	52
Bahamas: Byproduct, petroleum	[e]5	[e]5	[e]5	[e]5	5
Bahrain: Byproduct, petroleum	7	26	25	33	36
Belgium: Byproduct, all sources	257	267	270	270	270
Bolivia:[7] Native	[8]6	[8]14	[8]15	11	11
Brazil: [9] Byproduct, petroleum	44	57	92	131	150
Bulgaria:					
Pyrites[e]	305	310	315	300	300
Byproduct, all sources[e]	65	70	75	70	70
Total[e]	370	380	390	370	370
Canada:					
Pyrites	12	5	12	12	12
Byproduct:					
Metallurgy	736	676	667	903	720
Natural gas	6,475	6,248	5,935	6,000	5,700
Petroleum	160	200	200	190	160
Tar sands	100	118	213	300	250
Total	7,483	7,247	7,027	7,405	6,842
Chile:[7]					
Native:					
Refined	5	14	12	14	15
From caliche	27	18	65	74	75
Byproduct, metallurgy	29	20	27	33	35
Total	61	52	104	121	125
China:					
Native[e]	200	200	200	200	200
Pyrites[e]	1,252	1,605	1,682	1,700	1,700
Byproduct, all sources[e]	300	350	400	400	400
Total[e]	1,752	2,155	2,282	2,300	2,300
Colombia:					
Native	[r]27	[r]35	16	26	30
Byproduct, petroleum	2	[r]3	2	1	2
Total	[r]29	[r]38	18	27	32
Cuba:					
Pyrites	34	23	12	22	2
Byproduct, petroleum[e]	8	8	8	8	8
Total[e]	42	31	20	30	10

See footnotes at end of table.

Table 16.—Sulfur: World production in all forms, by country and source[1] —Continued

(Thousand metric tons)

Country[2] and source[3]	1977	1978	1979	1980[p]	1981[e]
Cyprus:[10] Pyrites	r69	r55	21	25	20
Czechoslovakia:					
Native	5	5	5	5	5
Pyrites	55	60	60	60	60
Byproduct, all sources	9	10	10	10	10
Total	69	75	75	75	75
Denmark: Byproduct, petroleum	11	14	8	6	6
Ecuador:					
Native[e]	5	5	5	5	4
Byproduct:					
Natural gas[e]	5	5	5	5	5
Petroleum[e]	3	5	5	5	5
Total[e]	13	15	15	15	14
Egypt:[9] Byproduct, petroleum and natural gas	5	3	3	3	20
Finland:					
Pyrites	130	87	151	144	150
Byproduct:					
Metallurgy	280	232	263	247	250
Petroleum[e]	25	30	30	30	30
Total[e]	435	349	444	421	430
France:					
Byproduct:					
Natural gas[11]	1,911	1,900	1,940	1,841	1,800
Petroleum[11]	r146	r161	184	222	206
Unspecified[12]	e160	e160	e160	150	150
Total	r2,217	r2,221	2,284	2,213	2,156
German Democratic Republic:					
Pyrites[e]	10	10	10	10	10
Byproduct, all sources[e]	340	350	350	350	350
Total[e]	350	360	360	360	360
Germany, Federal Republic of:					
Pyrites	235	221	203	198	200
Byproduct:					
Metallurgy[13]	385	r380	450	450	440
Natural gas[11]	r631	r650	690	814	[14]834
Petroleum[11]	186	190	214	220	[14]191
Unspecified[12]	r165	r160	93	e93	30
Total	r1,602	r1,601	1,650	1,775	1,695
Greece:					
Pyrites	54	61	63	61	60
Byproduct, petroleum[e]	3	3	3	4	4
Total[e]	57	64	66	65	64
Hungary:					
Pyrites[e]	3	3	3	3	3
Byproduct, all sources	8	9	9	9	9
Total[e]	11	12	12	12	12
India:[4]					
Pyrites	14	26	29	34	31
Byproduct:					
Metallurgy[e]	117	115	115	115	115
Petroleum	7	7	7	5	4
Total[e]	138	148	151	154	150

See footnotes at end of table.

Table 16.—Sulfur: World production in all forms, by country and source[1] —Continued

(Thousand metric tons)

Country[2] and source[3]	1977	1978	1979	1980[p]	1981[e]
Indonesia:[10] Native	2	([15])	([15])	([15])	([15])
Iran:					
Native[e]	188	150	75	70	50
Byproduct, petroleum and natural gas	400	300	200	150	100
Total[e]	588	450	275	220	150
Iraq:					
Frasch	620	600	550	700	700
Byproduct, petroleum and natural gas[e]	40	40	70	70	70
Total[e]	660	640	620	770	770
Ireland: Pyrites	[r]21	[r]19	13	11	11
Israel: Byproduct, petroleum and natural gas	10	10	10	10	10
Italy:					
Native	36	[r]104	19	23	22
Pyrites	371	330	302	331	310
Byproduct, all sources[e] [16]	259	[r]250	250	250	235
Total	666	[r]684	571	604	567
Japan:					
Pyrites	389	327	300	311	293
Byproduct:					
Metallurgy[17]	1,336	1,296	1,350	1,300	1,200
Petroleum[18]	1,100	1,105	1,241	1,173	1,000
Total	2,825	2,728	2,891	2,784	2,493
Korea, North:					
Pyrites[e]	250	255	255	255	255
Byproduct, metallurgy[e]	12	10	10	10	10
Total[e]	262	265	265	265	265
Korea, Republic of:					
Pyrites	--	--	([15])	([15])	([15])
Byproduct:					
Metallurgy[e]	33	47	54	54	54
Petroleum[e]	31	34	36	36	36
Total[e]	64	81	90	90	90
Kuwait: Byproduct, petroleum and natural gas	79	100	100	120	110
Libya: Byproduct, petroleum and natural gas[e]	17	19	20	22	16
Mexico:					
Frasch	1,723	[r]1,650	1,773	1,700	1,652
Byproduct:					
Metallurgy[e]	80	100	100	150	150
Petroleum and natural gas	[r]133	168	252	402	400
Total[e]	[r]1,936	[r]1,918	2,125	2,252	2,202
Morocco: Pyrites	45	61	63	36	38
Namibia: Pyrites	4	3	4	4	8
Netherlands:					
Byproduct:					
Metallurgy[e]	64	60	60	60	60
Petroleum[e]	[r]30	[r]24	18	52	45
Total[e]	[r]94	[r]84	78	112	105
Netherlands Antilles: Byproduct, petroleum	94	95	91	91	90
New Zealand: Byproduct, all sources	1	1	1	7	7
Norway:					
Pyrites	[r]154	[r]150	119	193	190
Byproduct:					
Metallurgy[e]	38	36	40	40	40
Petroleum[e]	7	7	6	6	6
Total[e]	[r]199	[r]193	165	239	236

See footnotes at end of table.

Table 16.—Sulfur: World production in all forms, by country and source[1] —Continued

(Thousand metric tons)

Country[2] and source[3]	1977	1978	1979	1980[p]	1981[e]
Pakistan:					
Native	1	1	1	1	(15)
Byproduct, all sources[e]	12	14	14	14	15
Total	13	15	15	15	15
Peru:					
Native	[r](15)	(15)	(15)	--	--
Byproduct, all sources	20	18	[e]20	[e]20	20
Total	20	18	20	20	20
Philippines: Pyrites	50	52	41	54	50
Poland:[19]					
Frasch[e]	4,321	4,546	4,310	4,667	4,250
Native[e]	450	505	520	518	472
Byproduct:					
Metallurgy[e 20]	314	315	310	300	300
Petroleum[e 20]	35	35	35	30	30
Gypsum[e]	30	20	20	20	20
Total[e]	5,150	5,421	5,195	5,535	5,072
Portugal:					
Pyrites	156	[r]136	151	155	130
Byproduct, all sources	2	1	1	2	2
Total	158	[r]137	152	157	132
Romania:					
Pyrites[e]	395	400	400	400	400
Byproduct, all sources[e]	110	120	130	140	150
Total[e]	505	520	530	540	550
Saudi Arabia:					
Native[e]	1	1	1	1	NA
Byproduct: Petroleum and natural gas[e]	12	14	125	460	600
Total	13	15	126	461	600
Singapore: Byproduct, petroleum	23	25	26	25	25
South Africa, Republic of:					
Pyrites	332	[r]219	243	493	502
Byproduct:					
Metallurgy	105	[e]100	[e]100	[e]100	127
Petroleum	28	[e]25	[e]25	[e]25	
Total	465	[r]344	368	618	629
Spain:					
Pyrites	[r]1,099	[r]1,046	1,091	1,096	1,100
Byproduct:					
Metallurgy	129	117	120	125	135
Petroleum	5	10	10	12	12
Coal (lignite) gasification[e]	2	3	3	3	3
Total[e]	[r]1,235	[r]1,176	1,224	1,236	1,250
Sweden:					
Pyrites	204	233	282	249	249
Byproduct:					
Metallurgy	135	130	130	130	130
Unspecified[21]	[e]30	[e]18	36	[e]40	40
Total	369	381	448	419	419
Switzerland: Byproduct, petroleum	2	3	3	3	3
Syria: Byproduct, petroleum and natural gas	[e]4	[e]6	[e]6	[e]5	8

See footnotes at end of table.

Table 16.—Sulfur: World production in all forms, by country and source[1] —Continued

(Thousand metric tons)

Country[2] and source[3]	1977	1978	1979	1980[p]	1981[e]
Taiwan:					
Pyrites	3	(15)	(15)	(15)	(15)
Byproduct, all sources	r8	10	9	8	9
Total	r11	10	9	8	9
Trinidad and Tobago: Byproduct, petroleum[4]	34	54	77	80	80
Turkey:					
Native	20	28	e30	30	30
Pyrites	18	e14	e14	21	24
Byproduct, all sources[e]	80	80	70	70	65
Total[e]	118	122	114	121	119
U.S.S.R.:					
Frasch[e]	500	800	800	900	925
Native[e]	2,400	2,700	2,700	2,800	2,850
Pyrites[e]	3,500	3,500	3,500	3,550	3,600
Byproduct:[e]					
Coal	40	40	40	40	40
Metallurgy	2,180	2,210	2,210	2,310	2,350
Natural gas	920	1,100	1,100	1,200	1,250
Petroleum	200	200	200	200	200
Total[e]	9,740	10,550	10,550	11,000	11,215
United Kingdom:					
Byproduct:					
Metallurgy	61	52	50	e50	50
Spent oxides	5	5	5	e6	8
Of petroleum refinery	60	70	70	e70	70
Total	126	127	125	e126	128
United States:					
Frasch	5,915	5,648	6,357	6,390	[14]6,348
Pyrites	169	301	400	322	[14]307
Byproduct:					
Metallurgy	960	1,103	1,167	1,003	[14]1,159
Natural gas	1,426	1,753	1,760	1,757	[14]1,971
Petroleum	2,198	2,309	2,310	2,316	[14]2,288
Unspecified	59	61	107	78	[14]72
Total	10,727	11,175	12,101	11,866	[14]12,145
Uruguay: Byproduct, petroleum	2	2	e2	e2	2
Venezuela: Byproduct, petroleum and natural gas	95	95	85	85	85
Yugoslavia:					
Pyrites	166	r171	190	e189	190
Byproduct:					
Metallurgy[e]	200	200	200	200	200
Petroleum[e]	5	r5	5	5	4
Total	371	r376	395	e394	394
Zaire: Byproduct, metallurgy	31	e30	e30	e30	e30
Zambia:					
Pyrites	8	r1	1	(15)	(15)
Byproduct, all sources	87	109	74	92	90
Total	95	r110	75	92	90
Zimbabwe:					
Pyrites	r22	r24	28	29	25
Byproduct, all sources[e]	5	5	5	5	5
Total[e]	r27	r29	33	34	30
Grand total	r52,341	r53,687	54,745	56,635	55,669

See footnotes at end of table.

Table 16.—Sulfur: World production in all forms, by country and source[1]—Continued

(Thousand metric tons)

Country[2] and source[3]	1977	1978	1979	1980[p]	1981[e]
Grand total—Continued					
Of which:					
Frasch	[r]13,079	[r]13,244	13,790	14,357	13,875
Native	[r]3,400	[r]3,798	3,664	3,778	3,764
Pyrites	[r]9,637	[r]9,801	9,987	10,297	10,260
Byproduct:					
Coal and coal gasification	42	43	43	43	43
Metallurgy	[r]7,354	[r]7,378	7,603	7,759	7,704
Natural gas	[r]11,368	[r]11,656	11,430	11,617	11,560
Petroleum	[r]4,472	[r]4,722	4,949	4,997	4,709
Tar sands	100	118	213	300	250
Petroleum and natural gas, undifferentiated	[r]830	792	910	1,360	1,453
Spent oxides	5	5	5	6	8
Unspecified sources	[r]1,997	[r]2,083	2,104	2,078	1,999
Gypsum	57	47	47	43	44

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

[1]Table includes data available through May 14, 1982.

[2]In addition to the countries listed, a number of nations may produce limited quantities of either elemental sulfur or compounds (chiefly H_2S or SO_2) as a byproduct of petroleum, natural gas, and/or metallurgical operations, but output, if any, is not quantitatively reported, and no basis is available for the formulation of reliable estimates of output. Countries not listed in this table that may recover byproduct sulfur from oil refining include Albania, Bangladesh, Brunei, Burma, Costa Rica, Guatemala, Honduras, Jamaica, Malaysia, Nicaragua, Paraguay, and the People's Democratic Republic of Yemen. Albania and Burma may also produce byproduct sulfur from crude oil and natural gas extraction. No complete listing of other nations that may produce byproduct sulfur from metallurgical operations (including processing of coal for metallurgical use) can be compiled, but the total of such output is considered as small. Nations listed in this table that may have production from sources other than those listed are identified by individual footnotes.

[3]The term "source" reflects both the means of collecting sulfur and the type of raw material. Sources listed include the following: (1) Frasch recovery; (2) native, comprising all production of elemental sulfur by traditional mining methods (thereby excluding Frasch); (3) pyrites (whether or not the sulfur is recovered in the elemental form or as acid); (4) byproduct recovery, either as elemental sulfur or as sulfur compounds from coal gasification, metallurgical operations including associated coal processing, crude oil and natural gas extraction, petroleum refining, tar sand cleaning, and processing of spent oxide from stack-gas scrubbers; and (5) recovery from the processing of mined gypsum. Recovery of sulfur in the form of sulfuric acid from artificial gypsum produced as a byproduct of phosphatic fertilizer production is excluded because to include it would result in double counting. It should be noted that production of Frasch sulfur, other native sulfur, pyrites-derived sulfur, mined gypsum-derived sulfur, byproduct sulfur from extraction of crude oil and natural gas, and recovery from tar sands are all credited to the country of origin of the extracted raw material; in contrast, byproduct recovery from metallurgical operations, petroleum refineries, and spent oxides 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]In addition, may produce limited quantities of byproduct sulfur from natural gas.

[5]Excluding sulfur content of auriferous pyrites, for which data are not available.

[6]Excluding sulfur recovered, if any, from processing copper concentrates.

[7]In addition, may produce limited quantities of byproduct sulfur from crude oil and natural gas and/or from petroleum refining.

[8]Exports; regarded as tantamount to production owing to minimal domestic consumption levels.

[9]In addition, may produce limited quantities of byproduct sulfur from metallurgical operations and/or coal processing.

[10]In addition, may produce limited quantities of byproduct sulfur from oil refining.

[11]Elemental byproduct recovered sulfur only; sulfur recovered as SO_2, H_2S, and/or other compounds is included under "Unspecified."

[12]Comprises all byproduct sulfur recovered in the form of compounds including that, if any, recovered from petroleum and natural gas operations, as well as total recovery from metallurgical operations.

[13]Includes only the elemental sulfur equivalent of sulfuric acid produced as a byproduct from metallurgical furnaces; additional output may be included under "Unspecified."

[14]Reported figure.

[15]Less than 1/2 unit.

[16]Includes recovery from gypsum, if any.

[17]Presumably includes sulfur recovered from coal processed to coke at metallurgical facilities, and excludes sulfur, if any, recovered by metallurgical facilities in elemental form.

[18]Includes sulfur recovered in the form of acid from coal, heavy oil, and other unspecified sources as well as sulfur, if any, recovered by metallurgical facilities in elemental form.

[19]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. Estimates for production of byproduct and gypsum-derived sulfur are based on officially published data on sulfuric acid production and additional information from unofficial sources.

[20]Estimates reported under "Metallurgy" represent byproduct recovery in the form of compounds (principally sulfuric acid) from all sources (including coal and fertilizer plants); estimates reported under "Petroleum" represent only elemental sulfur recovery from petroleum, with any recovery in the form of compounds included under "Metallurgy."

[21]Elemental sulfur only.

TECHNOLOGY

At an international conference, presentation of 63 papers included a review of worldwide and regional supply and markets for sulfur; descriptions of sulfur forming, handling, and transportation; uses of sulfur in asphalt paving; sulfur concretes; and new uses for sulfur.[10]

Capacity, reserves, water ratios, and general information about Frasch sulfur mines in the United States were discussed.[11] Sulfur recovery from petroleum refineries began in the early 1950's. As new capacity came onstream, production rose to 4 million metric tons by 1980.[12] Sulfur recovered from sour natural gas production in the Utah-Wyoming Overthrust Belt is expected to be 2,200 to 2,500 tons per day by 1983.[13]

Sulfur-forming methods were developed to meet environmental requirements for shipping sulfur through the Port of Vancouver, Canada. Prills or pellets are one of the most acceptable forms.[14] A sulfur-grinding plant was installed in Egypt to produce ground sulfur as a protective spray for fruits and vegetables.[15]

Processes to treat and upgrade spent sulfuric acid from a variety of sources were discussed.[16]

Cyclone-type furnaces have been tested to produce sulfur dioxide from pyrites.[17] A number of developments in the technology of flue gas desulfurization (FGD) and sulfur emission control were examined.[18]

Sulfur requirements will be increased by 335,000 tons per year at the Lee Creek, N.C., phosphate operations with the completion in 1982 of the third sulfuric acid plant.[19]

The change to high-analysis fertilizers has resulted in lower or no additions of sulfur to the soil. As the sulfur deficiencies have become apparent, direct application has been required.[20]

Chemical thermodynamic properties of elemental sulfur in crystal, liquid, and ideal gaseous states were evaluated using experimental data reported in the literature.[21]

Sulfur asphalt road paving is being tested on about 75 roads in 35 States in the United States and 150 roads in 15 countries worldwide. Applications of sulfur to hot-mix asphalt and sulfur binders were evaluated.[22]

Sulfur concrete production and performance were reviewed.[23]

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Talc and Pyrophyllite

By Robert A. Clifton[1]

Total domestic production of talc and pyrophyllite combined increased 8% in tonnage and 21% in value in 1981. Decreasing demand caused decreased sales and a 13% decrease in apparent domestic consumption. Exports increased significantly to a near record level. The value of exported talc, however, was not significantly different from that of 1980.

Legislation and Government Programs.—The national stockpile inventory of steatite, block or lump, was a reported 1,092 short tons at the end of 1981. This still far exceeded the goal of 28 tons. The inventory of steatite, with a goal of zero, was 1,089 tons.

The allowable depletion rates established under the Tax Reform Act of 1969 remained at 22% for domestic block steatite and 14% for foreign steatite through 1981.

Tariff rates on imported talc minerals follow: Crude and unground, 0.02 cent per pound; ground, washed, powdered and/or pulverized, 6% ad valorem; cut, sawed, or in blanks, crayons, cubes, disks, or other forms, 0.2 cent per pound; other not specifically provided for, 12% ad valorem.

Table 1.—Salient talc and pyrophyllite statistics

(Thousand short tons and thousand dollars)

	1977	1978	1979	1980	1981
United States:					
Mine production, crude:					
Talc	1,099	1,268	1,268	r1,127	1,236
Pyrophyllite	106	116	185	r113	107
Total	1,205	1,384	1,453	r1,240	1,343
Value:					
Talc	$12,524	$14,956	$19,365	r$25,247	$30,660
Pyrophyllite	561	811	998	r837	837
Total	13,085	15,767	[1]20,364	r26,084	31,497
Sold by producers, crude and processed:					
Talc	996	1,155	1,119	1,173	1,115
Pyrophyllite	118	116	195	158	106
Total	1,114	1,271	1,314	1,331	1,221
Value:					
Talc	$50,647	$68,781	$80,529	$84,523	$95,354
Pyrophyllite	1,708	2,804	4,413	4,254	3,454
Total	52,355	71,585	84,942	88,777	98,808
Exports[2]	322	267	316	275	311
Value	$9,166	$12,359	$15,210	$14,963	$15,095
Imports for consumption	22	19	22	21	[3]27
Value	$2,094	$1,946	$2,822	$3,720	[3]$4,562
Apparent consumption	814	1,023	1,020	1,077	937
World: Production	r6,717	r7,051	r7,547	p7,428	e7,292

eEstimated. pPreliminary. rRevised.
[1]Data do not add to total shown because of independent rounding.
[2]Excludes powders—talcum (in package), face, and compact.
[3]Does not include imported pyrophyllite.

DOMESTIC PRODUCTION

Talc.—Production of crude talc increased 10% in tonnage and 21% in value from that of 1980. Talc, including soapstone, was produced at 35 mines in 11 States in 1981. California's 12 mines were by far the largest number for any State. Mines in four States produced about 90% of the tonnage and value of talc in 1981. These States were, in decreasing order of tonnage produced, Montana, Texas, New York, and Vermont. Montana significantly led all States in the value of talc produced. Of the talc-producing States, only Nevada had no milling facilities.

The seven largest domestic producers of talc in 1981, listed alphabetically, were Cyprus Industrial Minerals Co., with mines in California, Montana, and Texas; Eastern Magnesia Talc Co. in Vermont; Pfizer Inc., Minerals, Pigments & Metals Div., in California and Montana; Southern Clay Products, Inc., in Texas; R. T. Vanderbilt Co., Inc., in New York; Westex Minerals, Inc., in Texas; and Windsor Minerals, Inc., in Vermont.

Pyrophyllite.—The pyrophyllite-producing mines were in North Carolina and California in 1981. Total production decreased to near the 1977 level. Four companies operated seven mines during the year.

Table 2.—Crude talc and pyrophyllite produced in the United States, by State

(Thousand short tons and thousand dollars)

State	1980 Quantity	1980 Value	1981 Quantity	1981 Value
California[1]	r98	r3,759	111	5,867
Georgia (talc)	25	116	26	182
Montana (talc)	r335	r11,798	324	13,383
North Carolina[2]	114	r862	104	825
Texas (talc)	r313	r4,649	282	4,127
Other[3] (talc)	r355	r4,900	496	7,113
Total	r1,240	r26,084	1,343	31,497

rRevised.
[1]Talc and pyrophyllite produced, only talc reported.
[2]Talc and pyrophyllite produced, only pyrophyllite reported.
[3]Includes Arkansas, California (pyrophyllite), Nevada, New York, North Carolina, Oregon, Vermont, and Virginia.

CONSUMPTION AND USES

Apparent domestic consumption of crude and processed talc and pyrophyllite decreased in 1981. Sales of talc and pyrophyllite declined in tonnage but increased in value.

The 1981 end-use distribution showed 38% of the ground talc used in ceramics, 21% in paint, 11% in plastics, 9% in paper, 8% in cosmetics, 4% in rubber, 3% in roofing, 1% in insecticides, with the remainder going to other uses.

The largest portion, 36%, of domestically produced ground pyrophyllite was used in refractories, 27% was used in insecticides, 11% in ceramics, 8% in roofing, and the remainder in other uses. A significant amount of pyrophyllite was imported and ground for use in the ceramics industry.

Table 3.—End uses for ground talc and pyrophyllite

(Thousand short tons)

Use	1980 Talc	1980 Pyrophyllite	1980 Total[1]	1981 Talc	1981 Pyrophyllite	1981 Total
Ceramics	282	13	295	375	12	387
Cosmetics[2]	59	--	59	75	--	75
Insecticides	11	28	39	13	29	42
Paint	197	1	198	206	1	207
Paper	102	--	102	88	--	88
Plastics	110	1	111	111	--	111
Refractories	2	69	71	2	39	41
Roofing	20	10	30	26	9	35
Rubber	37	1	38	36	--	36
Other[3]	83	19	102	50	17	67
Total[1]	903	141	1,045	982	107	1,089

[1]Data may not add to totals shown because of independent rounding.
[2]Incomplete data. Some cosmetic talc known to be included in "Other."
[3]Includes art sculpture, asphalt filler, crayons, floor tile, foundry facings, rice polishing, stucco, and other uses not specified.

PRICES

Talc prices varied over a wide range depending on the quality and degree and method of processing. In general, prices rose during 1981. Engineering and Mining Journal, December 1981, quoted prices for domestic talc, ground, in carload lots, f.o.b. mine or mill, containers included per short ton, as follows:

New Jersey:	
Mineral pulp, bags extra	$18.50- $20.50
Vermont:	
98% through 325 mesh, bulk	64.00
99.99% through 325 mesh, bags:	
Dry processed	136.00
Water beneficiated	213.00-228.00
New York:	
96% through 200 mesh	52.00- 58.00
98% to 99.25% through 325 mesh	66.00- 68.00
100% through 325 mesh, fluid-energy ground	136.00
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 14, 1981, listed the following prices per ton for paint-grade talcs in carload lots:

California:	
Bags, mill:	
White, Hegman No. 3-3-1/2	$103.00
Hegman No. 4-5	129.00
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
Fine micrometer talcs (Canadian, Hegman 6, Timmons, Ontario)	176.00

The approximate equivalents, in dollars per short ton, of the price ranges quoted in Industrial Minerals (London), December 1981, for steatite talc, c.i.f. main European ports, were as follows:

Australian, cosmetic (ex store)	$200-$300
Norwegian:	
Ground (ex store)	120- 150
Micronized (ex store)	170- 240
French, fine-ground	158- 228
Italian, cosmetic-grade	300
Chinese, normal (ex store):	
UK 200 mesh	220- 230
UK 300 mesh	230- 240

FOREIGN TRADE

Exports.—Talc exports increased 13% during 1981 to near record levels. The total value of exported talc changed very little and averaged less than $49 per ton. The value received for talc exported in 1981 varied between $26 per ton to Mexico and a reported $415 per ton to the Republic of Korea.

Mexico remained the major importer of U.S. talc, accounting for 53% of the tonnage in 1981, followed by Canada with 25%. A total of 64 countries imported U.S. talc in 1981. Canada, however, continued to lead in value with 31% of the total compared with Mexico's 28%.

Imports.—U.S. imports of talc increased 29% in 1981. The average value of these imports was $169 per ton. The cosmetic grades accounted for the high prices. Italy, with 38% of the total, was the leading source of imported talc, followed by Canada and France.

Table 4.—U.S. exports of talc[1]

(Thousand short tons and thousand dollars)

Year	Belgium-Luxembourg		Canada		Japan		Mexico		Other		Total	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1977	21	744	132	2,842	19	870	124	1,808	26	2,902	322	9,166
1978	20	1,106	55	3,734	19	1,304	133	2,274	40	3,941	267	12,359
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

[1]Excludes powders—talcum (in package), face, and compact.

Table 5.—U.S. imports for consumption of talc, by class and country

Year and country	Crude and unground		Ground, washed, powdered, or pulverized		Cut and sawed		Total unmanufactured	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value[1] (thousands)
1979	17,908	$1,655	3,565	$403	901	$764	22,374	$2,822
1980:								
Canada	--	--	3,759	385	142	90	3,901	475
France	3,968	319	384	71	--	--	4,352	390
Italy	9,425	1,443	289	86	--	--	9,714	1,529
Japan	--	--	26	14	571	831	597	845
Korea, Republic of	577	47	876	153	269	122	1,722	322
Other[2]	75	9	49	8	190	142	314	159
Total	14,045	1,818	5,383	717	1,172	1,185	20,600	3,720
1981:								
Canada	--	--	6,922	882	87	96	7,009	978
France	5,678	472	403	73	--	--	6,081	545
Italy	2,921	543	7,393	728	--	--	10,314	1,271
Japan	--	--	19	17	693	899	712	916
Korea, Republic of	1,718	216	326	62	189	109	2,233	387
Other[3]	76	23	91	56	487	386	654	465
Total	10,393	1,254	15,154	1,818	1,456	1,490	[4]27,003	[4]4,562

[1]Does not include talc, n.s.p.f.; 1979—$1,291,043; 1980—$1,292,902; 1981—$1,271,884.
[2]Includes Brazil, China, Hong Kong, India, Peru, Saudi Arabia, the Republic of South Africa, Taiwan, and the United Kingdom.
[3]Includes Austria, China, Costa Rica, the Federal Republic of Germany, Hong Kong, India, Kenya, and Taiwan.
[4]Does not include imported pyrophyllite.

WORLD REVIEW

The United States remained the world's largest talc producer and Japan remained the largest pyrophyllite producer during 1981. They shared 42% of the world's talc and pyrophyllite production.

Japan.—Imported talc has been replacing domestically produced pyrophyllite (roseki and roseki concentrate) in the Japanese paper filler industry.[2] Pyrophyllite production had decreased 30% between 1970 and 1975 and was about the same in 1980 as it was in 1975. Talc imports showed a large upswing during the 1975-80 period. Demand for pyrophyllite refractories decreased during this period.

Kenya.—A talc operation of sufficient size to end Kenya's import reliance on Indian talc for its Pan-African Paper Mills was expected to be onstream late in 1981. A hilltop mine and a mill near Webuye in eastern Kenya produced a flotation product of better than 90% purity, with 0.4% free iron and sufficient whiteness for the paper. The domestically owned operation was to be called Octagon Minerals and have a design capacity of 20 tons per day.

Zimbabwe.—The erratic talc production in Zimbabwe has been centered at two mines. The Tritan, Ltd., claims near Que Que, and the Hawkshead Mine near Umtali reportedly produced 1,200 short tons of talc in 1979 and 500 short tons in 1980. G. & W. Industrial Minerals, Ltd., of Salisbury ground the dark green ores to white powders in three grades and sold lump talc for carving.

Table 6.—Talc and pyrophyllite: World production, by country[1]

(Short tons)

Country[2]	1977	1978	1979	1980[p]	1981[e]
North America:					
Canada (shipments)	79,807	67,970	99,572	95,901	98,100
Mexico	180	2,909	2,756	3,000	3,000
United States	1,204,835	1,383,752	1,452,733	1,240,427	[3]1,342,916

See footnotes at end of table.

Table 6.—Talc and pyrophyllite: World production, by country[1] —Continued

(Short tons)

Country[2]	1977	1978	1979	1980[p]	1981[e]
South America:					
Argentina (talc, steatite, pyrophyllite)	[r]60,304	[r]51,601	38,390	36,080	36,397
Brazil (talc and pyrophyllite)[4]	279,857	287,174	402,870	[e]480,000	501,000
Chile	471	476	937	1,256	1,100
Colombia	[r]3,726	[r]4,762	6,708	[e]6,700	6,700
Paraguay	143	176	231	276	290
Peru (talc and pyrophyllite)	[r]12,605	[r]9,820	17,604	[e]16,200	16,200
Uruguay	1,829	1,900	[e]1,980	[e]1,980	1,870
Europe:					
Austria (unground talc)	114,357	117,780	128,860	128,648	126,800
Finland	172,604	215,126	294,515	350,425	330,700
France (ground talc)	315,812	322,646	333,416	331,881	340,600
Germany, Federal Republic of (marketable)	17,605	17,026	16,519	[e]16,500	16,500
Greece (steatite)	--	1,188	--	1,609	1,540
Hungary[e]	17,600	[r]19,300	19,300	19,300	19,300
Italy (talc and steatite)	[r]182,274	[r]184,901	173,484	182,879	220,500
Norway	108,122	106,611	96,435	93,696	27,600
Portugal	1,775	[r]1,884	3,006	2,864	2,870
Romania[e]	[r]66,100	[r]72,800	66,100	66,100	66,100
Spain (steatite)	[r]66,216	68,224	78,316	81,515	82,700
Sweden	23,384	23,503	19,562	3,307	4,400
U.S.S.R.[e]	500,000	520,000	530,000	540,000	550,000
United Kingdom	16,535	19,842	18,298	[e]19,800	19,800
Africa:					
Botswana	317	345	115	86	75
Egypt	7,708	6,509	4,857	4,417	4,410
South Africa, Republic of[5]	14,555	13,940	16,806	15,836	16,674
Zambia	[e]110	[e]110	--	284	275
Zimbabwe	[r]1,560	[r]836	1,179	503	500
Asia:					
Afghanistan[6]	6,295	1,957	551	--	--
Burma	222	431	434	367	330
China	165,000	165,000	165,000	165,000	165,000
India	310,431	[r]371,349	426,272	381,523	381,400
Japan[7]	[r]1,983,058	[r]1,868,333	1,883,698	1,927,718	1,705,300
Korea, North[e]	145,000	[r]165,000	175,000	185,000	185,000
Korea, Republic of (talc and pyrophyllite)	[r]678,174	733,128	857,825	792,752	770,000
Nepal[8]	85	562	358	1,609	1,650
Pakistan (pyrophyllite)	10,118	27,877	29,983	33,069	29,200
Philippines	[r]1,323	4,476	3,935	951	990
Taiwan	[r]11,199	10,964	12,339	10,925	27,600
Thailand (talc and pyrophyllite)	11,429	16,411	14,927	12,926	12,500
Oceania: Australia	[r]124,473	161,989	152,412	174,532	174,160
Total	[r]6,717,198	[r]7,050,588	7,547,283	7,427,842	7,292,047

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through May 5, 1982.
[2]In addition to the countries listed, Czechoslovakia produces talc, but available information is inadequate to make reliable estimates or output levels.
[3]Reported figure.
[4]Total of beneficiated and salable direct shipping production of talc and pyrophyllite.
[5]Includes talc and wonderstone.
[6]Data are for calendar year beginning March 20 of that stated.
[7]Includes talc and pyrophyllite; in addition, pyrophyllite clay is produced; output was as follows in short tons: 1977—485,248; 1978—468,566 (revised); 1979—449,233 (estimated); 1980—413,046; 1981—318,616.
[8]Data based on Nepalese fiscal year, beginning mid-July of year stated.

TECHNOLOGY

According to a chemical industry magazine, the paint industry needs and is finding ways to reduce raw material costs.[3] Silica and synthetic silicates are projected as partial replacements for titanium dioxide (TiO_2) and even the more traditional extenders including talc. At 20 cents per pound, these materials are less costly than TiO_2 but may not be competitive with talc. One company offers the silica in microspherical form (down to 4 micrometers in diameter), which improves the paint flow characteristics.

A paint trade publication describes a new talc product for that industry.[4] The stir-in product can be added at the end of batch manufacture to adjust viscosity and sheen.

[1]Physical scientist, Division of Industrial Minerals.
[2]Fujii, N. The Industrial Minerals of Japan. Ind. Miner. (London), No. 170, November 1981, pp. 21-51.
[3]Chemical Week. Silicates Buck Up Flattened Paint Makers. V. 129, No. 5, Dec. 16, 1981, p. 44.
[4]American Paint & Coatings Journal. Miscellaneous Materials. V. 66, No. 27, Dec. 14, 1981, p. 32.

Thorium

By William S. Kirk[1]

Monazite, the principal source of thorium, continued to be recovered as a byproduct at a mineral sands mine in Florida in 1981. Most of the thorium compounds used by the domestic industry during the year, however, came from imports, Government sales, or existing company stocks.

No major developments occurred in the nonenergy uses of thorium, which include refractories, mantles for incandescent lamps, hardeners in magnesium alloys, welding rods, and electronics.

The only commercial thorium-fueled nuclear reactor in the United States, located at Fort St. Vrain, Colo., continued to run at 70% of its electrical power capacity in 1981. The experimental thorium-fueled, light-water breeder reactor (LWBR) at Shippingport, Pa., continued to operate in 1981.

DOMESTIC PRODUCTION

Exploration.—Thorium resources in the Powderhorn district, Gunnison County, Colorado were assessed in a U.S. Geological Survey report.[2] The economic potential of thorium in the Powderhorn district was related, in part, to other minerals. Because of their small size or low grade, only a few of the 261 domestic thorium deposits contributed to total U.S. resources. Indicated and inferred reserves of ThO_2 totaled about 10,000 short tons in rock greater than 0.1% ThO_2 in grade.

Table 1.—Companies with thorium processing and fabricating capacity

Company	Plant location	Operations and products
Atomergic Chemetals Corp	Plainview, N.Y	Processes oxide, fluoride, and metal.
Babcock & Wilcox Co	Lynchburg, Va	Nuclear fuels.
Bettis Atomic Power Laboratory	West Mifflin, Pa	Nuclear fuels, Government research and development.
Cerac, Inc	Milwaukee, Wis	Processes compounds.
Ceradyne, Inc	Santa Anna, Calif	Processes oxide.
Chicago Magnesium Casting Corp	Blue Island, Ill	Magnesium-thorium alloys.
Consolidated Aluminum Corp	Madison, Ill	Magnesium-thorium alloy.
Controlled Castings Corp	Plainview, N.Y	Do.
General Atomic Co	San Diego, Calif	Nuclear fuels.
W. R. Grace & Co	Chattanooga, Tenn	Processes domestic and imported monazite; stocks thorium-containing residues.
Hitchcock Industries, Inc	South Bloomington, Minn	Magnesium-thorium alloys.

Table 1.—Companies with thorium processing and fabricating capacity —Continued

Company	Plant location	Operations and products
Teledyne Cast Products	Pomona, Calif	Magnesium-thorium alloys.
Union Carbide Corp., Nuclear Div	Oak Ridge, Tenn	Nuclear fuels, test quantities.
Wellman Dynamics Corp	Creston, Iowa	Magnesium-thorium alloys.
Westinghouse Electric Corp	Bloomfield, N.J	Processes compounds; produces metallic thorium.

Mine Production.—Associated Minerals (USA) Ltd. Inc. (AMC), an Australian-owned firm, produced monazite from a dredging operation in Green Cove Springs, Fla. It was the only company in the United States to produce monazite in 1981.

Refinery Production.—The only domestic firm, in 1981, with facilities for processing large tonnages of monazite was W. R. Grace & Co., Davison Chemical Div., at Chattanooga, Tenn. Although W. R. Grace did not produce for sale any thorium compounds, thorium was extracted from monazite and stored during the refining of rare-earth elements. W. R. Grace had about 4,700 tons of thorium residues stored at its plant site at the end of 1981.

Rhône-Poulenc Co., a French firm, completed the construction of its new rare-earth separation plant in 1981 and began operations. The Freeport, Tex., facility was to be capable of processing 7,000 tons of monazite per year. Approximately 400 tons per year of thorium residues that will be generated are expected to be stored.

CONSUMPTION AND USES

Based on imports, sales from the national stockpile, and other data, the estimated domestic consumption of thorium (in ThO_2 equivalence) was about 39 tons in 1981. The major nonenergy uses were refractories (14 tons) and mantles for Welsbach incandescent lamps (9 tons). Other nonenergy uses included hardeners in magnesium-thorium alloys (3 tons); thoriated tungsten welding rods (3 tons); and electronic, electro-optical, chemicals, and other applications and research (5 tons).

The Department of Energy's (DOE) experimental LWBR at Shippingport, Pa., continued producing electrical power for the Duquesne Light Co. power distribution grid during 1981. By the end of the year, the reactor had passed 24,000 effective full-power hours of operation with the LWBR core, having produced nearly twice the energy originally predicted. Initial loading of about 46 tons of thorium took place in 1977. At the end of its life, the spent core will be removed from Shippingport and sent to DOE's National Engineering Laboratory in Idaho for detailed examination and determination of breeding performance.

The Fort St. Vrain high-temperature, gas-cooled reactor continued to run at 70% of its electrical power capacity in 1981. The Public Service Co. of Colorado tested the reactor up to 100% of its power capacity. The core of the reactor contained about 22 tons of thorium and was the Nation's first commercial reactor to use a prestressed concrete reactor vessel, helium coolant, steam turbine drive, and a fully ceramic core utilizing the uranium-thorium fuel cycle.

STOCKS

On December 31, 1981, the stockpile of the General Services Administration contained 7,131,812 pounds of thorium nitrate (1,705 short tons of ThO_2 equivalent). The thorium nitrate goal was 600,000 pounds (143 tons of ThO_2 equivalent). The DOE inventory as of December 31, 1981, was 1,410 tons of thorium contained in various compounds.

PRICES

The average declared value of imported monazite at U.S. ports was $380 per short ton in 1981. The price per short ton of Australian monazite quoted in the Metal Bulletin (London) was A$345 to A$390 (US$389 to US$440) at the end of 1981.

Prices for thorium compounds, in U.S. dollars, varied depending on the quality. Thorium oxide, 99% pure, was quoted at $9.63 per pound at the end of 1981, and thorium oxide, 99.99% pure, was $17.27. Catalyst and lamp-grade thorium oxide were $17.95 and $21.14, respectively, at the end of the year.

FOREIGN TRADE

The United States exported thorium ores and concentrates in 1981 for the second consecutive year. Export data for thorium in other forms were combined with those for uranium. Although these two elements were not statistically differentiated, it was believed that the quantity of thorium in other forms was minor.

Monazite containing about 6% thorium oxide was imported from Australia. Imports of monazite and thorium nitrate rose above 1980 levels, and imports of thorium oxide nearly doubled.

Table 2.—U.S. foreign trade in thorium and thorium-bearing materials

(Quantity in pounds unless otherwise specified)

	1979		1980		1981		Principal sources and destinations, 1981
	Quantity	Value	Quantity	Value	Quantity	Value	
EXPORTS							
Ore and concentrate[1]	--	--	6,898	$17,226	285,285	$146,421	France 285,285.
Metals and alloys[2]	10,651	$216,630	2,652	61,321	429	10,639	Australia 216; New Zealand 136; Saudi Arabia 77.
IMPORTS							
Ore and concentrate:							
Monazite (short tons)	6,931	1,676,939	5,674	1,849,767	8,307	3,158,767	Australia 8,307.
ThO_2 content	831,720	XX	680,880	XX	996,796	XX	
Compounds:							
Nitrate	47,415	162,837	59,962	210,219	62,152	258,327	France 53,886; Canada 7,936; United Kingdom 330.
Oxide	31,509	160,490	20,557	144,038	40,450	377,164	France 36,431; Netherlands 4,008; Canada 11.
Oxide equivalent, in gas mantles[e 3]	2,867	476,842	3,713	677,642	2,646	556,894	Malta 2,069; Brazil 311; Others 266.
Metals and alloys	7,607	342,315	4,695	248,835	4,706	225,888	United Kingdom 4,706.
Other	181	33,688	501	65,478	665	106,538	United Kingdom 455; West Germany 108; Others 102.

[e]Estimated. XX Not applicable.
[1]No thorium ore and concentrates were exported in 1979.
[2]Includes uranium; thorium and uranium are undifferentiated in official statistics.
[3]Based on the manufacture of 1,000 gas mantles per pound ThO_2.

WORLD REVIEW

The chief source of the world's thorium is monazite, a byproduct of mineral sands mining for titanium and zirconium in many countries and for tin in Malaysia. Australia, India, Brazil, and Malaysia were the leading monazite producers among market-economy countries in 1981. Of those countries, Malaysia was the only source of monazite without various types of government export restrictions. Australia and Malaysia had little or no domestic processing capabilities beyond the monazite concentrating stage at the mine. Production quantities do not reflect world demand for thorium because monazite is processed almost entirely for its rare-earth element content.

Australia.—In Southern Goldfield Ltd.'s offshore exploration program for monazite-bearing mineral sands, a number of samples were analyzed.[3] The analyses showed that the assemblages of heavy minerals present indicate the possibility of economic grades if sufficient quantities of heavy minerals can be found in the area.

Allied Eneabba Ltd. announced that it had reached an agreement to acquire all the heavy mineral leases in the Eneabba area held by Westralian Sands Ltd. and its subsidiary, Ilmenite Pty.[4] According to the terms of the agreement, Allied was to form a new, wholly owned subsidiary to hold the leases. A total of 103 leases were involved, and in return, Westralian was to receive 27,500 tons of zircon from Allied over the following 3 years. It was estimated that the probable reserves were in excess of 5 million tons of heavy minerals. E. I. du Pont de Nemours & Co., a U.S. company, increased its percentage of ownership in Eneabba in 1981 to a reported 59%.[5]

Western Australia was reportedly planning to raise royalties on minerals sands mining from 2% to 2.5%.[6] This should have no significant effect on mineral sands prices.

Shareholders of Consolidated Goldfields Australia Ltd., Associated Minerals Consolidated Ltd., Renison Ltd., and the Mount Lyell Mining and Railway Co. Ltd. approved plans for the merging of the four companies.[7] The companies were to become wholly owned subsidiaries of a newly incorporated public company to be called Renison Goldfields Consolidated Ltd. (RGC).[8] The new company was to be 51% owned by the Australian public. This would mean RGC would not need Government approval for most company actions, including investing in AMC's Florida heavy minerals operations.

The Queensland Government decided to allow mineral sands mining on Moreton Island off the coast of Brisbane.[9] The decision, however, allowed mining of an area of less than 7% of the island.

Mineral sands mines were reportedly being forced out of business by the expansion of national parks and other state actions.[10] The development of about 45% of Australia's reserves of mineral sand on the east coast was frozen for environmental reasons.[11] According to a Mineral Sands Producers Association symposium, this restriction was excessive especially in view of improved environmental controls by mineral sands producers.

Egypt.—The most economically important mineral sands deposit in Egypt was reported to be in the Rosetta area.[12] The deposit contained an estimated 1.9 million tons of heavy minerals, of which 0.5% was monazite.

France.—The French thorium producer, Rhône-Poulenc S.A., was nationalized by the new Government in 1981. The nationalization, including the appointment of a company president by the Government, was expected to be completed in the first quarter of 1982. The company did not anticipate that any operational changes would occur as a result of the takeover.

India.—Completion of the $100 million Orissa mineral sands complex was rescheduled for the end of 1982.[13] The complex at Chatrapur, Orissa, on the east coast, originally had been scheduled for completion in June 1981. The plant was designed to produce 4,400 tons of monazite per year.

As part of the research program for the utilization of thorium, experiments on fast-breeder reactors were being planned and an experimental fast-breeder reactor was being built in 1981.[14] The reactor, at Kalpakkam Reactor Research Center near Madras, was supposed to become functional by 1983.

South Africa, Republic of.—Byproduct thorium sulfate was being recovered from the mining operations at the Palabora Complex in 1981.[15]

Elsewhere, the General Mining Union

Corp. was to commission, in 1981, a new plant for the production of 2,700 to 3,000 tons per year of monazite.[16] This level of monazite production would put South Africa among the world leaders.

Table 3.—Monazite concentrate: World production, by country[1]

(Metric tons)

Country[2]	1977	1978	1979	1980[p]	1981[e]
Australia	[r]9,379	[r]14,992	16,340	13,748	13,500
Brazil	[r]2,440	[r]2,540	1,890	1,205	1,500
India[3]	[r]2,734	[r]3,303	3,254	[e]4,210	4,300
Malaysia[4]	[r]1,977	[r]1,263	669	400	350
Sri Lanka	5	[r]213	213	63	60
Thailand	--	(5)	32	152	150
United States	W	W	W	W	W
Zaire	[r]96	[r]77	90	51	50
Total	[r]16,631	[r]22,388	22,488	19,829	19,910

[e]Estimated. [p]Preliminary. [r]Revised. W Withheld to avoid disclosing company proprietary data; not included in world total.

[1]Table includes data available through Apr. 15, 1982.

[2]In addition to the countries listed, China, Indonesia, Nigeria, North Korea, and the Republic of Korea produce monazite, but output, if any, is not reported quantitatively, and available general information is inadequate for formulation of reliable estimates of output levels.

[3]Data are for years beginning Apr. 1 of that stated.

[4]Exports.

[5]Revised to zero; figure previously reported (845 short tons) was the 1978 export, and apparently was possible because of production in 1975 and before that had not been shipped when mined. Exports were not permitted in 1976 and 1977.

TECHNOLOGY

As part of its program to investigate the substitution of domestic resources for expensive and domestically scarce catalytic materials, the U.S. Bureau of Mines investigated the effectiveness of a thorium-copper catalyst for use in methanol production.[17] The thorium-copper catalyst was found to be many times more effective than commercially used catalysts.

A report published in 1981 describes the immobilization of thorium in mine wastes.[18]

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[1]Physical scientist, Division of Nonferrous Metals.

[2]Olson, J. C., and D. C. Hedlund. Alkalic Rocks and Resources of Thorium and Associated Elements in the Powderhorn District, Gunnison County, Colo. U.S. Geol. Survey Prof. Paper 1049-C, 1981, 34 pp.

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Tin

By James F. Carlin, Jr.[1]

World tin mine production increased slightly in spite of a world economic slowdown and generally declining prices. The 1981 average Metals Week composite price of Straits (Malaysian) tin was $7.33 per pound, a decline of more than $1 from the average price of the prior year. The economic slowdown caused a significant decrease in tin consumption that contributed to a substantial imbalance of tin metal supply and demand. Price patterns throughout the year did not fully reflect the consumption decline owing to a large amount of price support purchasing, allegedly made by one or more major tin mining countries during the last half of the year.

Legislation and Government Programs.—The General Services Administration (GSA) continued its daily fixed-price tin sale program throughout the year, increasing the tempo of sales in the last half of the year. Starting December 14, GSA allowed stockpile tin to be sold to foreign users, and this change resulted in significantly increased sales volume. A total of 5,920 metric tons was sold in 1981. The GSA sales program generated considerable opposition from major tin mining countries who claimed the sales were harming their economies by depressing the tin price during a year of slack demand. On June 10, Associated Metals and Minerals Corp. (Asoma), the operator of the only domestic tin smelter, filed a lawsuit against GSA alleging that stockpile tin sales caused serious financial damage to the company; a subsequent judicial decision upheld the GSA position.

The United States continued as a member of the Fifth International Tin Agreement (ITA). The Fifth ITA had been scheduled to expire on July 1, 1981, but because key issues remained unresolved in talks for the

Table 1.—Salient tin statistics

(Metric tons unless otherwise specified)

	1977	1978	1979	1980	1981
United States:					
Production:					
Mine	W	W	W	W	W
Smelter	6,724	5,900	4,600	3,000	2,000
Secondary	18,503	21,100	21,493	18,638	15,438
Exports (including reexports)	5,480	4,692	3,417	4,294	6,080
Imports for consumption:					
Metal	47,774	46,776	48,355	45,982	45,874
Ore (tin content)	6,724	3,873	4,529	840	232
Consumption:					
Primary	47,596	48,403	49,496	44,342	40,229
Secondary	13,136	13,128	12,969	12,020	14,144
U.S. industry yearend stocks	21,366	17,217	r16,567	r15,745	11,675
Prices, average cents per pound:					
New York market	499.38	587.03	711.45	773.44	648.40
New York composite	534.60	629.58	753.89	846.00	733.05
London	486.92	583.83	700.93	761.99	649.53
Penang	485.96	567.65	672.33	745.56	637.85
World production:					
Mine	r230,694	r241,082	245,948	p246,493	e252,509
Smelter	r228,451	r244,108	r249,167	p250,099	e242,097

eEstimated. pPreliminary. rRevised. W Withheld to avoid disclosing company proprietary data.

Sixth ITA, it was decided to extend the provisions of the Fifth ITA one extra year, until July 1, 1982. On October 9, the office of the U.S. Trade Representative announced that the United States would not be joining the Sixth ITA.

The depletion allowances for tin remained 22% for domestic deposits and 14% for foreign deposits.

DOMESTIC PRODUCTION

PRIMARY TIN

Mine Production.—Some tin ore was produced as a byproduct of molybdenum mining in Colorado and some tin concentrates were produced in placer mining in Alaska. Domestic mine production of tin was withheld to avoid disclosing company proprietary data but amounted to only a small fraction of domestic tin requirements.

Smelter Production.—The lone domestic tin smelter, Gulf Chemical & Metallurgical Corp. (GCMC), a subsidiary of Asoma, located in Texas City, Tex., continued to operate without substantial amounts of imported tin concentrates.

The feed for the smelter was primarily domestic tin concentrates, secondary tin-bearing materials, and GCMC's stockpile of tin residues and slags. Tin smelter production was estimated at 2,000 tons.

SECONDARY TIN

The United States continued to be the world's largest producer of secondary tin. Secondary tin production declined as consumption requirements decreased. During the year four domestic detinning plants ceased operation: the Deming, N. Mex., the East Chicago, Ind., and the Baltimore, Md., plants of MRI Corp., a subsidiary of American Can Co.; and the Milwaukee, Wisc., plant of the Wisconsin Metal Chemical Corp.

Table 2.—Secondary tin recovered from scrap processed at detinning plants in the United States

	1980	1981[e]
Tinplate scrap treated metric tons	766,940	667,952
Tin recovered in the form of:		
Metal do	1,457	1,328
Compounds (tin content) do	321	265
Total[1] do	1,778	1,593
Weight of tin compounds produced do	1,533	1,220
Average quantity of tin recovered per metric ton of tinplate scrap used kilograms	2.32	2.38
Average delivered cost of tinplate scrap per metric ton	$89.39	$102.42

[e]Estimated; four detinning plants closed during 1981.
[1]Recovery from tinplate scrap treated only. In addition, detinners recovered 241 metric tons (220 metric tons in 1980) of tin as metal and in compounds from tin-base scrap and residues in 1981.

Table 3.—Tin recovered from scrap processed in the United States, by form of recovery

(Metric tons)

Form of recovery	1980	1981
Tin metal:		
At detinning plants	1,677	1,569
At other plants	26	18
Total	1,703	1,587
Bronze and brass:		
From copper-base scrap	10,352	8,864
From lead- and tin-base scrap	[e]50	30
Total	10,402	8,894

See footnotes at end of table.

Table 3.—Tin recovered from scrap processed in the United States, by form of recovery —Continued

(Metric tons)

Form of recovery	1980	1981
Solder	4,423	3,035
Type metal	525	576
Babbitt	378	261
Antimonial lead	856	791
Chemical compounds	321	265
Miscellaneous[1]	[e]30	29
Total	6,533	4,957
Grand total	18,638	15,438
Value (thousands)	$317,625	$220,547

[e]Estimated.
[1]Includes foil and terne metal.

Table 4.—Stocks, receipts, and consumption of new and old scrap and tin recovered in the United States in 1981

(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:									
Auto radiators (unsweated)	3,749	59,717	--	61,243	61,243	2,223	--	1,775	1,775
Brass, composition or red	3,653	55,579	10,657	44,499	55,156	4,076	340	1,475	1,815
Brass, low (silicon bronze)	528	2,772	893	1,958	2,851	449	--	15	15
Brass, yellow	3,445	42,503	7,586	34,339	41,925	4,023	10	315	325
Bronze	1,678	17,133	2,836	14,266	17,102	1,709	210	985	1,195
Low-grade scrap and residues	10,675	202,000	155,568	44,156	199,724	12,951	20	--	20
Nickel silver	544	2,763	315	2,308	2,623	684	3	18	21
Railroad-car boxes	254	1,750	--	1,768	1,768	236	--	60	60
Total	24,526	384,217	177,855	204,537	382,392	26,351	583	4,643	5,226
Brass mills:[1]									
Brass, low (silicon bronze)	3,724	57,305	57,305	--	57,305	2,142	--	--	--
Brass, yellow	19,864	241,163	241,163	--	241,163	17,788	125	--	125
Bronze	775	3,903	3,903	--	3,903	543	170	--	170
Nickel silver	3,756	19,746	19,746	--	19,746	3,020	--	--	--
Total	28,119	322,117	322,117	--	322,117	23,493	295	--	295
Foundries and other plants:[2]									
Auto radiators (unsweated)	456	5,271	1,528	2,287	3,815	1,912	--	115	115
Brass, composition or red	680	14,431	2,636	11,770	14,406	705	15	435	450
Brass, low (silicon bronze)	51	1,449	1,140	320	1,460	40	--	2	2
Brass, yellow	349	11,661	6,395	4,673	11,068	942	20	45	65
Bronze	869	695	396	307	703	861	40	25	65
Low-grade scrap and residues	--	1	--	1	1	--	--	--	--
Nickel silver	14	385	16	371	387	12	--	--	--
Railroad-car boxes	851	6,069	--	5,840	5,840	1,080	--	350	350
Total	3,270	39,962	12,111	25,569	37,680	5,552	75	972	1,047
Total tin from copper-base scrap	XX	XX	XX	XX	XX	XX	953	5,615	6,568

See footnotes at end of table.

Table 4.—Stocks, receipts, and consumption of new and old scrap and tin recovered in the United States in 1981 —Continued

(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
Lead-base scrap:									
Smelters, refiners, and others:									
Babbitt	167	6,656	--	6,729	6,729	94	--	595	595
Battery lead plates	34,724	735,029	--	731,255	731,255	38,498	--	1,514	1,514
Drosses and residues	12,484	83,900	--	84,799	84,799	11,585	2,226	--	2,226
Solder and tinny lead	1,931	11,605	--	11,829	11,829	1,707	--	1,893	1,893
Type metal	1,908	13,795	--	14,041	14,041	1,662	--	601	601
Total	51,214	850,985	--	848,653	848,653	53,546	2,226	4,603	6,829
Tin-base scrap:									
Smelters, refiners, and others:									
Babbitt	13	92	--	94	94	11	--	79	79
Block-tin pipe	3	71	--	69	69	5	--	68	68
Drosses and residues	54	447	471	--	471	30	55	--	55
Pewter	--	5	--	5	5	--	--	5	5
Total	70	615	471	168	639	46	55	152	207
Tinplate and other scrap:									
Detinning plants	--	--	667,952	--	667,952	--	1,834	--	1,834
Grand total	XX	XX	XX	XX	XX	XX	5,068	10,370	15,438

[e]Estimated; tin recovered new and old from copper-base scrap, brass mills, and foundries. XX Not applicable.
[1]Brass-mill stocks include home scrap, and purchased-scrap consumption is assumed equal to receipts; therefore, lines and total in brass-mill section do not balance.
[2]Omits "machine-shop scrap."

CONSUMPTION AND USES

Tin consumption declined owing to the general economic slowdown that impacted most usage categories. The tinplate category remained the largest use of primary tin. The solder category, which uses substantial quantities of secondary tin as well as primary tin, was the largest total use of tin.

Tinplate continued to lose ground to aluminum in its traditional container markets. Out of a total of 88.3 billion metal cans shipped, steel (tinplate and tin-free steel) accounted for 45% and aluminum accounted for 55%; this compared with a total of 87.9 billion metal can shipments in 1980, with steel accounting for 52% and aluminum 48%. Two-piece cans—both tinplate and aluminum—increased their penetration of the beverage markets, accounting for 98% of metal can shipments compared with 92% in 1980.

Overall, two-piece cans represented 66% of total metal can shipments compared with 60% in 1980.[2]

Brass mills consumed 815 tons of primary tin and 500 tons of secondary tin, compared with 715 tons of primary tin and 385 tons of secondary tin in 1980.

Table 5.—Consumption of primary and secondary tin in the United States

(Metric tons)

	1977	1978	1979	1980	1981
Stocks Jan. 1[1]	16,894	16,858	13,584	r12,938	9,456
Net receipts during year:					
Primary	48,215	46,821	r50,126	r43,545	41,162
Secondary	4,025	2,541	2,636	2,461	5,692
Scrap	10,604	10,499	r10,659	r7,709	8,050
Total receipts	62,844	59,861	r63,421	r53,715	54,904
Total available	79,738	76,719	r77,005	r66,653	64,360
Tin consumed in manufactured products:					
Primary	47,596	48,403	49,496	44,342	40,229
Secondary	13,136	13,128	12,969	12,020	14,144
Total	60,732	61,531	62,465	56,362	54,373
Intercompany transactions in scrap	2,148	1,604	1,602	835	726
Total processed	62,880	63,135	64,067	57,197	55,099
Stocks Dec. 31 (total available less total processed)	16,858	13,584	r12,938	r9,456	9,261

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)
1977	355,841	4,228,325	18,539	4.4
1978	338,351	4,022,524	17,280	4.3
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

[1]Includes small tonnage of secondary tin and tin acquired in chemicals.

Table 7.—Consumption of tin in the United States, by finished product

(Metric tons of contained tin)

Product	1980			1981		
	Primary	Secondary	Total	Primary	Secondary	Total
Alloys (miscellaneous)	W	134	134	1,900	535	2,435
Babbitt	1,537	843	2,380	1,412	2,432	3,844
Bar tin	486	W	486	455	W	455
Bronze and brass	2,147	5,331	7,478	2,205	4,836	7,041
Chemicals	W	W	W	4,417	W	4,417
Collapsible tubes and foil	526	W	526	561	W	561
Solder	11,653	3,965	15,618	11,210	4,589	15,799
Terne metal	(1)	(1)	(1)	(1)	(1)	(1)
Tinning	2,531	46	2,577	2,491	W	2,491
Tinplate[2]	16,346	--	16,346	13,306	--	13,306
Tin powder	1,098	11	1,109	983	W	983
Type metal	W	W	W	19	33	52
White metal[3]	914	W	914	1,027	174	1,201
Other	7,104	1,690	8,794	243	1,545	1,788
Total	44,342	12,020	56,362	40,229	14,144	54,373

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Included with "Alloys (miscellaneous)."
[2]Includes secondary pig tin and tin acquired in chemicals.
[3]Includes pewter, britannia metal, and jewelers' metal.

Table 8.—U.S. industry yearend tin stocks

(Metric tons)

	1977	1978	1979	1980	1981
Plant raw materials:					
Pig tin:					
Virgin[1]	6,173	4,129	r4,073	r10,423	7,034
Secondary	645	694	r219	r268	447
In process[2]	10,040	8,761	r8,646	r1,788	1,780
Total	16,858	13,584	r12,938	r12,479	9,261
Additional pig tin:					
Jobbers-importers	1,436	275	258	564	1,943
Afloat to United States	3,072	3,358	3,371	2,702	471
Total	4,508	3,633	3,629	3,266	2,414
Grand total	21,366	17,217	r16,567	r15,745	11,675

rRevised.
[1]Includes tin in transit in the United States. In 1979, the figure represents scrap purchased only.
[2]Tin content, including scrap. In 1980, data represents scrap only.

PRICES

The price of tin metal declined during the first half of the year, then rose sharply during the second half, ending the year at a higher price than at the beginning of the year. The average price for the year was more than $1 per pound lower than in 1980. Prices were influenced by the significant world oversupply of tin relative to demand, which tended to depress the price, and the massive price support buying program during the last half of the year that was allegedly undertaken by one or more major tin mining countries, which tended to increase the price.

Table 9.—Monthly composite price of Straits tin for delivery in New York

(Cents per pound)

Month	1980			1981		
	High	Low	Average	High	Low	Average
January	863.92	817.46	837.36	785.46	719.15	748.76
February	921.37	835.29	868.73	723.15	700.73	713.49
March	959.93	867.26	898.60	718.65	688.79	700.26
April	907.75	854.55	876.66	708.56	652.37	683.58
May	894.39	851.80	868.50	666.60	643.82	658.06
June	868.23	843.60	853.46	666.76	645.80	658.39
July	853.36	833.79	843.16	742.99	650.15	689.81
August	845.59	832.85	839.22	786.81	731.08	753.39
September	884.10	849.02	868.98	792.95	769.53	780.22
October	852.67	821.00	840.00	810.63	786.04	795.61
November	819.93	772.13	797.79	832.28	803.27	821.47
December	776.47	745.02	759.56	809.56	778.18	793.52
Average	XX	XX	846.00	XX	XX	733.05

XX Not applicable.

Source: Metals Week.

FOREIGN TRADE

Imports of tin concentrates declined sharply as the world's tin mining countries increased their smelter capacity, thus leaving less concentrates available for export.

Imports of tin metal from China became a significant item for the first time in several years. Malaysia, Thailand, Bolivia, and Indonesia remained the major sources for tin metal.

Imports of tin in all forms, ore and concentrate, metal, and waste and scrap, remained free of duty to all nations.

Table 10.—U.S. exports and imports for consumption of tin, tinplate, and terneplate in various forms

Year	Ingots, pigs, and bars				Tinplate and terneplate				Tinplate circles, strips, and cobbles		Tinplate scrap	
	Exports		Reexports		Exports		Imports		Exports		Imports	
	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)
1979	568	$8,074	2,849	$42,783	399,525	$204,986	2,942	$1,292	([1])	([1])	5,471	$513
1980	595	10,194	3,699	62,382	641,401	440,671	NA	NA	([1])	([1])	6,497	405
1981	2,361	31,053	3,719	55,505	345,718	220,993	NA	NA	([1])	([1])	5,080	414

NA Not available.
[1]Included with exports of tinplate and terneplate.

Table 11.—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)
1979	$16,732	1,350	$11,011	$12,513	202	$2,473
1980	9,154	1,312	4,215	13,819	171	2,285
1981	8,666	2,583	3,387	16,357	170	2,098

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

Country	1980 Quantity (metric tons)	1980 Value (thousands)	1981 Quantity (metric tons)	1981 Value (thousands)
Concentrates (tin content):				
Bolivia	528	$7,505	--	--
Canada	13	85	--	--
Indonesia	27	376	--	--
Mexico	1	2	--	--
Peru	--	--	232	$2,975
South Africa, Republic of	125	1,536	--	--
Thailand	146	1,585	--	--
Total	840	11,089	232	2,975
Metal:[1]				
Australia	145	2,400	552	8,121
Belgium-Luxembourg	190	3,365	--	--
Bolivia	5,597	90,730	8,277	110,520
Brazil	2,031	34,211	1,129	15,463
Canada	113	1,939	22	384
Chile	--	--	5	59
China	858	13,855	2,033	22,263
Germany, Federal Republic of	--	--	--	--
Hong Kong	--	--	50	631
India	--	--	1	16
Indonesia	6,477	104,383	7,096	99,791
Japan	10	158	--	--
Korea, Republic of	20	350	--	--
Macao	20	332	--	--
Malaysia	15,548	265,819	13,163	193,432
Mexico	--	--	70	666
Nigeria	770	13,092	520	6,935
Peru	260	3,496	99	1,490
Rhodesia	63	1,092	--	--
Singapore	864	14,685	656	9,516
South Africa, Republic of	181	3,113	34	466
Switzerland	5	85	--	--
Thailand	12,414	205,515	11,967	163,331
United Kingdom	416	7,562	46	665
Zimbabwe	--	--	154	2,131
Total	45,982	766,182	45,874	635,880

[1]Bars, blocks, pigs, or granulated.

WORLD REVIEW

International Tin Agreement.—Negotiations for the Sixth ITA, originally due to take effect on July 1, 1891, continued throughout the year. Since the differences between consumer country and producer country positions on such central issues as the International Tin Council's (ITC) buffer stock and export controls proved to be considerable, it was decided to extend the provisions of the Fifth ITA an additional year, to July 1, 1982, to allow more time for discussions.

On October 9, the U.S. Government announced it had decided not to join the Sixth ITA. Reportedly the U.S. was concerned that the new ITA would not provide for a sufficiently large tin buffer stock.

On October 17, 1981, the ITC revised upward by 6.85% the buffer stock price range (table 13). Throughout the year criticism was expressed by producer countries about the sale of GSA stockpile tin by the U.S. Government.

Table 13.—Changes in ITC buffer stock range

	Effective Oct. 17, 1981	Previous range
	M$ per kilogram[1]	M$ per kilogram[1]
Floor price	29.15	27.29
Lower sector	29.15-32.06	27.29-30.01
Middle sector	32.06-34.98	30.01-32.74
Upper sector	34.98-37.89	32.74-35.47
Ceiling price	37.89	35.47

[1]M$ Malaysian dollar.

Three major tin conferences were held in 1981: The International Lead-Zinc-Tin '80 Symposium, at the American Institute of Mining, Metallurgical, and Petroleum Engineers annual meeting, Las Vegas, Nev., in February; a conference on complex tin ores, sponsored by the Southeast Asia Tin Research and Development Center and The Indonesian State Tin Corp., in Bandung, Indonesia, in April; and a conference covering the mining and marketing of tin metal, sponsored by the ITC, held in Kuala Lumpur, Malaysia, in October.

Australia.—Renison Ltd., 51% owned by Consolidated Gold Fields Australia Ltd., was the leading producer, accounting for about one-half of the total Australian mine production. Renison continued studying the possibility of installing a tin fuming plant that would be based on a process developed in the German Democratic Republic. An acid leaching plant was commissioned to remove the acid-soluble iron carbonate and increase the tin grade of concentrates.

Aberfoyle Ltd., in which Cominco Ltd. has an interest, sold its tin mines in northeastern Tasmania to Forestwood Australia Ltd. and Gold Copper Exploration Ltd. The new partners announced intentions of revising current mining and processing operations, including the reprocessing of tailings.

A sulfide tin deposit was discovered near Bourke, New South Wales, on the Doradilla Prospect owned by Eastmet Ltd. and Aberfoyle Ltd. Reports indicated tin deposits grading at 1.2%.

Pacific Copper Mines Ltd. of Edmonton, Canada, reported positive results from an exploration program on its wholly owned tin-tungsten property at Jingellic, New South Wales, Australia. Preliminary assays indicated a combined average tin-tungsten grade of over 1%.

Tin mineralization was reported by Comstaff Pty. Ltd., a subsidiary of Anglo American Corp., on Apollo International Minerals N.L.'s Godkin Ridge Prospect in Tasmania. Additional drillings were planned.

Greenbushes Tin N.L. continued its drilling program at its mine site in Western Australia and reported probable reserves of 28.1 million tons, with an average grade of 0.114% tin, 0.043% tantalum pentoxide, and 0.031% columbium pentoxide. The firm reported that continuing exploration results were sufficiently encouraging, therefore, it was evaluating plans to develop a mine and also construct a refinery at nearby Kwinana.

The joint venture, which owns the Taronga Tin project near Emmaville, New South Wales, reported continued study and evaluation of the large tonnage, low-grade deposit. The partners were Newmont Holdings Pty. Ltd., ICI Australia Ltd., Endeavour Resources Ltd., and Pelsart Resources N.L. They announced proven reserves of 25 million tons of tin ore grading 0.2%, and silver byproduct estimated at 0.14 ounce of silver per ton.

Two smelters operated in 1981: The Associated Tin Smelter, Ltd., in Sydney on the east coast, and the Greenbushes smelter near Perth on the west coast.

Table 14.—Tin: World mine production, by country[1]

(Metric tons)

Country	1977	1978	1979	1980[p]	1981[e]
North America:					
Canada	328	360	337	264	248
Mexico	220	73	23	60	100
United States	W	W	W	W	W
South America:					
Argentina	[2]537	[2]362	386	351	340
Bolivia	[r]33,740	30,881	27,648	27,272	29,801
Brazil	[r]6,287	[r]6,341	7,005	6,930	9,000
Peru	[r]329	[r]458	870	1,077	1,519
Europe:					
Czechoslovakia[e]	[2]180	[2]180	[2]180	180	180
German Democratic Republic[e]	1,400	1,600	1,600	1,800	1,900
Portugal	267	[r]282	225	274	380
Spain	[r]641	[r]711	496	437	475
U.S.S.R.[e]	33,000	34,000	35,000	36,000	36,000
United Kingdom	[r]4,100	[r]3,132	2,708	3,291	[3]3,890
Africa:					
Burundi	[e]20	[e]20	8	([4])	--
Cameroon	14	14	8	10	10
Niger	130	125	73	78	75
Namibia	994	1,250	1,042	1,000	1,000
Nigeria	3,267	2,935	2,750	2,527	2,500
Rwanda	1,598	1,502	1,910	2,069	1,800
South Africa, Republic of	2,864	2,886	2,697	2,913	2,811
Swaziland	2	1	([4])	--	--
Tanzania	--	9	10	12	11
Uganda[e]	[2]120	[2]120	60	30	30
Zaire	5,073	4,390	3,879	3,000	2,200
Zambia[e]	3	([5])	1	([5])	([5])
Zimbabwe	1,280	[r]1,310	1,340	1,300	1,600
Asia:					
Burma	362	757	1,233	1,290	1,310
China[e]	13,000	14,000	14,000	14,600	15,000
Indonesia	25,926	27,411	29,440	32,527	34,869
Japan	605	603	660	549	562
Korea, Republic of	15	19	31	[3]8	10
Laos[e]	[2]600	[2]400	300	350	400
Malaysia	58,703	62,650	62,995	[3]61,404	59,938
Thailand	24,205	30,186	33,962	[3]33,685	32,000
Vietnam	[e]250	[e]250	[e]200	[3]370	550
Oceania: Australia	10,634	11,864	12,871	10,835	12,000
Total	[r]230,694	[r]241,082	245,948	246,493	252,509

[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, England. Table includes data available through June 9, 1982.
[2]Estimate by the International Tin Council.
[3]Reported figure.
[4]Revised to zero.
[5]Less than 1/2 unit.

Bolivia.—Tin production was hampered by strikes, plant operational problems, and declining ore grades. Workers at the tin mines of Corporación Minera de Bolivia struck for several weeks, reducing output at the Huanuni Mine.

The new La Palca volatilization plant, installed near Potosí by Machinoexport of the U.S.S.R. and under construction since 1971, began production in April but had to be closed by December owing to pollution problems. The plant was designed to process 4,000 tons per year of a preconcentrate assaying about 4% tin. The tin dust produced would supplement the concentrate feed for the Vinto low-grade tin smelter located about 300 kilometers away.

Brazil.—The largest tin ore producer, Paranapanema S.A. Mineração, reportedly expected to double its 1981 production of 3,500 tons within 2 years by developing a 60,000-ton deposit near Manaus in the Amazon River valley. Mineração Oriente Novo S.A. (Brumadinho Group), the second leading tin ore producer, announced two expansion projects, a dredging operation in Rondônia, and a project in Goiás State. The firm was a joint venture between the Canadian-based Brascan Ltd. and British Petroleum Ltd.

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

(Metric tons)

Country	1977	1978	1979	1980[p]	1981[e]
North America:					
Mexico[2]	1,000	1,000	1,268	1,642	1,600
United States[3]	6,724	5,900	4,600	3,000	2,000
South America:					
Argentina	[r]100	[r]100	100	200	150
Bolivia	13,045	16,254	14,950	18,191	20,005
Brazil	7,421	9,309	10,133	8,642	7,600
Europe:					
Belgium	3,520	3,295	2,165	3,000	2,500
German Democratic Republic[e]	[r]1,750	[r]1,750	2,000	2,200	2,300
Germany, Federal Republic of	[r]3,940	[r]4,767	4,096	2,257	1,816
Netherlands	2,100	[r]1,600	1,445	1,370	1,350
Portugal	[r]1,016	[r]854	1,121	938	1,000
Spain	5,343	4,575	4,412	4,100	3,400
U.S.S.R.[e]	33,000	34,000	35,000	36,000	36,000
United Kingdom	10,458	8,445	8,025	5,829	[4]3,396
Africa:					
Nigeria	3,315	2,984	2,858	2,678	2,700
South Africa, Republic of	582	637	819	1,100	2,056
Zaire	765	496	458	458	550
Zimbabwe	920	945	967	934	1,130
Asia:					
China	13,000	14,000	14,000	14,600	15,000
Indonesia	24,005	25,829	27,790	30,465	32,000
Japan	1,280	1,141	1,251	1,319	[4]1,314
Malaysia[5]	66,304	71,953	73,068	71,318	68,500
Thailand	23,102	28,945	33,058	34,689	31,000
Vietnam	[e]200	[e]200	[e]160	350	500
Oceania: Australia	5,561	5,129	5,423	4,819	4,230
Total	[r]228,451	[r]244,108	249,167	250,099	242,097

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Data derived in part from the Monthly Statistical Bulletin of the International Tin Council, London, England. Output reported throughout is primary tin only unless otherwise specified. This includes data available through June 6, 1982.
[2]Smelter output from domestic ores is as follows, in metric tons: 1976—481; 1977—220; 1978—73; 1979—23; and 1980—20 (estimated).
[3]Includes tin content of alloys made directly from ores.
[4]Reported figure.
[5]Includes small production of tin from smelter in Singapore.

Brascan sold 50% of its holdings in Brascan Recursos Natural (BRN), the Brazilian tin mining and smelting group, to British Petroleum. (In 1980, Brascan bought Companhia Estanífera do Brasil (CESBRA), which was then merged with two smaller Brascan tin-mining subsidiaries to form BRN). BRN operated mines in the Rondônia District and operated the tin smelter at Volta Redonda in Rio de Janeiro State, which produced about 40% of the total Brazilian tin metal output. BRN announced plans for major tin exploration in the Rondônia District.

The 10 tin smelters in Brazil possessed total nominal capacity of approximately 20,000 tons per year of tin metal, almost double the Brazilian concentrate output. The principal smelter operators were: CESBRA (the Brascan Group in Volta Redonda); Mamorá Mineração e Metalurgica Ltd. (Paranapenema Group in São Paulo); Companhia Industrial Amazonese S.A. (Best Group in Manaus); and Bera do Brasil S.A. (Brumadinho Enterprises in São Paulo).

Canada.—Construction proceeded on the Mount Pleasant Mine in New Brunswick. Billiton Canada Ltd. was the operator of the joint venture with Brunswick Tin Mines Ltd. Mining of tungsten and molybdenum was expected to start in 1982. Although low-grade tin ore was present, it was expected that no tin would be mined for several years.

Springpoint Resources Ltd. reported a tin find grading 0.3% during initial drilling at its Jackass Prospect near Nelson, British Columbia.

Shell Canada Resources Ltd. reported that it was nearing a decision about proceeding with mine construction at its tin prospect in East Kemptville, Nova Scotia.

China.—A major high-grade tin prospect was announced in Yunnan Province in southwest China. In the southern Province of Guangxi, it was reported that the new Changyingling ore dressing plant started up, with capacity to produce 900 tons per year of tin concentrate.

Seven tin smelters were in production, and an eighth was planned to be started in Liepen County in Guangxi Province by 1985. The largest is the Kokiu smelter in Yunnan Province, with a capacity of 10,000 tons of tin metal per year. The second largest is the Liuchow smelter in Guangxi Province, with a 2,000-ton annual capacity.

Indonesia.—Tin mine production continued the pattern of steady rises over recent years. The dominant tin miner was Perusahaan Terbatas Tambang Timah (P. T. Timah), the national mining organization. P. T. Timah took delivery of the Belitung 1, a new offshore tin mining dredge constructed from a British design, at its mining site near Pulan Belitung. The dredge has 0.62-cubic-meter meter buckets and can dig to a depth of 46 meters.

P. T. Koba Tin, the second largest tin producer, has compiled a record of considerable growth in recent years. The firm operated 13 gravel pump units and 1 strip mine in addition to the 2 small dredges that were being phased out. The reasons for the growth in output of this organization reportedly are the excellent tin grades of the exploited ground and the favorable energy costs that Indonesia enjoys compared with other tin producing countries.

The gravel pump mining sector in Indonesia consists of about 230 units.

A deposit of about 1 million tons of tin ore was discovered off the coast of Bangka Island. Tin ore reserves were also found off the coast of Singkep Island. The Ministry of Mines and Metallurgy reported the discovery of tin mineralization in mainland Sumatra to the west of the presently exploited tin belt.

Malaysia.—Tin mine production declined slightly, but Malaysia maintained its longheld position as the world's leading tin producer. At yearend 1981, there were 60 tin dredges, 593 gravel pump mines, and 57 opencast, underground, and other miscellaneous mines in operation, about 150 less than the number of total active mines at yearend 1980. The labor force decreased significantly to 35,198. The main decline in the number of mines occurred in the gravel pump sector.

The Malaysian mining industry has reportedly suffered severly from increased costs, especially fuel and labor expenses. This has been especially true in the gravel pump mining sector, which reportedly accounted for 56% of Malaysia's total production.

The world's largest tin mining company was formed when Malayan Tin Dredging Berhad merged with Malaysia Mining Corp. to form a new organization called Malaysia Mining Corp. Berhad (MMC). The new firm operated 40 of the 60 tin dredges in Malaysia and accounted for about 22% of Malaysia's total output of tin concentrates. The new firm had capital estimated at $1.1 billion. The major shareholder was Permodalan Nasional Berhad, the Malaysian Government's equity corporation, with 56.6% ownership (14.5% was held by Charter Consolidated Ltd., 3.8% was held by Datuk Keramat Holdings, and 25.1% was held by the public).

MMC was expected to commission two large new dredges in early 1982, the Berjuntai No. 9 and the dredge of Timah Dermawan. The Osborne & Chappell Group expected to commission a new dredge, the Petaling No. 9, in 1982.

MMC announced a joint venture to establish an international trading company, Nastra Sdn. Bhd., due to commence operation in early 1982. MMC's partners are: Petronas, the state oil development agency; the Federal Land Development Authority; and Kuok Bros. Sdn. Bhd., a Kuala Lumpur trading firm.

Singapore-based Straits Trading Co. Ltd. sold 42% of its ownership of the tin smelter at Penang (Butterworth) to MMC. Malaysia's only other tin smelter, also located in Penang, was owned by Datuk Keramat Smelting and processed both native tin concentrates and considerable quantities from Australia, Burma, and Brazil.

Perusahaan Sadur Timah Malaysia Sdn. Bhd. (Perstima), a joint venture tinplate plant, started operation in Pasir Gudang. Perstima was owned by a Malaysian canning firm, MMC, three Singapore canners, and two Japanese firms. The plant was expected to produce 90,000 tons of tinplate per year, using Japanese steel.

Spain.—Metalurgica de Nordeste de España, S.A. (MENSA) began construction of a 12,000-ton-per-year tin smelter at its Valga works in Galicia; it was expected to start production by 1983. MENSA's other smelter at Villagarcia de Arosa, with a capacity of 7,000 tons annually, could only treat tin concentrates with a minimum of 45% tin content; the new plant was being built to process low-grade concentrates from Spain and abroad. The firm also announced expansion of its Ayos Mine in Galicia. Spain had seven smelters and more than 50 tin mines, primarily along the western border.

Thailand.—Tin production declined slightly. The Board of Trade of Thailand attributed the decline primarily to depletion of tin ore. No major efforts have been made in recent years to survey for new deposits. Also cited were higher production costs that resulted in the shutdown of some mining operations and continued smuggling to Singapore.

The Industry Ministry granted a mining permit to Tongkha Harbour Ltd., a firm partially owned by Tongkha Harbour Tin Dredging Berhad of Malaysia, for mining in the island Province of Phuket.

The Thai Government reduced royalties on tin by about 10% to help miners lower production costs.

The newly formed Thai Tantalum Industries Corp., based in Bankok, announced plans for a $20 million tin slag smelter and tantalite processing complex that with adequate financing could begin production by late 1983.

Thailand's second major tin smelter, Thai Pioneer Enterprise Ltd., was commissioned with a startup capacity of 3,600 tons annually, and is situated in Pathum Thani near Bangkok. The West German-based Metallgesellschaft AG contracted to purchase the total production.

U.S.S.R.—Tin output continued to be inadequate to meet domestic needs, and imports accounted for about 20% of requirements. The major Soviet tin producing areas were the Soviet Far East, Yakut Autonomous Soviet Socialist Republic (A.S.S.R.), and Transbaykal, and the average content of tin ores reportedly ranged from 0.6% to 1% tin.

The largest tin producing district was the Maritime Kray in the Soviet Far East. The major producer in this region was the Khrustal'nyy complex, which operated both lode and placer deposits. The Khrustal'nyy complex operated the Khrustal'nyy, Ege-Khaya, Imeni Lazlo, Kholodnyy, and Alyaskavityy Mines.

The largest single tin producer in the U.S.S.R. was the Khingan complex at Birobidzhan (Jewish Autonomous Oblast'), Khabarovsk Kray of the Soviet Far East. At Khingan, the concentrator was renovated in 1979 and the Berezovyy Mine and a mine near Obluchye were being developed. The Solnechnyy complex in Khabarovsk Kray operated the Solnechyy, Molodezhnyy, and Pereval'nyy Mines.

There were three known tin smelters in the U.S.S.R., situated in the cities of Novosibirsk, Ryazan, and Podol'sk (near Moscow). Concentrates from Siberia and the Soviet Far East were sent to the largest smelter, at Novosibirsk.

Construction of a tin complex on the Sary-Dzhar River near Inulchek, Kirgiz Soviet Socialist Republic (S.S.R.), was scheduled to begin in the 1981-85 period. Intensive exploration programs were carried out. Positive results were reported in Magadan Oblast', Khabarovsk Kray, the Yakut A.S.S.R., and the Kirgiz S.S.R.[3]

United Kingdom.—The Williams, Harvey Ltd. tin smelter in Liverpool, with 8,000 tons annual capacity, closed down. The smelter had been under the control of a liquidator since 1973 and had been treating residues and low-grade concentrates.

Carnon Consolidated Tin Mines Ltd. announced a program to spend $6 million over 18 months to deepen the Clemows shaft at its Wheal Jane Mine.

South West Consolidated Minerals Ltd. was granted permission to redevelop the Redmoor Mine near Callington in Cornwall.

Amax Exploration of U.K., Inc., and its joint partner Hemerdon Mining & Smelting Ltd. sought permission to mine tungsten and tin at Hemerdon, near Plymouth. This action followed completion of a feasibility study initiated in 1978. Mineralization containing 42 million tons with an overall tin grade of 0.03% was identified.

TECHNOLOGY

Sirosmelt, a new method of smelting that increases metal yields and lowers energy consumption, was tested at the Associated Tin Smelter Ltd. in Sydney, Australia. Associated installed a prototype Sirosmelt unit to improve tin recovery from slag (the residue left after the main smelting process). Sirosmelt, developed by John Floyd at the Commonwealth Scientific and Industrial Research Organization, uses a cappucino-type method to reduce the time, energy, and expense of conventional smelting. While most smelting involves the reduction of tin concentrate in a sizable furnace with the solid charge being heated from above the surface by radiation from a flame, Sirosmelt delivers heat directly to the concentrate through a special lance. The lance comprises two tubes, one carrying the fuel, such as natural gas, and the other air. The mixture burns and bubbles beneath the molten slag's surface producing intense heat and rapidly melting the concentrate. The prototype at Associated was not yet being used in the main tin smelting stage, but in the recovery of tin from slag, which contains up to 18% tin. The Sirosmelt unit permits the molten slag to be treated immediately. Because it operates independently of the main smelter, both smelting and slag retreatment can proceed uninterrupted. Sirosmelt reportedly could smelt a concentrate containing only 20% to 30% tin, and its greater efficiency means the extra slag produced could be handled relatively inexpensively.[4]

Various advances were made in techniques of wave soldering, a new form of mass soldering that enables users to solve the problem of maintaining a clean, oxide-free solder surface for the processing of printed circuit boards. Circuit boards pass through the crest of a standing solder wave so that only the boards' lower surface makes contact with the wave.[5]

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[1]Physical scientist, Division of Nonferrous Metals.

[2]Can Manufacturers Institute. Metal Can Shipments Report 1981. Washington, D.C., 1982, p. 5.

[3]U.S. Bureau of Mines Yearbook, V. 3. The Mineral Industry of the U.S.S.R. 1981.

[4]American Metal Market. V. 89, No. 191, Oct. 2, 1981, p. 7.

[5]———. V. 89, No. 34, Feb. 20, 1981, p. 5.

Titanium

By Langtry E. Lynd[1] and Ruth A. Hough[2]

Titanium mill product shipments in 1981 were about 25,500 tons,[3] down 6% from the record level of 27,000 tons set in 1980. Demand for titanium metal was dropping sharply toward the end of 1981, mainly because of a slowdown in commercial aircraft production. Domestic production and consumption of titanium dioxide pigments increased in 1981, but consumption was still 5% below the level reached in 1979. U.S. production of ilmenite decreased 7% in 1981 to 509,000 tons, the lowest since 1950, owing to reduced production in Florida. Production of natural rutile increased slightly, and the production rate of the only domestic synthetic rutile plant reached its design capacity of 110,000 tons per year. Price quotations for ilmenite and titanium slag in U.S. markets increased 32% and 17%, respectively, while prices of ilmenite f.o.b. Australia remained in the range from $25 to $27 per long ton. Domestic spot prices for rutile, increased 6%, but prices of rutile, f.o.b. Australia, dropped 9% for bulk concentrates and 26% for bagged material during the year. Titanium sponge metal prices rose 9% to $7.65 per pound, and pigment prices increased about 20% to $0.75 per pound for rutile and $0.69 per pound for anatase.

Table 1.—Salient titanium statistics

	1977	1978	1979	1980	1981
United States:					
Ilmenite concentrate:					
Mine shipments ---- short tons	542,333	580,878	646,399	593,704	523,681
Value ---- thousands	$25,201	$25,628	$32,965	$32,041	$37,013
Imports for consumption ---- short tons	334,990	308,671	184,478	357,488	236,217
Consumption ---- do	866,504	792,289	791,063	[r]848,607	856,116
Titanium slag:					
Imports for consumption ---- do	150,564	149,172	111,210	194,994	268,825
Consumption ---- do	149,454	128,826	144,708	181,582	252,826
Rutile concentrate, natural and synthetic:					
Imports for consumption ---- do	123,800	289,617	283,479	281,605	202,373
Consumption ---- do	185,419	263,184	313,761	[r]297,582	285,371
Sponge metal:					
Imports for consumption ---- do	2,387	1,476	2,488	4,777	6,490
Consumption ---- do	16,236	19,854	23,937	26,943	[e]31,599
Price, Dec. 31, per pound	$2.98	$3.28	$3.98	$7.02	$7.65
Titanium dioxide pigments:					
Production ---- short tons	687,103	700,755	[r]742,081	[r]727,245	750,141
Imports for consumption ---- do	114,810	117,708	104,968	97,590	124,906
Apparent consumption ---- do	785,003	801,728	[r]837,042	[r]753,480	794,991
Price, Dec. 31, cents per pound:					
Anatase	43.5	46.0	53.0	57.0	69.0
Rutile	48.5	51.0	59.0	63.0	75.0
World production:					
Ilmenite concentrate ---- short tons	[r]3,652,870	[r]3,874,659	3,919,966	[p]4,018,919	[e]3,978,614
Titaniferous slag ---- do	[r]764,529	1,037,193	842,044	[p]1,343,210	[e]1,248,000
Rutile concentrate, natural ---- do	[r, 1]380,833	[r, 1]332,690	[1]391,726	[p, 1]459,634	[e, 1]398,447

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Excludes U.S. production data to avoid disclosing company proprietary data.

Legislation and Government Programs.—The Government stockpile goal for titanium sponge metal remained at 195,000 tons in 1981. The Government stockpile in December 1981 contained 21,465 tons of specification sponge metal and 10,866 tons of nonspecification material.

The Government stockpile goal for rutile was unchanged at 106,000 tons in 1981. The total rutile stockpile inventory in December 1981 was 39,186 tons.

Congress approved a program for construction of 100 B-1 bombers in the 1981-88 period. Each B-1 aircraft reportedly will cost about $180 million and will require up to 250,000 pounds of titanium mill products. Industry sources indicated that the U.S. supply of titanium in the next few years, augmented by additions to U.S. sponge capacity and imports from expanded Japanese facilities, will be ample for anticipated demand, including the B-1 program. The prime contractor for building the B-1 is Rockwell International Corp.[4]

A summary of trade and tariff information on titanium dioxide pigments was published by the U.S. International Trade Commission.[5]

DOMESTIC PRODUCTION

Concentrates.—Production of ilmenite in 1981 was the lowest since 1950. This low U.S. output was caused mainly by reduced production by the two Florida heavy mineral sand mining and milling operations of E. I. du Pont de Nemours & Co., Inc., at Starke and Highland, and that of Associated Minerals (U.S.A.) Inc., Ltd. (AMU), at Green Cove Springs. Production totals at the heavy mineral sand facility of ASARCO Incorporated at Manchester, N.J., and at the hardrock mining and milling operations of NL Industries, Inc., at Tahawus, N.Y., were about the same as in 1980. AMU was the only U.S. producer of natural rutile concentrate in 1981.

Kerr-McGee Chemical Corp., the only U.S. producer of synthetic rutile, increased the production rate of its plant at Mobile, Ala., to the design capacity of 110,000 tons per year. Feed for this plant has been mainly Australian ilmenite, but Florida ilmenite has also been used.

In November 1981, Asarco announced it would shut down its Manchester ilmenite mine near Lakehurst, N.J., in March 1982, because its sole customer, Du Pont, had decided to exercise an option to end a 10-year purchase agreement 1 year early. The reasons cited for this decision were the prospect of a long-term oversupply situation and escalating costs. Closure of the Manchester Mine, which began production in 1973, will reduce U.S. ilmenite annual production capacity by about 185,000 tons.

Ferrotitanium.—Ferrotitanium was produced by Shieldalloy Corp. at Newfield, N.J.; The Pesses Co. at Solon, Ohio; Reactive Metals and Alloys Corp., West Pittsburg, Pa.; and A. Johnson & Co., Inc., Lionville, Pa. Most of the production of ferrotitanium consisted of the 70% titanium grades.

Metal.—Production of titanium sponge metal in 1981 was 11% higher than that of 1980. Total U.S. sponge capacity reached about 30,600 tons in 1981, up 9% from that of 1980.

Sponge-producing companies during 1981 and their approximate annual capacities were TIMET (a division of Titanium Metals Corp. of America, at Henderson, Nev., jointly owned by NL Industries and Allegheny International, Inc.), 15,000 tons; RMI Co., Ashtabula, Ohio (owned by National Distillers and Chemical Corp. and United States Steel Corp.), 9,500 tons; Oregon Metallurgical Corp. (publicly owned with Armco Steel Corp. and Ladish Corp. as major stockholders), 4,500 tons; Teledyne Wah Chang Albany, Albany, Oreg., 1,500 tons; and D-H Titanium Co. (a joint venture of Dow Chemical Co. and Howmet Turbine Components Corp. at a demonstration electrolytic process plant at Freeport, Tex.), 100 tons.

The nine U.S. companies that produced titanium ingot in 1981 are listed in table 2. Total domestic titanium ingot capacity in 1981 was about 50,000 tons.

Table 2.—Companies producing titanium ingot in 1981

Company	Plant location
Crucible, Inc., Colt Industries	Midland, Pa.
Howmet Corp., Alloy Div	Whitehall, Mich.
Lawrence Aviation Industries, Inc	Port Jefferson, N.Y.
Martin Marietta Aluminum, Inc	Torrance, Calif.
Oregon Metallurgical Corp	Albany, Oreg.
RMI Co	Niles, Ohio.
Teledyne Allvac	Monroe, N.C.
Teledyne Wah Chang Albany	Albany, Oreg.
Titanium Metals Corp. of America	Henderson, Nev.

Table 3.—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)
1977	638,503	542,333	331,139	$25,201
1978	589,751	580,878	352,842	25,628
1979	639,292	646,399	389,535	32,965
1980	548,882	593,704	358,181	32,041
1981	509,342	523,681	310,854	37,013

[1]Includes a mixed product containing rutile, leucoxene, and altered ilmenite.

Table 4.—Components of U.S. titanium metal supply and demand

(Short tons)

Component	1977	1978	1979	1980	1981
Production:					
Ingot	26,302	31,385	37,414	[r]42,864	[e]45,923
Exports:					
Sponge	NA	97	180	113	58
Other unwrought	NA	210	155	344	257
Scrap	3,394	5,453	4,967	3,300	3,280
Ingot, slab, sheet bar, etc	1,050	1,340	1,984	3,278	4,203
Other wrought	--	689	1,316	1,845	1,846
Total	4,444	7,789	8,602	8,880	9,644
Imports:					
Sponge	2,387	1,476	2,488	4,777	6,490
Scrap	4,494	3,789	6,140	4,138	3,787
Ingot and billet	354	561	338	191	244
Mill products	--	1,125	942	946	1,116
Total	7,235	6,951	9,908	10,052	11,637
Stocks, end of period:					
Government: Sponge (total inventory)	32,331	32,331	32,331	32,331	32,331
Industry:					
Sponge	3,546	2,642	2,155	2,381	[e]3,720
Scrap	6,770	6,447	6,733	8,641	[e]10,484
Ingot	1,898	[r]2,569	2,366	[r]1,860	3,592
Other	42	73	200	2	7
Total industry	12,256	[r]11,731	11,454	[r]12,884	[e]17,803
Reported consumption:					
Sponge	16,236	19,854	23,937	26,943	[e]31,599
Scrap	10,889	12,318	13,986	15,406	[e]14,795
Ingot	25,241	30,746	[r]37,868	[r]43,360	[e]43,525
Mill products (net shipments)[1]	15,466	17,648	23,113	[r]27,133	25,492
Castings (shipments)[1]	188	180	[r]186	191	209

[e]Estimated. [r]Revised. NA Not available.

[1]Source: U.S. Bureau of the Census, Current Industrial Reports, Ser. DIB-991 and ITA-991.

In April 1981, International Titanium, Inc., owned by Ishizuka Research Institute of Japan and other Japanese and U.S. investors, announced it would build a \$25 million, 5,000-ton-per-year titanium sponge plant at Moses Lake, Wash.[6] The new plant was to make titanium tetrachloride ($TiCl_4$) from Australian rutile and to use magnesium reduction of the $TiCl_4$, with vacuum distillation to remove magnesium and magnesium chloride from the sponge. Construction was well advanced by the end of 1981, and sponge production was expected to begin early in 1982.[7]

In September 1981, Albany Titanium Co. announced it would build a titanium sponge plant at Albany, Oreg., to be in production in 1982. The facility was to have an initial annual capacity of about 250 tons, expanding later to 500 tons, and was to use purchased $TiCl_4$, magnesium reduction, and vacuum distillation treatment of the sponge. The company planned to produce a very high grade of titanium sponge, for sale mainly to ingot producers that use titanium scrap.[8]

TIMET was carrying out a \$50 million modernization program, to be completed in 1983, which will increase efficiency and raise titanium sponge capacity to 16,000 tons per year, with potential for increasing capacity to 20,000 tons per year by reactivating some of the facilities scheduled for shutdown. The heart of the project is a new magnesium recycling plant, additional chlorinating capacity, improved reduction facilities, and new ingot-melting furnaces.[9]

RMI Co. was conducting a \$50 million program to modernize and expand its titanium-producing facilities, raising their capacity to over 10,000 tons of mill products per year. The program was to include a \$20 million melt shop with two new vacuum arc melting furnaces, raising ingot capacity to an estimated 12,000 tons per year, a 3,000-ton press to increase the capacity of forging ingots into billets and slabs, and other facilities.[10]

Oregon Metallurgical Corp. (Oremet) completed a 50% expansion of sponge production capacity to 4,500 tons per year in mid-1981 and announced plans to increase ingot capacity by late 1982 to about 8,000 tons per year from its current level of about 5,500 tons at a cost of about \$9 million.

In late 1981, Armco increased its ownership of Oremet to about 76% by purchasing the Ladish Co., which had been the second largest stockholder with 14% of the shares. Armco reportedly was intending to purchase additional stock to increase its ownership of Oremet to 80%.

Wyman-Gordon Co. was reportedly committing up to \$30 million in 1981 for facilities to produce forging shapes close to final dimensions (near-net shape) by powder metallurgy. Included would be a new \$17 million, 8,000-ton isothermal forge. The company already operates two other isothermal forges rated at 1,800 and 3,000 tons.[11]

In April, Suisman and Blumenthal, Inc., Hartford, Conn., announced the formation of a subsidiary, the Suisman Titanium Corp. The new subsidiary will produce titanium turnings of high quality for use in producing rotating parts of jet engines. Development of Suisman Titanium's rotor-grade titanium turnings, to be known as ST-2001, involved 3 years of research on a process to remove particles of tungsten carbide tool bits. Such particles have been the chief inhibiting factor in the use of titanium turnings for ingot melting.[12]

Pigment.—Titanium dioxide pigment production increased about 5% in 1981, on a titanium dioxide content basis. Rutile pigment accounted for 73% of total output and was produced by five manufacturers. Five companies produced anatase pigment. Companies producing titanium dioxide pigment in 1981, with plant locations and estimated yearend capacity, are listed in table 5.

American Cyanamid Co. began a 10,000-ton-per-year expansion of its titanium dioxide plant in Savannah, Ga., to be completed in the third quarter of 1982. The expansion involves both chloride and sulfate processes.

NL Industries completed its Sayreville, N.J., sulfate process plant conversion to a continuous process modification that the company calls liquid phase digestion. The new process reportedly greatly reduces air emissions, recycles a large proportion of plant spent acid, and increases potential plant capacity.

Table 5.—Capacities of U.S. titanium dioxide pigment plants in 1981

Company and plant location	Pigment capacity (tons per year)	
	Sulfate process	Chloride process
American Cyanamid Co., Savannah, Ga	55,000	45,000
E. I. du Pont de Nemours & Co., Inc.:		
Antioch, Calif	--	35,000
De Lisle, Miss	--	150,000
Edge Moor, Del	--	110,000
New Johnsonville, Tenn	--	228,000
Gulf + Western Natural Resources Group, Chemicals Div. (formerly New Jersey Zinc Co.):		
Ashtabula, Ohio	--	30,000
Gloucester City, N.J	44,000	--
Kerr-McGee Chemical Corp., Hamilton, Miss	--	56,000
NL Industries, Inc., Sayreville, N.J	100,000	--
SCM Corp., Glidden Pigments Group:		
Ashtabula, Ohio	--	42,000
Baltimore, Md	66,000	42,000
Total	265,000	738,000

Table 6.—Components of U.S. titanium dioxide pigment supply and demand

(Short tons)

Component	1977 (gross weight)	1978 (gross weight)	1979 (gross weight)	1980		1981[p]	
				Gross weight	TiO_2 content	Gross weight	TiO_2 content
Production	687,103	700,755	[r]742,081	[r]727,245	665,209	750,141	700,648
Shipments:[1]							
Quantity	696,552	714,547	[r]756,941	731,546	681,264	778,116	727,854
Value (thousands)	$602,383	$621,909	$720,265	$795,734	$795,734	$947,881	$947,881
Imports for consumption	114,810	117,708	104,968	97,590	[e]90,915	124,906	[e]117,412
Exports	16,336	37,812	49,369	42,126	41,992	61,104	57,440
Stocks, end of period	114,447	93,370	54,008	[r]83,237	[r] [e]77,518	102,189	[e]96,058
Apparent consumption[2]	785,003	801,728	[r]837,042	[r]753,480	[r] [e]686,911	794,991	[e]742,080

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Includes interplant transfers.
[2]Apparent consumption = production plus imports minus exports minus stock increase.

Sources: U.S. Bureau of the Census and U.S. Bureau of Mines. 1980 is the first year for which actual TiO_2 content data are available for total production.

CONSUMPTION AND USES

Concentrates.—The total amount of titanium dioxide (TiO_2) consumed domestically in concentrates increased in 1981, along with the increase in TiO_2 pigment production. Nearly all of the increase in consumption was in the form of titanium slag.

Metal.—The titanium shortage, which limited consumption in 1979-80, eased considerably as new sponge metal capacity was brought into production in the United States and Japan, and demand slackened because of a slowdown in the commercial aircraft production rate.

By mid-1981, the decline in commercial aircraft orders was being reflected in a reduction in titanium producers' incoming orders and backlogs as customers delayed or canceled orders. Despite the anticipation of an increase in military spending, purchases for titanium-intensive programs, McDonnell Douglas Corp.'s F-15 and Grumman Aircraft Engineering Corp.'s F-14, were reduced. By the end of the year, it was apparent that abnormally high inventories had been accumulated by both producers and consumers. The Government's decision to proceed with the 100-aircraft B-1 bomber program was expected to increase titanium demand, with Rockwell International planning to order material for nine B-1 aircraft in 1982. Shipments of titanium to the nonaerospace industrial market continued strong despite adverse market conditions in the nuclear power and chemical industries.

Export demand for mill products, particularly commercially pure strip and welded tubing, was also strong.[13]

In 1981, mill product shipments were 50% in the form of billet; 33% sheet, strip, plate, tubing, pipe, and extrusions; 14% rod and bar; and 2% fastener stock and wire. Castings amounted to about 1% of mill product shipments. As in 1980, 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 in 1981, as in 1980, was estimated to be about 75% for aerospace and 25% for other industrial uses. Allowing for the portion of titanium scrap that was used in steel and other alloys, overall consumption of titanium was estimated at about 62% for aerospace, 20% for other industrial uses, and 18% for alloying purposes.

Table 7.—Consumption of titanium concentrates in the United States, by year and product

(Short tons)

Year and product	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]
1977	[2]866,504	[2]521,194	149,454	106,201	[3]185,419	[3]173,840
1978	792,289	475,448	128,826	91,490	263,184	245,184
1979	791,063	487,228	144,708	106,346	313,761	292,912
1980:						
Alloys and carbide	([4])	([4])	([5])	([5])	([4])	([4])
Pigments	[r]834,141	[r]502,108	181,582	133,993	[r] [6]226,506	[r] [6]211,599
Welding-rod coatings and fluxes	([4])	([4])	--	--	7,253	6,876
Miscellaneous[7]	[r]14,466	[r]11,207	--	--	63,823	59,407
Total	[r]848,607	[r]513,315	181,582	133,993	[r] [6]297,582	[r] [6]277,882
1981:						
Alloys and carbide	([4])	([4])	([5])	([5])	([4])	([4])
Pigments	843,055	501,301	252,826	186,020	[6]206,257	[6]192,779
Welding-rod coatings and fluxes	([4])	([4])	--	--	7,389	6,944
Miscellaneous[7]	13,061	9,721	--	--	71,725	66,873
Total	856,116	511,022	252,826	186,020	[6]285,371	[6]266,596

[e]Estimated. [r]Revised.
[1]Includes a mixed product containing rutile, leucoxene, and altered ilmenite.
[2]Includes estimate of imported ilmenite used to make synthetic rutile in the United States.
[3]Includes imported synthetic rutile, but excludes synthetic rutile made in the United States from imported ilmenite.
[4]Included with "Miscellaneous" to avoid disclosing company proprietary data.
[5]Included with "Pigments" to avoid disclosing company proprietary data.
[6]Includes synthetic rutile made in the United States.
[7]Includes ceramics, chemicals, glass fibers, and titanium metal.

Table 8.—Distribution of titanium-pigment shipments, titanium dioxide content, by industry

(Percent)

Industry	1977	1978	1979	1980	1981
Paints, varnishes, lacquers	52.0	47.9	47.4	44.1	43.4
Paper	20.7	20.8	21.8	24.3	23.8
Plastics (except floor covering and vinyl-coated fabrics and textiles)	11.7	11.6	11.8	10.6	11.4
Rubber	3.1	2.8	2.9	2.1	2.2
Printing ink	2.0	2.0	1.9	2.8	1.3
Ceramics	1.9	2.1	1.9	1.7	1.4
Other	6.2	6.7	7.1	8.2	8.6
Exports	2.4	6.1	5.2	6.2	7.9
Total	100.0	100.0	100.0	100.0	100.0

Table 9.—Consumption of titanium products[1] in steel and other alloys

(Short tons)

	1977	1978	1979	1980	1981
Carbon steel	780	601	529	423	641
Stainless and heat-resisting steel	2,049	2,394	2,368	1,620	1,552
Other alloy steel (includes HSLA)	859	936	959	848	903
Tool steel	W	W	W	W	W
Total steel[2]	3,688	3,931	3,856	2,891	3,096
Cast irons	92	144	129	102	63
Superalloys	482	743	1,197	1,053	645
Alloys, other than above	537	255	234	272	254
Miscellaneous and unspecified	16	9	9	13	26
Total consumption	4,815	5,082	5,425	4,331	4,084

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."

The largest use of titanium is for compressor blades and wheels, stator blades, rotors, and other parts in aircraft gas turbine engines. The second largest use is in airframe structures of both military and commercial aircraft, such as wing-carry-through structures, landing gears, ducting, weight-and-space-critical forgings, 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. The industrial market for the market economy countries in 1981 was estimated at 12,500 tons: 4,000 tons for chemical equipment (mainly anodes for sodium chloride and sodium chlorate production, tanks, vessels, mixers, and heat exchangers); 2,400 tons for powerplant heat exchangers; 1,350 tons in pulp and paper manufacture; 1,700 tons for metal coatings and recovery; 1,500 tons for oil refining, marine uses, and desalination; and 1,550 tons for other applications, including environmental and prosthetic devices.[14]

Pigment.—Consumption of titanium dioxide in pigments increased 8% in 1981, despite the continued slump in the home building industry and the general economic recession.

Ferrotitanium.—Consumption of ferrotitanium and titanium metal scrap in steel and other alloys decreased 6% in 1981, probably because of lower steel production.

STOCKS

Stocks of titanium materials in the United States are shown in table 10. The total TiO_2 content of stocks of concentrates dropped 4% in 1981, although stocks of slag and rutile increased 18% and 8%, respectively.

Table 10.—Stocks of titanium concentrates and pigment in the United States, December 31

(Short tons)

	Gross weight	TiO_2 content[e]
Ilmenite:		
1979	728,874	462,415
1980	[r]931,541	[r]584,280
1981	812,647	516,135
Titanium slag:		
1979	75,089	56,917
1980	171,898	127,981
1981	203,692	150,706
Rutile:		
1979	[e]127,443	119,947
1980	[r e]156,888	[r]147,670
1981	169,893	159,687
Titanium pigment:[1]		
1979	NA	[r]54,008
1980	NA	83,237
1981	NA	102,189

[e]Estimated. [r]Revised. NA Not available.

[1]Source: U.S. Bureau of the Census.

PRICES

Concentrates.—Price quotations of ilmenite in domestic markets rose from $55 per long ton to $65-$70 in January 1981 and further increased to $70-$75 in April, while ilmenite prices in Australia remained at $25-$27 per long ton throughout the year. At yearend, ilmenite, bulk lots, f.o.b. Titen, Fla., was quoted at $39 per long ton.

Rutile concentrate spot prices, f.o.b. Atlantic, Gulf, and Great Lakes ports, rose from $425-$450 per short ton to $450-$475 per short ton in the first quarter of 1981, where they remained through the end of the year. Australian rutile, bulk, f.o.b. Australian ports, was quoted at $310-$321 per short ton in the first quarter of 1981, decreased to $303-$313 during the second quarter, and ended the year at $276-$297 per short ton. Australian rutile, bagged, f.o.b. Australian ports, began the year at $371-$425 per short ton, decreasing to $321-$343 during the first quarter, $313-$334 during the second quarter, and $307-$327 at the end of 1981. Rutile, bulk lots, f.o.b. Titen, Fla., was quoted at $350 per short ton at yearend. Domestic synthetic rutile, f.o.b. Mobile, Ala., increased in April 1981 from $310 to $340 per short ton, where it remained through the end of 1981.

The price of titanium slag, 70% to 72% TiO_2, f.o.b. Sorel, Quebec, increased in March 1981 from $115 to $135 per long ton, while the price of titanium slag, 85% TiO_2, f.o.b. Richards Bay, Republic of South Africa, was estimated to be $170 to $180 per long ton throughout the year.

Metal.—The published price of domestic titanium sponge, f.o.b. plant, rose in January 1981 from $7.02-$7.22 per pound, and to $7.65 per pound in June 1981, remaining at that level for the rest of the year. Japanese sponge, c.i.f. U.S. ports, climbed from $7.50-$8.70 per pound to $8.85-$10.03 per pound in April, where it remained through yearend. Prices for mill products, per pound, increased during the year as follows: Bar, from $8.17-$10.73 to $18; billet, from $5.24-$7.13 to $15; plate, from $7.38-$9.04 to $17; sheet and strip, from $12.07-$14.10 to $20.

Pigment.—Prices of titanium dioxide pigment in January 1981 were 63 cents per pound for rutile and 57 cents per pound for anatase and rose during the year to the following levels for rutile and anatase, respectively: First quarter, 69 cents and 64 cents per pound; third quarter, 75 cents and 69 cents per pound.

FOREIGN TRADE

Exports and imports of titanium materials are shown in tables 11 through 14. The major change in 1981 was the 36% increase in titanium sponge metal imports, mainly from Japan, to 6,490 tons.

Table 11.—U.S. exports of titanium products, by class

Class	1979 Quantity (short tons)	1979 Value (thousands)	1980 Quantity (short tons)	1980 Value (thousands)	1981 Quantity (short tons)	1981 Value (thousands)
Concentrates:						
Ilmenite	NA	NA	NA	NA	NA	NA
Rutile	9,903	$2,057	17,830	$3,444	7,297	$2,099
Total	9,903	2,057	17,830	3,444	7,297	2,099
Metal:						
Sponge	180	1,019	113	1,088	58	451
Other unwrought	155	1,125	344	2,891	257	2,244
Scrap	4,967	18,265	3,300	12,681	3,280	6,811
Ingots, billets, slabs, etc	1,984	26,456	3,278	61,962	4,203	105,647
Other wrought	1,316	25,912	1,845	51,589	1,846	53,807
Total	8,602	72,777	8,880	130,211	9,644	168,960
Pigment and oxides:						
Titanium dioxide pigments	49,369	43,940	42,126	43,352	61,104	63,398
Titanium compounds, except pigment-grade	2,087	4,211	3,669	6,005	1,328	3,004
Total	51,456	48,151	45,795	49,357	62,432	66,402

NA Not available.

Table 12.—U.S. imports for consumption of titanium concentrates, by country[1]

Concentrate and country	1979 Quantity (short tons)	1979 Value (thousands)	1980 Quantity (short tons)	1980 Value (thousands)	1981 Quantity (short tons)	1981 Value (thousands)
Ilmenite:						
Australia	184,478	$2,846	338,676	$5,843	210,820	$5,202
Finland	--	--	27	1	--	--
India	--	--	18,739	829	--	--
Netherlands[2]	--	--	46	2	--	--
Norway	--	--	--	--	1,656	96
South Africa, Republic of	--	--	--	--	23,741	589
Total[3]	184,478	2,846	357,488	6,674	236,217	5,887
Titanium slag:						
Canada	81,289	7,814	145,475	14,299	246,137	27,326
South Africa, Republic of	29,921	3,286	49,519	6,115	22,685	3,001
Other	--	--	--	--	3	2
Total[3]	111,210	11,100	194,994	20,414	268,825	30,328
Rutile, natural:						
Australia	140,291	25,357	143,038	30,379	88,345	28,887
Malaysia	--	--	267	2,451	11	187
Sierra Leone	7,980	1,484	40,900	9,515	25,236	6,983
South Africa, Republic of	10,819	2,068	18,907	4,806	47,406	11,723
Sri Lanka	6,305	1,432	--	--	--	--
Thailand	--	--	197	1,643	--	--
Other	18	113	33	951	25	9
Total[3]	165,413	30,454	203,342	49,745	161,022	47,790
Rutile, synthetic:						
Australia	72,218	11,799	60,962	9,050	39,708	8,854
Germany, Federal Republic of	--	--	2	4	--	--
India	22,134	3,190	10,471	1,675	440	1,886
Japan	1,243	278	6,590	2,077	1,200	492
Taiwan	22,471	3,838	238	69	--	--
Other	--	--	--	--	3	2
Total[3]	118,066	19,105	78,263	12,874	41,351	11,234
Titaniferous iron ore:[4]						
Canada	153,714	4,880	10,185	423	12,271	509

[1]Adjusted by the U.S. 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 13.—U.S. imports for consumption of titanium dioxide pigments, by country

Country	1979 Quantity (short tons)	1979 Value (thousands)	1980 Quantity (short tons)	1980 Value (thousands)	1981 Quantity (short tons)	1981 Value (thousands)
Australia	6,119	$4,146	6,678	$5,830	5,341	$5,129
Belgium-Luxembourg	2,620	1,893	422	385	4,860	4,525
Canada	19,808	16,948	10,325	10,445	15,710	17,288
Finland	5,791	4,533	4,392	4,018	5,196	5,262
France	5,564	4,816	12,771	12,470	22,663	24,029
Germany, Federal Republic of	34,961	32,025	27,126	25,921	38,482	39,229
India	80	46	240	163	--	--
Italy	688	496	152	133	56	57
Japan	4,736	4,362	4,471	4,741	4,724	4,936
Mexico	--	--	60	46	--	--
Netherlands	20	17	323	318	2,635	1,893
Norway	2,395	1,970	4,217	3,716	4,992	4,583
South Africa, Republic of	599	351	1,110	878	--	--
Spain	9,630	7,383	7,579	6,595	13,017	13,061
Sweden	--	--	116	104	21	22
United Kingdom	11,348	8,781	17,608	16,220	7,011	7,200
Yugoslavia	461	416	--	--	112	106
Other	148	127	--	--	85	74
Total[1]	104,968	88,310	97,590	91,986	124,906	127,396

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

Table 14.—U.S. imports for consumption of titanium metal, by class and country

Class and country	1979 Quantity (short tons)	1979 Value (thousands)	1980 Quantity (short tons)	1980 Value (thousands)	1981 Quantity (short tons)	1981 Value (thousands)
Unwrought: Sponge						
China	99	$1,533	861	$17,474	633	$9,947
Japan	2,058	10,777	3,720	39,546	5,747	81,822
U.S.S.R	330	2,260	165	2,741	110	1,746
United Kingdom	1	10	(1)	1	--	--
Other	--	--	31	452	--	--
Total	2,488	14,580	4,777	60,214	6,490	93,515
Ingot and billet:						
Austria	--	--	--	--	58	792
Canada	2	49	(1)	2	(1)	3
China	--	--	45	1,625	80	2,150
France	2	38	--	--	--	--
Germany, Federal Republic of	(1)	(1)	24	812	48	988
Japan	13	154	61	1,459	38	678
U.S.S.R	313	2,473	48	613	--	--
United Kingdom	8	140	13	333	20	526
Other	(1)	5	1	10	--	--
Total[2]	338	2,859	191	4,854	244	5,139
Waste and scrap:						
Austria	59	286	57	702	30	83
Canada	332	1,319	284	1,792	1,483	5,436
China	--	--	454	4,842	74	812
Finland	93	160	181	792	127	511
France	41	244	144	1,874	103	1,054
Germany, Federal Republic of	321	1,706	568	3,722	213	1,267
Japan	469	2,706	211	2,227	251	1,820
South Africa, Republic of	170	1,762	10	136	--	--
Sweden	425	1,322	42	328	98	599
Switzerland	59	264	36	170	--	--
U.S.S.R	3,313	8,422	1,411	4,619	406	1,053
United Kingdom	726	3,552	668	6,472	876	6,128
Other	132	523	72	764	125	811
Total[2]	6,140	22,267	4,138	28,440	3,787	19,574

See footnotes at end of table.

Table 14.—U.S. imports for consumption of titanium metal, by class and country —Continued

Class and country	1979 Quantity (short tons)	1979 Value (thousands)	1980 Quantity (short tons)	1980 Value (thousands)	1981 Quantity (short tons)	1981 Value (thousands)
Wrought titanium:						
Canada	470	$3,799	486	$4,203	610	$4,617
China	--	--	66	2,308	--	--
Germany, Federal Republic of	29	434	28	486	55	1,863
Japan	393	5,081	344	7,576	377	11,810
United Kingdom	28	312	10	343	55	2,708
Other	22	518	12	352	19	575
Total[2]	942	10,144	946	15,269	1,116	21,573

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

WORLD REVIEW

Australia.—Although Australia was still the dominant producer of titanium minerals in 1981, the Australian share of world rutile production dropped from 70% in 1980 to 63% in 1981, considerably less than the 96% level that prevailed in 1976 before the present titanium mineral operations got underway in Sierra Leone and the Republic of South Africa. The Australian share of ilmenite production, however, was 37% in 1981, about the same as in 1980, and significantly higher than the 1976 level of 31%. In addition to increased competition from other natural rutile producers, Australian rutile was also facing increased competition from alternative concentrates such as synthetic rutile and high-TiO_2 slag. A position of oversupply in titanium minerals developed in the latter part of 1981 because of increasing availability from all of the above sources and to an easing of world demand for titanium dioxide pigment.

Australian exports of rutile were mainly to the United States, the United Kingdom, and Japan; exports of ilmenite were mainly to the United States, the United Kingdom, Spain, and the U.S.S.R.[15]

Allied Eneabba Pty. Ltd. reportedly was to acquire all the heavy mineral leases in the Eneabba area currently held by Westralian Sands Ltd. and its subsidiary, Ilmenite Pty. Ltd. Allied Eneabba was to supply 30,000 tons of zircon to Westralian Sands over the next 3 years. The acquisition was expected to extend the life of the Allied Eneabba Mine about 10 years, to beyond the year 2000.[16]

The McDonnell Douglas F/A-18 Hornet was selected as the new fighter plane for the Australian Air Force. The Australian Government agreed to buy 75 planes at a price equivalent to $2.79 billion. A key element of the agreement is an "offset" feature that includes a United States-Australian project to build in Australia a 10,000-ton-per-year titanium sponge plant, at a probable cost of about $115 million, and facilities for titanium fabrication. McDonnell Douglas and General Electric Corp. have reportedly held talks with three Australian mining firms—Metals Exploration Ltd., CSR Ltd., and Associated Minerals Consolidated Ltd.—about building the sponge plant.[17]

Belgium.—TiTech International, a U.S. aerospace manufacturer, was building a $13 million titanium casting plant at Charleroi. The plant was to go onstream in mid-1982 and to be owned 80% by the southern Belgium Province of Wallonia. The plant's furnace was to have a 1,200-pound pouring capacity.[18]

Canada.—In 1981, QIT-Fer et Titane Inc. shipped 2.08 million tons of ilmenite ore originating at QIT's Lac Tio Mine to its smelting plant in Sorel, Quebec. In addition, about 220,000 tons of ilmenite ore was exported, mainly to the Netherlands and the Federal Republic of Germany, predominantly for use as a metallurgical flux in electric furnaces.

China.—The largest titanium deposit in China is reportedly the 1.1-billion-ton Panzihua titaniferous magnetite deposit containing about 7% titanium in the form of ilmenite, near Dukou, Sichuan Province. The next largest titanium deposits are those in the Guangdong-Guangxi coastal sands, including Hainan Island, containing ilmenite in association with zircon and other heavy minerals. Chinese sponge-producing capacity in 1981 was probably about 3,000 tons per year, with production reportedly about 2,000 tons. The largest sponge plant, with a 1,000-ton-per-year capacity, was reportedly located in Chengdu and used Panzihua raw material. Other sponge plants have been reported in or near Fushun and Jinzhou in Liaoning Province, Shanghai, and Wuhan.[19] The estimated 1981 ilmenite production of 150,000 tons (table 15) indicates a potential TiO_2 pigment production of about 50,000 tons, after allowing for ilmenite required for metal production.

Table 15.—Titanium: World production of concentrates (ilmenite, leucoxene, rutile, and titaniferous slag), by concentrate type and country[1]

(Short tons)

Concentrate type and country	1977	1978	1979	1980[p]	1981[e]
Ilmenite and leucoxene:[2]					
Australia:					
Ilmenite	[r]1,138,687	[r]1,383,400	1,301,829	1,442,925	[3]1,452,033
Leucoxene	11,708	17,750	24,769	29,539	[3]21,657
Brazil	14,625	22,131	24,975	18,562	19,000
China	NA	NA	NA	NA	150,000
Finland	137,458	145,395	131,947	175,267	175,000
India	[4]151,402	[4]178,063	[4]161,867	185,078	[3]208,147
Malaysia[5]	169,388	205,929	220,262	208,470	160,000
Norway	913,267	845,461	[r]903,690	912,508	[3]724,907
Portugal	252	[r]358	[e]300	258	330
Sri Lanka	37,580	36,421	61,035	37,430	[3]88,197
U.S.S.R.[e]	440,000	450,000	450,000	460,000	470,000
United States[6]	638,503	589,751	639,292	548,882	509,343
Total	[r]3,652,870	[r]3,874,659	3,919,966	4,018,919	3,978,614
Rutile:					
Australia	358,561	283,376	302,621	323,801	[3]252,706
Brazil	141	402	484	472	440
India	[4]6,053	[r]6,239	[4]5,445	[4]5,908	[3]9,647
Sierra Leone[e]	--	--	11,000	52,356	[3]55,992
South Africa, Republic of[e]	5,000	[r]20,000	46,000	53,000	55,000
Sri Lanka	1,078	12,673	16,176	14,097	[3]14,662
U.S.S.R.[e]	10,000	10,000	10,000	10,000	10,000
United States	W	W	W	W	W
Total[6]	[r]380,833	[r]332,690	391,726	459,634	398,447
Titaniferous slag:					
Canada[7]	[r]763,175	937,000	525,846	964,210	840,000
Japan[7]	1,354	193	198	--	--
South Africa, Republic of[e 8]	--	100,000	316,000	379,000	408,000
Total	[r]764,529	1,037,193	842,044	1,343,210	1,248,000

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available. W Withheld to avoid disclosing company proprietary data.

[1]Table excludes production of anatase ore in Brazil (4,298,731 tons produced prior to 1979 and apparently largely mined in 1978; 7,373,074 tons mined during 1979; and unreported quantities mined in 1980 and 1981), all of which was stockpiled without beneficiation. This material reportedly contains 20% TiO_2. The table includes data available through June 10, 1982.

[2]Ilmenite is also produced in Canada and in the Republic of South Africa, but this output is not included here because it is almost entirely duplicative of output reported under "Titaniferous slag."

[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 72% TiO_2.

[8]Contains 85% TiO_2.

Egypt.—An ilmenite deposit with about 45 million tons of ore containing about 35% TiO_2 was reported. The deposit is located at Aby Ghalaga, about 62 miles south of Mersa Alam and about 19 miles west of the Red Sea, and occurs as a large lens in altered titaniferous gabbroic rocks. A black sand deposit east of Rosetta was reported to contain 4.28% of economic minerals, totaling about 1.9 million tons, including 50% ilmenite (45% TiO_2), 15% magnetite, 5% zircon, 0.5% rutile, and 0.5% monazite.[20]

India.—Completion of the $100 million first phase of the Orissa Minerals Sands Complex was set for yearend 1982. The plant's design provides for annual production of 240,000 tons of ilmenite (50% TiO_2) to be processed into 110,000 tons of synthetic rutile (90% TiO_2), 33,000 tons of sillimanite, 11,000 tons of natural rutile (95% to 97% TiO_2), 4,000 tons of monazite, and 2,000 tons of zircon. Based on this output, Indian Rare Earths Ltd. was reportedly willing to enter into long-term supply commitments to foreign firms willing to assist in setting up a titanium sponge-pigment plant.[21]

Japan.—Osaka Titanium Co. Ltd. was building a new 5,500-ton-per-year titanium sponge plant adjacent to its 14,300-ton-per-year headquarters plant at Amagasaki,[22] and reportedly planned to add another 7,700 tons per year of capacity by early 1983. Toho Titanium Co. Ltd. increased its annual sponge production capacity to 13,200 tons in 1981 and was reportedly expanding further to 15,900 tons, to be completed in 1983. Ishizuka Research Institute was to complete construction of a 1,400-ton-per-year sponge plant at Hiratsuka in late 1981. Total Japanese sponge production capacity at yearend 1981, excluding Osaka's newest addition, was therefore about 31,300 tons, including the 2,400-ton-per-year plant of Nippon Soda Co. Ltd.

Japanese titanium sponge metal production in 1981 was about 27,500 tons, compared with 21,257 tons in 1980.

Kobe Steel, Ltd., reportedly doubled its ingot-melting capacity to 6,600 tons per year since March 1980 and hoped to increase capacity to 7,900 tons per year by yearend 1981.

Sierra Leone.—Planned annual production capacity of the Sierra Rutile Ltd. Mine and mill was 110,000 tons of rutile per year, although 1981 production was only about 56,000 tons. At its full capacity rate, Sierra Rutile will supply a very significant part of the world's natural rutile. A comprehensive article describing the history, geology, mining, processing, and other factors involved in the Sierra Rutile project was published in 1981.[23]

South Africa, Republic of.—In 1981, Richards Bay Minerals (RBM) achieved a production level of over 90% of its titanium slag and rutile capacity. With about 700,000 tons of ilmenite (50% TiO_2) mined to produce 408,000 tons of slag, RBM was believed to be the world's largest heavy mineral sand mining company.

U.S.S.R.—Revised estimates of titanium sponge metal production in the U.S.S.R., based on a recently published figure of a 19% increase in titanium production during the 10th 5-year plan (1976-80),[24] were as follows in short tons: 1975—34,000; 1976—35,000; 1977—37,000; 1978—39,000; 1979—40,000; 1980—41,000; and 1981—42,000. The U.S.S.R. was reportedly planning to double the capacity of its 27,500-ton-per-year titanium sponge plant at Ust-Kamenogorsk. Future annual requirements are uncertain, but speculation was still strong that the U.S.S.R. may be using large amounts of titanium to build titanium-hulled submarines.[25] Reports of imports of ilmenite from Australia in 1979-81 suggest that availability of high-grade titanium concentrates in the U.S.S.R. may be limited.

United Kingdom.—A 10% slump in world demand for TiO_2 pigment in 1980 and the strength of the British pound were said to be major factors in the closing in early 1981 of two sulfate-process pigment plants: BTP Tioxide, Ltd., a 35,000-ton-per-year plant at Billingham[26] and Laporte Industries, Ltd., a 35,000-ton-per-year plant at Stallingborough. Laporte later announced plans to expand the annual capacity of its chloride-process pigment plant from 44,000 tons to 50,000-55,000 tons. The expansion was to be completed by 1982.[27]

IMI Titanium Ltd., the largest European producer of titanium mill products, opened a U.S. sales office in Denver, Colo., and planned to increase its melting capacity 25% to about 7,000 tons per year in 1982 or 1983 at an estimated cost of over $15 million. IMI will also have a 17.5% interest in the 5,500-ton-per-year titanium granule plant of Deeside Titanium Ltd., being built at Deeside, North Wales, to be completed in 1983. Billiton (U.K.) Ltd. owns 62.5% and Rolls Royce Ltd. owns 20% of Deeside Titanium.[28]

TECHNOLOGY

The Bureau of Mines conducted laboratory and larger scale studies on samples of domestic perovskite and ilmenite ore to devise a procedure for producing titanium carbide (TiC) from these ores. Carbiding of perovskite or calcium titanate slag made from ilmenite was done in an arc-melting furnace, using charge temperatures of about 4,350° F for 3 hours. The resulting mixture of TiC and calcium carbide (CaC_2) was ground and treated with water to decompose the CaC_2 to hydrated lime and acetylene, freeing the TiC. In fluid-bed-chlorination tests on the purified TiC, 98%

of the titanium was extracted at 840° F.[29] In other Bureau studies on electric arc furnace smelting of domestic titaniferous materials, fluid slags containing up to 79%, 70%, and 54% TiO_2 were obtained from east coast sand ilmenite, a rock ilmenite, and a titaniferous magnetite, respectively.[30] The Bureau also investigated a new technique for treating titanium slags with mixtures of sulfur dioxide and oxygen followed by leaching to remove calcium, magnesium, and manganese, which cause major problems if present during fluid-bed chlorination. By this technique, a slag sample having a combined level of 5% of these impurities was upgraded to a product containing about 80% TiO_2, with a combined impurity level of less than 0.4%.[31]

The Bureau also developed a new investment mold for titanium casting, made through an adaptation of the lost-wax process, using calcia-stabilized zirconium dioxide and a zirconium dioxide-forming binder. The castings formed in these molds were equal in chemical and mechanical performance to commercial-grade castings made from pressed graphite or other conventional mold materials.[32] Other Bureau work included demonstration of a fume-free process for producing commercial grade titanium castings that used bentonite-bonded olivine or zircon sand molds, as an alternative to the industrially used rammed-graphite process;[33] studies on the recovery of byproduct heavy minerals from sand and gravel operations in Oregon and Washington;[34] and a newly developed chemical conditioning technique, which greatly simplifies the preparation of plating baths for the electrodeposition of titanium diboride coatings.[35]

A National Materials Advisory Board (NMAB) panel study on the availability of titanium was sponsored by the U.S. Departments of Commerce, Defense, and Interior, and the Federal Emergency Management Agency. This contract study was to assess the production capability of the United States to meet current and future needs for titanium and its alloys. The NMAB panel's report was expected to be issued in August 1982.

A materials needs case study of the U.S. aerospace industry was made by the Department of Commerce under the National Materials and Minerals Policy, Research and Development Act of 1980. The materials cobalt, chromium, titanium, and tantalum, and the advanced technologies of rapid solidification and composites were selected for indepth study. One conclusion reached was that planned increases in domestic processing capacity should eliminate much of the difficulty experienced in obtaining timely delivery of titanium parts and materials.[36]

A U.S. Air Force development program was underway directed toward cutting costs of titanium fabrication by cold-forming structural components from 15-3 titanium, a beta phase alloy that contains 15% vanadium and 3% each of aluminum, chromium, and tin. The beta phase structure of 15-3 titanium makes it more amenable to cold-forming techniques than the widely used 6-4 titanium, with 6% aluminum and 4% vanadium. In the first phase of the program, TIMET demonstrated commercial manufacturing methods for producing 15-3 sheet. In the second phase, Fairchild-Republic Co., Farmingdale, N.Y., was working on the cold forming of prototype components.[37]

Efforts to cut the cost of titanium aircraft components emphasized the need for improving the ratio of buy weight to fly weight, using various near-net-shape technologies (forming directly to near the desired shape) such as casting, powder metallurgy,[38] isothermal rolling and forging,[39] superplastic forming-diffusion bonding,[40] and hot isostatic pressing.[41] A new powder-making facility was installed by Nuclear Metals Inc., Concord, Mass., that produces titanium and other metal powders by the company's plasma rotating electrode process (PREP). Design improvements in the PREP equipment have minimized or eliminated tungsten contamination in the powder.[42]

A new cutting tool geometry was developed that allows the machining of titanium at speeds as high as five times faster than conventional tools. The new ledge tool was described as a restricted clearance face tool—a tool insert in which a ledge or step has been cut into the flat rectangular cutting face.[43]

Process metallurgical problems that have held back usage of TiC powder as a wear surfacing powder have reportedly been solved. In standard American Society for Testing Materials (ASTM) wear tests and in field tests, TiC showed better abrasive and erosive wear properties than conventional carbide powder. TiC also had a cost advantage.[44]

Hard coatings of TiC are also applied by the chemical vapor deposition (CVD) process. Coating procedures, the types of materials suitable for such coatings, and the advantages of using CVD coatings, including titanium nitride, were described.[45]

The Metallurgical Society of AIME published a volume of papers on the use of titanium for energy and industrial applications.[46] The proceedings of a 1979 ASTM symposium on industrial applications of titanium and zirconium were published in 1981.[47] A more recent paper described the characteristics of titanium, such as availability, relative price stability, and physical properties, that make it a cost-effective material for equipment used in the chemical and metallurgical industries.[48]

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[2]Statistical assistant, Division of Nonferrous Metals.

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Tungsten

By Philip T. Stafford[1]

Consumption and imports of tungsten rose to record levels in 1981. Mine production increased 31% compared with that of 1980. Generally, tungsten prices remained within a narrow range except during the last quarter when they fell 10%.

During 1981, more than 95% of domestic production came from four mining operations; two were in California, and one each in Nevada and Colorado. One major new mine in Nevada was completed and ready to begin production in 1982. One large new ammonium paratungstate (APT) plant in Iowa began production in mid-1981.

The 18-year deadlock between tungsten producing and consuming countries continued, as no agreement was reached during 1981 at the Geneva conference on stabilization of the world tungsten market.

Legislation and Government Programs.—The General Services Administration 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 600,000 pounds of contained tungsten per month, of which 450,000 pounds was for domestic use and 150,000 pounds was for export. Additionally, supplemental offerings were made at the rate of 400,000 pounds per month, of which 300,000 pounds was for domestic use and 100,000 pounds for export. As a result of the regular and supplemental offerings, concentrate sales totaled 1,576,402 pounds of tungsten, of which 1,525,869 pounds was for domestic use and 50,533 pounds was for export. Actual shipments of excess con-

Table 1.—Salient tungsten statistics

(Thousand pounds of contained tungsten and thousand dollars)

	1977	1978	1979	1980	1981
United States:					
Concentrate:					
Mine production	6,008	6,896	6,643	6,072	7,948
Mine shipments	6,022	6,901	6,646	6,036	7,815
Value	$55,073	$56,691	$55,785	$50,575	$62,231
Consumption	17,100	18,806	21,589	20,432	21,692
Shipments from Government stocks	5,015	5,399	5,183	3,755	2,111
Exports	1,283	1,853	1,929	2,029	175
Imports for consumption	6,919	9,138	11,352	11,372	11,752
Stocks, Dec. 31:					
Producer	124	87	84	106	239
Consumer	826	1,424	1,538	1,325	1,480
Ammonium paratungstate:					
Production	14,940	16,062	17,758	16,897	19,522
Consumption	15,744	17,572	18,720	18,585	20,206
Stocks, Dec. 31: Producer and consumer	1,975	1,037	879	966	1,541
Primary products:					
Production	19,005	19,028	21,178	20,138	21,959
Consumption	16,905	18,296	20,433	20,200	21,192
Stocks, Dec. 31:					
Producer	3,139	3,349	3,385	3,524	3,245
Consumer	2,581	2,376	2,543	2,370	2,063
World: Concentrate:					
Production	[r]90,541	[r]102,742	[r]107,287	[p]114,059	[e]108,351
Consumption	[r]87,852	[r]100,442	[r]103,566	[p]108,923	[e]107,292

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

centrate from the stockpile totaled 2,110,548 pounds of contained tungsten in concentrate.

Stockpile goals in effect during 1981 remained as established in May 1980 by the Federal Emergency Management Agency and are shown in table 2.

Table 2.—U.S. Government tungsten stockpile material inventories and goals

(Thousand pounds of contained tungsten)

Material	Goals	Inventory by program, Dec. 31, 1981		
		National stockpile	DPA[1] inventory	Total
Tungsten concentrate:				
Stockpile grade	55,450	56,624	158	56,782
Nonstockpile grade	--	30,121	195	30,316
Total	55,450	86,745	353	87,098
Ferrotungsten:				
Stockpile grade	--	841	--	841
Nonstockpile grade	--	1,185	--	1,185
Total[2]	--	2,025	--	2,025
Tungsten metal powder:				
Stockpile grade	1,600	1,567	--	1,567
Nonstockpile grade	--	332	--	332
Total	1,600	1,899	--	1,899
Tungsten carbide powder:				
Stockpile grade	2,000	1,921	--	1,921
Nonstockpile grade	--	112	--	112
Total	2,000	2,033	--	2,033

[1]Defense Production Act (DPA) of 1950.
[2]Data may not add to totals shown because of independent rounding.

DOMESTIC PRODUCTION

Mine production rose 31% compared with that of 1980 and totaled 7.9 million pounds of contained tungsten in 1981, the largest amount since 1972. Mine shipments increased 29% to 7.8 million pounds. Although 29 mines in Alaska and 8 Western States reported production, 4 mines provided more than 95% of the 1981 domestic tungsten production. Only three mines operated continuously: the Pine Creek Mine and mill of the Metals Div., Union Carbide Corp. (UCC), located near Bishop, Calif., in Inyo County; the Climax Mine and mill of Climax Molybdenum Co., a division of AMAX Inc., at Climax, Colo., in Lake County; and the Emerson Mine and mill of the Metals Div., UCC, at Tempiute, Nev., in Lincoln County. The principal metal mined and concentrated at Pine Creek continued to be tungsten with minor amounts of byproduct copper, gold, molybdenum, and silver. UCC processed ore to produce APT, an intermediate form of tungsten suitable for ready conversion to tungsten metal powder.

The principal metal mined and concentrated at Climax was molybdenum. Concentrates of tungsten, tin, and pyrite were recovered as byproducts.

Scheelite ore was processed at Tempiute to a low-grade tungsten concentrate and shipped to the UCC Pine Creek facility, where it was converted to APT.

The Strawberry Mine and mill of Teledyne Tungsten, a subsidiary of Teledyne, Inc., near North Fork, Calif., in Madera County, produced tungsten concentrate except during the winter when it was closed owing to weather conditions.

Intermittent tungsten concentrate production and shipments were reported from Southeastern Region, Alaska; Pima and Pinal Counties, Ariz.; Los Angeles, Mono, San Bernadino, San Diego, and Tulare Counties, Calif.; Valley County, Idaho; Broadwater County, Mont.; Churchill, Elko, Mineral, and White Pine Counties, Nev.; Tooele County, Utah; and Stevens County, Wash.

Utah International Inc., a subsidiary of General Electric Co., completed construction of the Springer Mine, mill, and APT plant in the vicinity of the abandoned Sutton Mine near Imlay in Pershing County, Nev. The facility is expected to begin production of APT in early 1982 at its rated capacity of 1.6 million pounds of tungsten per year.

AMAX began APT production in mid-1981 at its Fort Madison, Iowa, plant, which has a capacity of 2.4 million pounds per year of tungsten contained in APT.

The major domestic companies engaged in tungsten operations during 1981 are listed in table 4.

Table 3.—Tungsten concentrate shipped from mines in the United States

Year	Quantity			Reported value, f.o.b. mine[1]		
	Short tons, 60% WO_3 basis[2]	Short ton units of WO_3[3]	Tungsten content (thousand pounds)	Total (thousands)	Average per unit of WO_3	Average per pound of tungsten
1977	6,331	379,729	6,022	$55,073	$145.03	$9.15
1978	7,252	435,117	6,901	56,691	130.29	8.22
1979	6,984	419,040	6,646	55,785	133.13	8.40
1980	6,343	380,561	6,036	50,575	132.90	8.38
1981	8,213	492,764	7,815	62,231	126.29	7.96

[1]Values apply to finished concentrate and are in some instances f.o.b. custom mill.
[2]A short ton of 60% tungsten trioxide (WO_3) contains 951.6 pounds of tungsten.
[3]A short ton unit equals 20 pounds of tungsten trioxide (WO_3) and contains 15.86 pounds of tungsten.

Table 4.—Major producers of tungsten concentrate and principal tungsten processors in 1981

Company	Location of mine, mill, or processing plant
Producers of tungsten concentrate:	
Climax Molybdenum Co., a division of AMAX Inc	Climax, Colo.
Teledyne Tungsten	North Fork, Calif.
Union Carbide Corp., Metals Div.[1]	Bishop, Calif., and Tempiute, Nev.
Processors of tungsten:	
AMAX Inc., AMAX Tungsten Div	Fort Madison, Iowa.
Adamas Carbide Corp	Kenilworth, N.J.
Fansteel Inc	North Chicago, Ill.
General Electric Co	Euclid, Ohio, and Detroit, Mich.
GTE Products Corp	Towanda, Pa.
Kennametal Inc	Latrobe, Pa., and Fallon, Nev.
Li Tungsten Corp	Glen Cove, N.Y.
Teledyne Firth Stirling	McKeesport, Pa.
Teledyne Wah Chang Huntsville	Huntsville, Ala.
Union Carbide Corp., Metals Div	Niagara Falls, N.Y.
Westinghouse Electric Corp	Bloomfield, N.J.

[1]At its Pine Creek Mine and mill in California, UCC processes ore "straight through" to APT.

CONSUMPTION AND USES

Domestic consumption of tungsten in primary products rose 6% in 1981 to a record level. The major end use, 65% of the total, continued to be in cutting and wear-resistant materials, primarily as tungsten carbide. Other end uses were mill products, 18%; specialty steels, 5%; chemicals, 4%; superalloys, 2%; and hard-facing rods and materials, 2%.

Consumption of major intermediate tungsten products used to make end-use items was distributed as follows: tungsten carbide, 58%; tungsten metal powder, 28%; and ferrotungsten, 2%.

Table 5.—Production, disposition, and stocks of tungsten products in the United States

(Thousand pounds of contained tungsten)

	Hydrogen- and carbon-reduced metal powder	Tungsten carbide powder		Chemicals	Other[1]	Total
		Made from metal powder	Crushed and crystal-line			
1980						
Gross production during year	18,116	11,693	2,042	6,480	238	38,569
Used to make other products listed here	11,937	237	370	5,887	--	18,431
Net production	6,179	11,456	1,672	593	238	20,138
Disposition:						
To other processors	338	2,931	443	117	102	3,931
To end-use consumers	8,968	7,238	438	505	150	17,299
To make products not listed in this table	1,440	1,858	1,394	10	--	4,702
Producer stocks, Dec. 31	1,947	719	644	155	58	[2]3,524
1981						
Gross production during year	19,754	11,146	2,532	7,606	383	41,421
Used to make other products listed here	11,485	282	526	7,075	94	19,462
Net production	8,269	10,864	2,006	531	289	21,959
Disposition:						
To other processors	569	2,916	602	42	41	4,170
To end-use consumers	10,043	6,553	521	548	201	17,866
To make products not listed in this table	1,854	2,058	1,592	13	--	5,517
Producer stocks, Dec. 31	1,721	684	626	121	93	3,245

[1]Includes ferrotungsten, scheelite (produced from scrap), nickel-tungsten, and self-reducing oxide pellets.
[2]Data do not add to total shown because of independent rounding.

Table 6.—Consumption and stocks of tungsten products in the United States, by end use in 1981

(Thousand pounds of contained tungsten)

End use	Ferro-tungsten	Tung-sten metal powder[1]	Tung-sten carbide powder	Scheelite (natural, synthetic)	Tung-sten scrap[2]	Other tungsten materi-als[3]	Total
Steel:							
Stainless and heat-resisting	50	--	--	40	8	3	101
Alloy	65	--	--	W	W	1	66
Tool	260	--	--	623	W	64	947
Cast irons	W	--	--	--	--	--	W
Superalloys	W	53	W	W	312	74	439
Alloys (excludes steels and superalloys):							
Cutting and wear-resistant materials	--	1,745	11,979	--	W	8	13,732
Other alloys[4]	11	241	217	--	25	3	497
Mill products made from metal powder	--	3,854	W	--	--	1	3,855
Chemical and ceramic uses	--	--	--	--	--	849	849
Miscellaneous and unspecified	32	2	158	104	410	--	706
Total	418	5,895	12,354	767	755	1,003	21,192
Consumer stocks, Dec. 31, 1981	96	79	1,353	183	153	199	2,063

W Withheld to avoid disclosing company proprietary data; included in "Miscellaneous and unspecified."
[1]Includes both carbon-reduced and hydrogen-reduced tungsten metal powder.
[2]Does not include that used in making primary tungsten products.
[3]Includes melting base, self-reducing tungsten, tungsten chemicals, and others.
[4]Includes welding and hard-facing rods and materials and nonferrous alloys.

PRICES

In 1981, the average value of tungsten concentrate shipped from domestic mines and mills, as reported to the Bureau of Mines, decreased 5% to $126.29 per short ton unit of WO_3, when compared with the 1980 value. Excess tungsten concentrate for domestic use was purchased from GSA during the year at prices ranging from $120.26 to $139.26 per short ton unit. The price of tungsten concentrate purchased for export was $129.74 per short ton unit.

The European prices of tungsten concentrate, as reported in Metal Bulletin of London, the U.S. spot quotations, and the International Tungsten Indicator, showed similar trends and monthly and annual averages during 1981. The price of concentrates has been unusually stable since 1978 and remained within a narrow price range in 1981, except for a drop of 10% during the last quarter.

The reported price of APT delivered to large-volume contract customers was $168 per short ton unit at the beginning of 1981. It rose to $174.50 on April 1, fell to $165 on October 1, and fell further to $159.25 on December 1, remaining at that level for the remainder of 1981.

The price of hydrogen-reduced tungsten metal powder, 99.9% pure, f.o.b. shipping point, as quoted in Metals Week, remained stable throughout 1981 in the price range of $13.90 to $15.50 per pound. Within this range, the price was primarily dependent upon the particle size of the tungsten powder.

Table 7.—Monthly price quotations of tungsten concentrate in 1981

Month	Metal Bulletin (London), wolframite, European market, 65% WO_3 basis[1]: Dollars per metric ton unit of WO_3		Metal Bulletin: Equivalent prices, dollars per short ton unit of WO_3			Metals Week, U.S. spot quotations, dollars per short ton unit of WO_3 65% basis, c.i.f. U.S. ports[2]			International Tungsten Indicator, weighted average price,[3] 60% to 79% WO_3	
	Low	High	Low	High	Average	Low	High	Average	Dollars per metric ton unit	Dollars per short ton unit
January	143.50	150.00	130.18	136.08	132.85	127.30	133.50	130.56	144.34	130.94
February	148.00	154.50	134.26	140.16	136.87	135.50	137.00	136.25	144.71	131.28
March	147.50	154.50	133.81	140.16	137.74	135.50	139.00	136.75	147.64	133.94
April	144.00	150.00	130.63	136.08	132.90	130.00	135.50	132.75	147.31	133.64
May	142.00	146.00	128.82	132.45	130.28	129.00	131.00	130.20	144.24	130.85
June	144.00	150.00	130.63	136.08	133.41	131.00	133.00	132.00	144.63	131.21
July	146.00	152.00	132.45	137.89	135.88	132.00	135.00	133.80	144.46	131.05
August	144.00	150.00	130.63	136.08	132.90	128.00	135.00	132.88	145.92	132.38
September	138.00	148.00	125.19	134.26	130.58	126.00	131.00	128.50	144.17	130.78
October	132.00	143.00	119.75	129.73	124.23	118.00	129.00	122.70	142.31	129.10
November	129.00	137.00	117.03	124.28	120.09	115.00	123.00	119.13	137.81	125.02
December	120.00	132.00	108.86	119.75	114.08	110.00	121.00	115.25	132.01	119.76

[1]Low and high prices are reported semiweekly. Monthly equivalent averages are arithmetic averages of semiweekly equivalent low and high prices. The equivalent average price per short ton unit of WO_3, which is an average of all semiweekly low and high prices, excluding duty, was $130.25 for 1981.

[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 $129.16 for 1981.

[3]Weighted average price per short ton unit of WO_3, excluding duty, was $130.16 for 1981.

FOREIGN TRADE

Exports of tungsten in concentrate and primary products decreased 13% from 6 million pounds in 1980 to 5.2 million pounds in 1981. Imports increased 7% from 13.7 million pounds in 1980 to 14.6 million pounds in 1981.

Tariff rates for tungsten materials in effect January 1, 1982, as published in the Tariff Schedules of the United States, Annotated (1982), are shown in table 17.

Table 8.—U.S. exports of tungsten ore and concentrate, by country

(Thousand pounds and thousand dollars)

Country	1980 Tungsten content	1980 Value	1981 Tungsten content	1981 Value
Brazil	55	551	--	--
Canada	--	--	10	60
Germany, Federal Republic of	1,263	10,064	93	482
Guatemala	2	13	--	--
Japan	89	542	--	--
Netherlands	91	620	--	--
Sweden	466	3,147	72	608
United Kingdom	63	517	--	--
Total	2,029	15,454	175	1,150

Table 9.—U.S. exports of ammonium paratungstate, by country

(Thousand pounds and thousand dollars)

	1980 Gross weight	1980 Tungsten content[1]	1980 Value	1981 Gross weight	1981 Tungsten content[1]	1981 Value
Australia	1	([2])	1	1	([2])	2
France	3	2	8	3	2	7
Germany, Federal Republic of	--	--	--	1	([2])	5
Japan	([2])	([2])	1	--	--	--
United Kingdom	4	3	32	--	--	--
Total[3]	8	6	42	4	3	14

[1]Tungsten content estimated by multiplying gross weight by 0.7066.
[2]Less than 1/2 unit.
[3]Data may not add to totals shown because of independent rounding.

Table 10.—U.S. exports of tungsten carbide powders, by country

(Thousand pounds and thousand dollars)

Country	1980 Tungsten content	1980 Value	1981 Tungsten content	1981 Value
Argentina	36	402	11	182
Australia	6	36	8	132
Austria	27	295	39	255
Belgium-Luxembourg	21	355	12	349
Brazil	31	917	35	836
Canada	260	4,030	311	5,033
Chile	4	21	--	--
Denmark	100	1,123	--	--
Finland	32	315	--	--
France	144	1,577	11	78
Germany, Federal Republic of	217	3,333	216	3,056
India	2	49	3	74
Ireland	8	137	4	94
Israel	98	999	128	908
Italy	74	1,784	13	332
Japan	88	1,107	66	992
Korea, Republic of	8	186	1	39
Mexico	109	2,404	155	2,613
Netherlands	31	734	92	1,036
Peru	1	1	6	74
Singapore	3	79	([1])	10
South Africa, Republic of	1	27	3	45
Spain	2	60	--	--
Sweden	55	828	([1])	4
Switzerland	13	280	30	404

See footnotes at end of table.

Table 10.—U.S. exports of tungsten carbide powders, by country —Continued

(Thousand pounds and thousand dollars)

Country	1980 Tungsten content	1980 Value	1981 Tungsten content	1981 Value
Thailand	(1)	14	1	24
United Kingdom	60	1,452	65	1,538
Venezuela	(1)	7	1	23
Other	r10	r165	1	26
Total[2]	1,440	22,716	1,213	18,158

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

Table 11.—U.S. exports of tungsten and tungsten alloy powder, by country

(Thousand pounds and thousand dollars)

Country	1980 Gross weight	1980 Tungsten content[1]	1980 Value	1981 Gross weight	1981 Tungsten content[1]	1981 Value
Australia	(2)	(2)	8	68	54	815
Austria	38	30	478	--	--	--
Belgium-Luxembourg	--	--	--	(2)	(2)	1
Brazil	3	3	50	13	10	178
Bulgaria	21	16	297	--	--	--
Canada	67	54	1,035	67	53	875
Finland	31	25	406	18	14	205
France	6	5	71	7	5	80
Germany, Federal Republic of	170	136	3,767	135	108	2,491
Israel	1,051	841	11,647	1,900	1,520	21,571
Italy	1	1	22	1	1	30
Japan	3	3	41	62	50	721
Mexico	11	9	151	24	19	299
Netherlands	1	1	10	366	293	4,677
Sweden	3	2	18	--	--	--
Switzerland	4	3	66	1	1	16
Turkey	--	--	--	6	4	119
United Kingdom	7	5	106	5	4	113
Other	9	7	135	1	1	16
Total[3]	1,425	1,140	18,308	2,672	2,138	32,207

[1]Tungsten content estimated by multiplying gross weight by 0.80.
[2]Less than 1/2 unit.
[3]Data may not add to totals shown because of independent rounding.

Table 12.—U.S. exports of miscellaneous tungsten-bearing materials

(Thousand pounds and thousand dollars)

Product and country	1980 Gross weight	1980 Value	1981 Gross weight	1981 Value
Tungsten and tungsten alloy wire:				
Brazil	21	1,067	22	1,705
Canada	50	2,788	37	2,019
Japan	14	1,100	16	1,289
Mexico	23	1,597	14	1,697
United Kingdom	15	r1,155	4	528
U.S.S.R.	31	1,078	21	807

See footnotes at end of table.

Table 12.—U.S. exports of miscellaneous tungsten-bearing materials —Continued

(Thousand pounds and thousand dollars)

Product and country	1980 Gross weight	1980 Value	1981 Gross weight	1981 Value
Tungsten and tungsten alloy wire —Continued				
Other	r57	r6,088	52	5,244
Total[1]	211	14,872	166	13,288
Unwrought tungsten and alloy in crude form, waste, and scrap:				
Canada	223	1,805	179	1,553
Germany, Federal Republic of	325	2,656	224	1,322
Israel	141	1,560	2	15
South Africa, Republic of	79	953	7	95
Sweden	52	608	156	1,216
Thailand	--	--	58	151
United Kingdom	100	557	107	321
Other	150	1,765	94	625
Total	1,070	9,904	827	5,298
Other tungsten metal:				
Austria	5	80	29	88
Canada	57	2,302	42	1,634
Germany, Federal Republic of	300	6,773	255	5,342
United Kingdom	96	2,701	63	2,025
Other	r94	r3,037	77	3,314
Total	552	14,893	[1]467	12,403

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

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

(Thousand pounds and thousand dollars)

Country	1980 Tungsten content	1980 Value	1981 Tungsten content	1981 Value
Australia	235	1,762	304	2,364
Bolivia	2,794	21,730	2,511	19,724
Brazil	63	503	444	3,546
Burma	--	--	272	2,080
Canada	2,914	22,943	2,005	15,222
China	2,025	16,130	2,532	20,674
France	154	995	228	1,796
Germany, Federal Republic of	--	--	1	18
Guatemala	25	45	2	5
Hong Kong	21	171	--	--
Korea, Republic of	19	147	156	1,257
Malaysia	67	550	62	483
Mexico	515	2,548	616	3,655
Netherlands	19	149	--	--
Peru	526	4,047	652	4,787
Portugal	576	4,322	1,028	8,159
Rwanda	46	356	19	154
Salvador	--	--	11	34
Singapore	23	194	--	--
Spain	94	754	49	396
Taiwan	36	242	--	--
Thailand	1,046	8,223	706	5,543
Turkey	60	452	52	393
United Kingdom	27	192	14	103
Zaire	87	674	89	802
Total	11,372	87,129	[1]11,752	91,195

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

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

(Thousand pounds and thousand dollars)

Country	1980 Tungsten content	1980 Value	1981 Tungsten content	1981 Value
Australia	--	--	16	141
China	23	213	743	6,585
France	95	851	--	--
Germany, Federal Republic of	153	1,584	49	444
Japan	--	--	23	228
Korea, Republic of	133	1,312	215	1,960
Netherlands	19	181	--	--
Taiwan	(1)	1	--	--
United Kingdom	23	236	--	--
Total	446	4,378	1,046	9,358

[1]Less than 1/2 unit.

Table 15.—U.S. imports for consumption of ferrotungsten, by country

(Thousand pounds and thousand dollars)

Country	1980 Tungsten content	1980 Value	1981 Tungsten content	1981 Value
Argentina	17	160	--	--
Austria	68	583	92	814
Brazil	24	224	16	144
Canada	8	72	--	--
France	10	101	17	167
Germany, Federal Republic of	17	168	26	259
Portugal	125	1,138	155	1,462
Sweden	177	1,593	19	174
Total	446	4,039	325	3,020

Table 16.—U.S. imports for consumption of miscellaneous tungsten-bearing materials

(Thousand pounds and thousand dollars)

Product and country	1980 Tungsten content	1980 Value	1981 Tungsten content	1981 Value
Other metal-bearing materials in chief value of tungsten:				
Chile	102	1,405	--	--
United Kingdom	9	76	19	129
Other	r1	r12	(1)	3
Total	112	1,493	19	132
Waste and scrap containing not over 50% tungsten:				
South Africa, Republic of	--	--	364	217
United Kingdom	22	66	1	18
Other	4	26	6	46
Total	26	92	371	281
Waste and scrap containing over 50% tungsten:				
Belgium	31	198	36	320
Canada	72	648	83	691
France	20	153	72	569
Germany, Federal Republic of	10	101	251	2,049
Israel	73	579	445	3,220
Japan	38	342	109	1,002
Korea, Republic of	4	46	28	201
Netherlands	--	--	70	598
Poland	--	--	28	257

See footnotes at end of table.

Table 16.—U.S. imports for consumption of miscellaneous tungsten-bearing materials —Continued

(Thousand pounds and thousand dollars)

Product and country	1980		1981	
	Tungsten content	Value	Tungsten content	Value
Waste and scrap containing over 50% tungsten —Continued				
Singapore	47	571	78	1,078
Sweden	4	10	22	193
United Kingdom	42	327	241	1,812
Other	r35	r20	23	169
Total[2]	375	2,995	1,488	12,162
Unwrought tungsten, except alloys, in lumps, grains, and powders:				
France	13	189	--	--
Germany, Federal Republic of	69	786	91	1,153
Korea, Republic of	361	3,948	271	3,127
Other	25	r320	9	111
Total	468	5,243	371	4,391
Unwrought tungsten, ingots, and shot	(1)	1	(1)	1
Unwrought tungsten, other:[3]				
Canada	1	8	--	--
Japan	8	117	--	--
Singapore	15	244	--	--
Other	--	--	3	48
Total	24	369	3	48
Unwrought tungsten, alloys	17	421	2	92
Wrought tungsten:[3]				
Austria	25	r1,099	17	584
Canada	105	1,171	75	901
Japan	12	1,190	15	1,393
United Kingdom	8	212	36	306
Other	11	192	43	905
Total[2]	161	3,862	186	4,089
Calcium tungstate:				
Germany, Federal Republic of	24	640	27	610
Sodium tungstate:	--	--	(1)	3
Tungsten carbide:				
Belgium	8	169	15	272
China	1	1	66	708
Germany, Federal Republic of	385	6,459	536	7,587
Korea, Republic of	72	791	110	1,302
Mexico	37	974	18	356
Other	r12	r123	12	149
Total	515	8,517	757	10,374
Other tungsten compounds:				
China	--	--	90	644
Germany, Federal Republic of	65	648	(1)	9
Other	1	19	1	3
Total	66	667	91	656
Mixtures, organic compounds, chief value in tungsten:				
Canada	13	275	1	17
Germany, Federal Republic of	5	79	4	66
Netherlands	(1)	6	--	--
Total	18	360	5	83

rRevised.
[1]Less than 1/2 unit.
[2]Data may not add to totals shown because of independent rounding.
[3]Estimated from reported gross weight.

Table 17.—U.S. import duties on all forms of tungsten

Tariff classification	Article	Rate of duty effective Jan. 1, 1982	
		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	8.8% ad valorem	35% ad valorem.
629.25	Waste and scrap containing by weight not over 50% tungsten.	6.6% ad valorem	50% ad valorem.
629.26	Waste and scrap containing by weight over 50% tungsten.	4.2% ad valorem	Do.
629.28	Unwrought tungsten, except alloys, in lumps, grains, and powders.	15 cents per pound on tungsten content and 12.5% ad valorem.	58% ad valorem.
629.29	Unwrought tungsten, ingots, and shot	9.8% ad valorem	50% ad valorem.
629.30	Unwrought tungsten, other	11.5% ad valorem	60% ad valorem.
629.32	Unwrought tungsten, alloys, containing by weight not over 50% tungsten.	6.1% ad valorem	35.5% ad valorem.
629.33	Unwrought tungsten, alloys, containing by weight over 50% tungsten.	11.5% ad valorem	60% ad valorem.
629.35	Wrought tungsten	10.3% ad valorem	Do.
416.40	Tungstic acid	13.3% ad valorem	55% ad valorem.
417.40	Ammonium tungstate	12.1% ad valorem	49.5% ad valorem.
418.30	Calcium tungstate	10.8% ad valorem	43.5% ad valorem.
420.32	Potassium tungstate	19.4% ad valorem	50.5% ad valorem.
421.56	Sodium tungstate	11.7% ad valorem	46.5% ad valorem.
422.40	Tungsten carbide	5 cents per pound on tungsten content and 12.5% ad valorem.	55.5% ad valorem.
422.42	Other tungsten compounds	11.2% 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 an 18-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 1982 and requested the UNCTAD Secretariat to prepare market and price studies for the session.

Canada.—The mine and mill operated by Canada Tungsten Mining Corp. Ltd. at Tungsten, Northwest Territories, accounted for all Canadian concentrate production, totaling 4.4 million pounds of tungsten, a decrease of 37% from that of 1980. The drop was the result of a 6-month strike that was settled in May. Recovery was 84.5% from 234,000 tons of ore at a grade of 1.4% WO_3. Ore reserves were reported by the company to contain 85 million pounds of tungsten at yearend.[2]

Development of the Mount Pleasant tungsten-molybdenum mine, in Charlotte County, New Brunswick, continued, and it is expected to begin producing in late 1982. The joint venture between Billiton Canada Ltd. and Brunswick Tin Mines Ltd. is expected to produce concentrate containing 3.2 million pounds of tungsten and 1.3 million pounds of molybdenite (MoS_2) from a 2,200-ton-per-day mill. Minable ore reserves are placed at 57 million pounds of tungsten in ore grading 0.393% WO_3 and 0.204% MoS_2.

Table 18.—Tungsten: World concentrate production, by continent and country[1]

(Thousand pounds of contained tungsten)[2]

Continent and country	1977	1978	1979	1980[p]	1981[e]
North and Central America:					
Canada	3,995	5,046	5,726	7,010	[3]4,393
Mexico	421	516	556	586	[3]439
United States	6,008	6,896	6,643	6,072	[3]7,948
South America:					
Argentina	154	214	130	77	111
Bolivia	[r]5,355	[r]5,373	5,445	5,873	[3]6,031
Brazil	2,672	2,568	2,595	2,504	2,646
Peru	1,160	1,283	1,243	1,210	[3]1,149
Europe:					
Austria	2,460	2,599	3,298	3,296	3,197
Czechoslovakia[e]	175	175	175	175	175
France	1,440	1,340	1,102	1,270	1,210
Portugal	2,216	2,433	3,036	3,457	3,090
Spain	677	789	868	983	750
Sweden	439	[r]699	703	721	[3]818
U.S.S.R.[e]	18,100	18,700	19,200	19,200	19,500
United Kingdom	172	143	146	[e]150	150
Africa:					
Burundi	[e]4	[e]4	--	--	--
Namibia[e] [4]	330	330	360	330	--
Rwanda	[r]860	[r]750	1,113	990	[3]1,150
Uganda[e]	240	240	120	110	88
Zaire	375	326	247	159	300
Zimbabwe	[r]265	[r]287	243	198	200
Asia:					
Burma	613	1,038	1,526	1,814	1,796
China[e]	[r]19,800	[r]25,400	28,900	33,100	29,800
India	49	46	44	49	84
Japan	1,702	1,709	1,645	1,473	1,470
Korea, North[e]	4,740	4,740	4,740	4,850	4,850
Korea, Republic of	5,809	[r]5,910	5,981	6,034	[3]5,824
Malaysia	218	159	117	82	148
Thailand	4,859	7,026	4,026	3,560	2,870
Turkey	[r]22	[r]15	287	805	816
Oceania:					
Australia	5,198	[r]5,968	7,039	7,881	7,315
New Zealand	13	20	33	40	33
Total	[r]90,541	[r]102,742	107,287	114,059	108,351

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through June 29, 1982.
[2]Conversion factors: WO_3 to W, multiply by 0.7931; 60% WO_3 to W, multiply by 0.4758.
[3]Reported figure.
[4]Production of Brandberg West Mine of South Africa Company, Ltd., only.

A feasibility study was made of the MacTung tungsten deposit near MacMillan Pass along the Yukon-Northwest Territories boundary by AMAX through its subsidiary, AMAX of Canada Ltd. The target date for production from a 1,000-ton-per-day mine-mill complex is late 1986. Reserves are placed at 63 million tons of ore at the grade of 0.95% WO_3 or 950 million pounds of tungsten, which is the largest known deposit in the market economy countries.

China.—In Hunan Province in Chen County, the Shizhuyuan Mine is being developed for tungsten production. Initial annual production of concentrate is estimated at 5.3 million pounds of tungsten from a 3,000-ton-per-day mill. Ore reserves are reported to be 190 million tons at 0.30% to 0.35% WO_3 or 1,100 million pounds of tungsten.

Thailand.—Concentrate production continued to decrease annually from the record level of 7 million pounds of tungsten in 1978 to 2.9 million pounds in 1981, a decrease of 59% in 4 years. During 1981, the drop in production from that of 1980 was 19%, which was caused by a combination of guerrilla activity in the Khao Soon area, depletion of the highly productive deposits of the Phrae area, and a poor spot market.

Table 19.—Tungsten: World concentrate consumption, by country[1]

(Thousand pounds of contained tungsten)

Country[2]	1978	1979	1980[p]	1981[e 3]
Reported consumption:				
Australia	88	93	168	150
Austria	5,240	5,725	5,117	4,000
Canada	679	[e]660	660	600
France	3,611	2,112	1,354	1,600
Japan	4,489	5,712	6,462	5,050
Korea, Republic of	3,042	3,219	3,161	4,100
Mexico	[r e]88	[e]88	[e]88	90
Portugal	388	[e]441	470	600
Sweden	3,494	4,049	4,751	4,500
United Kingdom	4,383	3,446	3,228	2,200
United States	18,806	21,589	20,432	21,692
Apparent consumption:[4]				
Argentina	[r]132	192	42	50
Belgium-Luxembourg	[r e]220	[e]220	[e]220	220
Brazil	[r]1,285	1,892	2,046	2,000
China[e 3]	5,300	5,500	10,000	10,500
Czechoslovakia[e 3]	2,900	2,900	2,900	2,900
German Democratic Republic[e]	600	600	600	600
Germany, Federal Republic of	3,585	4,354	3,305	3,300
Hungary[e]	1,320	1,320	1,320	1,320
India[e]	600	600	600	600
Italy[e]	130	155	200	170
Korea, North[e 3]	3,500	3,500	3,500	3,500
Netherlands	886	[e]437	500	500
Poland	4,806	3,395	1,947	1,200
South Africa, Republic of[e]	550	550	550	550
Spain	320	317	302	300
U.S.S.R.[e 3]	[r]30,000	30,500	35,000	35,000
Total	[r]100,442	[r]103,566	108,923	107,292

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

[1]Source, unless otherwise specified, is the Quarterly Bulletin of the UNCTAD Committee on Tungsten: Tungsten Statistics. V. 16, No. 1, January 1982, 54 pp.

[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.

United Kingdom.—AMAX Exploration of U.K. Inc. and Hemerdon Mining and Smelting (U.K.) Ltd. plan to construct a tungsten-tin mine and mill near Plymouth, Devon County. The expected annual capacity is 4.4 million pounds of tungsten in concentrate and 450 tons of tin. The goal for opening is 1985, but this is dependent on Government approval and favorable economic conditions at that time. Minable ore reserves are placed at 130 million pounds of tungsten.

[1]Physical scientist, Division of Ferrous Metals.

[2]Canada Tungsten Mining Corp. Ltd. (Toronto, Canada). 1981 Annual Report, 16 pp.

Vanadium

By Peter H. Kuck[1]

In 1981, demand for vanadium increased in the United States, Western Europe, and Japan despite weakening conditions in the international steel industry. This increase in demand resulted primarily from a sharp rise in the sale of oil country tubular goods and the growing use of ferrovanadium in the production of high-strength low-alloy pipe and sheet. In the United States, steel mills and foundries maintained their stocks of ferrovanadium and other vanadium additives at minimal levels because of the recession and persistent high interest rates. Imports of ferrovanadium rose 274% to a record 984 short tons of contained vanadium. As a result, domestic ferroalloy producers saw their own vanadium stocks climb and were forced to make a series of production cutbacks in the last quarter of the year.

The Republic of South Africa remained the world's largest producer of vanadium ores and slags. However, large purchases of Chinese vanadium pentoxide and slags by Japanese and European ferroalloy producers in a buyer's market forced South African mining companies to operate well below capacity. In the United States, uranium-vanadium operations on the Colorado Plateau were hurt by the competitive market for pentoxide overseas, and by the continuing drop in the spot price of yellowcake (U_3O_8). Domestic processors increased their reliance on foreign vanadium-bearing iron slags and petroleum ashes. Imports of these byproduct materials were 36% higher than in 1980 and totaled 2,435 tons of contained vanadium.

Legislation and Government Programs.—The National Defense Stockpile goals of 1,000 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 the General Services Administration (GSA) on May 1, 1980. As of December 31, 1981, U.S. Government inventory consisted of 541 tons of contained vanadium in the form of pentoxide and 2 tons of vanadium metal.

During the second half of 1981, GSA tried unsuccessfully to acquire 900 tons (gross weight) of vanadium pentoxide in exchange for surplus pig tin and tungsten concentrate held in the stockpile. On June 25, the U.S. Department of Commerce issued revised stockpile purchase specifications for pentoxide. The new specifications covered two grades of fused flake suitable for production of ferrovanadium and nonferrous master alloys. A vanadium barter transaction with Continental Resources Inc. of New York City was canceled in December because of the vagaries of the international tin market and related legal complications.

Bureau of Mines research included investigations to improve the recovery of vanadium from low-grade uranium ores and a study of the environmental effects of burning high-vanadium fossil fuels.

Table 1.—Salient vanadium statistics

(Short tons of contained vanadium unless otherwise specified)

	1977	1978	1979	1980	1981
United States:					
Production:					
Ore and concentrate:					
Recoverable vanadium[1]	6,504	4,272	5,520	4,806	5,126
Value ... thousands	$74,488	$56,776	$73,892	$64,370	$71,496
Vanadium oxides recovered from ore[2]	5,208	5,204	5,758	5,506	6,368
Vanadium oxides recovered from petroleum residue[3]	912	1,097	1,617	1,520	1,900
Consumption	5,261	6,630	6,719	6,139	6,863
Exports:					
Ferrovanadium (gross weight)	658	1,309	880	803	435
Ore and concentrate		191	101	46	56
Vanadium pentoxide, anhydride (gross weight)	192	1,239	630	724	346
Other compounds (gross weight)		291	316	190	61
Imports (general):					
Ferrovanadium (gross weight)	558	535	738	328	1,236
Ores, slags, residues	2,812	2,234	2,442	1,786	2,435
Vanadium pentoxide, anhydride	444	656	907	856	354
World: Production from ores, concentrates, and slags	[r]32,813	[r]33,719	[r]37,311	[p]38,281	[e]38,933

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

[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.

DOMESTIC PRODUCTION

Mine production of vanadium increased in 1981 because of growing demand for ferrovanadium by the steel industry. Colorado was the leading producing State, followed by Utah. In both States the vanadium was obtained as a coproduct from the mining of uraniferous sandstones on the Colorado Plateau. The companies mining these carnotite-tyuyamunite or montroseite-uraninite ores were hurt when domestic utilities began selling surplus inventories of uranium concentrate in the aftermath of the Three Mile Island nuclear power mishap. These sales, combined with the nationwide recession, high interest rates, and a downturn in nuclear powerplant construction, caused the price of uranium concentrate (represented by Nuexco's Exchange value) to plummet from $40.75 per pound U_3O_8 in early 1980 to $23.50 in mid-1981.

In March 1981, Union Carbide Corp. resumed production of vanadium oxides at its Hot Springs Mine and mill complex in central Arkansas. The Hot Springs mill, which has an annual capacity of approximately 7,500 tons of V_2O_5 equivalent, had been closed during most of the second half of 1980. In the same month, Union Carbide closed its uranium and vanadium processing mill at Uravan, Colo., because of surplus stocks of U_3O_8 and environmental problems. The Uravan mill was reopened on September 18. Underground operations continued at the company's Deremo-Snyder and Sunday Group Mines in San Miguel County during the 6-month closure. Ore was also shipped to Uravan from the King Solomon and several smaller mines in Montrose County.

In April, Cotter Corp., a subsidiary of Commonwealth Edison Co., suspended vanadium extraction operations at its Canon City mill southwest of Colorado Springs, Colo. The mill was still being fed vanadium-poor uraninite ore from the company's Schwartzwalder Mine in Jefferson County. Cotter also halted development work at its new C-JD-7 open pit mine in the Paradox Valley west of Naturita, Colo. The new mine had been designed to produce 500 tons of ore per day, averaging 1.25% V_2O_5 and 0.25% U_3O_8.

At yearend, Atlas Corp. cut back operations at its uranium-vanadium mines and mill in southeastern Utah because of the depressed uranium market. The Snow and Probe Mines, 12 miles southwest of Green River in Emery County, and the Calliham Mine, 20 miles east of Monticello in San Juan County, were all placed on standby. The Pandora Mine, near LaSal in San Juan County, was being operated at a reduced rate. The company shut down the uranium alkaline leach circuit at its Moab mill but continued processing carnotite ores for vanadium and uranium through the more economical strong-acid-leach circuit. Shipments of high-grade ore to Moab from

Atlas's new Velvet Mine in the Sage Plains area helped offset any declines in the company's earnings brought on by declining uranium prices.

Energy Fuels Nuclear, Inc., brought its new White Mesa mill near Blanding, Utah, into full production. The mill has been using an acid leach and solvent extraction process to recover vanadium and uranium from carnotite ores mined at several locations on the Colorado Plateau. In this process the uranium is extracted first. The vanadium-rich raffinates are then fed through a second solvent extraction circuit. The dissolved vanadium is stripped with soda ash, precipitated as ammonium metavanadate, dried, and converted to fused pentoxide.

Kerr-McGee Chemical Corp. continued to produce vanadium pentoxide from ferrophosphorus at Soda Springs, Idaho. The vanadium-bearing ferrophosphorus was a byproduct of nearby elemental phosphorus plants.

The pentoxide recovered from imported vanadium-bearing materials and vanadium recovered directly as ferrovanadium from slags and residues, regardless of source, are not included in tables 2 or 3. Feed materials of foreign origin in these two categories include iron slags from Chile, China, and the Republic of South Africa as well as utility ashes, spent catalysts from refineries, and a variety of petroleum residues. U.S. production from petroliferous materials in 1981 totaled 1,900 tons of contained vanadium, 25% more than the 1,520 tons for 1980.

Pentoxide 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 681 tons of pentoxide in 1981, compared with 686 tons in 1980. In addition, the New York utility recovered a significant amount of low-grade vanadium ash from furnace wash waste. New waste water treatment systems were installed at both the Northport and Port Jefferson power stations to improve recovery of the low-grade ash.

In May, Engelhard Minerals & Chemicals Corp. split into two publicly held companies, Phibro Corp. and Engelhard Corp. Phibro Corp. acquired the vanadium extraction plant at Bartlesville, Okla., while Engelhard Corp. retained the ferrovanadium plant at Strasburg, Va. The Bartlesville plant became fully operational in 1981 and was processing a variety of stockpiled oil residues and ashes of Caribbean origin.

Gulf Chemical & Metallurgical Co. announced plans to increase the capacity of its catalyst processing facility near Freeport, Tex., by approximately 400%. The expansion was to take place in three stages and was scheduled to be completed by January 1983. Gulf Chemical extracts vanadium from spent catalysts supplied by oil refineries and petrochemical plants and converts the metal into fused pentoxide.

On July 1, Union Carbide sold its ferroalloys plant at Marietta, Ohio, to a group led by Elkem AS of Norway. Elkem Metals Co., the U.S. subsidiary of the group, continued to produce Carvan and Nitrovan in the eight vacuum furnaces at Marietta for Union Carbide on a toll basis. Also in July, Cabot Corp. completed construction of a $13 million aluminum master alloy plant in Henderson County, Ky. One of the products from the new Henderson plant was aluminum waffle ingot containing 3% zirconium and 2% vanadium. After intense and prolonged negotiations, Newmont Mining Corp. agreed on October 21 to let Consolidated Gold Fields Ltd. of London increase its holdings of Newmont stock from 16.2% to 26%. The Federal Trade Commission was investigating the complicated acquisition but decided not to seek an injunction blocking the immediate transaction. Newmont, an international gold, copper, and coal mining company, owns 83% of Foote Mineral Co., a major U.S. producer of both vanadium chemicals and ferrovanadium. Newmont also has a significant interest in the Highveld Steel and Vanadium Corp. of South Africa.

Producers of primary vanadium chemicals included Foote Mineral Co., Cambridge, Ohio; Stauffer Chemical Co., Weston, Mich.; and Union Carbide Corp., Niagara Falls, N.Y. Vanadium oxytrichloride and vanadium tetrachloride were the two ranking chemicals after pentoxide.

Table 2.—Mine production and recoverable vanadium of domestic origin produced in the United States

(Short tons of contained vanadium)

Year	Mine production[1]	Recoverable vanadium[2]
1977	7,565	6,504
1978	4,446	4,272
1979	5,841	5,520
1980	5,832	4,806
1981	5,852	5,126

[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]
1977	9,341	9,297
1978	9,785	9,290
1979	10,338	10,279
1980	10,048	9,829
1981	11,366	11,367

[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 increased 12% in 1981. Approximately 86% of the vanadium was consumed by the iron and steel industry as ferrovanadium or related vanadium-carbon ferroalloys. Strong demand for petroleum industry tubular goods produced a significant increase in consumption of ferrovanadium for Ni-Cr-Mo-V, Cr-Mo-V, and other full alloy steels. Consumption of ferrovanadium by producers of high-strength low-alloy steels increased 7% despite weak demand for steel overall by the automotive, machinery, and construction industries. Demand for vanadium in titanium alloys by the aerospace industry also increased significantly despite cutbacks in commercial aircraft production. Consumption of ammonium metavanadate, granular pentoxide, and other vanadium chemicals for catalysts declined 5% because of cutbacks in the production of sulfuric acid and the continuing weak demand for adipic acid.

In addition to the consumers' stocks shown in table 5, producers' stocks of vanadium as fused oxide, precipitated oxide, metavanadates, metal, alloys, and chemicals totaled 4,030 tons of contained vanadium at yearend 1981, compared with 3,390 tons (revised) at yearend 1980.

Table 4.—Producers of vanadium alloys or metal in the United States in 1981

Producer	Plant location	Product[1]
Cabot Corp., Engineered Products Group	Boyertown, Pa	VAl and ZrVAl.
Do	Henderson, Ky	VAl and ZrVAl.
Do	Wenatchee, Wash	VAl and ZrVAl.
Engelhard Corp., Minerals & Chemicals Div	Strasburg, Va	FeV.
Foote Mineral Co., Ferroalloys Div	Cambridge, Ohio	FeV and Ferovan.[2]
Metallurg, Inc., Shieldalloy Corp	Newfield, N.J	FeV.
Pesses Co., The	Pulaski, Pa	FeV and VAl.
Reading Alloys, Inc	Robesonia, Pa	Do.
Teledyne, Inc., Teledyne Wah Chang, Albany Div	Albany, Oreg	V.
Union Carbide Corp., Metals Div	Marietta, Ohio[3]	Carvan[2] and Nitrovan.[2]
Do	Niagara Falls, N.Y	FeV and VAl.

[1]FeV, ferrovanadium; V, vanadium metal; VAl, vanadium aluminum; ZrVAl, zirconium vanadium aluminum.
[2]Registered trade marks for proprietary products.
[3]Plant sold to a group led by Elkem AS of Norway on July 1, 1981.

Table 5.—Consumption and consumer stocks of vanadium materials in the United States

(Short tons of contained vanadium)

Type of material	1980 Consumption	1980 Ending stocks	1981 Consumption	1981 Ending stocks
Ferrovanadium[1]	5,338	770	5,941	548
Oxide	41	20	40	10
Ammonium metavanadate	22	16	21	7
Other[2]	738	73	861	118
Total	6,139	879	6,863	683

[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.—Consumption of vanadium in the United States, by end use

(Short tons of contained vanadium)

End use	1981
Steel:	
Carbon	1,278
Stainless and heat resisting	35
Full alloy	1,832
High-strength low-alloy	2,123
Tool	584
Unspecified	--
Total steel	5,852
Cast irons	42
Superalloys	31
Alloys (excluding steels and superalloys):	
Cutting and wear-resistant materials	W
Welding and alloy hard-facing rods and materials	9
Nonferrous alloys	852
Other alloys[1]	W
Chemical and ceramic uses:	
Catalysts	56
Other[2]	W
Miscellaneous and unspecified	21
Total consumption	6,863

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 1981 was \$3.05 to \$4.04 per pound V_2O_5, f.o.b. mill. On May 15, this price spread narrowed to \$3.35 to \$3.65 per pound V_2O_5, and remained in effect for the remainder of the year. At the same time, the spread for technical air-dried vanadium pentoxide (chemical grade) narrowed from \$3.35-\$4.57 to \$4.10-\$4.57.

On January 2, 1981, domestic producers and processors increased prices for selected vanadium alloys. Carvan (82% to 86% V) and Ferovan (40% V minimum) went from \$7.05 to \$7.75 per pound of contained vanadium. The U.S. price quotation for the 80% V grade of ferrovanadium made by Engelhard, Shieldalloy Corp., and Union Carbide went from \$7.75 per pound of contained vanadium to \$8.50 per pound. In April, Reading Alloys, Inc., and Union Carbide increased prices on their vanadium-aluminum alloys. The new price of the 65% vanadium-35% aluminum alloy was \$12.75 per pound of contained vanadium, up from \$11.30. The price for the 50-50 alloy rose from \$12.20 to \$14.50 per pound of contained vanadium.

FOREIGN TRADE

A strong dollar combined with a recession in the European coal and steel community caused U.S. exports of both ferrovanadium and pentoxide to plummet in 1981. Exports of ferrovanadium totaled 435 tons (gross weight), 46% less than the 803 tons for 1980. The average declared value for the ferrovanadium was $5.06 per pound of alloy, compared with $4.36 for 1980. Exports of vanadium pentoxide (anhydride) totaled 346 tons (gross weight), a 52% decrease from the 724 tons of 1980.

At the same time, the strong dollar and depressed steel industry in Europe produced a sharp increase in imports of ferrovanadium. Canada lost a significant part of its market share to the European market economy countries but still accounted for 44% of the imported alloy in terms of contained weight. Imports of vanadium pentoxide (anhydride) decreased dramatically. The Republic of South Africa remained the principal source of imported pentoxide, but China replaced Finland as the second leading source.

Imports of vanadium contained in slags, residues, and ashes totaled 2,435 tons, a 36% increase from 1980 imports. The bulk of this material was slag produced in the Republic of South Africa from Bushveld titaniferous magnetite ores. Shipments of vanadium-bearing slag from Chile resumed after a 25-month hiatus during which Compañia de Acero del Pacífico S.A. switched from open-hearth to basic oxygen furnaces at its Huachipato steelworks. No slags were received from either China or the U.S.S.R. Italy, Venezuela, and the Netherlands Antilles provided domestic processors with vanadium-bearing petroleum residues.

Ammonium vanadate imports amounted to 14 tons (gross weight), of which 13 tons came from the United Kingdom and 1 ton from Japan. In addition, 45 tons of potassium vanadate were received from the United Kingdom. Imports classified as "Other vanadium compounds" totaled 88 tons (gross weight), of which 87 tons came from the United Kingdom. Imports of vanadium carbide and unwrought vanadium metal were relatively minor and totaled less than 1 ton each.

Table 7.—U.S. exports of vanadium in 1981, 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
Algeria	--	--	--	--	1	11	--	--
Argentina	61	347	--	--	--	--	--	--
Australia	27	90	--	--	--	--	--	--
Belgium-Luxembourg	--	--	--	--	1	4	--	--
Brazil	--	--	--	--	52	165	6	19
Canada	764	3,861	--	--	16	54	39	163
Chile	--	--	--	--	--	--	(2)	9
Dominican Republic	--	--	--	--	--	--	(2)	1
France	--	--	--	--	(2)	3	63	234
Germany, Federal Republic of	--	--	--	--	103	265	8	7
Indonesia	--	--	--	--	8	50	--	--
Italy	--	--	--	--	--	--	2	1
Japan	--	--	34	157	107	302	--	--
Korea, Republic of	2	12	--	--	--	--	--	--
Malaysia	1	5	--	--	--	--	2	8
Mexico	14	83	77	417	271	888	1	2
Pakistan	--	--	--	--	7	35	--	--
South Africa, Republic of	--	--	--	--	109	170	(2)	8
Sweden	--	--	--	--	(2)	2	--	--
Taiwan	--	--	--	--	14	49	--	--
United Kingdom	--	--	--	--	(2)	1	--	--
Venezuela	--	--	--	--	--	--	(2)	3
Yugoslavia	--	--	--	--	2	13	--	--
Total[3]	869	4,397	111	575	692	2,012	121	455

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

Table 8.—U.S. imports of ferrovanadium, by country

(Thousand pounds and thousand dollars)

Country	1980 Gross weight	1980 Vanadium content	1980 Value	1981 Gross weight	1981 Vanadium content	1981 Value
General imports:						
Austria	37	30	189	169	137	913
Belgium-Luxembourg	--	--	--	441	356	2,299
Canada	559	450	2,999	1,114	873	6,072
China	--	--	--	11	9	55
Germany, Federal Republic of	60	44	303	664	534	3,555
Sweden	--	--	--	38	30	199
United Kingdom	--	--	--	35	28	194
Total[1]	656	524	3,491	2,472	1,968	13,288
Imports for consumption:						
Austria	35	32	174	169	137	913
Belgium-Luxembourg	--	--	--	441	356	2,299
Canada	559	450	2,999	1,114	873	6,072
China	--	--	--	11	9	55
Germany, Federal Republic of	60	44	303	664	534	3,555
Sweden	--	--	--	38	30	199
United Kingdom	--	--	--	35	28	194
Total[1]	654	525	3,477	2,472	1,968	13,288

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

Table 9.—U.S. imports of vanadium pentoxide (anhydride), by country

Country	1980 Gross weight (pounds)	1980 Vanadium content (pounds)	1980 Value	1981 Gross weight (pounds)	1981 Vanadium content (pounds)	1981 Value
General imports:						
China	44,092	24,699	$127,716	298,173	167,026	$804,317
Finland	1,945,020	1,089,534	5,489,711	119,049	66,687	352,183
Germany, Federal Republic of	--	--	--	3,594	2,013	16,707
Japan	--	--	--	551	309	2,744
South Africa, Republic of	1,066,103	597,195	2,744,149	842,658	472,028	2,345,447
United Kingdom	4	2	2,155	19	11	5,839
Total	3,055,219	1,711,430	8,363,731	1,264,044	708,074	3,527,237
Imports for consumption:						
China	44,092	24,699	127,716	227,625	127,508	621,020
Finland	1,945,020	1,089,534	5,489,711	119,049	66,687	352,183
Germany, Federal Republic of	--	--	--	3,594	2,013	16,707
Japan	--	--	--	551	309	2,744
South Africa, Republic of	1,066,097	597,191	2,744,149	842,658	472,028	2,345,447
United Kingdom	4	2	2,155	19	11	5,839
Total	3,055,213	1,711,426	8,363,731	1,193,496	668,556	3,343,940

WORLD REVIEW

Growing demand for full-alloy and high-strength low-alloy steels caused world consumption of vanadium to increase in 1981 despite little or no increase in raw steel production. World capacity to produce pentoxide also grew and was more than adequate to meet demand. Exports of pentoxide from China and Australia offset attempts by traditional producers to limit supply. The existing imbalance between supply and demand widened during the year, forcing some producers to cancel mine expansion projects and cut back milling operations.

Australia.—Agnew Clough Ltd. began shipping fused pentoxide flake from its new plant at Wundowie in Western Australia. The first shipment went to Nissho-Iwai Co., Ltd., a Japanese trading company supporting the project with a 7-year supply contract. Japan received a total of 121 tons of Australian pentoxide during calendar year 1981.[3] The Wundowie plant has a design capacity of 1,790 tons of fused flake per year. Magnetite-rich lateritic ore, averaging

1.2% V_2O_5, from the nearby Coates layered gabbro intrusion is used as feed. The laterite ore is ground, mixed with soda ash, and then calcined in a multistage fluid-bed roaster to form sodium vanadate.[3]

Western Mining Corp., Ltd., announced that it expected to bring the Yeelirrie project, located 240 miles northwest of Kalgoorlie, into production by the end of 1985. The principal ore mineral is carnotite, which has been precipitated onto the carbonate cemented clays and sands of a Tertiary river channel. A pilot plant has been in operation at Kalgoorlie for more than a year, using a pressurized sodium carbonate leach process to extract vanadium and uranium from the ground calcrete.[4]

Austria.—Treibacher Chemische Werke AG has installed a new Herreshoff multiple-hearth furnace with a capacity of 2,200 tons per year at its ferroalloys plant in Carinthia. The new furnace was being used to roast vanadium-bearing slags from Highveld's smelting operations in the Republic of South Africa. The vanadium, which is converted to soluble sodium vanadate during the roasting process, can then be leached with water and later precipitated as ammonium polyvanadate. An old 1,000-ton-per-year Herreshoff furnace was being kept on standby.[5]

Belgium-Luxembourg.—The Société Anonyme d' Applications de Chemie Industrielle continued to produce 80% V ferrovanadium at its Langerbruggekaai ferroalloys plant near Ghent.[6] The plant has a capacity of 1,100 tons per year of ferrovanadium and can make nine pours in 24 hours. Continental Alloys S.A., a subsidiary of Aciéries Réunies de Burbach-Eich-Dudelange S.A. (the Arbed Steel Group), produced ferrovanadium at Dommeldange in Luxembourg. This second ferroalloys plant has a capacity of 1,300 tons per year and has been in operation since 1969. Pentoxide was being produced at Dommeldange from Highveld slag and then converted to the ferroalloy by an aluminothermic process. U.S. imports of ferrovanadium from the Belgium-Luxembourg Economic Union totaled 221 tons (gross weight) in 1981.

Canada.—Masterloy Products Ltd., a subsidiary of International Minerals & Chemical Corp., has been importing vanadium pentoxide from both the Republic of South Africa and the United States to make ferrovanadium. The company has a ferroalloys plant in Gloucester Township near Ottawa that has been producing about 1,000 short tons per year of the 80% V grade by aluminothermic reduction.[7]

Chile.—The iron ores of the El Laco deposit in the Province of Antofagasta contain significant vanadium, according to a report from the University of Santiago.[8] Exploration work carried out by the defunct Compañía Minera Santa Fé between 1962 and 1966 showed that the seven ore bodies comprising the deposit contain at least 400 million tons of high-grade magnetite, hematite, and martite ore averaging 64% to 69% Fe. The mineralization is related to Plio-Pleistocene andesitic volcanism. Mining El Laco will present a challenge because of its remote location in the high Andes, at altitudes ranging from 14,000 to 16,000 feet above sea level.

China.—The Central Iron and Steel Research Institute (a unit of the Ministry of Metallurgical Industry) has been investigating ways of improving the recovery of vanadium from iron smelting operations in Sichuan, Hebei, and Anhui Provinces. The Institute has been able to produce 23% V_2O_5 slag by blowing hot metal containing only 0.355% atomic vanadium in an oxygen bottom-blown converter.[9] The vanadium-bearing slags exported by the China Metallurgical Import and Export Corp. in 1980 contained only 11% to 21% V_2O_5.

India.—Production of ferrovanadium totaled 125 tons in 1981, an increase of 33% from the 94 tons reported for 1980. Electric Control Gear Pte. Ltd. of Ahmedabad was the principal ferrovanadium producer, but Industrial Development Corp. of Orissa, Ltd., was reportedly constructing a 530-ton-per-year facility at Rairangpur in Orissa under a joint agreement with Norway and the U.S.S.R.[10]

Japan.—According to the Japan Ferroalloys Association, 4,479 tons of ferrovanadium was produced in 1981, a 15% increase over the 3,887 tons (revised) produced in 1980.[11] Imports of ferrovanadium increased from 337 tons in 1980 to 913 tons in 1981.[12] Austria, Brazil, China, and the Federal Republic of Germany (FRG) were the principal suppliers of the alloy. Japan also imported 4,346 tons of vanadium pentoxide during the year. The Republic of South Africa was the principal pentoxide supplier and accounted for 72% of the total gross weight. The Republic of South Africa, however, lost a significant part of its market share to China. Imports of Chinese pentoxide totaled 945 tons, a tenfold increase from 1980 imports, making China the second largest supplier of pentoxide to Japan.

Table 10.—Vanadium: World production from ores and concentrates, by country[1]

(Short tons of contained vanadium)

Country	1977	1978	1979	1980[p]	1981[e]
Production from ores, concentrates, and slags:[2]					
Australia (in vanadium pentoxide product)[e]	--	--	--	--	95
Chile[e 3]	950	760	510	300	140
China (in vanadiferous slag product)[e]	NA	2,200	4,000	5,000	5,000
Finland (in vanadium pentoxide product)	2,055	3,092	3,051	3,135	[4]3,432
Namibia (in lead vanadate concentrate)[5]	826	485	--	--	--
Norway[e]	590	510	630	540	540
South Africa, Republic of:[6]					
Content of pentoxide and vanadate product[e]	4,059	4,023	4,300	4,500	4,200
Content of vanadiferous slag product[e]	8,329	8,377	9,300	9,500	9,900
Subtotal[e]	[6]12,388	12,400	13,600	14,000	14,100
U.S.S.R.[e]	[r]9,500	[r]10,000	[r]10,000	10,500	10,500
United States (recoverable vanadium)	6,504	4,272	5,520	4,806	[4]5,126
Total	[r]32,813	[r]33,719	[r]37,311	38,281	38,933
Production from petroleum residues, ashes, and spent catalysts:[7]					
Japan (in vanadium pentoxide product)[e]	W	600	720	775	800
United States (in vanadium pentoxide and ferrovanadium product)	912	1,097	1,617	1,520	[4]1,900
Total	912	1,697	2,337	2,295	2,700
Grand total	33,725	35,416	39,648	40,576	41,633

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available. W Withheld to avoid disclosing company proprietary data.

[1]Table expanded to include output derived from petroleum residues, ashes, and spent catalysts for countries for which such data is available; 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 23, 1982.

[2]Production in this section is credited to the country that was the origin of the vanadiferous raw material.

[3]Based on U.S. imports of vanadium-bearing slag for the years 1977-79.

[4]Reported figure.

[5]Data represent output of South West Africa Co. Ltd. for the years ending June 30 of that stated.

[6]For 1977 the Republic of South Africa officially reported the undistributed total production of vanadium in pentoxide and vanadate products as well as in vanadium-bearing slags. 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. Vanadium content of pentoxide and vanadate products represents the difference between the reported total and the calculated estimate for vanadium in slag.

[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.

Norway.—In June, the corporate assembly of Elkem decided to terminate vanadiferous pig iron production at its Bremanger Works and close the Raudsand Mine.[13] The iron mining and smelting operation had been running a deficit for several years. Underground mining was scheduled to halt at the end of 1981 after 104 years of operation, but sufficient concentrates were on hand to permit smelting to continue until June 1982. The 10-megavolt-ampere (MVA) pig iron furnace will eventually be rebuilt to produce ferrosilicon. In 1980, Raudsand produced 152,664 tons of vanadiferous magnetite concentrates and 3,483 tons of ilmenite concentrates.[14]

South Africa, Republic of.—Highveld Steel and Vanadium Corp. Ltd. produced 67,816 tons (gross weight) of slag containing about 25% V_2O_5 in the fiscal year ending June 30, 1981.[15] Slag production at Highveld's Witbank iron and steel works in the Transvaal has more than quadrupled since 1969, the first year of operation. Slag production in fiscal years 1979 and 1980 totaled 58,388 and 63,215 tons, respectively. In November 1980, funds were approved for a second pig iron and slag plant at Witbank. Mannesmann Demag Metallgewinnung of Duisburg, FRG, will supply a 63-MVA submerged arc electric reduction furnace for the new facility.[16] Lurgi Chemie und Huettentechnik GmbH of Frankfurt, FRG, was awarded a contract for three rotary kilns.[17] The 275,000-ton-per-year kilns will be used at the new iron plant to prereduce vanadium-bearing titaniferous magnetite ore from the Mapochs Mine, north of Roossenekal. Lurgi built all 10 of the prereduction kilns already in operation at the existing iron plant. Weakening sales of South African pentoxide in Japan, the United States, and some European countries forced Highveld to further reduce fused flake production at its Vantra division. Only one of the eight Vantra roasting units was in operation at the end of the 1981 fiscal year.

In March, Ucar Minerals Corp. Ltd. shut down its 3,500-ton-per-year pentoxide production plant at Brits, 37 miles northwest of Pretoria, for extended maintenance.[18] The Ucar plant at Bon Accord, which previously produced both fused pentoxide and Carvan, has been closed since October 1980.

Sweden.—AB Statsgruvor has applied to the Swedish Government for permission to open a vanadium mine in the Kramsta area, near the village of Jarvsjo, about 175 miles north-northwest of Stockholm. The Kramsta deposit contains an estimated 14 million tons of titaniferous iron ore with an average content of 24% Fe, 3.4% Ti, and 0.15% V, and could yield as much as 2,800 tons of V_2O_5 per year.[19] Statsgruvor, a subsidiary of Luossavaara-Kiirunavaara AB, plans to beneficiate the ore by a process similar to that used at the Mustavaara Mine in Finland.

U.S.S.R.—The U.S.S.R. Ministry of Ferrous Metals has been expanding vanadiferous iron ore production at the Kachkanar open pit complex in the central Ural Mountains, as part of the eleventh 5-year plan (1981-85). Titaniferous magnetite, averaging 0.35% V, was being extracted from segregations in two gabbro-pyroxenite massifs. After concentration, the magnetite was being shipped to either the Nizhniy Tagil or the Chusovoy metallurgical plants for smelting into pig iron. The Nizhniy Tagil converter slag has typically averaged 21% V_2O_5; the Chusovoy slag, 17%.

The Soviet news agency Tass announced the discovery of vanadium- and nickel-rich bituminous deposits in western Kazakhstan.[20] The carbonaceous shales of the Balasauskandyk deposit in Kazakhstan apparently contain significant sulvanite ($3\ Cu_2S\text{-}V_2S_5$) and roscoelite (vanadium mica). The Soviet newspaper, Socialist Industry, also reported that a pilot system was being operated at the oil-burning Kostromskoye Municipal Power Station to recover vanadium from stack gases and boiler ashes.[21]

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[1]Physical scientist, Division of Ferrous Metals.
[2]Japan Tariff Association. Japan Exports and Imports. V. 12, 1981, pp. 125, 319.
[3]Metal Bulletin Monthly. No. 130, October 1981, pp. 121-124.
[4]The Northern Miner. V. 67, No. 28, Sept. 17, 1981, p. B12.
[5]Metal Bulletin Monthly. No. 131, November 1981, pp. 47-53.
[6]Metal Bulletin Monthly Supplement. No. 136, April 1982, p. 57.
[7]Department of Energy, Mines and Resources (Canada). Vanadium—An Imported Mineral Commodity. Miner. Bull. MR 188, December 1980, pp. 8-11.
[8]Metal Bulletin. No. 6605, July 14, 1981, p. 35.
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[10]Metal Bulletin Monthly. No. 130, October 1981, pp. 132-133.
[11]Japan Metal Journal. V. 12, No. 14, Apr. 5, 1982, p. 6.
[12]Work cited in footnote 2.
[13]Elkem AS. 2nd Tertial Report. 1981, p. 4.
[14]Bergverks-Nytt. No. 1, January 1981, pp. 7-8.
[15]Highveld Steel and Vanadium Corp. Ltd. Annual Report 1981, pp. 3-11.
[16]33 Metal Producing. V. 19, No. 5, May 1981, p. 9.
[17]Mining Journal (London). V. 297, No. 7622, Sept. 18, 1981, p. 207.
[18]American Metal Market. V. 89, No. 57, Mar. 25, 1981, p. 8.
[19]Nilsson, D. Vanadium in Sweden. Skillings' Min. Rev., v. 70, No. 23, June 6, 1981, pp. 6-8.
[20]Mining Journal (London). V. 297, No. 7632, Nov. 27, 1981, p. 414.
[21]Babak, E. How a "Golden Vein" Was Found and Lost. Sotsialisticheskaya Industriya (Socialist Industry) (Moscow), July 3, 1981, p. 2.

Vermiculite

By A. C. Meisinger[1]

Domestic production of vermiculite concentrate in 1981 declined 5% in quantity sold and used to 320,000 tons but increased 11% in value to $26 million compared with those of 1980.

Vermiculite was mined and beneficiated from deposits in Montana, South Carolina, and Virginia, with W. R. Grace & Co. accounting for most of the production.

Exfoliated vermiculite was produced at 48 plants in 31 States and, although output was slightly lower than that of 1980, value of sales increased 8% to $59 million.

The average value, f.o.b. plant, increased 17% for concentrate sold and used and 10% for exfoliated vermiculite, compared with those of 1980.

The principal uses of exfoliated vermiculite in 1981 were for concrete aggregate, 22%; premixes, 20%; fertilizer carriers, 14%; block insulation, 13%; and loose-fill insulation, 12%.

Table 1.—Salient vermiculite statistics

(Thousand short tons and thousand dollars unless otherwise specified)

	1977	1978	1979	1980	1981
United States:					
Sold and used by producers:					
Concentrate	359	337	346	337	320
Value	$18,600	$19,700	$22,000	$23,500	$26,200
Average value[1] dollars per ton	$51.81	$58.46	$63.58	$69.73	$81.88
Exfoliated	321	270	278	281	274
Value	$50,500	$49,000	$51,300	$54,500	$58,600
Average value[1] dollars per ton	$157.32	$181.48	$184.53	$193.95	$213.87
Exports to Canada	[e]45	35	33	38	NA
Imports from the Republic of South Africa	[e]40	[e]28	[e]27	[e]32	NA
World: Production[2]	574	[r]598	595	[p]588	[e]576

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available.
[1]Based on rounded data.
[2]Excludes production by centrally planned economy countries.

DOMESTIC PRODUCTION

U.S. production of vermiculite concentrate in 1981 was 320,000 tons valued at $26.2 million, a decrease of 5% in quantity sold and used but an increase of 11% in value over that of 1980.

The principal vermiculite mining and beneficiating operations were those of W. R. Grace & Co. at Libby, Mont., and Enoree, S.C. Vermiculite was also mined and processed in 1981 by Patterson Vermiculite Co. near Enoree, S.C., and by Virginia Vermiculite, Ltd., in Louisa County, Va.

Exfoliated vermiculite sold and used in 1981 was 274,000 tons valued at $58.6 million, a slight decrease in quantity but an increase of 8% in value. Production came from 48 plants in 31 states compared with 47 plants in 30 states in 1980. Producers and plant locations are shown in table 3. An unknown quantity of vermiculite imported from the Republic of South Africa during the year was also exfoliated in domestic plants.

The principal producing States were, in order of decreasing exfoliated vermiculite output, Ohio, California, Texas, Florida, South Carolina, New Jersey, and Illinois.

Table 2.—Exfoliated vermiculite sold and used, by end use

End use	1980		1981	
	Short tons	Percent of total	Short tons	Percent of total
Aggregates:				
Concrete	66,700	24	61,200	22
Plaster	2,900	1	4,000	2
Premixes[1]	40,100	14	55,700	20
Total	109,700	39	120,900	44
Insulation:				
Loose-fill	38,200	14	32,500	12
Block	37,200	13	36,600	13
Other[2]	2,700	1	3,800	2
Total	78,100	28	72,900	27
Agricultural:				
Horticultural	20,600	7	20,500	8
Soil conditioning	24,100	9	17,500	6
Fertilizer carrier	45,000	16	39,600	14
Total	89,700	32	77,600	28
Other[3]	3,100	1	2,400	1
Grand total[4]	281,000	100	274,000	100

[1]Includes acoustic, fireproofing, and texturizing uses.
[2]Includes high-temperature and packing insulation and sealants.
[3]Includes various industrial uses not specified.
[4]Data do not add to totals shown because of independent rounding.

Table 3.—Active vermiculite exfoliating plants in the United States in 1981

Company	County	State
A-Tops Corp	Beaver	Pennsylvania.
Brouk Co	St. Louis	Missouri.
Cleveland Gypsum Co., Div. of Cleveland Builders Supply Co	Cuyahoga	Ohio.
International Vermiculite Co	Macoupin	Illinois.
Koos, Inc	Kenosha	Wisconsin.
Mica Pellets, Inc	Dekalb	Illinois.
O. M. Scott & Sons	Union	Ohio.
P & H Inc	Hennepin	Minnesota.
Patterson Vermiculite Co	Laurens	South Carolina.
Robinson Insulation Co	Cascade	Montana.
Do	Ward	North Dakota.
The Schundler Co	Middlesex	New Jersey.
Shelter Shield Products, Div. of Insulation Sales Co	Franklin	Kansas.
Strong-Lite Products Corp	Jefferson	Arkansas.
Verlite Co	Hillsborough	Florida.
Vermiculite-Intermountain, Inc	Salt Lake	Utah.
Vermiculite of Hawaii, Inc	Honolulu	Hawaii.
Vermiculite Products, Inc	Harris	Texas.
W. R. Grace & Co., Construction Products Div	Irondale	Alabama.
	Maricopa	Arizona.
	Pulaski	Arkansas.
	Alameda	California.
	Orange	Do.
	Denver	Colorado.

Table 3.—Active vermiculite exfoliating plants in the United States in 1981 —Continued

Company	County	State
W. R. Grace & Co., Construction Products Div. Continued	Broward	Florida.
	Duval	Do.
	Hillsborough	Do.
	Du Page	Illinois.
	Campbell	Kentucky.
	Orleans	Louisiana.
	Prince Georges	Maryland.
	Hampshire	Massachusetts.
	Wayne	Michigan.
	Hennepin	Minnesota.
	St. Louis	Missouri.
	Douglas	Nebraska.
	Mercer	New Jersey.
	Cayuga	New York.
	Guilford	North Carolina.
	Oklahoma	Oklahoma.
	Multnomah	Oregon.
	Lawrence	Pennsylvania.
	Greenville[1]	South Carolina.
	Davidson	Tennessee.
	Bexar	Texas.
	Dallas	Do.
	Milwaukee	Wisconsin.

[1]Two plants in county.

CONSUMPTION AND USES

Exfoliated vermiculite sold and used by producers in 1981 totaled 274,000 tons, a small decline from that of 1980. Total use for concrete aggregates, plaster aggregates, and premixes increased 10% to 120,900 tons, or 44% of domestic consumption. Use in premixes increased 39%, whereas insulation uses declined slightly, and agricultural uses declined 13%.

PRICES

The average value of vermiculite concentrate sold and used by U.S. producers in 1981 was $81.88 per ton, f.o.b. plant, an increase of 17% over that reported in 1980. The average value for exfoliated vermiculite sold and used was $213.87 per ton, f.o.b. plant, an increase of 10% over that of 1980.

Engineering and Mining Journal quoted 1981 yearend prices for unexfoliated vermiculite as follows: Per short ton, f.o.b. mine, Montana and South Carolina, domestic, $78 to $106; and the Republic of South Africa, c.i.f. Atlantic ports, $100 to $160. For comparison, 1980 yearend quoted prices per ton were $64 to $98 for domestic ore and $100 to $160 for South African ore.

FOREIGN TRADE

The United States annually imports significant quantities of vermiculite from the Republic of South Africa and exports vermiculite to Canada; tonnages have equaled about one-tenth of domestic sales.

WORLD REVIEW

Estimated world vermiculite production in 1981 was 576,000 tons, a small decrease from that of 1980. The United States and the Republic of South Africa, together, accounted for 92% of world production.

[1]Industry economist, Division of Industrial Minerals.

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

(Short tons)

Country	1977	1978	1979	1980[p]	1981[e]
Argentina	5,319	[r]4,878	6,478	10,920	[2]8,054
Brazil	3,987	4,443	8,137	8,818	11,000
Egypt	--	654	770	800	800
India	3,172	2,079	3,376	3,779	4,000
Japan[e]	15,000	16,000	17,000	19,000	19,000
Kenya	4,762	2,054	2,491	2,819	2,900
South Africa, Republic of	182,343	230,485	211,173	204,698	[2]210,101
Tanzania[e]	20	20	20	20	20
United States (sold and used by producers)	359,000	337,000	346,000	337,000	[2]320,000
Total	573,603	[r]597,613	595,445	587,854	575,875

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Excludes production by centrally planned economy countries. Table includes data available through June 30, 1982.
[2]Reported figure.

Zinc

By James H. Jolly[1]

The trends of the U.S. zinc industry followed those of the overall economy in 1981. Zinc consumption was relatively strong in the first half of the year but weakened in the second half with the onset of economic recession. Zinc prices followed the same trend, rising through August, but falling in the last 3 months. Smelter production was up 6% over that of 1980, but capacity utilization fell in the latter half of the year. A major primary smelter closed down in November. Mine production, affected by midyear strikes and mine closures late in the year, decreased marginally in 1981. Imports of concentrate for consumption rose substantially as smelters withdrew large quantities of concentrate from bonded warehouses during the year. Slab zinc imports were up 49% over those of 1980. In the latter half of the year, slab zinc imports did not contract with decreasing consumption, and producer, consumer, and merchant stocks increased substantially.

Table 1.—Salient zinc statistics

	1977	1978	1979	1980	1981
United States:					
Production:					
Domestic ores, recoverable content metric tons	407,889	302,669	267,341	[r]317,103	312,418
Value thousands	$309,338	$206,854	$219,841	[r]$261,671	$306,879
Slab zinc:					
From domestic ores metric tons	322,208	267,350	255,344	231,850	256,934
From foreign ores do	86,156	139,348	217,137	108,606	86,728
From scrap do	45,914	34,774	53,212	29,396	49,322
Total do	454,278	441,472	525,693	369,852	392,984
Secondary zinc[1] do	284,065	304,047	316,818	274,967	291,528
Exports of slab zinc do	215	723	279	302	323
Imports (general):					
Ores and concentrates (zinc content) do	111,410	188,003	224,952	129,923	117,736
Slab zinc do	523,206	617,840	527,212	410,642	602,694
Stocks of slab zinc, Dec. 31:					
Producer and consumer do	170,237	137,253	151,661	92,151	126,581
Merchant do	NA	NA	NA	33,650	68,773
Government stockpile do	347,828	345,872	345,684	342,380	340,581
Consumption:					
Slab zinc do	999,505	1,050,585	1,000,606	811,146	834,199
All classes do	1,367,704	1,441,810	1,394,314	1,142,409	1,183,563
Price: Prime Western, cents per pound (delivered)	34.39	30.97	37.30	[2]37.43	[2]44.56
World:					
Production:					
Mine thousand metric tons	[r]5,920	[r]5,846	[r]5,870	[p]5,779	[e]5,844
Smelter do	[r]5,812	[r]5,884	[r]6,269	[p]6,057	[e]6,140
Price: Prime Western, London, cents per pound	26.71	26.88	33.59	34.47	38.34

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available.
[1]Excludes redistilled slab zinc.
[2]Based on U.S. High Grade, cents per pound.

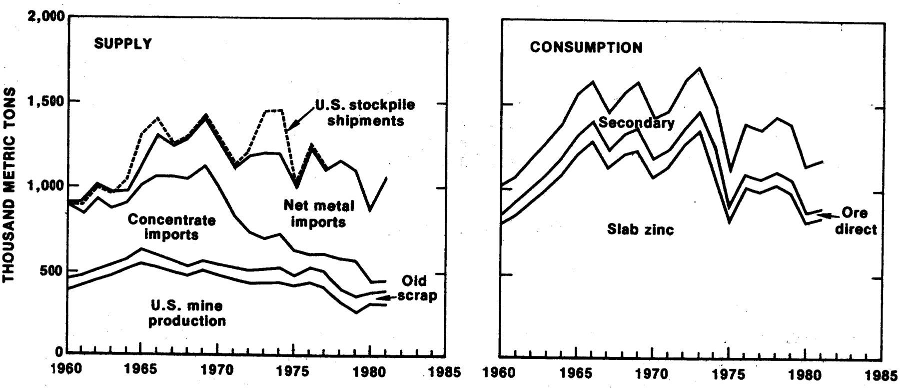

Figure 1.—Trends in supply and consumption in the United States.

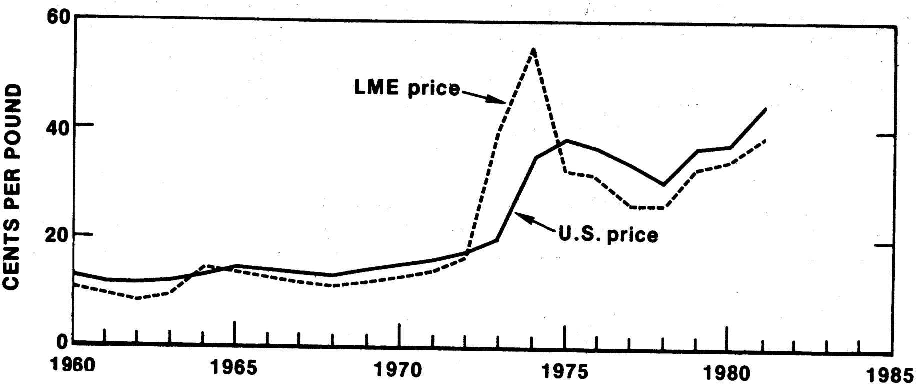

Figure 2.—Trends in average London Metal Exchange (LME) and domestic zinc prices.

Legislation and Government Programs.—The National Defense Stockpile goal for zinc was 1,292,739 tons, unchanged from that of May 1980. The total zinc inventory at yearend 1981 was 343,206 tons, including 2,625 tons of zinc in stockpiled brass.

Early in 1981, the U.S. Bureau of the Mint announced its intention to change the composition of the traditional copper penny to one composed largely of zinc. The new penny, to be circulated in early 1982, was expected to save the Government about $50 million per year, mainly because of the lower cost of zinc compared with that of copper.

The State of Wisconsin amended its controversial 1977 mining tax law in November improving the development prospects of two large zinc-copper deposits, Crandon and Flambeau. The amended law significantly reduced net proceeds taxes and provided additional tax deductions for mining companies.

The Comprehensive Environmental Response, Compensation, and Liability Act of 1980, Public Law 96-510, also known as Superfund, went into effect on April 1. A major provision of the law was to establish a 5-year, $1.6 billion fund to clean up disposal sites and spills of hazardous substances. The taxes on the production of two zinc compounds included in the law were $2.22 per short ton for zinc chloride and $1.90 per short ton for zinc sulfate.

At its annual session in Geneva, Switzerland, in October, the International Lead and Zinc Study Group projected that both production and consumption of zinc would increase in 1982 but consumption would probably not recover to the 1979 level.

DOMESTIC PRODUCTION

MINE PRODUCTION

U.S. mine production of recoverable zinc from 16 States was slightly less in 1981 than that produced in 1980. Most of the decrease in output occurred in Missouri, New Jersey, and Virginia. The 25 leading U.S. zinc-producing mines accounted for almost 98% of the recoverable zinc mined in 1981, unchanged from that of 1980. The remaining 2% of production was recovered mainly as a byproduct from silver, copper, and gold mines in the Western States and two fluorspar mines in Illinois. The 10 leading mines accounted for 65% of the total mine production in 1981 compared with 70% in 1980.

Tennessee was the principal zinc-producing State in 1981, a position the State has held 22 times in the last 25 years. Zinc was produced from zinc ore at eight underground mines and from copper-zinc ore at three underground operations and one open pit at the Copperhill deposit.

ASARCO Incorporated increased zinc output by 10% over that of 1980 at its four Tennessee mines—Young, New Market, Immel, and Coy. Asarco milled 2.6 million tons of ore at these mines in 1981, producing 62,600 tons of zinc in concentrate. Asarco's Tennessee mines had ore reserves of 7.2 million tons grading 3.36% zinc at yearend.

In September, Jersey Miniere Zinc Co. resumed development of its Gordonsville, Tenn., mine, which is adjacent to the company's operating Elmwood Mine. Jersey Miniere planned to start milling Gordonsville ore in April 1982 attaining a milling rate of 2,700 tons per day by July. The zinc concentrates will be processed at the company's Clarksville, Tenn., refinery. Combined ore reserves at the Elmwood and Gordonsville Mines were about 28 million tons grading 3.7% zinc.

The New Jersey Zinc Co., owned by Gulf + Western Industries, Inc., operated four mines in Tennessee in 1981; however, two mines, Lost Creek and Idol, were closed during the year because of high labor and environmental costs and diminished ore reserves. Production at the company's two Jefferson City mines was increased to make up for production losses from the mine closings.

Zinc production as a coproduct came from seven lead mines in Missouri. Output of zinc at the Buick Mine, owned jointly by AMAX Inc. and Homestake Mining Co., fell 44% to 20,345 tons in 1981 owing mainly to a 78-day strike. The mine expansion program at Buick initiated in 1976 was largely completed in 1981. Another development program was underway to open a satellite ore body, which will allow increased ore production rates in 1982. At yearend, ore reserves at the Buick Mine were 40 million tons averaging 5.9% lead and 1.6% zinc. Production of zinc from the Magmont Mine, a joint venture of Cominco American Inc. and Dresser Industries, Inc., increased 20% to 14,400 tons in 1981, although lead output fell, owing to changes in ore grade mined. The Magmont East extension was brought into production in 1981; the development of the Magmont West ore body was expected to be completed in 1982. These ore bodies, although lower grade than the original Magmont ore body, are expected to extend the life of the mine to about 1990. Magmont's ore reserves were 5 million tons grading 7.8% lead, 1.1% zinc, and 9.3 grams of silver per ton. In nonproducing areas, an additional 3.4 million tons of ore reserves grading 3.4% lead and 1.6% zinc have been blocked out. Asarco continued development of its new $77 million lead-zinc mine and mill near West Fork, Mo. The company planned to achieve the full production rate of 3,450 tons of ore per day by mid-1984. Annual production is projected to be about 46,000 tons of lead and 6,800 tons of zinc.

In New York, St. Joe Minerals Corp., a subsidiary of Fluor Corp. since August 1981, was developing its Pierrepont Mine 28 miles from St. Joe's zinc mine and mill complex in Balmat. Ore reserves are 2.3 million tons grading about 15% zinc. The company planned to process the ore at its Balmat mill at a rate of 450 tons per day beginning in April 1982.

Production of zinc in Idaho was reported from 20 mines, but about one-half produced less than 100 tons each as a byproduct. The two principal zinc mines were the Bunker Hill Mine, The Bunker Hill Co. (BH), a subsidiary of Gulf Resources and Chemical Corp., and Star Unit, equally owned by Hecla Mining Co. and BH. Gulf Resources announced in August that it was closing the Bunker Hill Mine, mill, and smelter operation because of unprofitability, lack of adequate supplies of ore concentrates, and environmental problems. Layoffs began in November and were three-fourths completed by the end of December. Zinc production at the Star Unit increased slightly to about 14,650 tons in 1981. Ore mined increased but the zinc grade declined. Ore reserves of the Star Unit were about 1.0 million tons at yearend representing a modest reduction due primarily to lower metal prices. Production at Idaho's third largest zinc producer, the Lucky Friday silver mine, was 1,089 tons, down about 25% from that of 1980 owing mainly to a mine strike early in the year. The new silver shaft was at a depth of 4,900 feet at yearend and was expected to reach an ultimate depth of 7,500 feet. When completed to the 6,100-foot level, the production capacity of the Lucky Friday is expected to increase by 35%.

In Colorado, zinc was produced at 14 mining operations in 1981. The principal producer was the Leadville Mine, managed by Asarco but jointly owned with Resurrection Mining Co. Zinc output at the Leadville Mine in 1981 was up 6% to 11,900 tons despite lower production of lead and gold and only a marginal increase in silver output. Leadville ore reserves at yearend totaled 1.6 million tons grading 9.33% zinc, 4.28% lead, 0.22% copper, 2.3 ounces of silver per ton, and some gold.

New Jersey Zinc closed its Austinville, Va., mines and mill in December, putting 300 miners out of work. Company officials cited increased labor costs, poor zinc market, and environmental regulations as the major reasons for the shutdown.

New Jersey Zinc's Sterling zinc mine in Ogdensburg, N.J., was sold along with its Palmerton, Pa., and Depue, Ill., zinc plants to a group of private investors who formed a new company, New Jersey Zinc Co., Inc. (JZI). New Jersey Zinc's other mines and its 60% participation in Jersey Miniere were not affected by the divestiture.

Noranda Mines Ltd. planned to develop its Green Creek claims on Admiralty Island, 10 miles southwest of Juneau, Alaska, by 1985 if all the necessary State and Federal permits can be obtained. Noranda has identified about 3.5 million tons of ore averaging 8% to 10% zinc, 2.5% lead, 0.5% copper, 310 grams of silver per ton, and some gold.

U.S. Minerals Co. and Placer Amex Inc. planned to jointly spend $25 million to explore and develop the Montana Tunnels zinc-lead-silver deposit near Helena, Mont. Reserves were estimated to be 23 million tons grading about 8.4% zinc, 3.4% lead, 0.5 ounce of silver per ton, and some gold. The deposit is open both laterally and at depth. The deposit reportedly could be brought into production for an additional $50 million.

Exxon Minerals Co., U.S.A., continued feasibility studies at its Pinos Altos zinc-copper mine, but reportedly would not make a decision to proceed with commercial development until 1984. Estimated reserves were 7 million tons averaging 3% zinc, 2% copper, plus recoverable quantities of silver and gold.

SMELTER AND REFINERY PRODUCTION

U.S. slab zinc production at 6 primary plants and 12 secondary plants increased 6% over that of 1980. The U.S. zinc smelting and refining industry changed considerably in 1981. The large primary zinc plant of Bunker Hill in Idaho was closed down; the Palmerton, Pa., smelter changed ownership and was scheduled to produce only zinc oxide, dust, and powder; two new secondary slab zinc plants and one zinc oxide plant came onstream in Michigan; the zinc dust production facilities at the Monaca, Pa., smelter were reactivated and smelter capacity was increased; a new secondary zinc plant was nearing completion in Tennessee; and several expansions of primary smelters were underway.

The Sauget, Ill., electrolytic zinc plant jointly owned by AMAX and Homestake treated record levels of zinc concentrates in 1981. Sources of concentrate were the Buick Mine, AMAX's share of production from Newfoundland Zinc Co., and purchased zinc material. The plant produced 67,680 tons of refined zinc in 1981 as well as 422 tons of cadmium and 108,000 tons of byproduct sulfuric acid.

Zinc production at Asarco's Corpus Christi zinc plant in Texas was 46,900 tons in 1981, up 10% from that of 1980. A $42 million modernization program was expected to be completed in April 1982. The improvements will enable the plant to process a broad range of zinc concentrates and to reduce operating costs.

St. Joe increased the capacity of its Monaca, Pa., zinc plant from 45,000 to 68,000 tons per year in 1981. The plant could be used to produce either oxide or metal. In June, St. Joe reactivated its dust production facilities at Monaca and was capable of making about 3,600 tons per year in at least three major dust grades. The zinc dust-making equipment was modified to permit the use of any grade of zinc scrap, including drosses, concentrates, and diecasting scrap.

National Zinc Co. brought its $2.3 million secondary zinc recovery plant in Bartlesville, Okla., onstream in June. The plant was designed to separate about 900 tons of zinc skimmings per month into zinc oxide and zinc metal by a hydrometallurgy process. Recovered metal, expected to be 3,600 to 4,500 tons per year, is remelted and blended with High Grade to make Controlled Lead Grade. The oxide is processed at the company's primary zinc refinery also in Bartlesville. The use of secondary material in the refinery, which reportedly was having roaster problems, permitted National Zinc to produce at the refinery's rated capacity, 51,000 tons per year.

In September, Huron Valley Steel Corp. opened its new secondary zinc refinery in Belleville, Mich., and a zinc oxide plant in Trenton, Mich. The refinery, which uses a vertical column distillation process, was expected to attain in early 1982 a capacity to produce 32,600 tons per year of Special High Grade zinc metal. The zinc oxide plant, which uses a proprietary process, has a rated capacity of 22,000 tons of zinc oxide per year. In early December, Interamerican Zinc Co. began operating its secondary zinc facility in Adrian, Mich. The new 15,000-ton-per-year plant was in addition to its 7,000-ton-per-year plant built in 1977. Interamerican was producing both Prime Western and Continuous Galvanizing Grade metal.

Pacific Smelting Co., a subsidiary of Australian Mining & Smelting Ltd. (AM&S), planned to complete the construction of its new, secondary zinc plant in Memphis, Tenn., by March 1982. Together with Pacific Smelting's zinc facilities in California, the company will have a total capacity to produce 36,000 tons per year of zinc oxide and/or galvanizing grades of zinc metal. Initial plans called for production of zinc oxide at the new plant, principally for the rubber industry.

Zinc Oxide.—The source of domestic zinc oxide production was about one-half from ores and concentrates, about one-fifth from slab zinc, and about one-third from secondary material. Total French process zinc oxide was about 40% of the total produced in 1981. Lead-free zinc oxide was produced at 14 plants and leaded zinc oxide was produced at 1 plant.

In 1981, Asarco's production of zinc oxide was up 54% to 51,000 tons at its zinc oxide plants in Columbus, Ohio, and Hillsboro, Ill. Production was significantly lower in 1980 owing mainly to a 3-month strike at the Columbus plant. JZI produced both American and French process zinc oxide and had the largest capacity. The annual zinc oxide capacity of JZI's Palmerton plant was estimated at 87,000 tons at yearend. Zinc concentrates used in the production of American process zinc oxide were from the company's Sterling Mine at Ogdensburg, N.J., and foreign sources.

Zinc Salts.—Zinc sulfate was produced by about 14 companies from secondary material and from ore. Zinc chloride production from five companies was derived entirely from secondary material.

Slag-Fuming Plants.—Slag-fuming plants processed lead blast furnace slags and residues to produce zinc oxide fume. The fume was either sold or used as oxide or sent to smelters and refineries for processing into metallic zinc. Three plants operated in 1981—Asarco in El Paso, Tex., and East Helena, Mont.; and Bunker Hill in Kellogg, Idaho. Asarco recovered 27,400 tons of zinc in fume operations in 1981 compared with 14,150 tons in 1980. The fume was shipped to Asarco's Corpus Christi zinc refinery for processing.

Byproduct Sulfuric Acid.—Production of byproduct sulfuric acid from six zinc plants was 545,890 tons in 1981.

CONSUMPTION AND USES

Zinc consumption improved marginally in 1981 despite reduced construction activity and the lowest level of automobile production in the United States in 20 years. Consumption in most product uses was static or declined, but usage in galvanizing, especially for sheet and strip, and in some brass products increased. Galvanizing continued to be the principal use of slab zinc, consuming 49%; followed by zinc-base alloys, 29%; brass and bronze, 14%; and other, 8%. Special High Grade constituted 43% of slab zinc consumption and was used mainly in diecasting alloys. Prime Western accounted for 33% of the slab zinc consumption and was largely used in galvanizing.

A survey on shipments of hot-dip galvanized steel by end use conducted by the Zinc Institute Inc. and the American Hot Dip Galvanizers Association indicated the largest end-use industry was electric utilities, 27%; followed by fabricated wire products, 19%; heavy construction, which was mainly industrial plants, 14%; transportation, 12%; agriculture, 8%; light construction, which was mainly nonresidential building, 7%; and other, 13%.

The United States Steel Corp. and a number of hot-dip galvanizers switched to High Grade zinc from Prime Western and Controlled Lead grades to feed their galvanizing lines in 1981 because of premium pricing for the leaded metal grades. The price differentials reportedly made it worthwhile for galvanizers to prepare their galvanizing alloys in-house. Galvalume—a 55% aluminum, 43.4% zinc, and 1.6% silcon alloy—continued to make inroads on the consumption of traditional galvanizing alloys in the steel sheet and coil industry. Jones & Laughlin Steel Corp., National Steel Corp., and two foreign steel companies added galvalume lines in 1981. A strong switch from galvanized coating to galvalume, such as occurred in Australia where about 80% of the coated steel roofing and siding market has been captured by galvalume, could significantly affect zinc consumption and growth.

Another Zinc Institute study reported that the weight of zinc diecastings, including optional equipment, used in the average U.S. automobile for the 1981 model year was 24.14 pounds. Averages for the major U.S. automobile manufacturers were General Motors Corp., 25.3 pounds; Chrysler Corp., 22.9 pounds; Ford Motor Co., 20.9 pounds; and American Motors Corp., 31.5 pounds. For the 1982 model year, an average of 22.7 pounds per car was projected.

Fabrication of the new zinc penny, a copper-plated zinc coin, began late in the year, but distribution was not expected until January 1982. The new coin, which is similar in all respects to the current copper coin except that it is 19% lighter in weight, is composed of 97.6% zinc and 2.4% copper compared with the current penny's composition, 5% zinc and 95% copper. When at full production in 1983, The Bureau of the Mint expected to consume about 45,000 tons per year of Special High Grade zinc to make pennies. The shift to the high zinc composition penny was expected to reduce Government costs because zinc prices are lower than those of copper and because more pennies can be made per given weight of new alloy versus the old alloy.

The apparent consumption of zinc oxide was about 177,000 tons, down from about 182,000 tons in 1980. Reported shipments to user industries increased more than 9% in 1981. All end-use categories, except miscellaneous, received increased shipments. The rubber and chemicals industries had the largest tonnage increases. Among miscellaneous uses, zinc oxide was used in floor coverings, fabrics, lubricants, plastics, and rayon manufacturing. The use of zinc sulfate in agriculture continued to increase in 1981 with lesser amounts used for rayon, flotation reagents, and chemicals. Leaded zinc oxide was used in rubber, and lithopone was used mainly in paints. Zinc chloride was used mainly in wood preserving, soldering fluxes, and batteries.

STOCKS

Annual data collected by the Bureau of Mines indicated that primary and secondary producer stocks of slab zinc at yearend were 98% higher compared with the start of the year. Monthly data as reported by the American Bureau of Metal Statistics showed that producer stocks at plants and elsewhere declined through May but thereafter, except for September, increased for the rest of the year.

Inventories of slab zinc at consumer plants generally trended downward during the first half of the year and trended upward in the last half. Consumer stocks were 18% higher at the end of 1981 than at the end of 1980.

Merchant stocks began the year at 33,650 tons, declined to 22,220 tons by the end of April, increased and firmed at about 36,000 tons in the summer months, and rose sharply to 68,773 tons in the last 3 months of the year.

PRICES

High Grade slab zinc was 41.25 cents per pound at the beginning of the year. On March 20, Bunker Hill raised its High Grade price 2 cents to 43.25 cents per pound; all other producers raised their prices to this level by the end of March. In late April, Hudson Bay Mining and Smelting Co. Ltd., Bunker Hill, and others raised their High Grade prices to 45.25 cents. National Zinc adjusted its premium pricing structure owing to increased debasing costs on April 27, raising its premiums by 0.5 cent per pound to 0.75 cent above the High Grade base for Controlled Lead Grade and to 1.25 cents per pound for Continuous Galvanizing Grade. By early May, all North American producers were selling High Grade for 46.25 cents per pound and most had adopted premium pricing for leaded grades. On July 30, Hudson Bay Mining, followed by all North American producers, raised its High Grade price 3 cents to 49.25 cents per pound. In the last 4 months of the year, demand weakened and stocks increased dramatically. On October 1, Asarco cut its High Grade price 4.25 cents per pound to 45 cents; within a week other producers were at 46.25 cents per pound for High Grade. Asarco again lowered its price for High Grade on December 1 to 44 cents per pound and on December 4 to 42 cents. At yearend, producer's list prices for High Grade ranged from 42 to 46.25 cents per pound. Special High Grade list prices were 0.5 cent per pound higher than High Grade throughout the year.

The list price for zinc oxide at the start of the year was 47.25 cents per pound for American process, lead-free pigment grade; 48.75 cents per pound for French process, regular; and 50 to 51 cents per pound for photoconductive grade. The price for 12% leaded zinc oxide was 42.75 cents per pound for 50-short-ton railcar quantities. In April, zinc oxide prices were raised 2 cents per pound in line with increases in zinc metal prices. In August, list prices were 53.25 cents per pound for American process, lead-free pigment-grade zinc oxide; 54.75 cents per pound for French process regular grade; 56 to 58 cents per pound for photoconductive grade; and 44.75 to 47.5 cents per pound for 12% leaded grade. Zinc oxide prices declined during the last 4 months of the year paralleling the decrease in zinc metal prices. American and French process lead-free zinc oxide ended the year at 50 to 52 cents and 51.5 to 53.5 cents per pound, respectively.

The price for zinc sulfate, granular monohydrate industrial, 36% zinc in 100-pound bags in carload lots, remained at $26.50 to $29.00 throughout 1981. Technical-grade zinc chloride, 50% solution, was quoted at $10 to $17 per 100 pounds in tanks until the middle of August when the quote was raised. The high quote remained steady at $18.20 per 100 pounds to the end of the year; the low quote ranged from $12.25 to $16, ending the year at $12.25 per 100 pounds.

FOREIGN TRADE

Exports of zinc ores and concentrates remained at the relatively high level established in 1980, partially because tightness in the world concentrate supply brought higher prices. Some additional concentrates became available for export in the latter half of the year because of the closing of the Bunker Hill smelter.

General imports of zinc in ores and concentrates continued to decrease in 1981, whereas imports for consumption increased by 63,340 tons. Duties on imported zinc ores and concentrates were suspended in late 1980; consequently, substantial withdrawals of zinc concentrates from bonded warehouses occurred in 1981. Of the general imports, 9,281 tons entered bonded warehouses in 1981 compared with 51,636 tons in 1980. Of the imports for consumption, 137,254 tons was withdrawn from bonded warehouses in 1981 compared with 104,084 tons in 1980 and 4,497 tons in 1979.

Table 2.—U.S. import duties for zinc materials, January 1, 1981

Item	TSUS No.	Most favored nation (MFN)	Non-MFN
Ores and concentrates	602.20	0.58 cent per pound on zinc content.	1.67 cents per pound on zinc content.
Fume	603.50	0.58 cent per pound on zinc content.	1.67 cents per pound on zinc content.
Unwrought, other than alloys	626.02	1.9% ad valorem	1.75 cents per pound.
Alloys	626.04	19% ad valorem	45% ad valorem.
Waste and scrap	626.10	4.4% ad valorem	11% ad valorem.

Slab zinc imports for consumption increased 49% over those imported in 1980. Canada was by far the principal exporter of slab zinc to the United States, supplying slightly more than one-half in 1981. Peru, formerly a minor import source, was the second principal supplier in 1981 and could remain a major import source because of significant additions to slab zinc production capacity in 1981.

In December, the U.S. Department of Commerce decided to retroactively lower the penalty import duties of unwrought zinc from Spain for 1980 from 2.65% to 2.05% ad valorem and not impose any penalty duty for 1981. If the decision is upheld, the penalty duties for 1980-81 will be refunded. The penalty duty was imposed on April 7, 1977, to offset the Spanish Government's indirect aid to its zinc industry.

WORLD REVIEW

World consumption of zinc in 1981 continued to reflect weakness in the world economy. Zinc usage was especially affected by the general world slowdown in construction activity and the low level of automobile production. According to the World Bureau of Metal Statistics (WBMS),[2] slab zinc consumption in the market economy countries was about 4.24 million tons in 1981 compared with 4.38 million tons in 1980. Consumption on a regional basis was about the same in all areas except in Western Europe where consumption was down by 123,700 tons from that of 1980. Of the major consuming countries, Belgium, Brazil, France, the Federal Republic of Germany, Italy, and Japan used less slab zinc in 1981, and Canada, Mexico, Spain, the United Kingdom, and the United States used more. WBMS reported that commercial slab zinc stocks fell during the first half of the year but increased significantly in the second half of the year, ending the year at about 856,000 tons or 19% more than at the end of 1980. Producer stocks worldwide increased 10% during 1981 to 544,000 tons by yearend; consumer stocks were 163,000 tons, up 2,000 tons from that of 1980; and merchant stocks were 75,000 tons, up from 40,000 tons 1 year earlier. London Metal Exchange stocks decreased about 12,000 tons, ending 1981 at 74,000 tons. The United States, Canada, and the Organization for Economic Cooperation and Development (OECD) countries, excluding the Federal Republic of Germany, had large stock increases. Japanese producer stocks declined and the Japanese Government released 26,000 tons of zinc from its stockpile in 1981.

World mine output, according to the Bureau of Mines, rose marginally in 1981, despite mine closures, production cutbacks late in the year, and strikes. The potential reduction in output was compensated for by new mines coming onstream or higher production levels at certain mines. Of the major producers, mine production increased in Australia, Canada, Japan, Peru, and Sweden, and decreased in Ireland, Mexico, Poland, and the United States. Ireland's production was especially affected by a strike in the last half of 1981 that cut the country's output by about 50% for the year. Polish zinc production was affected mainly by decreasing ore grades and political problems.

Primary smelter production also rose slightly with decreases in production in Japan, Poland, Italy, and Mexico being offset by increases in Canada, the United States, Peru, Spain, the Netherlands, France, and Brazil. The availability of zinc concentrates tightened in 1981, and custom smelters experienced supply problems and higher than normal costs for concentrates. Some European smelters were particularly affected by the strike at the Tara Mine in Ireland because concentrate from the mine was a principal source for their smelter feed. A new smelter came onstream in Peru, and one smelter in the United States and one in Belgium closed down for economic reasons. Japanese smelter production continued to fall owing to reduced automobile production and to a general decrease in exports.

After a 3-year investigation, the European Commission on Competition of the European Economic Community (EEC) reached a preliminary finding that a group of European zinc producers have conspired to fix zinc production, prices, and markets. An EEC decision on whether to impose penalties was pending.

Australia.—Mine production increased marginally from that of 1980, despite reduced production at several major mines early in the year owing mainly to labor problems.

Aberfoyle Ltd., 49% owned by Cominco Ltd., officially opened its Que River zinc-silver-lead mine in Tasmania in February. Que River ores were processed at the Rosebery mill of EZ Industries Ltd. (EZI); however, because of construction delays in expanding the mill's capacity, ore deliveries from the Que River Mine did not reach the scheduled rate of 200,000 tons per year until late in the year. The Que River deposit has 2.5 million tons of ore reserves grading 13.3% zinc, 7.7% lead, 6 ounces of silver per ton, and some gold. An additional 2.7 million tons of inferred ore of lesser grade also has been identified.

MIM Holdings Ltd. (40%) and Western Selcast Ltd. (60%) began production at their Teutonic Bore copper-zinc-silver mine in Western Australia in February and shipped the first zinc concentrate at midyear to its marketing agent, Mount Isa International Pty. Ltd. An estimated 25,500 tons of 53% zinc concentrate was produced from milling 145,000 tons of ore in fiscal year 1981. Annual zinc output is expected to be about 27,000 tons per year. Recoverable ore reserves at Teutonic Bore were 1.4 million tons grading 4.1% copper, 11.1% zinc, and 4.7 ounces of silver per ton.

Construction of EZI's Elura Mine and mill proceeded on schedule with production to start in late 1982. Design capacity is 130,000 tons per year of zinc concentrate and 100,000 tons per year of silver-lead concentrate from 1.1 million tons of ore. Reserves were 27 million tons grading 8.3% zinc, 5.6% lead, and 4.5 ounces of silver per ton.

MIM continued its Mount Isa expansion program to increase output of lead, zinc, and silver by 20%. In 1981, the mill modernization and much of the mine development work was completed. The program was scheduled for completion in mid-1982 at an estimated cost of $60 million. MIM produced 193,800 tons of zinc concentrate in 1981, down from 201,400 tons produced in 1980.

AM&S's production of zinc in 1981 decreased slightly to about 235,000 tons owing to lower output at its Broken Hill operation. Zinc production increased at AM&S's Cobar Mine because higher lead grades offset reduced mill throughput and at its Woodlawn Mine because high milling rates and improved zinc recovery offset milling of lower grade ores.

Australian slab zinc production decreased in 1981 despite the near capacity operation of the Cockle Creek and Port Pirie zinc plants. EZI's Risdon smelter was affected early in the year by strikes at Broken Hill mines. EZI was increasing the capacity of the Risdon zinc plant by 4,000 to 214,000 tons per year. The expansion was scheduled for completion in 1982. AM&S was planning the construction of a 75,000-ton-capacity electrolytic zinc refinery adjacent to its Cockle Creek zinc smelter. Employment of the new pressure leach technology of Sherritt Gordon Mines Ltd. was under consideration for the new refinery.

Belgium.—The Société de Prayon S.A. closed its 70,000-ton-per-year electrolytic zinc plant at Ehein in May reportedly because of financial difficulties. Metallurgie Hoboken-Overpelt S.A. commissioned a new plant at its Overpelt zinc refinery capable of producing 25,000 tons of zinc oxide annually from zinc- and copper-bearing scrap extracted from car hulks. The new plant employs proprietary technology developed by Huron Valley.

Canada.—Canada continued to lead the world in zinc mine production accounting for about one-fifth of world production in 1981. Production in 1981 was up 23% compared with that of 1980 when output was down because of strikes and production problems at some of the major producers. Principal producers were Noranda, Cominco, and Kidd Creek Mines Ltd., formerly Texasgulf Metals Co. Late in 1981, Texasgulf Metals, the Canadian assets of Texasgulf Inc., were sold to the Government's Canadian Development Corp. for $450 million. Several new zinc mines came onstream during the year and several were under development.

Cominco completed construction and development work at its Polaris Mine on Little Cornwallis Island. The Polaris Mine is the northernmost mine in the world. Ore was first fed to the mill on November 4. When fully in operation, expected in January 1982, the annual production of the mine, constructed at a cost of $135 million,[3] was planned to be 187,000 tons of zinc concentrate and 42,000 tons of lead concentrate. Ore reserves were 2.3 million tons grading 14.1% zinc and 4.3% lead.

In November, Les Mines Gallen Limitee, owned by Noranda (51%) and McDonald Mines Ltd. (49%), began production at its zinc-silver-gold open pit mining operation in northern Quebec. The ore was milled at Noranda's Horne facilities 10 miles away. The planned production rate of 1,360 tons of ore per day was expected to be reached in early March 1982. The mine, which has ore reserves of 1.6 million tons averaging 5.4% zinc, was developed for $4 million.

Cyprus Anvil Mining Corp. continued its long-term Vangorda Plateau development program in the Yukon. Modifications to the Anvil concentrator, completed at a cost of $59 million in 1981, were necessary to handle the ores from the Vangorda and Grum deposits that are planned for production in the next few years. Cyprus Anvil's Cirque deposit in British Columbia was being explored. The company reportedly has delineated 27 million tons of ore averaging 7.8% zinc, 2.2% lead, and 48 grams of silver per ton.

In New Brunswick, Brunswick Mining & Smelting Corp. Ltd. (BMS), controlled by Noranda, mined 3.4 million tons of ore compared with 1.85 million tons in 1980 when production was affected by a 4-month strike. Zinc output totaled about 235,600 tons or 21% of Canadian production in 1981. BMS completed expansion of its No. 12 Mine near Bathurst early in the year and increased ore production by 1,000 tons per day to about 9,100 tons per day. Proven and probable ore reserves at the end of 1981 were 100 million tons grading about 9.1% zinc, 3.7% lead, and 2.8 ounces of silver per ton.

BMS announced plans to build a $300 million zinc reduction plant at Belledune, New Brunswick, in cooperation with Heath Steele Mines Ltd., also a Noranda subsidiary. Construction on the 100,000-ton-per-year zinc plant was scheduled to start in May 1982 and be completed in late 1984.

Cominco's principal sources of zinc and lead concentrate for its Trail, British Columbia, integrated smelter and refining complex continued to be the Sullivan Mine at Kimberley, British Columbia, and the Pine Point Mine in the Northwest Territories. Ore production in 1981 was the highest since 1964 at the Sullivan Mine where zinc concentrate output improved 15% to 119,000 tons owing in part to improved ore grades. Ore reserves at the Sullivan Mine were 46 million tons grading 6% zinc and 4.5% lead at yearend. Zinc concentrate output at the Pine Point Mine declined 9% to 249,000 tons in 1981 because lower grade zinc ores were mined. Significantly higher strip ratios, longer hauling distance, and increased energy and labor costs caused a sharp rise in the cost of production. At yearend, ore reserves at the Pine Point Mine were 37 million tons grading 5.4% zinc and 1.9% lead.

Cominco continued modernization and expansion of its Trail zinc plant. The world's first zinc pressure leaching plant was under construction and was expected to be operational in 1982. It will add 24,000 tons per year to the plant's capacity. The new pressure leaching plant separates sulfur by hydrometallurgical means rather than by roasting, producing elemental sulfur instead of sulfur dioxide.

Canadian Electrolytic Zinc Ltd. was adding 8,000 tons to its current 218,000-ton annual zinc smelter capacity by 1984, and Kidd Creek was expanding its zinc facilities at Timmins, Ontario, by 17,000 tons by 1983.

Asarco's zinc production at its Buchans Mine in Newfoundland continued to drop because the ore reserves in developed areas were decreasing. Efforts were underway to develop new ore zones. Esso Resources Canada, Ltd., closed down the Gays River zinc mine in Nova Scotia in August because of problems with water seepage and low ore quality. The Yava Mine of Yava Mines Ltd. also closed reportedly because exploration results failed to confirm the ore tonnage needed to justify moving a mill to the mine site.

Germany, Federal Republic of.—Preussag AG Metall announced plans to cut the capacity of its 100,000-ton-per-year Harlingerode zinc refinery by 30% and convert it to a secondary plant in 1982.

Ireland.—Tara Mines Ltd. was struck by trade unions in early July. The strike was not resolved by yearend at which time the mine was placed on a care and maintenance basis. For the first 6 months of the year, Tara treated a total of 1.1 million tons of ore, producing about 205,000 tons of lead and zinc concentrate, about the same as in the comparable period in 1980. At yearend, ore reserves at Tara totaled 53.3 million tons grading 9.6% zinc and 2.7% lead.

In May, the Irish Planning Board rejected Bula Ltd.'s application for the development of an open pit mine near Navan because it would be too close to residential properties and pose pollution problems. Bula was planning to apply for permission to develop an underground mine, although about 40% of the ore body reportedly would be inaccessible if mined in this manner. Estimated ore reserves in the ore body were 20 million tons averaging about 6.7% zinc and 1.3% lead.

Plans to build a state-run zinc smelter at Ballylongford, County Kerry, were scrapped early in the year by the Irish Government because of low zinc prices and rising energy costs. Abandonment of the Government plan revived consideration of a long-pending U.S.S.R. offer to build a smelter in Ireland.

Mexico.—Mine and smelter production were both lower in 1981 owing mainly to strikes at three of the country's largest zinc-producing mines—the Santa Barbara and Santa Eulalia Mines owned by Industrial Minera México S.A. (IMM) and the San

Francisco Mine of Compañía Frisco, S.A. In March, Mexico Desarrollo Industrial Minero, S.A., the major shareholder in IMM, signed a $250 million loan agreement with a consortium of banks to finance the completion of several major expansion and construction projects. Mine capacity expansions were completed at the Velardena and Taxco Mines in 1981. Programs at the Santa Barbara Mine, scheduled to be completed in January 1982, will double mine output to about 5,000 tons per day. The new $175 million electrolytic zinc refinery, which IMM is building at San Luis Potosí, was expected to be onstream in 1982. The new refinery has a design capacity of 113,000 tons of zinc annually.

The $170 million Real de Angeles silver-lead-zinc mine—owned by Frisco, S.A. de C.V., 33%; Comisión de Fomento Minero, 33%; and Placer Development Ltd., 34%—was expected to come onstream in mid-1982. The mine was expected to be one of the world's largest silver mines. Production of ore by open pit methods was planned at a rate of 10,000 tons per day, resulting in an annual output of 7 million ounces of silver, 31,000 tons of lead, 26,000 tons of zinc, and 415 tons of cadmium. Ore reserves were estimated at 59 million tons averaging about 1.0% lead, 0.92% zinc, and 2.3 ounces of silver per ton.

Peru.—Refined zinc production in 1981 was almost double that produced in 1980 owing to completion of Empresa Minera del Perú's Cajamarquilla zinc refinery near Lima early in the year. The new 100,000-ton-per-year electrolytic refinery produced 49,553 tons of zinc metal in 1981.

Mine production increased in 1981 despite a number of strikes at mines during the year. Centromín Peru S.A. was the principal zinc producer with a production of about 180,500 tons of zinc in concentrate. Centromín's Cerro de Pasco Mine was the largest producing mine. The San Vicente Mine at San Ramon, operated by San Ignacio de Morococha S.A., was the largest producer in the private sector in 1981 with an output of zinc in concentrate of 35,925 tons. Morococha continued its expansion program at the mine to increase annual zinc production capacity from 39,000 to 52,000 tons. The capacity increase was expected to be onstream in 1982.

Extracciones y Tratamiento de Minerales, S.A. (EXTRAMIN), owned one-third by Cía. Minera Huaron, S.A., and two-thirds by the Société Minière et Metallurgique de Penarroya, planned to process 90,000 tons of ore per year produced by small miners in the Province of Recuay and the surrounding area. For this purpose, EXTRAMIN bought a 300-ton-per-day portable plant that will annually produce 10,000 tons of zinc-lead-copper-silver bulk concentrates. The plant was expected to be in operation in the first half of 1982.

Thailand.—Government officials from Thailand and Belgium signed accords in November guaranteeing the financing and construction of a $144 million, 60,000-ton-per-year zinc refinery in Tak Province. The refinery, expected to be completed in 1984, was projected to have a life of 11 years based on the 3.7 million tons of zinc ore reserves covered in the agreement.

TECHNOLOGY

Oxidation pressure leaching of zinc concentrates was expected to play a prominent role in future zinc plant design, replacing the roast-leach section that is currently standard in the industry. The one-pressure process step, developed by Sherritt Gordon Mines Ltd., was described.[4] The process reportedly eliminates the need for residue treatments and produces elemental sulfur, rather than sulfur dioxide; acid plants and smokestacks are not required, and air pollution and workplace hygiene are greatly improved.

A new process for leaching zinc sulfide concentrates with gaseous mixtures of sulfur dioxide and oxygen in aqueous solution was described.[5] The direct leaching of zinc concentrates by this approach was seen as one method of expanding the present Risdon, Australia, zinc plant without the need for additional roasting and acidmaking capacity.

The material, casting, and cost advantages and applications of gravity cast zinc alloys compared with competitive alloys was reviewed.[6]

The Bureau of Mines continued investigations to recover zinc and other metals from byproduct and waste materials. Zinc was successfully recovered from sludge generated from electroplating and metal finishing operations by a roast, leach-purification, electrowinning process.[7] The electrowon zinc, however, required more extensive purification procedures than in commercial operations because greater than normal amounts of impurities were extracted with the zinc. A hydrometallurgical method was developed to extract zinc and other metals from copper filter cake, a product produced during one of the process steps designed to remove impurities from zinc electrolyte in electrolytic zinc plants.[8] Greater than 97% of the zinc and other principal metals in the cake were selectively recovered by the process developed.

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, England.

Progress reports of the projects supported by the International Lead and Zinc Research Organization, Inc. (ILZRO), are released annually in the ILZRO Research Digest. A new galvanizing alloy developed by ILZRO reportedly exceeded the performance capabilities of conventional galvanizing in corrosion resistance, ductility, weldability, paintability, and other criteria.[9] The new alloy, which is called Galfan, short for galvanizing fantastique, is composed of 95% zinc and 5% aluminum with some mischmetal.

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[1]Physical scientist, Division of Nonferrous Metals.
[2]World Bureau of Metal Statistics (London). World Metal Statistics, v. 35, No. 5, May 1981, p. 17.
[3]Where necessary, values have been converted from Canadian dollars (C$) to U.S. dollars at the rate of C$1.199=US$1.00.
[4]Engineering and Mining Journal. Sherritt Commercializes Zinc Pressure Leaching. V. 182, No. 12, December 1981, pp. 76-79.
Parker, E. G. Oxidative Pressure Leaching of Zinc Concentrates. CIM Bull., v. 74, No. 829, May 1981, pp. 145-150.
[5]Adams, R. W., and I. G. Matthew. Leaching of Metal Sulfide Concentrates at Atmospheric Pressure Using SO_2/O_2 Mixtures. Proc. Australas. Inst. Min. Metal., No. 280, December 1981, pp. 41-53.
[6]Apelian, D., M. Paliwal, and D. C. Herrschaft. Casting With Zinc Alloys. J. Met., v. 33, No. 11, November 1981, pp. 12-19.
[7]Stephenson, J. B., E. R. Cole, and D. L. Paulson. Recovery of Zinc From Wastewater Treatment Sludge. Resource Recovery and Conservation, v. 6, No. 3-4, November 1981, pp. 203-210.
[8]Hebble, T. L., V. R. Miller, and D. L. Paulson. Recovery of Principal Metal Values From Electrolytic Zinc Waste. BuMines RI 8582, 1981, 12 pp.
[9]American Metal Market. Galvanizing Alloy Tests Called Successful by ILZRO. V. 89, No. 159, July 31, 1981, p. 8.

Table 3.—Mine production of recoverable zinc in the United States, by month

(Metric tons)

Month	1980[r]	1981
January	28,674	25,476
February	26,815	25,663
March	28,582	28,503
April	27,221	26,343
May	25,877	25,602
June	27,419	23,883
July	24,913	24,174
August	25,504	25,218
September	24,386	28,937
October	28,558	28,698
November	24,327	25,972
December	24,827	23,949
Total	317,103	312,418

[r]Revised.

Table 4.—Mine production of recoverable zinc in the United States, by State

(Metric tons)

State	1977	1978	1979	1980	1981
Arizona	3,973	W	W	W	138
California	2	W	W	--	W
Colorado	36,530	22,208	9,910	13,823	W
Idaho	28,121	32,353	29,660	27,722	W
Kentucky	--	52	--	--	W
Maine	6,594		--	--	--
Missouri	74,107	59,038	61,682	[r]62,886	52,904
Montana	72	79	104	71	25
Nevada	1,517	1,371	W	2	W
New Jersey	30,358	28,915	31,118	28,859	16,198
New York	64,264	26,463	12,133	33,629	36,889
Pennsylvania	20,706	19,099	21,447	22,556	24,732
Tennessee	82,044	87,906	85,119	[r]111,754	117,684
Utah	16,111	3,509	W	[r]W	1,576
Virginia	12,040	10,974	11,406	12,038	9,731
Washington	5,055	W	--	--	--
Other	26,395	10,703	4,762	[r]3,763	52,541
Total	407,889	[1]302,669	267,341	[r]317,103	312,418

[r]Revised. W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Data do not add to total shown because of independent rounding.

Table 5.—Production of zinc and lead in the United States in 1981, 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
1980: Total	[r]5,861,248	[r]205,142	2,439	9,144,127	[r]62,886	497,928	1,052,771	26,097	33,329
1981:									
Arizona	--	--	--	([1])	([1])	([1])	--	--	--
Colorado	--	--	--	--	--	--	([1])	W	([1])
Idaho	([1])	W	([1])	([1])	W	([1])	845,579	W	26,821
Missouri	--	--	--	7,729,301	52,904	389,721	--	--	--
Montana	--	--	--	549	4	21	--	--	--
New Jersey	89,037	16,198	--	--	--	--	--	--	--
New York	509,799	36,889	968	--	--	--	--	--	--
Pennsylvania	491,543	24,732	--	--	--	--	--	--	--
Tennessee	4,511,557	115,369	--	--	--	--	--	--	--
Utah	--	--	--	--	--	--	33,160	1,575	1,660
Virginia	398,291	9,731	1,607	--	--	--	--	--	--
Other[2]	11,431	149	--	7	--	4	11	43,260	3
Total	6,011,658	203,068	2,575	7,729,857	52,908	389,746	878,750	44,835	28,484
Percent of total recoverable zinc and lead	XX	65	1	XX	17	87	XX	14	6

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[3]: Gross weight (dry basis)	All other sources[3]: Zinc	All other sources[3]: Lead	Total: Gross weight (dry basis)	Total: Zinc	Total: Lead
1980: Total	1,901,533	3,694	([1])	[r]38,752,055	[r]19,284	[r]16,670	[r]56,711,734	[r]317,103	[r]550,366
1981:									
Arizona	--	--	--	[1]64,180,556	[1]138	[1]993	64,180,556	138	993
Colorado	--	--	--	[1]826,211	W	[1]11,431	826,211	W	11,431
Idaho	--	--	--	[1]869,640	W	[1]11,576	1,715,219	W	38,397
Missouri	--	--	--	--	--	--	7,729,301	52,904	389,721
Montana	--	--	--	559,064	21	173	559,613	25	194
New Jersey	--	--	--	--	--	--	89,037	16,198	--
New York	--	--	--	--	--	--	509,799	36,889	968
Pennsylvania	--	--	--	--	--	--	491,543	24,732	--
Tennessee	1,783,605	2,315	--	--	--	--	6,295,162	117,684	--
Utah	--	--	--	4,082	1	2	37,242	1,576	1,662
Virginia	--	--	--	--	--	--	398,291	9,731	1,607
Other[2]	--	--	--	2,398,598	9,132	555	2,410,047	52,541	562
Total	1,783,605	2,315	--	68,838,151	9,292	24,730	85,242,021	312,418	445,535
Percent of total recoverable zinc and lead	XX	1	--	XX	3	6	XX	100	100

[r]Revised. W Withheld to avoid disclosing company proprietary data; included with "Other." XX Not applicable.
[1]Zinc ore, lead ore, zinc-lead ore, copper-lead ore, and ore from "All other sources" combined to avoid disclosing company proprietary data.
[2]Includes Alaska, California, Illinois, Kentucky, Nevada, New Mexico, and Oregon. Zinc and lead recovered from tailings not distinguishable as to State origin.
[3]Zinc and lead recovered from copper, gold, silver, and fluorspar ores, and from mill tailings and miscellaneous cleanups.

Table 6.—Twenty-five leading zinc-producing mines in the United States in 1981 in order of output

Rank	Mine	County and State	Operator	Source of zinc
1	Balmat	St. Lawrence, N.Y.	St. Joe Minerals Corp	Zinc ore.
2	Freidensville	Lehigh, Pa	The New Jersey Zinc Co	Do.
3	Elmwood	Smith, Tenn	do	Do.
4	Young	Jefferson, Tenn	ASARCO Incorporated	Do.
5	Buick	Iron, Mo	AMAX Lead Co. of Missouri	Lead ore.
6	Zinc Mine Works	Jefferson, Tenn	United States Steel Corp	Zinc ore.
7	Bunker Hill	Shoshone, Idaho	The Bunker Hill Co	Lead-zinc ore.
8	New Market	Jefferson, Tenn	ASARCO Incorporated	Zinc ore.
9	Sterling	Sussex, N.J	The New Jersey Zinc Co., Inc.	Do.
10	Immel	Knox, Tenn	ASARCO Incorporated	Do.
11	Star Unit Area	Shoshone, Idaho	Hecla Mining Co	Lead-zinc ore.
12	Jefferson City and Beaver Creek.	Jefferson, Tenn	The New Jersey Zinc Co	Zinc ore.
13	Leadville	Lake, Colo	ASARCO Incorporated	Lead-zinc ore.
14	Milliken	Reynolds, Mo	Ozark Lead Co	Lead ore.
15	Austinville and Ivanhoe	Wythe, Va	The New Jersey Zinc Co	Zinc ore.
16	Magmont	Iron, Mo	Cominco American, Inc	Lead ore.
17	Coy	Jefferson, Tenn	ASARCO Incorporated	Zinc ore.
18	Idol	Grainger, Tenn	The New Jersey Zinc Co	Do.
19	Fletcher	Reynolds, Mo	St. Joe Minerals Corp	Lead ore.
20	Brushy Creek	do	do	Do.
21	Viburnum No. 29	Washington, Mo	do	Do.
22	Viburnum No. 28	Iron, Mo	do	Do.
23	Sunnyside	San Juan, Colo	Standard Metals Co	Gold ore.
24	Copperhill Plant	Polk, Tenn	Cities Service Co	Copper-zinc ore.
25	Iverness	Hardin, Ill	Iverness Mining Co	Fluorspar ore.

Cave-in-Rock Inverness

Table 7.—Primary and redistilled secondary slab zinc produced in the United States

(Metric tons)

	1977	1978	1979	1980	1981
Primary:					
From domestic ores	322,208	267,350	255,344	231,850	256,934
From foreign ores	86,156	139,348	217,137	108,606	86,728
Total	408,364	406,698	472,481	340,456	343,662
Redistilled secondary:					
At primary smelters	26,448	24,085	40,343	13,113	13,568
At secondary smelters	19,465	10,689	12,868	16,283	35,754
Total	[r]45,913	34,774	[1]53,212	29,396	49,322
Grand total (excludes zinc recovered by remelting)	[1]454,278	441,472	525,693	369,852	392,984

[r]Revised.
[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	1977	1978	1979	1980	1981
Special High	151,214	179,812	173,082	148,384	133,439
High	38,494	32,830	39,247	24,552	51,990
Continuous Galvanizing	--	41,250	62,683	45,275	55,008
Controlled Lead	--	25,422	40,319	18,650	38,660
Prime Western	256,238	162,158	210,362	132,991	113,887
Intermediate	8,332	--	--	--	--
Total	454,278	441,472	525,693	369,852	392,984

Table 9.—Annual slab zinc capacity of primary zinc plants in the United States, by type of plant

Type of plant	Plant location	Slab zinc capacity (metric tons) 1980	1981
Electrolytic:			
AMAX Zinc Co., Inc	Sauget, Ill	76,000	76,000
ASARCO Incorporated	Corpus Christi, Tex	98,000	104,000
The Bunker Hill Co	Kellogg, Idaho	103,000	(1)
Jersey Miniere Zinc Co	Clarksville, Tenn	82,000	82,000
National Zinc Co	Bartlesville, Okla	51,000	51,000
Vertical-retort:			
The New Jersey Zinc Co	Palmerton, Pa	109,000	(2)
St. Joe Zinc Co	Monaca, Pa	50,000	68,000

[1]Zinc plant closed in December 1981.
[2]Slab production discontinued; plant produces zinc oxides, dusts, and powders.

Table 10.—Secondary slab zinc plant capacity in the United States

(Metric tons)

Company	Plant location	Capacity 1980	1981
Arco Alloys Corp	Detroit, Mich		
Belmont Smelting & Refining Works	Brooklyn, N.Y		
W. J. Bullock, Inc	Fairfield, Ala		
T. L. Diamond & Co., Inc	Spelter, W. Va		
Huron Valley Steel Corp	Belleville, Mich		
Illinois Smelting & Refining Co	Chicago, Ill		
Interamerican Zinc Co	Adrian, Mich	46,000	90,000
New England Smelting Works, Inc	West Springfield, Mass		
The New Jersey Zinc Co	Depue, Ill		
Prolerized Schiabo Neu Co	Jersey City, N.J		
Do	Los Angeles, Calif		
Pacific Smelting Co	Torrance, Calif		
S-G Metals Industries Inc	Kansas City, Kans		

Table 11.—Stocks and consumption of new and old zinc scrap in the United States in 1981, by class of consumer and type of scrap

(Metric tons, zinc content)

Class of consumer and type of scrap	Stocks, Jan. 1	Receipts	Consumption: New scrap	Old scrap	Total	Stocks, Dec. 31
Smelters and distillers:						
New clippings	42	460	487	--	487	15
Old zinc	582	8,801	--	8,649	8,649	734
Remelt zinc	217	96	--	307	307	6
Engravers' plates	54	574	--	571	571	57
Rod and die scrap	2,166	4,396	--	5,512	5,512	1,050
Diecastings	1,179	11,967	--	11,741	11,741	1,405
Fragmentized diecastings	1,156	20,528	--	19,236	19,236	2,448
Remelt die-cast slab	2,047	16,487	--	17,823	17,823	711
Skimmings and ashes	17,185	26,352	28,574	--	28,574	14,963
Sal skimmings	148	296	416	--	416	28
Die-cast skimmings	3,709	5,001	6,531	--	6,531	2,179
Galvanizers' dross	10,931	46,649	51,312	--	51,312	6,268
Flue dust	3,209	3,270	3,325	--	3,325	3,154
Chemical residues	295	2,304	2,304	--	2,304	295
Other	9	1,505	1,450	--	1,450	64
Total	42,929	148,686	94,399	63,839	158,238	33,377
Chemical plant, foundries, and other manufacturers:						
Old zinc	10	23	--	23	23	10
Rod and die scrap	10	131	--	131	131	10
Diecastings	18	268	--	268	268	18
Skimmings and ashes	2,580	4,510	5,279	--	5,279	1,811
Sal skimmings	1,720	4,278	4,020	--	4,020	1,978
Die-cast skimmings	161	264	264	--	264	161
Galvanizers' dross	2	8,861	6,749	--	6,749	2,114

Table 11.—Stocks and consumption of new and old zinc scrap in the United States in 1981, 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
Chemical plant, foundries, and other manufacturers —Continued						
Flue dust	756	12,641	12,641	--	12,641	756
Chemical residues	3,835	7,727	7,796	--	7,796	3,766
Other	821	7,674	7,674	--	7,674	821
Total	9,913	46,377	44,423	422	44,845	11,445
All classes of consumers:						
New clippings	42	460	487	--	487	15
Old zinc	592	8,824	--	8,672	8,672	744
Remelt zinc	217	96	--	307	307	6
Engravers' plates	54	574	--	571	571	57
Rod and die scrap	2,176	4,527	--	5,643	5,643	1,060
Diecastings	1,197	12,235	--	12,009	12,009	1,423
Fragmentized diecastings	1,156	20,528	--	19,236	19,236	2,448
Remelt die-cast slab	2,047	16,487	--	17,823	17,823	711
Skimmings and ashes	19,765	30,862	33,853	--	33,853	16,774
Sal skimmings	1,868	4,574	4,436	--	4,436	2,006
Die-cast skimmings	3,870	5,265	6,795	--	6,795	2,340
Galvanizers' dross	10,933	55,510	58,061	--	58,061	8,382
Flue dust	3,965	15,911	15,966	--	15,966	3,910
Chemical residues	4,130	10,031	10,100	--	10,100	4,061
Other	830	9,179	9,124	--	9,124	885
Total	52,842	195,063	138,822	64,261	203,083	44,822

Table 12.—Production of zinc products from zinc-base scrap in the United States

(Metric tons)

Product	1977	1978	1979	1980	1981
Redistilled slab zinc	45,913	34,774	53,212	29,396	49,322
Zinc dust	35,992	33,346	34,141	35,557	39,626
Remelt zinc	268	94	89	229	195
Remelt die-cast slab	3,535	3,775	3,911	3,568	6,722
Zinc-die and diecasting alloys	7,560	6,024	6,328	4,146	6,902
Galvanizing stocks	2,088	2,686	2,731	2,461	2,612
Secondary zinc in chemical products	55,312	58,650	59,148	55,890	62,557

Table 13.—Zinc recovered from scrap processed in the United States, by kind of scrap and form of recovery

(Metric tons)

	1980	1981
KIND OF SCRAP		
New scrap:		
Zinc-base	122,654	138,515
Copper-base	115,909	116,681
Magnesium-base	268	143
Total	238,831	255,339
Old scrap:		
Zinc-base	42,424	62,891
Copper-base	22,300	22,014
Aluminum-base	591	376
Magnesium-base	217	230
Total	65,532	85,511
Grand total	304,363	340,850
FORM OF RECOVERY		
As metal:		
By distillation:		
Slab zinc[1]	29,396	49,322

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)

	1980	1981
FORM OF RECOVERY —Continued		
As metal —Continued		
By distillation —Continued		
Zinc dust	35,557	39,626
By remelting	2,690	2,807
Total	67,643	91,755
In zinc-base alloys	7,714	13,624
In brass and bronze	172,040	172,165
In aluminum-base alloys	591	376
In magnesium-base alloys	485	373
In chemical products:		
Zinc oxide (lead free)	31,306	36,236
Zinc sulfate	13,195	14,313
Zinc chloride	10,944	11,572
Miscellaneous	445	436
Total	236,720	249,095
Grand total	304,363	340,850

[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
1977	43,177	$45,414	$0.477
1978	38,487	37,427	.441
1979	36,186	36,075	.452
1980	42,640	41,202	.438
1981	43,734	53,871	.554

Table 15.—Consumption of zinc in the United States

(Metric tons)

	1977	1978	1979	1980	1981
Slab zinc	999,505	1,050,585	1,000,606	811,146	834,199
Ores and concentrates (zinc content)[1]	86,490	89,959	79,710	58,986	60,643
Secondary (zinc content)[2]	281,709	301,266	313,998	272,277	288,721
Total	1,367,704	1,441,810	1,394,314	1,142,409	1,183,563

[1]Includes ore used directly in galvanizing.
[2]Excludes redistilled slab and remelt zinc.

Table 16.—Slab zinc consumption in the United States, by industry and product

(Metric tons)

Industry and product	1977	1978	1979	1980	1981
Galvanizing:					
Sheet and strip	236,025	268,687	267,825	220,744	248,006
Wire and wire rope	21,459	22,801	23,557	22,748	22,119
Tubes and pipe	42,657	47,379	45,643	37,075	39,418
Fittings (for tubes and pipe)	5,820	6,926	8,231	7,394	6,369
Tanks and containers	3,057	2,896	4,081	3,297	5,781
Structural shapes	26,623	33,264	33,875	33,376	33,667
Fasteners	3,891	4,839	4,993	3,189	3,693
Pole-line hardware	4,475	4,869	4,839	4,078	3,788
Fencing, wire cloth, netting	20,371	24,997	21,920	16,022	17,722
Other and unspecified uses	32,060	37,356	37,839	31,304	30,484
Total	396,438	454,014	452,803	379,227	411,047
Brass products:					
Sheet, strip, plate	70,168	70,181	64,222	37,730	42,006
Rod and wire	39,525	46,284	51,130	32,554	36,639
Tube	5,542	6,779	6,690	4,702	6,440
Castings and billets	4,076	4,427	3,634	2,808	2,880
Copper-base ingots	7,544	6,581	6,800	17,190	20,167
Other copper-base products	1,455	7,236	8,928	3,842	4,854
Total	128,310	141,488	141,404	98,826	112,986
Zinc-base alloys:					
Diecasting alloys	359,744	345,968	308,722	248,024	234,957
Dies and rod alloys	557	544	68	--	--
Slush and sand-casting alloys	6,829	7,622	5,266	6,203	8,408
Total	367,130	354,134	314,056	254,227	243,365
Rolled zinc	27,406	24,869	22,044	21,100	[1]23,156
Zinc oxide	38,514	37,202	35,513	27,047	18,981
Other uses:					
Light-metal alloys	5,585	11,030	12,850	11,137	8,183
Miscellaneous[2]	36,122	27,848	21,936	19,582	16,481
Total	41,707	38,878	34,786	30,719	24,664
Grand total	999,505	1,050,585	1,000,606	811,146	834,199

[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.—Slab zinc consumption in the United States in 1981, by industry

(Metric tons)

Industry	Special High Grade	High Grade	Continuous Galvanizing Grade	Controlled Lead Grade	Prime Western	Remelt	Total
Galvanizing	26,168	39,336	18,171	65,392	261,139	841	411,047
Brass and bronze	43,564	56,367	29	2,407	10,235	384	112,986
Zinc-base alloys	242,579	612	--	--	174	--	243,365
Rolled zinc	10,618	--	--	12,538	--	--	23,156
Zinc oxide	17,996	--	--	--	985	--	18,981
Other	20,555	1,327	--	--	2,782	--	24,664
Total	361,480	97,642	18,200	80,337	275,315	1,225	834,199

Table 18.—Slab zinc consumption in the United States in 1981, by State

(Metric tons)

State	Galva-nizers	Brass mills[1]	Die-casters[2]	Other[3]	Total
Alabama	27,390	W	--	W	29,960
Arizona	--	--	--	W	W
Arkansas	W	--	--	--	W
California	28,149	3,044	7,956	1,053	40,202
Colorado	W	--	W	W	W
Connecticut	2,028	16,297	W	W	24,663
Delaware	W	W	--	W	W
Florida	4,004	--	--	--	4,004
Georgia	W	--	W	--	W
Hawaii	W	--	--	--	W
Idaho	--	--	W	W	W
Illinois	55,580	21,738	42,176	8,659	128,153
Indiana	54,352	W	3,439	W	72,261
Iowa	63	--	W	W	1,878
Kansas	--	W	W	W	W
Kentucky	W	--	--	--	W
Louisiana	2,821	--	W	W	3,916
Maine	W	--	--	--	W
Maryland	W	--	--	W	15,604
Massachusetts	W	W	--	W	4,525
Michigan	1,070	13,926	42,323	329	57,648
Minnesota	590	--	--	--	590
Mississippi	1,012	--	--	--	1,012
Missouri	5,653	W	W	W	7,229
Nebraska	6,592	W	--	W	7,147
New Jersey	2,034	5,601	W	W	13,530
New York	15,181	W	56,584	W	92,051
North Carolina	W	--	W	W	W
Ohio	58,158	W	35,756	W	102,727
Oklahoma	W	--	--	W	4,157
Oregon	1,227	W	--	W	1,234
Pennsylvania	48,481	6,149	W	W	89,508
Rhode Island	W	W	W	W	W
South Carolina	W	--	--	--	W
Tennessee	W	--	W	W	W
Texas	16,584	W	W	W	29,112
Utah	W	W	--	--	W
Virginia	W	W	W	W	585
Washington	W	--	--	W	1,578
West Virginia	W	--	--	W	23,473
Wisconsin	739	W	4,584	W	6,941
Undistributed	78,498	45,847	50,547	56,760	69,286
Total[4]	410,206	112,602	243,365	66,801	832,974

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

	1980			1981		
		Value			Value	
	Metric tons	Total (thousands)	Average per pound	Metric tons	Total (thousands)	Average per pound
Production:[1]						
Photoengraving plate	W	W	W	W	W	W
Strip and foil	16,453	$20,511	$0.660	W	W	W
Total rolled zinc[2]	20,545	27,415	.605	22,414	$32,738	$0.663
Exports	2,103	3,810	.821	1,500	3,226	.976
Imports	1,341	1,041	.352	332	472	.645
Available for consumption	20,614	XX	XX	19,355	XX	XX

W Withheld to avoid disclosing company proprietary data; included with "Total rolled zinc." XX Not applicable.
[1]Figures represent net production. In addition, 19,421 tons in 1980 and 19,892 tons in 1981 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. Bureau of Mines not at liberty to publish separately.

Table 20.—Production and shipments of zinc pigments and compounds[1] in the United States

(Metric tons)

	1980		1981	
	Production	Shipments	Production	Shipments
Zinc oxide	145,509	135,776	145,304	148,951
Zinc sulfate	35,159	35,696	38,682	37,879
Zinc chloride, 50° Baumé[2]	24,632	18,400	26,678	19,597

[1]Excludes leaded zinc oxide and lithopone.
[2]Includes zinc content of zinc ammonium chloride and chromated zinc chloride.

Table 21.—Zinc content of zinc pigments[1] and compounds produced by domestic manufacturers

(Metric tons)

	1980				1981			
	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	54,081	28,161	31,306	113,548	54,569	25,657	36,236	116,462
Zinc sulfate	1,045	--	13,195	14,240	1,353	--	14,313	15,666
Zinc chloride[2]	--	--	5,666	5,666	--	--	6,043	6,043

[1]Excludes leaded zinc oxide, zinc-sulfide, and lithopone.
[2]Includes zinc content of zinc ammonium chloride and chromated zinc chloride.

Table 22.—Distribution of zinc oxide shipments, by industry

(Metric tons)

Industry	1977	1978	1979	1980	1981
Rubber	101,729	97,989	93,075	61,796	69,364
Paints	12,519	13,237	12,503	12,165	12,346
Ceramics	7,354	9,245	9,236	5,702	7,822
Chemicals	26,327	27,057	27,710	17,551	20,561
Agriculture	5,499	4,847	4,397	6,930	7,328
Photocopying	21,352	19,096	16,148	9,604	10,308
Other	15,322	9,981	16,700	22,028	21,222
Total	190,102	181,452	179,769	135,776	148,951

Table 23.—Distribution of zinc sulfate shipments

(Metric tons)

Year	Agriculture	Other	Total
1978	12,778	9,045	21,823
1979	18,512	7,363	25,875
1980	27,768	7,928	35,696
1981	30,928	6,951	37,879

Table 24.—Stocks of slab zinc in the United States, December 31

(Metric tons)

	1977	1978	1979	1980	1981
Primary producers	76,637	34,570	56,971	18,190	41,124
Secondary producers	7,123	3,358	2,095	4,362	3,540
Consumers	86,477	99,325	92,595	69,599	81,917
Merchants	NA	NA	[1]NA	33,650	68,773
Total	170,237	137,253	151,661	125,801	195,354

NA Not available.
[1]Stocks on Jan. 1, 1980, were 63,637 tons, which can be considered identical to stocks at yearend 1979.

Table 25.—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
1980	25,459	7,541	934	3,098	32,504	63	69,599
1981	32,467	9,423	2,153	3,805	33,957	112	81,917

Table 26.—Average monthly U.S., LME,[1] and European producer prices for Prime Western zinc and equivalent

(Metallic zinc, cents per pound)

Month	1980			1981		
	United States	LME cash	European producer	United States	LME cash	European producer
January	37.44	35.03	35.38	41.19	35.22	37.42
February	37.50	39.39	36.35	41.25	33.11	37.42
March	38.00	33.64	37.42	41.30	34.33	37.42
April	38.01	32.04	36.35	42.56	37.31	38.19
May	37.50	31.31	35.38	45.20	38.56	40.14
June	36.44	30.71	35.38	46.12	38.06	41.96
July	35.50	32.32	35.38	46.25	39.21	41.96
August	35.73	34.83	35.38	47.47	43.28	41.96
September	[2]36.63	36.07	35.38	48.72	42.57	45.36
October	[2]37.27	36.49	36.31	45.87	40.41	45.36
November	[2]38.58	36.33	37.43	46.15	39.74	45.36
December	[2]40.59	35.50	37.43	42.59	38.31	43.09
Average	37.43	34.47	36.13	44.56	38.34	41.30

[1]London Metal Exchange.
[2]Based on High Grade zinc.

Source: Metals Week.

Table 27.—U.S. exports of zinc and zinc alloys, by country

Country	1979		1980		1981	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Unwrought zinc and zinc alloys:						
Argentina	42	$77	1	$1	--	--
Australia	5	25	1	6	1	$1
Bahrain	--	--	1	1	--	--
Belgium-Luxembourg	3	16	--	--	9	25
Canada	98	277	232	456	320	760
Chile	29	47	97	98	6	17
Colombia	2	4	--	--	4	7
Costa Rica	2	5	6	11	26	44
Dominican Republic	90	76	38	41	26	25
Ecuador	1	5	2	4	4	8
Egypt	27	56	20	61	14	26
Germany, Federal Republic of	14	23	1	4	1	1
Guatemala	1	3	63	112	1	6
Honduras	--	--	2	5	--	--
Israel	20	36	3	81	5	20
Italy	2	2	2	5	--	--
Japan	9	22	21	69	29	88
Korea, Republic of	([1])	5	--	--	16	50
Leeward and Windward Islands	--	--	13	33	15	100
Liberia	2	5	--	--	--	--
Mexico	98	242	73	544	21	193
Netherlands	19	25	20	45	--	--
Netherlands Antilles	--	2	--	--	--	--
New Zealand	([1])	2	1	2	1	7
Nicaragua	--	--	1	2	1	2
Nigeria	2	3	4	11	10	13
Panama	7	13	4	9	25	64
Philippines	7	9	9	10	2	3
Saudi Arabia	60	100	4	14	28	120

See footnotes at end of table.

Table 27.—U.S. exports of zinc and zinc alloys, by country —Continued

Country	1979 Quantity (metric tons)	1979 Value (thousands)	1980 Quantity (metric tons)	1980 Value (thousands)	1981 Quantity (metric tons)	1981 Value (thousands)
Unwrought zinc and zinc alloys —Continued						
Singapore	--	--	64	$119	1	$3
South Africa, Republic of	31	$47	1	2	30	51
Spain	(1)	3	9	20	12	22
Switzerland	3	7	--	--	3	7
Taiwan	11	41	45	57	7	18
United Arab Emirates	3	4	--	--	5	9
United Kingdom	9	115	27	92	57	275
Venezuela	31	43	1	3	14	28
Yugoslavia	--	--	9	21	--	--
Other	17	45	12	37	7	77
Total	645	1,385	787	1,976	701	2,070
Wrought zinc and zinc alloys:						
Algeria	--	--	25	47	2	8
Argentina	86	142	67	125	74	145
Australia	9	12	15	37	32	69
Austria	19	46	--	--	9	26
Belgium-Luxembourg	110	64	11	20	1	6
Bermuda	--	--	(1)	1	1	1
Canada	897	1,601	631	994	909	1,503
Chile	13	18	15	27	13	24
Colombia	33	55	56	125	75	137
Denmark	3	6	6	14	4	12
Dominican Republic	70	106	704	585	10	11
Ecuador	552	522	21	52	14	35
Egypt	22	33	20	32	2	5
El Salvador	--	--	3	5	4	11
Finland	--	--	4	11	1	3
France	9	19	72	200	9	20
Germany, Federal Republic of	--	--	1	8	4	34
Greece	8	12	--	--	--	--
Guatemala	5	9	9	18	10	26
Guyana	4	9	5	12	4	14
Hong Kong	33	49	38	65	69	80
India	28	45	24	48	60	124
Israel	54	90	42	76	27	50
Italy	90	173	92	241	45	99
Japan	18	38	--	--	28	65
Korea, Republic of	2	6	31	55	8	34
Kuwait	1	2	1	2	5	26
Lebanon	15	25	26	51	3	8
Malaysia	50	84	26	78	6	10
Mexico	164	376	144	301	393	786
Netherlands	--	--	(1)	2	6	11
New Zealand	18	28	10	16	9	18
Pakistan	14	24	14	27	19	38
Panama	3	7	1	2	7	11
Peru	62	136	22	40	50	109
Philippines	61	105	101	161	37	93
Portugal	38	67	35	67	3	7
Saudi Arabia	33	59	11	51	172	378
Singapore	38	31	51	59	24	48
South Africa, Republic of	100	170	77	137	116	197
Spain	69	115	71	126	23	46
Sri Lanka	38	65	22	42	22	44
Sweden	4	9	1	6	--	--
Switzerland	--	--	2	6	3	5
Syria	10	18	27	59	--	--
Taiwan	241	336	127	195	33	85
Thailand	12	17	13	25	--	--
Turkey	7	12	14	26	12	26
United Arab Emirates	--	--	4	8	2	7
United Kingdom	79	187	125	596	128	314
Uruguay	27	49	6	10	8	13
Venezuela	49	80	21	49	21	61
Other	87	167	63	138	143	315
Total	3,285	5,224	2,907	5,078	2,660	5,198

[1]Less than 1/2 unit.

Table 28.—U.S. exports of zinc

Year	Ores and concentrates		Blocks, pigs, anodes, etc.: Unwrought		Blocks, pigs, anodes, etc.: Unwrought alloys		Wrought zinc and zinc alloys: Sheets, plates, strip		Wrought zinc and zinc alloys: Angles, bars, pipes, rods, etc.		Waste and scrap (zinc content)		Dust (blue powder)	
	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)
1979	20,095	$7,317	279	$553	366	$832	1,824	$3,385	1,461	$1,839	28,149	$14,142	966	$1,450
1980	54,457	29,473	302	664	485	1,312	2,103	3,810	804	1,268	29,542	14,121	4,512	7,491
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

Table 29.—U.S. exports of zinc ores and concentrates, by country

(Zinc content)

Country	1980		1981	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Algeria	3,469	$2,592	5,173	$4,156
Belgium-Luxembourg	13,512	8,463	10,868	4,079
Bulgaria	--	--	6,565	4,992
Canada	26,367	11,095	21,748	9,587
Dominican Republic	4	3	1	1
Ecuador	--	--	5	2
Finland	6,447	4,298	57	13
France	654	1,764	--	--
Germany, Federal Republic of	3,693	1,100	6,240	3,493
Italy	--	--	1,860	1,457
Korea, Republic of	--	--	1	1
Leeward and Windward Islands	--	--	82	36
Mexico	15	17	2	2
Netherlands	--	--	165	271
Philippines	--	--	10	6
Saudi Arabia	52	38	48	56
Singapore	3	1	--	--
Taiwan	241	102	6	5
United Kingdom	--	--	1,401	1,123
Total	54,457	29,473	54,232	29,280

Table 30.—U.S. general imports of zinc, by country

Country	1979		1980		1981	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
ORES AND CONCENTRATES (zinc content)						
Argentina	3	$3	--	--	--	--
Australia	708	94	1,473	$195	903	$201
Belgium	--	--	--	--	497	242
Bolivia	11,935	5,157	--	--	--	--
Canada	143,957	57,938	63,017	25,631	53,673	22,607
Chile	1,240	683	14	2	432	295
Colombia	16	2	--	--	6	1
Germany, Federal Republic of	7,802	4,101	2,422	1,271	8,687	5,301
Honduras	13,383	5,112	7,031	2,558	4,167	2,623
Mexico	16,207	5,007	15,790	4,053	20,045	10,969
Nicaragua	4	3	--	--	--	--
Peru	29,697	14,419	40,176	19,879	29,326	20,348
Total	224,952	92,519	129,923	53,589	117,736	62,587
BLOCKS, PIGS, OR SLABS[1]						
Algeria	5,317	4,250	6,005	4,497	721	579
Australia	33,721	25,634	24,798	18,046	25,830	22,043
Austria	--	--	629	556	--	--
Belgium-Luxembourg	11,228	8,153	2,310	2,336	14,018	12,151
Brazil	--	--	--	--	1,493	1,159
Canada	259,543	197,270	280,075	222,411	308,647	285,642
Chile	--	--	--	--	1,450	1,212
China	208	90	1,220	886	1,492	1,140
Finland	26,410	21,361	18,128	12,998	29,156	25,231
France	13,445	10,608	6,835	5,619	17,882	16,491
Germany, Federal Republic of	19,110	14,813	12,056	8,939	22,817	24,228
Ghana	--	--	--	--	65	20
Hong Kong	105	79	--	--	--	--
Italy	5,492	3,880	1,999	1,514	7,625	7,298
Japan	10,118	7,971	--	--	7,090	6,204
Korea, Republic of	2,300	1,721	1,400	1,047	1,500	1,240
Mexico	39,332	28,873	23,859	17,881	15,091	13,458
Namibia	--	--	--	--	994	836
Netherlands	3,180	2,314	6,508	5,183	20,216	17,579
Norway	--	--	--	--	10,801	9,200
Peru	7,394	5,488	3,951	2,798	43,339	37,836
Poland	100	75	--	--	600	573
Spain	66,738	43,703	10,727	7,592	28,671	23,545
Taiwan	104	16	--	--	--	--
Tanzania	1,200	848	1,028	731	--	--

See footnotes at end of table.

Table 30.—U.S. general imports of zinc, by country—Continued

Country	1979 Quantity (metric tons)	1979 Value (thousands)	1980 Quantity (metric tons)	1980 Value (thousands)	1981 Quantity (metric tons)	1981 Value (thousands)
BLOCKS, PIGS, OR SLABS[1] —Continued						
United Kingdom	2,383	$1,315	4,112	$3,142	13,280	$11,012
Yugoslavia	--	--	--	--	999	867
Zaire	14,880	11,812	--	--	28,540	22,778
Zambia	4,904	2,277	5,002	3,443	377	296
Total	527,212	392,551	410,642	319,619	602,694	542,618

[1]In addition, in 1981, 165 tons of zinc anodes were imported from Canada, Denmark, the Federal Republic of Germany, Japan, the Netherlands, Norway, Sweden, and Taiwan.

Table 31.—U.S. imports for consumption of zinc, by country

Country	1979 Quantity (metric tons)	1979 Value (thousands)	1980 Quantity (metric tons)	1980 Value (thousands)	1981 Quantity (metric tons)	1981 Value (thousands)
ORES AND CONCENTRATES (zinc content)						
Argentina	3	$3	--	--	--	--
Australia	50	7	8,782	$4,590	1,964	$305
Belgium	--	--	--	--	497	242
Bolivia	11,935	5,157	--	--	--	--
Canada	9,912	3,277	110,285	42,093	179,566	70,037
Chile	1,240	683	--	--	432	295
Colombia	16	2	14	2	6	1
Germany, Federal Republic of	7,802	4,101	2,422	1,271	8,687	5,301
Honduras	13,383	5,112	7,031	2,558	4,363	2,677
Mexico	13,457	4,340	13,660	3,640	21,120	11,165
Nicaragua	4	3	--	--	--	--
Peru	29,697	14,419	40,176	19,879	29,075	20,230
Total	87,499	37,104	182,370	74,033	245,710	110,253
BLOCKS, PIGS, OR SLABS[1]						
Algeria	4,276	3,415	6,005	4,497	721	579
Angola	989	793	--	--	--	--
Australia	33,721	25,634	24,798	18,046	25,830	22,043
Austria	--	--	629	556	--	--
Belgium-Luxembourg	12,327	9,061	2,310	2,336	14,018	12,151
Brazil	--	--	--	--	1,493	1,159
Canada	259,543	197,270	280,075	222,411	308,647	285,642
Chile	--	--	--	--	1,450	1,212
China	236	93	1,327	934	1,492	1,140
Finland	25,160	20,298	18,128	12,998	29,156	25,231
France	13,792	10,873	7,799	6,486	18,135	16,385
Germany, Federal Republic of	19,110	14,813	12,056	8,939	22,727	24,159
Ghana	1,003	589	--	--	65	20
Hong Kong	--	--	105	62	--	--
Italy	5,492	3,880	1,999	1,514	6,626	6,518
Japan	10,118	7,971	--	--	15,003	12,456
Korea, Republic of	2,300	1,721	1,400	1,047	1,500	1,240
Mexico	36,833	27,385	23,652	17,728	15,146	13,491
Namibia	--	--	--	--	994	836
Netherlands	3,180	2,314	6,508	5,183	20,915	18,010
Norway	--	--	--	--	9,934	8,389
Peru	7,394	5,488	3,951	2,798	43,339	37,836
Poland	100	75	--	--	600	573
Spain	66,738	43,703	10,727	7,592	28,671	23,545
Switzerland	1	1	--	--	--	--
Taiwan	104	16	--	--	--	--
Tanzania	1,200	848	1,028	731	--	--
United Kingdom	2,383	1,315	2,064	1,607	15,630	12,770
Yugoslavia	--	--	--	--	999	867
Zaire	14,829	11,767	--	--	28,540	22,778
Zambia	3,301	1,276	5,602	3,823	376	296
Total	524,130	390,599	410,163	319,288	612,007	549,326

[1]In addition, in 1981, 165 tons of zinc anodes were imported from Canada, Denmark, the Federal Republic of Germany, Japan, the Netherlands, Norway, Sweden, and Taiwan.

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)
1979	87,499	$37,104	524,130	$390,599	244	$267	3,259	$1,530
1980	182,370	74,033	410,163	319,288	1,342	1,041	3,470	1,361
1981	245,710	110,253	612,007	549,326	332	472	5,782	2,578

	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)	
1979	4,454	$1,735	28	$2	3,586	$3,440	$434,677
1980	4,062	1,732	25	7	3,928	3,672	401,134
1981	7,629	4,090	184	61	7,993	9,519	676,299

[1]Unwrought alloys of zinc were imported as follows: 1979—78 metric tons ($72,725); 1980—41 metric tons ($37,846); and 1981—102 metric tons ($40,713).
[2]In addition, manufactures of zinc were imported as follows: 1979—$213,699; 1980—$254,317; and 1981—$437,930.

Table 33.—U.S. imports for consumption of zinc pigments and compounds

	1980		1981	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Zinc oxide	29,843	$23,727	29,109	$25,333
Zinc sulfide	409	401	661	689
Lithopone	[r]1,189	598	1,594	692
Zinc chloride	1,008	726	1,434	880
Zinc sulfate	3,871	1,350	2,857	1,186
Zinc cyanide	20	37	41	86
Zinc hydrosulfite	337	371	221	340
Zinc compounds, n.s.p.f.	1,951	2,852	2,698	4,295

Table 34.—Zinc: World mine production (content of ore), by continent and country[1]

(Thousand metric tons)

Continent and country	1977	1978	1979	1980[p]	1981[e]
North America:					
Canada[2]	1,070.5	1,066.9	1,099.9	894.6	[3]1,097.2
Guatemala	1.0	1.0	[e]1.0	[e]1.0	.5
Honduras	26.5	24.3	22.0	19.6	18.0
Mexico[2]	265.5	244.9	245.5	238.2	[3]211.6
Nicaragua	11.2	3.6	--	--	--
United States[2]	407.9	302.7	267.3	317.1	[3]312.4
South America:					
Argentina	39.2	36.6	37.5	33.7	30.0
Bolivia	61.4	53.9	51.6	50.3	[3]47.0
Brazil	[r]57.6	[r]58.7	89.9	101.0	103.0
Chile[2]	3.9	1.8	1.8	1.1	1.1
Colombia	--	--	--	--	.1
Ecuador	2.0	1.3	[e]1.6	[e]1.6	1.6
Peru[2]	[r]405.3	[r]402.6	432.0	487.6	[3]496.7
Europe:					
Austria	19.7	22.5	20.5	19.1	[3]18.2
Bulgaria[e]	87.0	88.0	85.0	87.0	90.0
Czechoslovakia	9.4	8.8	8.8	7.2	7.2
Finland	62.9	52.9	51.6	58.4	[3]53.6
France	41.8	39.9	36.6	36.8	[3]37.4
Germany, Federal Republic of[2]	111.4	97.4	96.9	99.7	[3]91.8
Greece	18.0	25.6	23.2	25.9	[3]26.8
Greenland	76.6	82.4	87.3	86.8	[3]86.4
Hungary	[r]3.0	[r]2.8	2.6	2.8	2.0
Ireland	116.3	176.0	212.3	228.7	120.3
Italy	79.3	74.0	66.3	58.4	[3]41.5
Norway	30.3	28.9	29.1	28.2	[3]31.0
Poland[2]	188.0	194.0	182.7	187.8	[3]146.5

See footnotes at end of table.

Table 34.—Zinc: World mine production (content of ore), by continent and country[1] —Continued

(Thousand metric tons)

Continent and country	1977	1978	1979	1980[p]	1981[e]
Europe —Continued					
Romania	[e]62.0	60.0	60.0	60.0	55.0
Spain	98.3	146.8	142.7	183.1	180.0
Sweden	140.2	162.8	169.9	167.4	[3]180.9
U.S.S.R.[e 2]	735.0	770.0	770.0	785.0	790.0
United Kingdom	7.7	2.7	.6	4.4	9.6
Yugoslavia	112.4	103.8	101.7	[e]94.3	117.9
Africa:					
Algeria	2.7	4.8	4.9	8.2	6.2
Congo (Brazzaville)	5.3	4.8	[e]4.0	[e]3.5	[e]3.0
Morocco	7.8	4.3	4.5	6.1	6.3
Namibia	38.3	36.6	29.0	31.9	[3]39.6
Nigeria	--	--	--	--	.1
South Africa, Republic of	69.6	65.2	53.8	79.1	86.6
Tunisia	7.1	7.4	8.7	7.6	[3]7.5
Zaire[2]	73.0	73.7	68.0	67.0	76.0
Zambia[2]	45.0	50.0	46.6	35.5	22.2
Asia:					
Burma	1.8	2.6	3.0	4.1	4.5
China[2]	[r]155.0	160.0	160.0	160.0	160.0
Cyprus	.2	--	--	--	--
India	[r]25.4	[r]36.3	39.5	26.5	[3]31.6
Iran	61.5	[e]45.0	[e]25.0	20.0	15.0
Japan[2]	275.7	274.6	243.4	238.1	242.0
Korea, North[e 2]	150.0	145.0	145.0	140.0	140.0
Korea, Republic of	68.4	66.4	62.5	56.8	[3]56.5
Philippines	12.4	9.5	9.7	6.8	6.9
Thailand[4]	.3	--	--	--	--
Turkey[e]	67.1	40.7	27.1	20.4	20.4
Vietnam[e]	10.0	8.0	6.0	6.5	6.0
Oceania:					
Australia	491.6	473.3	531.8	493.7	[3]508.4
New Zealand	.1	[e].1	[e].1	[e].1	.1
Total	[r]5,919.6	[r]5,845.9	5,870.5	5,778.7	5,844.2

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through July 7, 1982.
[2]Recoverable content of concentrates.
[3]Reported figure.
[4]Content of zinc concentrates; additional quantities of zinc may be contained in lead concentrates produced, but information is inadequate to make reliable estimates of such production.

Table 35.—Zinc: World smelter production, by country[1]

(Thousand metric tons)

Country	1977	1978	1979	1980[p]	1981[e]
North America:					
Canada, primary	494.9	495.4	580.4	591.6	[2]618.6
Mexico, primary	174.4	173.1	161.7	143.9	[2]126.5
United States:					
Primary	408.4	406.7	472.5	340.5	[2]343.7
Secondary	45.9	34.8	53.2	29.4	[2]49.3
Total	454.3	441.5	525.7	369.9	[2]393.0
South America:					
Argentina, primary	29.0	23.9	36.7	25.4	23.0
Brazil:					
Primary	47.0	56.1	63.5	78.3	[2]91.9
Secondary	8.5	12.2	12.7	17.7	[2]19.0
Total	55.5	68.3	76.2	96.0	[2]110.9
Peru, primary	66.9	[r]62.9	68.2	63.8	[2]125.0
Europe:					
Austria, primary and secondary	16.7	21.7	23.2	22.1	23.2
Belgium:					
Primary	247.6	233.9	256.7	239.0	[2]247.2
Secondary	10.6	[r]7.6	9.1	10.2	10.2
Total	258.2	[r]241.5	265.8	249.2	257.4

See footnotes at end of table.

Table 35.—Zinc: World smelter production, by country[1] —Continued

(Thousand metric tons)

Country	1977	1978	1979	1980[p]	1981[e]
Europe —Continued					
Bulgaria, primary and secondary	90.0	91.0	89.0	90.0	90.0
Czechoslovakia, primary and secondary	[e]11.5	[e]11.5	11.5	9.6	9.6
Finland, primary	138.0	132.9	147.1	146.7	[2]139.8
France:					
Primary[e]	223.3	216.2	229.0	232.8	246.8
Secondary[e]	15.0	15.0	20.0	20.0	25.0
Total[e]	238.3	231.2	249.0	252.8	[2]271.8
German Democratic Republic, primary and secondary[e]	15.5	16.0	17.0	17.5	17.5
Germany, Federal Republic of:					
Primary	335.1	288.7	333.7	[2]342.8	[2]331.2
Secondary	19.7	18.1	21.8	27.8	[2]35.4
Total	354.8	306.8	355.5	370.6	[2]366.6
Greece, secondary	(3)	[r](4)	NA	.3	NA
Hungary, secondary	.6	[e].6	[e].6	[e].6	.6
Italy, primary and secondary	169.4	177.6	202.8	206.4	[2]180.9
Netherlands, primary and secondary	109.4	135.4	154.0	169.5	[2]182.6
Norway, primary	69.8	71.6	77.8	79.4	[2]80.3
Poland, primary and secondary	228.0	222.0	209.0	215.3	[2]167.1
Portugal, primary	--	--	--	2.0	9.0
Romania, primary and secondary	51.9	49.8	46.5	45.9	40.0
Spain, primary	156.6	177.0	182.7	151.8	184.0
U.S.S.R.:					
Primary	735.0	770.0	770.0	785.0	790.0
Secondary	80.0	80.0	80.0	80.0	80.0
Total	815.0	850.0	850.0	865.0	870.0
United Kingdom, primary and secondary	81.5	73.6	76.7	86.7	81.7
Yugoslavia:					
Primary	89.2	[e]85.2	[e]87.9	[e]77.5	86.4
Secondary	9.6	[e]10.0	[e]11.0	[e]7.0	10.0
Total	98.8	95.2	98.9	84.5	[2]96.4
Africa:					
Algeria, primary	[r]16.0	25.7	27.3	30.0	33.2
South Africa, Republic of, primary[5]	76.0	79.1	75.4	81.4	[2]87.2
Zaire, primary	51.0	43.5	43.5	43.8	[2]57.5
Zambia, primary	40.1	42.4	38.2	32.7	[2]33.2
Asia:					
China, primary and secondary	155.0	160.0	160.0	160.0	160.0
India:					
Primary	36.0	59.4	63.3	43.6	[2]57.4
Secondary	NA	NA	NA	.3	[2].2
Total	36.0	59.4	63.3	43.9	[2]57.6
Japan:					
Primary	778.4	767.9	789.4	735.2	[2]670.2
Secondary	26.6	24.8	27.0	49.9	[2]49.9
Total	805.0	792.7	816.4	785.1	[2]720.1
Korea, North, primary[5]	135.0	130.0	120.0	120.0	120.0
Korea, Republic of, primary	32.8	59.0	83.0	79.1	[2]83.9
Thailand, primary	(4)	(4)	(4)	--	--
Turkey, primary	20.9	20.0	20.0	13.1	15.0
Vietnam, primary[e]	9.0	7.2	5.4	5.5	5.5

See footnotes at end of table.

Table 35.—Zinc: World smelter production, by country[1] —Continued

(Thousand metric tons)

Country	1977	1978	1979	1980[p]	1981[e]
Oceania:					
Australia:					
Primary	249.7	290.1	305.1	301.0	[2]295.9
Secondary[e]	6.7	4.7	5.0	5.0	5.0
Total	256.4	294.8	310.1	306.0	[2]300.9
Grand total	[r]5,812.2	[r]5,884.3	6,268.6	6,057.1	6,139.6
Of which:					
Primary	[r]4,660.1	[r]4,717.9	5,038.5	4,785.9	4,902.4
Secondary	223.2	[r]207.8	240.4	248.2	284.6
Undifferentiated	[r]928.9	[r]958.6	989.7	1,023.0	952.6

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

[1]Table combines data provided in tables 39-40 of the 1977 edition of this chapter. 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 7, 1982.

[2]Reported figure.

[3]Revised to zero.

[4]Less than 50 metric tons.

[5]May include small quantities of secondary.

Zirconium and Hafnium

By William S. Kirk[1]

Zircon production by domestic mining companies increased by 15% in 1981. Zircon exports increased while imports decreased. Domestic consumption increased over that of 1980. Production and shipments of zirconium mill products fell slightly in 1981 owing to the continued weak demand in nuclear powerplant construction. Demand for hafnium in superalloys dropped owing to the decline in production of jet aircraft engines.

Zircon use was largely in foundry sands, refractories, abrasives, ceramics, and as a source of zirconium metal. Zirconium metal was used mostly in nuclear reactors, corrosion-resistant equipment for industrial plants, and refractory alloys. Hafnium was used in nuclear reactors, refractory alloys, and cutting-tool alloys.

The second domestic hafnium supplier came online in 1981. The first shipment of hafnium control rods was made to a modern commercial nuclear powerplant. A company in France brought online a new zirconium-hafnium separation process.

Legislation and Government Programs.—There were no stockpile goals for zirconium or hafnium materials. The U.S. Department of Energy had an inventory as of December 31, 1981, of approximately 150 short tons of zirconium sponge, 1,000 tons of zirconium ingots and shapes, 1 ton of zirconium crystal bar, 2 tons of zirconium scrap, 27 tons of hafnium ingots and shapes, 12 tons of hafnium crystal bar, 5 tons of hafnium oxide, and 1 ton of hafnium scrap.

Table 1.—Salient zirconium statistics in the United States

(Short tons)

	1977	1978	1979	1980	1981
Zircon:					
Production	W	W	W	W	W
Exports	14,364	7,671	8,856	7,727	11,630
Imports	65,204	91,009	110,842	113,784	91,108
Consumption[e 1]	162,000	164,000	168,000	[r]140,000	150,000
Stocks, yearend, dealers' and consumers'[2]	26,052	38,307	37,465	[r]69,473	50,310
Zirconium oxide:					
Production[3]	7,414	8,605	11,130	10,218	8,251
Producers' stocks, yearend[3]	718	931	975	[r]1,216	1,470

[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 1981

Company	Location	Materials
ZIRCONIUM MATERIALS		
Associated Minerals (USA) Ltd., Inc	Bow, N.H	Oxide.
Do	Green Cove Springs, Fla	Zircon.
The Carborundum Co	Falconer, N.Y	Refractories and oxide.
C-E Cast Industrial Products	Long Beach, Calif	Milled zircon.
C-E Refractories, Div. of Combustion Engineering, Inc	St. Louis, Mo	Refractories.
Do	Camden, N.J	Refractories and zircon.
Do	Vandalia, Mo	Do.
CIBA-GEIGY Corp., Drakenfeld Colors	Washington, Pa	Ceramic colors and milled zircon.
Continental Mineral Processing Corp	Sharonville, Ohio	Milled zircon.
Corhart Refractories Co	Buckhannon, W. Va	Refractories.
Do	Corning, N.Y	Do.
Do	Louisville, Ky	Do.
Didier-Taylor Refractories Corp	Cincinnati, Ohio	Do.
Do	South Shore, Ky	Do.
E. I. du Pont de Nemours & Co	Wilmington, Del	Zircon and foundry mixes.
Elkem Metals Co	Alloy, W. Va	Alloys.
Ferro Corp	Cleveland, Ohio	Ceramics and ceramic colors.
Foote Mineral Co	Cambridge, Ohio	Alloys.
A. P. Green Refractories Co., Remmey Div	Philadelphia, Pa	Refractories.
Harbison-Walker Refractories Co	Mount Union, Pa	Do.
Lincoln Electric Co., Inc	Cleveland, Ohio	Welding rods.
M & T Chemicals, Inc	Andrews, S.C	Milled zircon.
Magnesium Elektron, Inc	Flemington, N.J	Alloys, chemicals, oxide.
Norton Co	Huntsville, Ala	Oxide.
Reading Alloys	Robesonia, Pa	Alloys.
Ronson Metals Corp	Newark, N.J	Baddeleyite (oxide).
Sherwood Refractories Co	Cleveland, Ohio	Zircon cores.
Shieldalloy Corp	Newfield, N.J	Welding rods and alloys.
Sola Basic Industries, Engineered Ceramics Div	Gilberts, Ill	Ceramics.
TAM Ceramics	Hightstown, N.J	Milled zircon, oxide, alloys, chloride.
Teledyne Wah Chang Albany	Albany, Oreg	Oxide, chloride, sponge, ingot, powder, crystal bar, mill products.
Thiokol Corp., Ventron Chemicals Div	Beverly, Mass	Alloys and powder.
Transelco, Inc	Dresden, N.Y	Chemicals, ceramics, oxide.
Western Zirconium Co	Ogden, Utah	Oxide, sponge, ingot, mill products.
Zedmark, Inc	Butler, Pa	Refractories.
ZIRCOA Products	Cleveland, Ohio	Oxide and ceramics.
HAFNIUM MATERIALS		
Teledyne Wah Chang Albany	Albany, Oreg	Oxide, sponge, ingot, crystal bar.
Western Zirconium Co	Ogden, Utah	Oxide, sponge, crystal bar, ingot.

DOMESTIC PRODUCTION

Zircon was recovered as a coproduct of titanium mineral concentrates from mineral sands at the dredging and milling facilities owned and operated by E. I. du Pont de Nemours & Co. at Starke and Highland, Fla., and Associated Minerals (USA) Ltd. Inc. (AMC) at Green Cove Springs, Fla. 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.

Four firms produced 47,527 tons of milled (ground) zircon in 1981 from domestic and imported concentrates. Four companies, excluding those that produce metal, produced 8,251 tons of zirconium dioxide.

The production of alloys containing 3% to 70% zirconium increased 17% over that of 1980. Hafnium crystal bar production was estimated at 50 tons in 1981.

Teledyne Wah Chang Albany (TWCA) was reportedly working at less than 50% of its production capacity in 1981 because of reduced demand for zirconium resulting from the continued slowdown in commercial nuclear powerplant construction. About one-half of the approximately 180 TWCA employees laid off in 1980 were rehired in 1981. In August 1981, TWCA restarted its sand-chlorination and separation departments which had been closed in 1980.

A new hafnium supplier came online in 1981. Western Zirconium Co., of Ogden, Utah, completed its $3 million expansion to recover hafnium as a byproduct of its zirconium operation. Also during the year, Western Zirconium neared the end of its material qualification phase, a quality-control process required by its customers using zirconium in nuclear reactors. Toward the end of the year, the company began converting 500,000 pounds of its unused zirconium production capacity to titanium production capacity.

CONSUMPTION AND USES

Zirconium compounds, natural and manufactured, were used in refractories, ceramics, polishes, glazes, enamels, welding rods, chemicals, and sandblasting. Zirconium chemicals were finding increased application in the paint, textile, and pharmaceutical industries.

Foundries used about 50% of domestic zircon consumption in 1981. The remainder was consumed by refractory, abrasive, ceramic, metal, 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-TiO_2 blends for welding-rod coatings; and for sandblasting applications.

Zircon had largely replaced tin oxide as the major opacifying agent in ceramics because of its low price and its ability to combine well with the majority of colors used.[2]

In 1981, 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 yttria-stabilized zirconia in ceramic coatings in aircraft engines continued to grow in 1981, but quantities of zirconia consumed remained small.

Zirconia-based solids were among the materials being developed for solar collectors.[3] Another new market for zirconia ceramics was expected to open up in the automobile industry, where they would be the working components in oxygen sensors that are a part of microprocessor control of engines.[4]

The nuclear power industry accounted for 90% of the consumption of zirconium metal with the remainder being used primarily for corrosion-resistant applications in the chemical industry and for superalloys and electronics. Shipments of zirconium mill products declined for the fourth consecutive year in 1981.[5] The decline in demand was a result of the continued cancellations and delays in the construction of commercial nuclear powerplants. There were no new orders for commercial nuclear powerplants for the third consecutive year in 1981, and during the year, orders for six units were canceled.

Hafnium metal consumption for nuclear reactor control rods rose during the year. In 1981, the first sale of hafnium control rods to be used in a modern commercial nuclear power reactor was made; approximately 8,000 pounds of hafnium control rods, manufactured by Western Zirconium, a subsidiary of Westinghouse Electric Corp., was sold to Texas Utilities Co. for use in its Commanche Peak reactor.

Table 3.—Estimated[1] consumption of zircon in the United States, by end use

(Short tons)

Use	1980	1981
Zircon refractories[2]	[r]25,000	25,000
AZS refractories[3]	8,000	5,000
Zirconia[4] and AZ abrasives[5]	18,000	13,000
Alloys[6]	2,000	5,000
Foundry applications	55,000	75,000
Other[7]	32,000	27,000
Total	[r]140,000	150,000

[r]Revised.
[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)

Use	1980	1981
AZ abrasives	4,500	4,500
AZS refractories[3]	r2,000	1,000
Other refractories	2,000	2,000
Chemicals	700	600
Glazes, opacifiers, colors	900	500
Total	r10,100	8,600

rRevised.
[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	1980	1981
Zircon concentrate held by dealers and consumers, excluding foundries	r64,960	44,532
Milled zircon held by dealers and consumers, excluding foundries	r4,513	5,778
Zirconium:[1]		
Oxide	r1,216	1,470
Sponge, ingot, scrap, alloys	469	594
Refractories	r6,434	6,786
Hafnium: Sponge and crystal bar[e]	35	35

eEstimated. rRevised.
[1]Excludes material held by zirconium sponge metal producers.

Table 6.—Published prices of Australian zircon

(U.S. dollars per ton)

	Standard grade	Intermediate grade	Premium grade
December 1980	75- 80	80- 91	91-102
January 1981	80- 85	85- 91	91-102
September 1981	94- 99	99-104	104-110
December 1981	102-107	107-113	113-123

Table 7.—Published prices of zirconium and hafnium materials

Specification of material	1980	1981
Zircon:		
Domestic, standard grade, f.o.b. Starke, Fla., bulk, per short ton[1]	$165.00	$165.00
Domestic, 75% minimum quantity zircon and aluminum silicates, Starke, Fla., bulk, per short ton[1]	99.00	99.00
Imported sand, containing 65% ZrO_2, f.o.b., bulk, per metric ton[2]	$83.00- 89.00	$113.00-118.00
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	.33- .50	.35- .50
99%+ ZrO_2, minus 325-mesh, c.i.f. Atlantic ports, per pound	.85- 1.00	.85- 1.00
Zirconium oxide:[3]		
Chemically pure, white, ground, barrels or bags, works, per pound	4.75	4.75
Lump-electric fused, bags, 500- to 1,999-pound lots, from works, per pound	NA	NA
Lump-electric fused, bags, smaller lots, from works, per pound	NA	NA
Milled, bags, carlots, from works, per pound	NA	NA
Glass-polishing grade, ton lots, bags, 94% to 97% ZrO_2, from works, per pound	1.11	1.11
Opacifier grade, 3,300-pound lots, 85% to 90% ZrO_2, bags, per pound	.81	.81
Stabilized oxide, 100-pound bags, 91% ZrO_2, milled, per pound	1.57	1.57
Zirconium oxychloride: Crystal, cartons, 5-ton lots, from works, per pound[3]	.515	.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	75.00-125.00	50.00-137.50
Sponge, per pound	10.00- 14.00	12.00- 17.00
Sheets, strip, bars, per pound	20.00- 35.00	18.00- 40.00
Hafnium: Sponge, per pound	55.00-110.00	70.00-125.00

NA Not available.

[1]E. I. du Pont de Nemours & Co. price list December 1980 (effective Jan. 1, 1981) and December 1981 (effective Jan. 1, 1982).

[2]Industrial Minerals (London). No. 159, December 1980, p. 89; and No. 171, December 1981, p. 93.

[3]Chemical Marketing Reporter. V. 218, No. 26, Dec. 29, 1980 (effective Dec. 26, 1980), p. 37; and v. 221, No. 1, Jan. 4, 1982 (effective Dec. 31, 1981), p. 52.

[4]Ronson Metals Corp. Baddeleyite price lists. Jan. 1, 1981, and Jan. 1, 1982.

[5]American Metal Market. V. 88, No. 251, Dec. 31, 1980, p. 8; and v. 89, No. 250, Dec. 29, 1981, p. 16.

Table 8.—U.S. exports of zirconium ore and concentrate, by country

Country	1980		1981	
	Pounds	Value	Pounds	Value
Argentina	62,675	$11,217	462,601	$73,559
Belgium-Luxembourg	118,400	29,808	--	--
Brazil	1,645,001	385,623	2,897,162	541,605
Canada	3,143,409	357,123	2,445,021	504,117
Colombia	2,123,060	492,962	2,086,724	486,367
Dominican Republic	--	--	123,157	30,252
France	57,095	11,813	107,300	26,279
Germany, Federal Republic of	3,532,411	725,790	2,876,866	600,897
India	61,398	13,822	293,844	67,882
Italy	643,463	126,692	--	--
Leeward and Windward Islands	--	--	221,600	25,986
Mexico	3,348,996	355,512	10,370,083	1,068,233
Suriname	--	--	80,000	1,770
Venezuela	499,649	134,605	1,048,834	305,195
Other	r219,112	r87,022	247,211	106,168
Total	15,454,669	2,731,989	23,260,403	3,838,310

rRevised.

Table 9.—U.S. exports of zirconium, by class and country

Class and country	1980		1981	
	Pounds	Value	Pounds	Value
Zirconium and zirconium alloys, wrought:				
Belgium-Luxembourg	14,610	$528,550	98,100	$4,798,002
Canada	429,394	9,859,018	312,446	8,649,143
France	11,024	403,969	5,753	178,256
Germany, Federal Republic of	28,155	603,429	73,067	1,746,642
Japan	483,353	12,301,055	551,147	13,327,468
Sweden	25,700	418,787	4,303	147,096
Switzerland	76	2,081	17,701	650,713
United Kingdom	6,576	165,366	28,950	481,469
Other	r25,075	r540,771	4,996	179,164
Total	1,023,963	24,823,026	1,096,463	30,157,953
Zirconium and zirconium alloys, unwrought and waste and scrap:				
Belgium-Luxembourg	9,650	27,633	--	--
Canada	4,721	104,730	21,404	455,389
Germany, Federal Republic of	37,154	149,237	8,838	31,259
Italy	2,955	15,368	--	--
Japan	92,401	1,368,953	128,577	2,781,204
Netherlands	11,638	94,904	2,454	10,010
United Kingdom	198,558	2,646,492	100,996	1,539,640
Other	r6,937	r177,720	2,505	39,359
Total	364,014	4,585,037	264,774	4,856,861

rRevised.

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

Country	1980		1981	
	Pounds	Value	Pounds	Value
Argentina	2,047	$3,207	11,025	$21,995
Belgium-Luxembourg	59,108	24,894	--	--
Brazil	17,033	53,793	51,992	136,354
Canada	3,355,702	1,031,755	222,284	158,318
France	298,357	1,034,908	84,405	272,827
Germany, Federal Republic of	60,063	175,331	43,476	90,603
Hong Kong	2,879	4,511	29,191	45,742
Hungary	36,000	39,192	72,600	90,750
India	1,978	3,099	59,021	36,893
Italy	66,405	70,519	83,108	99,257
Japan	347,803	406,311	171,140	290,753
Mexico	91,794	73,592	133,730	38,279
Netherlands	140,087	266,959	36,998	47,184
Sweden	26,845	38,161	69,177	103,816
Taiwan	15,411	30,545	17,082	45,232
Thailand	9,076	14,857	40,000	4,000
United Kingdom	223,775	315,970	405,741	710,107
Other	r23,809	r92,099	33,908	61,551
Total	4,778,172	r3,679,703	1,564,878	2,253,661

rRevised.

Table 11.—U.S. imports for consumption of zirconium ores, by country

Country	1979		1980		1981	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Australia	101,144	$15,605	97,968	$8,888	71,852	$6,930
Austria[1]	124	15	20	3	--	--
Canada[1]	2,312	564	1,082	165	2,444	305
Malaysia	--	--	--	--	72	5
South Africa, Republic of[2]	7,262	779	14,714	1,539	16,740	1,138
Total	110,842	16,963	113,784	10,595	91,108	8,378

[1]Believed to be country of shipment rather than country of origin.
[2]In addition, very small quantities of baddeleyite were imported.

Table 12.—U.S. imports for consumption of zirconium and hafnium in 1981, by class and country

Class and country	Pounds	Value
Zirconium, wrought:		
France	1,023,045	$19,413,819
Germany, Federal Republic of	2,729	10,330
Japan	28	5,760
Total	1,025,802	19,429,909
Zirconium, unwrought and waste and scrap:		
Belgium-Luxembourg	437	8,750
Canada	31,111	74,049
Denmark	8	1,005
Germany, Federal Republic of	10,664	42,573
Japan	17,181	28,462
United Kingdom	4,920	11,321
Total	64,321	166,160
Zirconium alloys, unwrought:		
Japan	17,178	29,250
United Kingdom	10,911	42,714
Total	28,089	71,964
Zirconium oxide:		
Canada	15,966	5,396
France	23,389	23,924
Germany, Federal Republic of	907	51,991
Japan	2,207	23,883
Switzerland	33	20,657
U.S.S.R	38,006	97,009
United Kingdom	389,827	1,188,704
Total	470,335	1,411,564
Zirconium compounds:		
France	132,276	136,159
Germany, Federal Republic of	5,292	114,275
Japan	4,000	956
Singapore	2,205	437
Switzerland	176	4,140
South Africa, Republic of	733,833	312,780
U.S.S.R	176	420
United Kingdom	826,949	473,724
Total	1,704,907	1,042,891
Hafnium, unwrought and waste and scrap: France	5,310	125,543

WORLD REVIEW

The world zircon market in 1981 edged toward tight supply. Although prices rose gradually toward the last of the year, demand remained strong. The tightening of supply was primarily owing to developments in Australia, the most important of which were a drop in the price of and demand for rutile, a titanium mineral found in heavy mineral sands together with zircon. This caused a decline in the production of rutile and a corresponding decline in zircon production. The other developments were a drop in production on the east coast owing to environmental constraints and a temporary suspension of production in one area of the west coast because of storm damage.

Australia leads the world in the production of zircon, although with the rise of mineral sands mining at Richards Bay in the Republic of South Africa, it no longer dominates the world market.

Zircon is also produced in Brazil, China, India, Malaysia, the Republic of South Africa, Sri Lanka, Thailand, the U.S.S.R., and the United States.

Baddeleyite is produced in the Republic of South Africa and Brazil, and is also found in eastern Africa, Sri Lanka, and the U.S.S.R.

It was estimated that worldwide refractory, ceramic, and foundry uses in 1981 accounted for 91% of zircon consumption.[6] The Western European steel industry was reportedly starting to use substantial quantities of zircon for ladle refractory linings.[7]

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

(Short tons)

Country	1977	1978	1979	1980[p]	1981[e]
Australia	438,972	431,671	490,500	541,837	[2]468,552
Brazil	5,125	4,741	3,973	4,335	4,400
China[e]	10,000	10,000	12,000	14,000	15,000
India[3]	[r] [e]11,800	12,309	13,426	16,300	16,500
Malaysia[4]	[r]1,995	1,022	1,401	500	660
South Africa, Republic of	18,546	[e]40,000	[e]90,000	[e]88,000	110,000
Sri Lanka	[e]11	3,634	1,664	3,341	3,530
Thailand	[r]334	28	128	67	55
U.S.S.R.[e]	70,000	75,000	80,000	80,000	80,000
United States	W	W	W	W	W
Total	[r]556,783	[r]578,405	693,092	748,380	698,697

[e]Estimated. [p]Preliminary. [r]Revised. W Withheld to avoid disclosing company proprietary data; excluded from total.

[1]Includes data available through May 5, 1982.

[2]Reported figure.

[3]Data are for fiscal year beginning April 1 of that stated.

[4]Exports (production not officially reported; exports believed to closely approximate total output).

In 1981, consumption in market economy countries of reactor-grade zirconium ingot for commercial nuclear powerplants totaled about 6.5 million pounds.[8] Another 1.5 million pounds was used for other applications.

Australia.—Australia produced 468,552 tons of zircon in 1981, down 13% from that of 1980. Exports to the United States decreased 27%, and exports to Japan and Italy were also down. Exports to Western Europe (other than Italy) remained close to 1980 levels. Australian zircon is recovered as a coproduct of titanium sand mining along the eastern coast (37%) and in Western Australia (63%). The productive momentum continued to swing toward the west coast owing to environmental legislation as well as the depletion of reserves.

In Southern Goldfield Ltd.'s offshore exploration program for mineral sands, a number of samples were analyzed.[9] The analyses indicated the possibility of economic grades if sufficient quantities of heavy minerals could be found in the area.

Murphyores Holdings Ltd. was planning exploration and development at several of its mineral sands sites.[10] The main thrust of the development was to be at its Gladstone site. Murphyores has estimated reserves at 150,000 tons of zircon.

Allied Eneabba Pty. Ltd. announced that it reached agreement to acquire all the heavy mineral leases in the Eneabba Area held by Westralian Sands Ltd. and its subsidiary Ilmenite Pty.[11] According to the terms of the agreement, Allied Eneabba was to form a new, wholly owned subsidiary to hold the leases. A total of 103 leases was involved, and in return Westralian was to receive 27,500 tons of zircon from Allied Eneabba over the following 3 years. It was estimated that the probable reserves were in excess of 5 million tons of heavy minerals. Du Pont, a United States company, reportedly increased its percentage of ownership in Allied Eneabba in 1981 to 59%.[12]

Shareholders of Consolidated Goldfields Australia Ltd., Associated Minerals Consolidated Ltd., Renison Ltd., and the Mount Lyell Mining and Railway Co. Ltd. approved plans for the merging of the four companies.[13] The companies were to become wholly owned subsidiaries of a newly incorporated public company called Renison Goldfields Consolidated (RGC).[14] The changes would create the Goldfields groups' only publicly listed Australian company; the public would own 51% of RGC. This would mean the company would not need Government approval for most company actions, including investing in the AMC Florida operation.

Consolidated Rutile Ltd., as of June 30, 1981, had calculated reserves (proven plus probable) of 719,000 tons of zircon.[15] Consolidated also had a 75% beneficial interest in areas that had calculated reserves of 789,000 tons of zircon.

Mineral sands mines in New South Wales were reportedly being forced out of business by the expansion of national parks and other state actions.[16] Mining of about 45% of Australian reserves of mineral sands on the east coast was prohibited for environmental reasons.[17] According to a Mineral Sands Producers Association symposium, this restriction was excessive, especially in view of improved environmental controls by mineral sands producers.

Western Australia was reportedly planning to raise royalties on mineral sands mining from 2% to 2.5%.[18] This would reportedly have no significant effect on mineral sands prices.

The Queensland government decided to allow mineral sands mining on Moreton Island off the coast of Brisbane.[19] The decision, however, allowed mining of an area of less than 7% of the island.

Brazil.—Empresas Nucleares Brasileiras decided to investigate the possibility of extracting zirconium from uranium ore taken from the Osamu Utsumi mine.[20]

Rutilo e Ilmenita do Brasil S.A. was planning to begin mining zircon in 1983 in Mataraca in the State of Pernambuco.[21] Production was expected to be 16,500 tons per year and was earmarked for internal consumption.

Centro Tecnico Aeroespacial was conducting a study for Cía. de Mineracoes, Industria e Comerico to determine the feasibility of obtaining zirconia from caldasite.[22]

Canada.—The Norton Co.'s abrasives plant in Niagara Falls, Ontario, was planning a $3 million expansion of its zirconia-crushing facilities.[23]

Egypt.—A paper presented to the Regional Conference on Development and Utilization of Mineral Resources in Africa in February 1981 stated that the most important mineral sands localities occurred in the Rosetta area.[24] The deposit contains an estimated 1.9 million tons of heavy minerals, of which 5% is zircon.

France.—Cie. Européeanne du Zirconium Ugine Sandvik, a Péchiney Ugine Kuhlmann subsidiary, brought online its molten salt process for separating zirconium and hafnium. This was the first time the process had been used at production scale.

India.—Completion of the $100 million Orissa mineral sands complex was rescheduled for the end of 1982.[25] The complex at Chatrapur, Orissa, on the east coast was originally scheduled for completion in June 1981. The plant was designed to produce 2,200 tons of zircon per year.

Japan.—Zirconium Industry Co., owned by TWCA, Ishizuka Research Institute Ltd., and Mitsui and Co., was planning to begin building a zirconium production plant by the end of 1982. The plant was to employ a process developed by Ishizuka that could produce zirconium at a lower cost than was possible previously. The plant was expected to have an annual production capacity of 2.2 million pounds of zirconium by 1985.

The Japanese Government moved closer to approval of a new national stockpile of rare and strategic metals.[26] The stockpile, which was to include zirconium, reportedly was to insure supplies for certain high-technology industries, including electronics, aerospace, and nuclear power.

Japan was reported to be substantially reducing its long-range nuclear energy capacity goals.[27] This could have an adverse effect on future zirconium demand.

Sierra Leone.—Zircon was found in the

Mogbwemo deposit on the southwestern coast of Sierra Leone.[28] The zircon, however, did not occur in economic quantities and was not being exploited. The deposit was being mined for rutile by Sierra Rutile Ltd.

South Africa, Republic of.—The Palabora complex was producing baddeleyite and zirconium sulfate in 1981.[29]

Richards Bay Minerals, the mineral sands mining operation on the northern Natal coast, was planning an expansion that would increase its output of zircon 30% by 1982.[30]

TECHNOLOGY

The Bureau of Mines conducted research using zirconia as an alternative mold material for titanium investment casting.[31] The research demonstrated that molds prepared from calcia-stabilized zirconia with zirconia-forming binders can be used to prepare precision investment castings of titanium with minimal brittle case formation and cast metal contamination. The significance of this is that zirconia, which is readily available, nontoxic in character, and relatively inexpensive, can be successfully substituted for molds that are presently used in the titanium-casting industry, but that are produced from materials not meeting all these criteria.

The Bureau of Mines also published a report on investigations to recover byproduct heavy minerals from sand and gravel operations in Oregon and Washington.[32] Samples from more than 40 locations were concentrated and evaluated.

Ultraviolet (UV) photographic images can be stored in lead lanthanum zirconate titanate (PLZT) ceramics.[33] The results of studies published in 1981 indicate that ion implantation can extend the absorption spectrum from the near-UV to the visible. Ion implantation also resulted in increasing photosensitivity by four orders of magnitude over unimplanted PLZT.[34] Implanted ferroelectric-phase PLZT was the most sensitive, nonvolatile, selectively erasable storage medium known.

High-resolution, pressurized ion exchange was used to separate zirconium and hafnium sulfate complexes from Dowex resin by chromatographic elution with sulfuric acid solutions.[35]

A pressurized continuous annular chromatograph (CAC) was developed for truly continuous zirconium-hafnium separations.[36] Zirconium containing less than 0.01% hafnium, and hafnium containing less than 1% zirconium were produced in this way. The CAC, because of its continuous feed and product withdrawal and its adaptability to large-scale operations, could make chromatography a more competitive process in the industrial sector.

A report was published on the separation of zirconium tetrachloride ($ZrCl_4$) from hafnium tetrachloride ($HfCl_4$) by the selective reactivity of $HfCl_4$ vapor with solid or molten alkali chlorides and their mixtures.[37]

A progress report was presented on the design and construction of a small pilot plant for the separation of $ZrCl_4$ from $HfCl_4$ by means of an extractive distillation operation.[38] Results of the research indicated that $ZrCl_4$ and $HfCl_4$ could be separated in a suitably designed fractional distillation column at close to atmospheric pressure if fused salts such as sodium chloride were used to provide solutions of the tetrachlorides so that an extractive distillation operation could be conducted.

The results were published of research conducted on the fused salt electrolytic process for reclamation of zirconium and titanium scrap.[39]

Ceramic coatings improve the performance and durability of gas-turbine engines.[40] To date, the use of ceramic coatings on the moving parts of the engines has not been possible because of thermal strain-induced spalling during engine operation. Recent work has resulted in plasma-sprayed zirconia coatings with much greater spall resistance.

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Other Metals

By Staff, Division of Nonferrous Metals

CONTENTS

ARSENIC[1]

Demand for arsenic exceeded supply, and major domestic and foreign producers allocated available supplies to customers for the fourth consecutive year. Major demand for arsenic was about evenly divided between industrial chemicals and agricultural chemicals.

Legislation and Government Programs.—Effective April 1, 1981, taxes were collected from companies producing and importing 42 chemicals and petroleum products designated as hazardous. The revenue was used to begin funding of the 5-year, $1.6 billion "superfund" being established under Public Law 96-510, the Comprehensive Environmental Response, Compensation, and Liability Act, designed to help clean up spills of hazardous substances throughout the United States. As hazardous chemicals, arsenic metal and arsenic trioxide were taxed at the rate of $4.45 and $3.41 per short ton, respectively.

In 1978, the Occupational Safety and Health Administration (OSHA) lowered the maximum worker exposure to arsenic from the previous ceiling of 500 micrograms per cubic meter of air to 10 micrograms per cubic meter over an 8-hour time period. The decision was challenged in court by U.S. nonferrous metal producers. In April 1981, the U.S. Court of Appeals ordered OSHA to make a risk assessment of the nature of the health problem caused by arsenic. In October 1981, OSHA organized a group of engineers from the United Steelworkers of America, OSHA, and ASARCO Incorporated to begin a 2-year study of conditions in U.S. nonferrous metal smelters.[2]

DOMESTIC PRODUCTION

Arsenic trixoide and arsenic metal were produced at the Tacoma, Wash., copper smelter of Asarco. Asarco processed arsenic residues and high-arsenic copper concentrates from both imported and domestic sources, but primarily from imported sources. Production data cannot be published.

Koppers Co., Inc., produced arsenic trioxide for internal consumption at its newly built arsenic acid plant near Atlanta, Ga. The company was a net purchaser and major consumer of arsenic trioxide. Arsenic trioxide is used to produce arsenic acid, an intermediate chemical used to produce arsenical wood preservatives for pressure treating lumber.

The Tacoma smelter has been operating at a production rate of about 70,000 tons of copper per year, or about two-thirds capacity, in order to better comply with local and Federal air pollution regulations. Even with reduced production, the Tacoma smelter frequently has had trouble complying with Federal regulations that require capture of 90% sulfur dioxide emissions. At present, about 45% of sulfur dioxide emissions are captured. In order to reduce emissions, Asarco announced a program costing \$4.5 million to install secondary hoods on converters and \$1.1 million for opacity control at Tacoma. The secondary hood installation should allow the Tacoma smelter to capture up to 400 tons per year of arsenic currently lost through air emissions. In addition, more sulfur dioxide will be recovered than at present.

In addition to the smelter retrofitting measures being taken, the Puget Sound Air Pollution Control Authority (PSAPCA) ordered Asarco to study arsenic emissions from the smelter's slag; market conditions for sulfuric acid, liquid SO_2, and gypsum; the feasibility of scrubbers; and the feasibility of eliminating scrubber waste. PSAPCA granted the Tacoma smelter a variance to continue operating through the end of 1982.[3] However, as a condition for the variance, PSAPCA required the smelter to remove 90% of its sulfur dioxide emissions by 1987. An Asarco spokesperson said that to do so would require the company to spend about \$100 million, an amount beyond the current financial capability of the company.

CONSUMPTION AND USES

Estimated distribution of arsenic in 1981 was 45% in industrial chemicals (wood preservatives and mineral flotation reagents), 45% in agricultural chemicals (herbicides and plant desiccants), 5% in glass and ceramics, 3% in nonferrous alloys (added in metallic form), and 2% in other uses (animal feed additives and pharmaceuticals).

Consumption of arsenical wood preservatives increased in 1980, the latest year for which data were available. Consumption, in short tons, was as follows:

	1978	1979	1980
Chromated copper arsenate (CCA)	12,494	16,882	18,082
Ammoniacal copper arsenate (ACA)	W	532	537
Fluor chrome arsenate phenol (FCAP)	112	W	W

W Withheld to avoid disclosing company proprietary data.

Source: American Wood-Preservers' Association.

PRICES AND GRADES

The price of domestically produced arsenic trioxide (95% minimum) was increased from 31.75 cents per pound to 34.25 cents per pound in March, to 35.00 cents per pound in June, and to 40.00 cents per pound in September, according to Metals Week. The price of domestically produced metal in 1-ton lots, delivered, was increased from \$3.00 per pound to \$3.25 per pound in June, decreased to \$3.15 per pound in July, and again decreased to \$2.75 per pound in September.

Table 1.—Arsenic price quotations

(Cents per pound, yearend)

	1979	1980	1981
Trioxide, domestic, 95% As_2O_3, f.o.b. Tacoma, Wash	24	32	40
Trioxide, Mexican, 99.13% As_2O_3, f.o.b. Laredo, Tex	30	46	78
Trioxide, imports	32	35	45
Metal, domestic, 99% As	190	300	275

FOREIGN TRADE

Imports of arsenic trioxide increased over 50% to nearly 19,000 tons in 1981, valued in excess of \$13 million. For the first time, Canada was the largest source of imports, followed by Sweden and Mexico. The trioxide imported from Canada was very low grade, valued at an average price of only 8 cents per pound. Most of the Canadian trioxide was further refined by the Koppers Co. and used in producing arsenical wood preservatives.

Imports of arsenic acid in 1981 were six times the level imported in the previous year. The major source was the United Kingdom.

Table 2.—U.S. imports for consumption of arsenic trioxide content, by country

Country	1979 Quantity (short tons)	1979 Value (thousands)	1980 Quantity (short tons)	1980 Value (thousands)	1981 Quantity (short tons)	1981 Value (thousands)
Belgium-Luxembourg	184	$50	388	$142	1,379	$708
Bolivia	--	--	--	--	41	77
Canada	277	80	486	110	6,152	965
China	--	--	--	--	475	585
France	3,242	1,376	2,780	1,597	826	1,093
Germany, Federal Republic of	6	15	116	92	146	226
Japan	--	--	58	79	--	--
Korea, Republic of	--	--	18	26	218	389
Mexico	3,125	1,799	3,720	2,681	3,931	5,261
Netherlands	--	--	57	26	--	--
Peru	477	148	--	--	55	57
Portugal	--	--	--	--	73	142
South Africa, Republic of	--	--	--	--	19	17
Spain	--	--	135	170	159	198
Sweden	5,014	2,086	4,770	2,429	5,403	3,259
U.S.S.R	--	--	--	--	44	91
United Kingdom	(1)	8	(1)	(1)	37	59
Total	12,325	5,562	12,528	7,352	18,958	[2]13,126

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

Table 3.—U.S. imports for consumption of arsenicals, by class

Class	1979 Quantity (short tons)	1979 Value (thousands)	1980 Quantity (short tons)	1980 Value (thousands)	1981 Quantity (short tons)	1981 Value (thousands)
Arsenic trioxide (As_2O_3)	12,325	$5,562	12,528	$7,352	18,958	$13,126
Metallic arsenic	405	1,881	266	1,524	323	2,079
Sulfide	39	112	11	2	--	--
Sodium arsenate	1	3	(1)	2	(1)	3
Arsenic acid	176	94	271	197	1,666	2,400
Arsenic compounds, n.e.c	1	76	1	113	5	133

[1]Less than 1/2 unit.

Table 4.—U.S. imports for consumption of arsenicals, by country[1]

(Short tons)

Country	Metal (TSUS 632.04) 1980	Metal (TSUS 632.04) 1981	Acid (TSUS 416.05) 1980	Acid (TSUS 416.05) 1981	Lead arsenate (TSUS 419.00) 1980	Lead arsenate (TSUS 419.00) 1981
Canada	13	12	--	--	--	--
China	--	33	--	--	--	--
Mexico	--	--	251	605	--	--
Peru	--	5	--	--	20	99
Sweden	252	273	--	20	--	--
United Kingdom	--	--	20	1,041	--	--
Total	[2]266	323	271	1,666	20	99

[1]Figures of less than 1/2 unit are not indicated in this table.
[2]Data do not add to total shown because of independent rounding.

Table 5.—U.S. import duties for arsenicals

Item	TSUS No.	Most favored nation (MFN) Jan. 1, 1981	Most favored nation (MFN) Jan. 1, 1982	Most favored nation (MFN) Jan. 1, 1987	Non-MFN, Jan. 1, 1982
Arsenic metal	632.04	1.5 cents per pound.	1.3 cents per pound.	Free	6.0 cents per pound.
Trioxide and sulfide	417.62, 417.60	Free	Free	do	Free.
Other compounds	417.64	4.7% ad valorem.	4.5% ad valorem.	3.7% ad valorem.	25% ad valorem.

WORLD REVIEW

An arsenic symposium sponsored by the Chemical Manufacturers Association and the National Bureau of Standards was held at the National Bureau of Standards in Gaithersburg, Md., November 4-6, 1981. Speakers presented papers describing the production, use, and biomedical and environmental aspects of arsenic.

At the symposium, a spokesperson from Asarco mentioned that world production of arsenic trioxide peaked at just under 70,000 tons in 1970. Ten years later, world production had decreased to less than one-half the 1970 level. A growing public awareness of the need to protect workers and the environment from excessive exposure to arsenic was one contributing factor to the decline in arsenic demand and, hence, production in the developed countries.

Canada.—Cominco Ltd.'s new gallium arsenide production plant opened June 18 in Vancouver, British Columbia.[4] High-purity arsenic and gallium metal are combined at high pressure and temperature. In a period of about 36 hours, a gallium arsenide crystal is grown from the melt. The crystals are cut, polished, and sold in the form of wafers. The electronics industry uses the wafers for manufacturing semiconductor chips.

Chile.—The St. Joe Minerals Co.'s mine at El Indio, about 300 miles north of Santiago, Chile, was officially dedicated in December 1981. In addition to producing gold, silver, and copper, the mine will produce an estimated 5,000 to 8,000 tons of arsenic trioxide to be shipped to Leonard J. Buck Co. in the United States for direct sale. Shipments were scheduled to begin sometime in 1982.[5]

Sweden.—Supplies of arsenic to the United States were temporarily curtailed in 1981 when shipments from Sweden were halted for 6 weeks in May and the first half of June as a result of a work stoppage owing to a labor-management disagreement.

Table 6.—White arsenic (arsenic trioxide):[1] World production, by country[2]

(Short tons)

Country[3]	1977	1978	1979	1980[p]	1981[e]
France	6,661	[e]6,500	[e]6,100	[e]5,800	5,700
Germany, Federal Republic of[e]	400	400	--	400	400
Japan	131	100	201	313	331
Korea, Republic of	713	604	[e]650	NA	NA
Mexico	6,332	6,884	7,206	6,980	7,100
Namibia[4]	2,882	2,647	2,448	1,420	1,500
Peru	1,507	1,386	3,552	3,533	3,500
Portugal	245	[r]279	380	220	220
Sweden[5]	[r]6,613	[r e]6,700	[e]5,600	[e]4,500	4,400
U.S.S.R.[e]	8,300	8,400	8,500	8,500	8,500
United States	W	W	W	W	W
Total	[r]33,784	[r]33,900	34,637	31,666	31,651

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available. W Withheld to avoid disclosing company proprietary data.

[1]Includes calculated arsenic trioxide equivalent of output of elemental arsenic and arsenic compounds other than white arsenic, where inclusion of such materials would not duplicate reported white arsenic production.

[2]Table includes data available through June 2, 1982.

[3]In addition to the countries listed, Austria, Belgium, China, Czechoslovakia, Finland, 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.

[4]Output of Tsumeb Corp. Ltd. only.

[5]Output of white arsenic for sale plus the white arsenic equivalent of the output of metallic arsenic for sale.

TECHNOLOGY

The Environmental Protection Agency investigated methods for safe disposal of arsenic-bearing flue dusts.[6] Flue dusts containing arsenic and other metals were dissolved in water, sulfuric acid, ferric sulfate, ferric chloride, aqueous ammonia, and sodium hydroxide, in various combinations. Arsenic was fixed in a number of matrix materials including clay, cement, slag, and concrete. Leaching of arsenic to the environment was minimal when calcium or iron arsenate was incorporated in any of the above matrix materials.

CESIUM AND RUBIDIUM[7]

DOMESTIC PRODUCTION

There was no known domestic production of cesium- or rubidium-bearing minerals during 1981. Cesium compounds and small quantities of cesium metal were produced from imported cesium ore (pollucite). Rubidium compounds and metal were produced from imported lepidolite ores. Production of both cesium and rubidium compounds remained virtually unchanged through 1981 compared with that of the previous year, and a major producer indicated that no significant change was imminent.

Cabot Corp. (KBI Div.) was the major producer of cesium and rubidium products from its plant at Revere, Pa.; other potential suppliers included Callery Chemical Co., Callery, Pa., and Kerr-McGee Chemical Corp., Trona, Calif.

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 advantage. Commercial consumption included uses for high-voltage rectifying tubes, which change alternating current to direct current, and for infrared lighting where cesium vapor emits light with a wavelength that is invisible. In photoelectric cells, cesium chloride was used because its color sensitivity is higher than that of other alkali salts. An increased use of cesium compounds in catalysts for production of organic compounds was announced. The process is proprietary and no further information was forthcoming.

PRICES

The yearend 1981 market quotations for cesium and rubidium metal and their respective compounds remained unchanged from prices in 1980. Cesium metal was $225 per pound, and rubidium metal was priced at $661.40 per kilogram for technical grade and $826.75 per kilogram for high-purity metal, according to industry sources.

Table 7.—Prices of selected cesium and rubidium compounds in 1981

Compound	Base price per pound[1]	
	Technical grade	High-purity grade
Cesium bromide	$29	$67
Cesium carbonate	29	67
Cesium chloride	31	70
Cesium fluoride	37	77
Cesium hydroxide	35	75
Rubidium carbonate	65	104
Rubidium chloride	66	105
Rubidium fluoride	71	110
Rubidium hydroxide	71	110

[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

Imports of cesium compounds, including cesium chloride, during 1981 doubled over those of 1980. Most of the increase was attributed to receipts from the Federal Republic of Germany, which rose sharply as compared with levels previously reached in 1979. Trade data on raw materials and metal were not available. Tariff schedules, established by the Tokyo Round of trade negotiations, are shown in table 9.

WORLD REVIEW

The Tantalum Mining Corp. of Canada Ltd.—owned jointly by Cabot, 37.5%; Hudson Bay Mining & Smelting Co., Ltd., 37.5%; and the Manitoba Provincial Government, 25%—continued operations at its Bernic Lake property near Lac du Bonnet in Manitoba, Canada.

Bikita Minerals (Pvt.) Ltd., which operates several mines in the Victoria district of Zimbabwe, increased its production schedules in an attempt to regain its position as a major producer following the removal of sanctions that had been imposed by the United Nations.

Table 8.—U.S. imports for consumption of cesium compounds, by country

Country	1980				1981			
	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
Canada	--	--	--	--	22	$808	--	--
France	--	--	--	--	--	--	226	$12,117
Germany, Federal Republic of	5,303	$274,716	5,383	$291,579	8,570	363,375	15,333	658,567
United Kingdom	1,134	52,473	2	699	264	14,355	--	--
Total	6,437	327,189	5,385	292,278	8,856	378,538	15,559	670,684

Table 9.—U.S. import duties for cesium and rubidium

Item	TSUS No.	Most favored nation (MFN) Jan. 1, 1982	Most favored nation (MFN) Jan. 1, 1987	Non-MFN, Jan. 1, 1982
Ore and concentrate	601.66	Free	Free	Free.
Cesium	415.10	7.3% ad valorem	5.3% ad valorem	25% ad valorem.
Cesium chloride	418.50	5.3% ad valorem	4% ad valorem	Do.
Other cesium compounds	418.52	4.6% ad valorem	do	Do.
Rubidium	415.40	4.5% ad valorem	3.7% ad valorem	Do.
Rubidium compounds	423.00	do	do	Do.

TECHNOLOGY

A group of companies involved in electric power equipment, energy technology, and energy engineering have joined to form a new trade association to promote magnetohydrodynamics (MHD). The group will be called the MHD Industrial Forum. Elected to the group's board of directors were representatives of Avco Corp., Westinghouse Electric Corp., Babcock and Wilcox, TRW, Lipsen and Hamberger, Gilbert Associates, General Electric Co., Burns and Roe, Inc., and Brown and Co.

A process to treat pathogens in sewage sludge by irradiating them with cesium-137 to make the sludge safe for use as animal feed or as a soil conditioner has been developed by researchers at Sandia Laboratory. At a $350,000 pilot facility near Albuquerque, N. Mex., the researchers treated 8 tons per day of sewage with the isotope, a byproduct of nuclear reactors. Experiments using the treated sludge as a food supplement for sheep and cattle and as a fertilizer-soil conditioner for desert soils showed that the material had significant nutrient value and produced no abnormalities attributable to the treatment process or to pathogens in animals that eat it. It was estimated that the process could produce treated sludge at $25 per dry ton.[8]

GERMANIUM[9]

Published prices for domestic and imported germanium rose during 1981 with spot market prices for the metal commanding premiums over the published prices. Estimated domestic production also increased slightly in 1981 despite raw material shortages and increased imports. Demand for the metal was up especially in infrared and fiber optic applications.

DOMESTIC PRODUCTION

Production by both primary and secondary manufacturers was limited by the availability of raw materials in 1981. As a result, producers reportedly could not accept orders from new customers and had to operate an informal allocation system for regular customers.

Eagle-Picher Industries, Inc., Quapaw, Okla., was the sole domestic producer of primary germanium. Kawecki Berylco Industries, Inc., Revere, Pa.; and Atomergic Chemetals Co., Plainview, N.Y., produced germanium products using imported metal, oxide, and scrap, and domestic waste and new scrap. During 1981, a number of companies investigated the possibility of recovering and producing germanium. Potential sources of raw material included flue dusts and residues from primary metal-processing streams. None of these companies, however, were known to have begun production in 1981.

The principal source of raw material for primary production continued to be residues from zinc processing in the Kansas-Missouri-Oklahoma zinc district. Central Tennessee was an additional source of germanium-rich residues; however, these residues were exported.

Domestic primary and secondary production was estimated to be approximately 28,000 kilograms. Based on the U.S. producer price for refined germanium, the approximate value of this production was $26 million.

CONSUMPTION AND USES

The estimated consumption pattern for various end uses of germanium in 1981 was infrared systems, 40%; fiber optics, 15%; semiconductors, 23%; detectors, 10%; and other uses, 12%.

Germanium added to glass increases its refractive index. Such glass was used in 1981 to produce wide-angle camera lenses, microscope objectives, and infrared and laser devices. Especially important among these applications were infrared systems because germanium-containing lenses and windows transmit thermal radiation in a manner similar to visible light transmission by optical glass. As a result, infrared systems were finding increased use in military guidance and weapon-sighting systems. Other important uses for germanium glass included nonmilitary surveillance and monitoring systems in fields such as satellite mapping and fire alarms.

Although not used in all fiber optic systems, germanium was an important constituent in many applications of this technology. Fiber optics can be used as replacements for conventional wire telecommunication systems. In these applications, germanium dioxide was used in the high-index optical core reducing the need for signal amplifiers. Fiber optic systems offer a compact, short-circuit-free transmission medium that is not susceptible to electromagnetic distortion or tapping using existing technology.

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 electronics; to improve the hardness of copper, aluminum, and magnesium alloys; and as a catalyst in the production of polyester fibers in some foreign countries. There was also interest in the use of certain organogermanium compounds in the treatment of some kinds of cancer and in the prevention of various animal diseases.

PRICES

The U.S. producer price for germanium metal was $784 per kilogram at the beginning of 1981. In early March, the price was raised to $923 per kilogram. It remained at this level until early December when it was raised to $1,060 per kilogram, where it stayed until yearend. The U.S. producer price for germanium dioxide of $487 per kilogram in January was raised to $575 per kilogram in early March. The price remained at this level until early December when it was raised to its yearend price of $660 per kilogram.

The New York dealer price for germanium metal was $753.50 per kilogram at the beginning of the year and was raised to $945 per kilogram on April 1, 1981. A month later the price was reduced to $884 per kilogram, reportedly owing to strengthening of the U.S. dollar against the Belgian franc. In early September, the price was raised to $950 per kilogram, where it remained until yearend. The January dealer dioxide price was $444 per kilogram. On April 1, it was raised to $556 per kilogram, and in early May it was reduced to $519.75, reportedly for the same reason as the metal price reduction. The yearend price of $570 per kilogram was established on September 1, 1981.

Significantly, although many nonferrous metals were being discounted from published prices on the spot market, quotes for germanium metal and germanium dioxide generally commanded premiums above the published price throughout the year. These premiums ranged from $100 to $350 per kilogram for both products.

FOREIGN TRADE

U.S. imports of germanium metal (unwrought and waste and scrap) in 1981 were extremely high compared with those of previous years. However, with the higher 1981 prices, the lower average value per kilogram for the imports indicated that much of the material was low-grade waste and scrap. The U.S.S.R., after a year of not exporting germanium metal, supplied some material to the United States in 1981 although the amount was significantly less than in some previous years. Wrought germanium metal imports were also significantly higher than the 1,801 kilograms and 168 kilograms imported in 1980 and 1979, respectively.

The U.S. import duties for germanium metal and germanium dioxide were reduced in 1981 in accordance with the multilateral trade agreements made in Tokyo in 1979.

Table 10.—U.S. imports for consumption of germanium, by country

Country	1980 Quantity (kilograms)	1980 Value	1981 Quantity (kilograms)	1981 Value
Unwrought and waste and scrap:				
Belgium-Luxembourg	247	$1,041,094	9,560	$1,792,340
China	61	44,840	3,380	2,588,859
France	--	--	40	39,999
Germany, Federal Republic of	89	38,072	899	316,768
Japan	299	154,425	60	42,187
Switzerland	(1)	377	1,093	71,689
U.S.S.R	--	--	163	159,544
United Kingdom	832	258,412	1,476	916,100
Total	1,528	1,537,220	16,671	5,927,486
Wrought:				
Belgium-Luxembourg	1,801	1,464,838	3,025	4,120,440
China	--	--	405	103,842
Germany, Federal Republic of	--	--	1,957	1,922,906
Japan	(1)	1,738	101	88,583
Netherlands	--	--	191	164,513
United Kingdom	--	--	(1)	268
Total	1,801	1,466,576	5,679	6,400,552

[1]Less than 1/2 unit.

Table 11.—U.S. import duties for germanium metal and germanium dioxide

Item	TSUS No.	Most favored nation (MFN) Jan. 1, 1981	Most favored nation (MFN) Jan. 1, 1982	Non-MFN, Jan. 1, 1981-Jan. 1, 1982
Germanium dioxide	423.00	4.7% ad valorem	4.5% ad valorem	25% ad valorem.
Metal, unwrought and waste and scrap[1]	628.25	do	do	Do.
Metal, wrought	628.30	8.1% ad valorem	7.7% ad valorem	45% ad valorem.

[1]Duty on waste and scrap suspended until June 30, 1981, as provided by Public Law 95-508.

WORLD REVIEW

The dependence of certain industries in Japan, such as the electronics, aerospace, and nuclear power industries, on metal imports prompted the Primary Product Committee, a Ministry of International Trade and Industry advisory body, and Keidanren, a federation of economic associations, to propose increasing Japan's national stockpile of rare and strategic metals. Germanium was among the metals to be included in the expanded stockpile. Japan had an existing modest stockpile of some metals; however, it was reported that stocks of some of these metals were equivalent to only 1 week's supply. Among the proposals of these groups were increases in the stockpile to a 3-month minimum supply and diversification of Japan's sources of these metals. Final action had not been taken by yearend.

The growing demand for fiber optics prompted a number of companies to consider expansion of their existing plants and/or construction of new plants. The increased capacity was expected to be available in 2 to 4 years.

In late 1981, Zaire decided to restart germanium production, citing new uses for the metal as the reason.

INDIUM[10]

Indium was produced by three firms: Indium Corp. of America in Utica, N.Y.; NJZ Alloys, Inc., Palmerton, Pa., a joint venture of The New Jersey Zinc Co. and Indium Corp.; and Nedlog Technology Inc., Laramie, Wyo., which started operations this year. Both NJZ and Nedlog sent their indium product to Indium Corp. for further refining and marketing. Asarco, a company with a long history of indium production, continued to keep its indium facility idled this year. Data on domestic production, which declined slightly, were withheld to avoid disclosing company proprietary information. Small quantities of secondary indium were available from specialty metal recycling firms.

CONSUMPTION AND USES

Indium consumption generally declined in 1981 in all usage categories. Consumption for nuclear control rods remained low. Research studies continued on several new uses, especially for solar cells. 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 declined steadily during 1981. The price was $10.75 per troy ounce at the start of the year and was lowered in five stages to end the year at $5.90 per troy ounce. The price decreases were attributed to lower demand, the need to meet competitive European prices, and a worldwide oversupply situation.

FOREIGN TRADE

Imports of indium rose sharply. Japan was the leading supplier, followed by Belgium-Luxembourg, Peru, and the United Kingdom. The 1981 value of indium imports, at $3 million, was lower than that of recent years, reflecting declining indium prices.

The duty on unwrought and waste and scrap indium (TSUS 628.45) was 1.7% ad valorem for the most favored nations (MFN) and 25% ad valorem for the non-MFN; the duty on waste and scrap was suspended until June 30, 1981, by Public Law 95-508, and then reestablished. The duty on wrought indium (TSUS 628.50) was 7.7% ad valorem for MFN and 45% ad valorem for non-MFN. For compounds (TSUS 423.96), the duty was 3.8% ad valorem for MFN and 25% ad valorem for non-MFN.

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

(Thousand troy ounces and thousand dollars)

Country	1979		1980		1981	
	Quantity	Value	Quantity	Value	Quantity	Value
Unwrought and waste and scrap:						
Belgium-Luxembourg	124	1,504	148	2,349	91	579
Canada	36	458	36	690	14	159
China	--	--	--	--	5	30
France	--	--	--	--	59	307
Germany, Federal Republic of	16	176	3	50	(1)	8
Italy	--	--	--	--	4	17
Japan	3	24	10	167	105	601
Mexico	3	4	--	--	--	--
Netherlands	3	36	(1)	8	13	85
Peru	90	1,172	84	1,318	85	619
Switzerland	--	--	(1)	(1)	(1)	2
United Kingdom	7	219	14	404	65	580
Zaire	--	--	--	--	5	42
Total	282	3,593	295	4,986	446	3,029
Wrought:						
Belgium-Luxembourg	1	13	--	--	--	--
Canada	(1)	6	(1)	1	--	--
Germany, Federal Republic of	1	7	--	--	(1)	3
Ireland	--	--	--	--	(1)	2
Japan	--	--	--	--	1	7
Netherlands	(1)	1	(1)	4	--	--
Peru	9	137	4	80	10	60
United Kingdom	1	22	(1)	32	4	51
Total	12	186	4	117	15	123

[1]Less than 1/2 unit.

WORLD REVIEW

In response to declining indium prices, world production decreased in 1981. Major refiners included Metallurgie Hoboken-Overpelt S.A. in Belgium, Cominco in Canada, Preussag AG in the Federal Republic of Germany, Penarroya S.A. in France, Nippon Mining Co., Ltd., in Japan, and Mining and Chemical Products Ltd. in the United Kingdom.

SELENIUM[11]

Consumption in 1981 of selenium for photocopying increased, but glass, chemical, and pigment applications remained essentially unchanged from those of the previous year.

Table 13.—Salient selenium statistics

(Pounds of contained selenium unless otherwise specified)

	1977	1978	1979	1980	1981
United States:					
Production, primary	499,475	508,636	587,118	310,588	555,454
Shipments to consumers	353,098	324,378	467,338	310,764	458,240
Imports for consumption	585,673	799,853	683,903	625,472	686,887
Exports, metal, waste and scrap	67,610	227,449	333,282	180,269	133,430
Apparent consumption	871,161	896,782	817,959	755,967	1,011,697
Stocks, yearend, producer	323,119	507,377	627,157	626,981	644,980
Producers' price, average per pound, commercial and high-purity grades	$17.12-$20.86	$15.00-$18.00	$13.65-$15.31	$10.95-$12.66	[1]$4.38
World: Refinery production	[r]3,051,850	[r]3,132,985	[r]3,572,302	[p]3,018,200	[e]2,953,944

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Represents average dealer price of commercial grade; other prices are average producer prices. In 1981, all producers ceased listing published prices.

Legislation and Government Programs.—Controversy continued on the toxic effects versus beneficial effects of selenium. Effective August 28, 1981, the Food and Drug Administration (FDA) ruled to allow the addition of limited quantities of selenium to the feed of laying chickens. As a result of this action, selenium may now be added in limited quantities to the complete feed for all food animals. However, FDA denied a request by the American Feed Manufacturers Association to grant selenium the status of generally recognized as safe.[12]

DOMESTIC PRODUCTION

During 1981, primary selenium was recovered at three copper refineries: AMAX Copper Inc., at Carteret, N.J.; Asarco at Amarillo, Tex.; and Kennecott Corp. at Magna, Utah. The selenium was recovered from copper refinery anode slimes along with gold, silver, and tellurium, and from residues of pollution abatement plants at domestic and foreign nonferrous smelters and refineries. Two domestic companies that shipped selenium-containing materials to these refineries were Phelps Dodge Refining Corp. and The Anaconda Company. High-purity selenium metal and various selenium compounds were produced from commercial-grade metal by the three copper refineries and other processors.

Secondary selenium was recovered from used xerographic drums by the Xerox Corp., in Webster, N.Y., and by Selenium Inc. (a division of Refinement International), in Mapleville, R.I. Selenium Inc. also recovered selenium from used selenium rectifiers. The two U.S. companies recovered a total of about 100,000 pounds of secondary selenium in 1980 and an additional 100,000 pounds in 1981, considerably more than the estimated 10,000 pounds of selenium recovered in 1979.

CONSUMPTION AND USES

Consumption of selenium exceeded 1 million pounds and was the highest level since 1975. The increase in consumption was caused by an increase in demand for selenium in xerography. Apparent consumption of selenium was calculated by adding selenium shipments to imports and subtracting exports.

The following are estimates of selenium consumption by end-use categories in 1981: Electronic and photocopier components, 50%; glass manufacturing, 22%; chemicals and pigments, 20%; and other, 8%. About 500,000 pounds of selenium was consumed for electronic and photocopier end uses in 1981, about half of which was primary selenium and the other half was old scrap recovered from used xerographic drums and rectifiers by domestic and foreign refiners.

STOCKS

U.S. producer stocks in 1981 increased slightly over the 1980 level and represented about 8 months' supply at the 1981 rate of apparent consumption. Stocks included granular selenium, a semirefined form of selenium.

PRICES AND GRADES

Selenium is usually sold as a commercial-grade (99.5% minimum) powder available in several mesh sizes. Pellets and sticks are also sold.

The oversupply of selenium in the United States in recent years continued, and prices continued to decline in 1981. Because of falling prices, all producers ceased listing published prices, and are now quoting prices on a daily basis. The last complete list of prices was published on January 4, 1981. At that time, the price of commercial-grade selenium was $8.50 to $12.00 per pound and the price of high-purity selenium was $11.50 per pound. Dealer prices for commercial-grade selenium declined from $5-$6 per pound in January to $3-$4 per pound in December.

FOREIGN TRADE

Exports of selenium decreased for the second consecutive year, and the United Kingdom continued to be the largest recipient of exports. Imports of selenium increased in 1981, and Canada continued to be the largest source of imports. A large percentage of selenium imported from Canada was refined from old scrap.

The U.S. import duties for selenium were changed as shown in table 16.

Table 14.—U.S. exports of selenium metal, waste and scrap in 1981, by country

Country	Quantity (pounds of contained selenium)	Value
Australia	9,292	$27,361
Belgium	17,454	91,155
Bermuda	150	1,088
Canada	8,052	56,731
Chile	383	2,777
India	420	4,263
Japan	5,969	23,777
Mexico	24,923	126,719
Philippines	664	9,234
Singapore	920	6,668
South Africa, Republic of	2,205	7,165
Sweden	1,709	42,715
Taiwan	220	1,598
United Kingdom	61,069	266,527
Total	133,430	667,778

Table 15.—U.S. imports for consumption of selenium in 1981, by country

Country	Quantity (pounds of contained selenium)	Value
Unwrought and waste and scrap:		
Belgium-Luxembourg	27,537	$423,403
Canada	375,059	4,708,526
Chile	10,782	54,120
Germany, Federal Republic of	42,785	280,857
Japan	47,732	807,136
Peru	44,001	170,705
Sweden	14,009	332,429
United Kingdom	60,423	347,698
Yugoslavia	4,400	19,400
Total	626,728	7,144,274
Selenium dioxide:		
Canada	1,409	7,043
Germany, Federal Republic of	11,718	96,356
Sweden	9	424
United Kingdom	1	354
Total	13,137	104,177
Selenium salts:		
Germany, Federal Republic of	173	338
Japan	446	342
Korea, Republic of	2,902	8,900
United Kingdom	165	4,500
Total	3,686	14,080
Sodium selenite:		
Canada	5,277	72,090
Germany, Federal Republic of	18,952	216,869
Japan	507	6,013
Netherlands	507	5,169
Switzerland	243	2,425
United Kingdom	6,465	102,773
Total	31,951	405,339

Table 15.—U.S. imports for consumption of selenium in 1981, by country —Continued

Country	Quantity (pounds of contained selenium)	Value
Other selenium compounds:		
Canada	10,236	$76,850
Germany, Federal Republic of	3	322
Japan	31	4,583
United Kingdom	1,115	16,764
Total	11,385	98,519
Grand total	686,887	7,766,389

Table 16.—U.S. import duties for selenium

Item	TSUS No.	Most favored nation (MFN) Jan. 1, 1981	Jan. 1, 1982	Jan. 1, 1987	Non-MFN, Jan. 1, 1982
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	4.7% ad valorem.	4.5% ad valorem.	3.7% ad valorem.	25% ad valorem.

WORLD REVIEW

World production of selenium in 1981 was virtually the same as that of 1980. The largest producers were Japan, Canada, and the United States.

Metal Bulletin Ltd. and the Minor Metals Traders' Association sponsored a 2-day seminar May 20-21, 1981, in Rotterdam, Netherlands, on marketing minor metals. Topics covered included future demand and consumption, pricing, warehousing and distribution, scrap and recycling, and substitution. The proceedings will be available from Metal Bulletin Ltd.

Canada.—Noranda Mines Ltd. in Canada is estimated to recover 100,000 to 200,000 pounds of selenium per year from secondary sources. The Canadian plant recovered selenium from scrap imported from Europe, Japan, and the United States.

Table 17.—Selenium: World refinery production, by country[1]

(Pounds)

Country[2]	1977	1978	1979	1980[p]	1981[e]
Belgium[e]	130,000	130,000	130,000	130,000	130,000
Canada[3]	905,111	865,924	1,128,113	1,000,015	925,940
Chile	18,291	18,001	62,369	37,699	33,070
Finland	25,693	37,104	38,671	38,030	37,920
Japan	1,005,306	1,060,422	1,124,356	1,038,376	948,000
Mexico	110,231	176,369	165,346	101,413	19,800
Peru	[r]35,132	28,499	40,389	60,704	52,910
Sweden	176,370	123,459	149,914	149,914	150,000
United States	499,475	[r]508,634	587,117	310,582	[4]555,454
Yugoslavia	111,024	116,492	101,979	101,413	99,200
Zambia	35,217	68,081	44,048	50,054	1,650
Total	[r]3,051,850	[r]3,132,985	3,572,302	3,018,200	2,953,944

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

[1]Insofar as possible, data relate to refinery output only; thus, countries that produce selenium contained in copper ores, copper concentrates, blister copper, and/or refinery residues, but do not recover refined selenium from these materials indigenously, are excluded to avoid double counting. Table includes data available through May 19, 1982.

[2]In addition to the countries listed, Australia, the Federal Republic of Germany, and the U.S.S.R. produce refined selenium, but output is not reported, and available information is inadequate for formulation of reliable estimates of output levels. Australia is known to produce selenium in intermediate metallurgical products (Peko Wallsend Ltd. at June and Warrego Mines, Tennant Creek) and has facilities to produce elemental selenium (Port Kembla refinery of the Electrolytic Refining and Smelting Co. of Australia Pty. Ltd.); output by Peko Wallsend is not reported in order to avoid double counting, and output, if any, by the Port Kembla refinery is unreported.

[3]Refinery output from all sources, including imported materials and secondary sources.

[4]Reported figure.

TECHNOLOGY

The proceedings of the Second International Symposium on Selenium in Biology and Medicine held in 1980 were published.[13]

TELLURIUM[14]

U.S. tellurium data, with the exception of imports and apparent consumption, have been withheld in this publication to avoid disclosing company proprietary data.

Table 18.—Salient tellurium statistics[1] in the United States

(Pounds of contained tellurium unless otherwise specified)

	1977	1978	1979	1980	1981
Refinery production	W	W	W	W	W
Shipments to consumers	W	W	W	W	W
Imports for consumption	171,291	173,989	167,760	64,860	83,671
Apparent consumption	393,479	402,232	494,010	177,880	187,887
Stocks, yearend, producer	W	W	W	W	W
Producers' price, average per pound, commercial grade	$17.15	$20.00	$20.00	$19.77	[2]NA

NA Not available. W Withheld to avoid disclosing company proprietary data.
[1]World refinery production for selected countries given in table 21.
[2]The published list price of tellurium was suspended Jan. 5, 1981. From Oct. 7, 1980, until Jan. 4, 1981, the producer price was $18 to $20 per pound.

DOMESTIC PRODUCTION

Tellurium and tellurium dioxide were recovered domestically as byproducts of electrolytic copper refining by AMAX Copper Inc. at Carteret, N.J., and by Asarco at Amarillo, Tex. One domestic company that shipped tellurium-containing materials to AMAX was Phelps Dodge Refining. High-purity tellurium, tellurium master alloys, and tellurium compounds were produced by primary and intermediate processors from commercial-grade metal and tellurium dioxide.

CONSUMPTION AND USES

Consumption of tellurium increased slightly in 1981 compared with the level of the previous year but was significantly below the nearly 500,000 pounds consumed in 1979. The closure of Oxirane Corp.'s ethylene glycol plant late in 1979 sharply reduced the quantity of tellurium catalysts used, and the continued decline in domestic automobile sales caused less tellurium-alloyed steel to be used. Tellurium consumption by end use in 1981 was estimated as follows: Iron and steel products, 65%; nonferrous metals, 20%; chemicals, 10%; and other uses including rubber manufacturing, 5%.

PRICES AND GRADES

Producers ceased listing published prices of tellurium on January 5, 1981; after January 5, they quoted prices to customers on a daily basis. In September 1981, one producer quoted a price of $14 per pound. Tellurium metal is usually marketed in the form of minus 200-mesh powder, or as slabs, tablets, or sticks. Normal commercial grades contain a minimum 99% or 99.5% tellurium. Tellurium dioxide is sold in the form of minus 40- to minus 200-mesh powder containing a minimum 75% tellurium.

FOREIGN TRADE

Canada and Peru were the leading suppliers of imports. Data on tellurium exports were not available. U.S. import duties for tellurium in 1981 are shown in table 19, with scheduled changes.

Table 19.—U.S. import duties for tellurium

Item	TSUS No.	Most favored nation (MFN) Jan. 1, 1981	Most favored nation (MFN) Jan. 1, 1982	Most favored nation (MFN) Jan. 1, 1987	Non-MFN, Jan. 1, 1982
Tellurium metal	632.48	3.0% ad valorem	2.5% ad valorem	Free	25% ad valorem.
Compounds	421.90	4.7% ad valorem	4.5% ad valorem	3.7% ad valorem	Do.

Table 20.—U.S. imports for consumption of tellurium in 1981, by country

Country	Quantity (pounds of contained tellurium)	Value
Unwrought and waste and scrap:		
Canada	35,738	$1,172,156
Germany, Federal Republic of	56	6,048
Hong Kong	7,921	154,497
Japan	6,668	72,502
Peru	16,390	178,805
U.S.S.R	3,376	44,084
United Kingdom	2,256	28,825
Total	72,405	1,656,917
Compounds:		
Canada	8,160	94,380
Germany, Federal Republic of	450	6,536
Hong Kong	2,425	41,771
Japan	80	3,376
United Kingdom	151	7,893
Total	11,266	153,956
Grand total	83,671	1,810,873

WORLD REVIEW

Metal Bulletin Ltd. and the Minor Metals Traders' Association sponsored a 2-day seminar May 20-21, 1981, in Rotterdam, Netherlands, on marketing minor metals. Topics covered included future demand and consumption, pricing, warehousing and distribution, scrap and recycling, and substitution. The proceedings were expected to be available from Metal Bulletin Ltd.

TECHNOLOGY

Ametek Corp. of Philadelphia, Pa., developed a new cadmium telluride photovoltaic solar cell. Laboratory reports indicated that the solar cell could be as much as seven times less expensive to produce than a comparable silicon cell. Ametek reported that commercial production would not begin for at least 1 year.[15]

Table 21.—Tellurium: World refinery production, by country[1]

(Pounds)

Country[2]	1977	1978	1979	1980[p]	1981[e]
Canada[3]	81,617	99,867	104,067	99,208	98,800
Fiji	[e]27,000	[e]50,000	[e]50,000	25,022	--
Hong Kong	--	(4)	(4)	(4)	--
India	--	--	--	[5]440	500
Japan	[r]143,300	[r]152,119	123,459	152,119	132,300
Peru	40,499	33,911	46,742	44,322	47,840
United States	W	W	W	W	W

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

[1]Insofar as possible, data relate to refinery output only; thus, countries that produce tellurium contained in copper ores, copper concentrates, blister copper, and/or refinery residues, but do not recover refined tellurium, are excluded to avoid double counting. Table is not totaled because of the exclusion of data from major world producers, notably the U.S.S.R. and the United States. Table includes data available through June 2, 1982.

[2]In addition to the countries listed, Australia, Belgium, the Federal Republic of Germany, and the U.S.S.R. are known to produce refined tellurium, but output is not reported, and available information is inadequate for formulation of reliable estimates of output levels. Moreover, other major copper-refining nations such as Chile, Zaire, and Zambia may produce refined tellurium, but output in these nations is conjectural.

[3]Refinery output from all sources, including imports and secondary sources.

[4]Revised to zero.

[5]Pilot plant production.

THALLIUM[16]

DOMESTIC PRODUCTION

Asarco, the only domestic producer of thallium and thallium compounds, announced that it was discontinuing the sale of these products. The company also reported that it will continue to recover thallium at the Globe plant in Denver, Colo., and that the metal will be stockpiled. Trace amounts of thallium are contained in certain zinc-bearing ores and are concentrated in smelter flue dusts and residues that provide the commercial source for production of thallium.

USES

The uses of thallium included electronic components, gamma radiation detection equipment, additives for changing the refractive index and density of glass, low-temperature mercury switches, photosensitive devices, and radioactive isotopes for cardiovascular diagnostic procedures. Future domestic requirements of thallium were expected to be met by imports and withdrawals from stocks.

PRICES

The domestic producer price of thallium in 25-pound lots was $7.50 per pound during 1981. Metal traders reported that the price of imported thallium metal ranged from $40 to $45 per pound.

WORLD REVIEW

World production data for thallium were not available. The U.S. reserves in zinc ores were estimated at 75,000 pounds. Rest-of-world reserves were estimated to be 725,000 pounds of thallium.

[1]Prepared by J. Roger Loebenstein, physical scientist.
[2]American Metal Market. Joint Effort Planned on Arsenic Problem. V. 89, No. 208, Oct. 27, 1981, p. 7.
[3]———. Asarco Gets Tacoma Smelter Variance. V. 89, No. 223, Nov. 17, 1981, p. 2.
[4]The Northern Miner. Cominco's New Gallium Arsenide Plant. V. 67, No. 19, July 16, 1981, p. A-22.
[5]Metal Bulletin (Monthly). El Indio Dedicated. January 1982, p. 71.
Metal Bulletin. Arsenic Attracted by U.S. Production Squeeze. No. 6573, Mar. 17, 1981, p. 17.
[6]Mehta, A. K. Investigation of New Techniques for Control of Smelter Arsenic Bearing Wastes. EPA-600/S2-81-049, September 1981, 6 pp.
[7]Prepared by John A. Rathjen, mineral specialist.
[8]U.S. Department of the Interior. Compendex Review (Library). V. 8, No. 29, accession number 79-27531A.
[9]Prepared by Robert G. Reese, physical scientist.
[10]Prepared by James F. Carlin, Jr., physical scientist.
[11]Prepared by J. Roger Loebenstein, physical scientist.
[12]Bulletin of the Selenium-Tellurium Development Association, Inc. Selenium Now Approved for Addition to All Animal Feeds. No. 21, p. 1.
[13]Spallholz, J. E., J. L. Martin, and H. E. Ganther (ed). Selenium in Biology and Medicine (Proceedings of the Second International Symposium on Selenium in Biology and Medicine, at Texas Tech. University, Lubbock, Tex., May 12-16, 1980). Avi Publishing Co., Westport, Conn., 1981, 573 pp.
[14]Prepared by J. Roger Loebenstein, physical scientist.
[15]Chemical Week. Cadmium Telluride Provides Low-Cost Solar Cells. Apr. 15, 1981, p. 54.
Bulletin of the Selenium-Tellurium Development Association, Inc. Ametek's Research Into Solar Energy Begins to Pay Off. No. 21, pp. 2, 18.
[16]Prepared by Patricia A. Plunkert, physical scientist.

Table 22.—U.S. imports for consumption of thallium in 1981, by country

Country	Compounds: Gross weight (pounds)	Compounds: Content[e] (pounds)	Compounds: Value	Unwrought and waste and scrap: Gross weight (pounds)	Unwrought and waste and scrap: Value
Belgium-Luxembourg	47	38	$1,848	25	$967
Canada	--	--	--	3	1,456
France	1	1	1,633	--	--
Germany, Federal Republic of	373	298	21,402	221	7,486
Japan	164	131	6,615	--	--
United Kingdom[1]	48	38	45,546	--	--
Total	633	506	77,044	249	9,909

[e]Estimated.
[1]Includes 1 pound of extremely pure material with a value of $42,219.

Table 23.—U.S. import duties for thallium

Item	TSUS No.	Most favored nation (MFN): Jan. 1, 1981	Most favored nation (MFN): Jan. 1, 1982	Non-MFN, Jan. 1, 1981-Jan. 1, 1982
Unwrought metal	632.50	3.8% ad valorem	3.1% ad valorem	25% ad valorem.
Compounds	422.00	4.7% ad valorem	4.5% ad valorem	Do.

Other Nonmetals

By Staff, Division of Industrial Minerals

CONTENTS

ASPHALT (NATIVE)[1]

Native asphalt was produced in 1981 by five companies in three States, Alabama, Texas, and Utah. Texas was the leading State in production of native asphalt. Total production increased in 1981 to 1.26 million tons, while value increased 10.5% to $27.7 million.

Bituminous limestone, used primarily for street and road repair, was produced by Whites Uvalde Mines and Uvalde Rock Asphalt Co., both in Uvalde County, Tex., and Southern Stone Co., Colbert County, Ala.

Gilsonite was produced by American Gilsonite Co., Uinta County, Utah, and Ziegler Chemical and Mineral Corp., Weber County, Utah. This material was used for purposes other than road repair.

GREENSAND[2]

Greensand (glauconite) was produced in 1981 only by Inversand Co., a subsidiary of Hungerford and Terry, Inc., near Clayton, N.J. Production and sales information is withheld to avoid disclosing company proprietary data. A newspaper article reported that about 10,000 tons is mined each year.[3]

Raw greensand was resold by Zook and Ranch, Inc., as a soil conditioner and source of slowly released potash to organic farmers. Processed greensand was sold as a filter media for the removal of manganese and iron from drinking water supply systems.

IODINE[4]

Apparent consumption of iodine in the United States increased slightly during 1981 along with the price of crude iodine. The two U.S. producers of crude iodine increased production of iodine for sale on the open market. A joint venture project between two Japanese companies and a U.S. company announced a new plant for the production of iodine from oilfield brines. The General Services Administration (GSA) received authorization from Congress to sell excess iodine from the stockpile.

Legislation and Government Programs.—The U.S. Government strategic stockpile contained 7,971,977 pounds of crude iodine at yearend 1981. The iodine, packed in 25-pound glass jars, was acquired by barter after Congressional authorization in 1948. The stockpile goal remained at 5,800,000 pounds. Authorization was given by Congress for GSA to sell 2,213,000 pounds of the excess iodine for domestic use only. Approximately 500,000 pounds of iodine was available for sale during November and December 1981 and January 1982. The authorization allowed the sale of 1 million pounds in fiscal year 1982-83 and 213,000 pounds in fiscal year 1984. The first bid opening was November 10, 1981. Five firms bid on the entire 200,000 pounds authorized for disposal. Only 900 pounds was sold for $6.20 per pound. During December, 35,000 pounds of crude iodine was sold for $5.90 per pound and 1,000 pounds at $5.87 per pound. By yearend, 36,900 pounds of stockpile excess had been sold for $217,879.20.

The Food and Drug Administration (FDA) planned to require that medical uses of ethylenediamine dihydriodide (EDDI) have an approved new drug application. There was no action, however, during 1981.[5] EDDI was recommended for use as an aid in removal of mucus from the upper respiratory tract of chickens, turkeys, and swine, and as a preventative for soft tissue lumpy jaw in sheep and cattle. Four companies reported EDDI production during 1981 to the Bureau of Mines. Production of animal feed material decreased in 1980-81 as a result of voluntary efforts on the part of EDDI-producing companies to lower the consumption of iodine in animals, especially lactating dairy cattle.

The depletion allowance for iodine remained at 14% of gross income but may not exceed 50% of net income without the depletion deduction.

DOMESTIC PRODUCTION

Two companies supplied approximately 25% of U.S. consumption during 1981. The companies, located in Michigan and Oklahoma, produce iodine from subsurface brines.

The Dow Chemical Co. recovered iodine from mineral-rich brines of the Detroit River Group of Devonian Age at Midland, Mich. Dow's iodine production was reported to have increased during 1981 because of the strong demand for iodine compounds. Dow announced during 1980 plans to build a world-scale iodine plant. No further details were released concerning the plant in 1981.

Woodward Iodine Operations of Woodward, Okla., increased output. Woodward Iodine is a joint venture between Amoco Production Co. (49%) and PPG Industries, Inc. (51%). Iodine of greater than 99.9% purity is recovered by a conventional process with proprietary refinements from brine of the Morrowan Formation of Pennsylvanian Age associated with natural gas. Production was less than the 2-million-pound design capacity. Maintenance problems with the pumps, which are required to reinject stripped brine, have been solved.

Calabrian International Co., the largest U.S. importer of iodine, announced during 1980 that it would build a 3-million-pound-per-year iodine facility. No further information was available.

During 1981, North American Brine Resources (NABR) announced plans for a $2.3 million investment in a plant in Kingfisher County, Okla., to produce crude iodine. NABR is composed of 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. (USA) (10%). The plant was scheduled to begin production of 265,000 to 353,000 pounds per year starting in 1982. NABR operated a pilot plant during 1980 to perfect the technology to recover iodine from the high strontium brine. The technology was reported to be an absorption process. The brine being used is reported to contain 150 to 1,200 parts per million of iodine.

CONSUMPTION AND USES

The Bureau of Mines consumption canvass for iodine received responses from 32 plants in 14 States. The 1981 canvass indicated a 17% increase in gross weight of crude iodine consumed. The increase was primarily the result of a tenfold increase in the use of iodine for sanitation.

The major downstream uses of iodine for 1981 were estimated as follows: Animal feed supplements (mainly for cattle), 20%; catalysts (for synthetic rubber, stabilized rosin, tall oil, and other uses), 20%; pharmaceuticals, 18%; sanitary and industrial disinfectants, 14%; stabilizers (as in nylon precursors), 11%; inks and colorants, 6%; photographic equipment, 5%; and other uses, 6%. Other uses included the making of high-purity metals, motor fuels, iodized salt, smog inhibitors, and lubricants. Iodine also has application in cloud seeding and radiopaque diagnosis in medicine. The major changes in demand were an increase in usage for sanitary preparations and catalysts.

West Chemical Products, Inc., granted a nonexclusive, royalty-free license to use certain trademarks for the sale of certain iodine-based product trademarks to Ciba-Geigy of Basel, Switzerland. This replaced the license agreement that had been in effect since 1975 and was terminated on June 5, 1981. The new agreement does not include the low-iodine technology covered by U.S. Patent 4,271,149.

Two companies that consume iodine were merged with other companies during 1981. Fischer Scientific Co. was acquired by Allied Corp. in November for $330 million. Allied acquired 46% of Fischer's common stock. National Distillers and Chemicals bought 9% of Mallinckrodt, Inc.'s outstanding shares and showed an interest in acquiring Mallinckrodt. Mallinckrodt uses large amounts of iodine to produce pharmaceuticals and catalysts at its plant in St. Louis, Mo., and X-ray contrast media at its plant in Raleigh, N.C. In 1982, a 15-year trust representing 17% of the company's stock was to change into the hands of Washington University in Missouri and Harvard University in Massachusetts. In December, Mallinckrodt announced an agreement to sell 32% of the company's common shares to Avon Products, Inc. Avon also planned to buy the 17% interest held by Harvard and Washington Universities.

Concern over excessive intakes of iodine in the human diet uncovered some unexpected sources. Dairy products were reported to contribute up to 38% of the iodine intake. One source of iodine in dairy products is iodophors, complexes of iodine with organic carriers, which are used to clean, sanitize, and disinfect dairy cattle and equipment. The major sources of the overuse of iodine in dairy products were salt licks and feed supplements for cows which contributed iodine levels above those recommended by the FDA. Red food dye contains up to 50% iodine (erthrosine, red dye No. 3), and algae or kelp food additives contain high amounts of iodine.[6]

Establishing an accurate pattern of demand by end use is difficult because iodine is frequently converted into intermediate compounds and marketed as such before reaching its ultimate end use. Moreover, iodine and iodides used in catalytic and other dissipative processes are not well covered. This situation has been revealed consistently in recent years by import figures that exceeded reported consumption figures.

Table 1.—Crude iodine consumed in the United States, by product

Product	1980			1981		
	Number of plants	Consumption		Number of plants	Consumption	
		Thousand pounds	Percent of total		Thousand pounds	Percent of total
Reported consumption:						
Resublimed iodine	9	427	9	9	697	13
Potassium iodide	9	976	21	8	931	17
Sodium iodide	4	414	9	5	691	13
Other inorganic compounds	10	933	20	10	1,163	21
Ethylenediamine dihydriodide	4	588	12	4	562	10
Organic compounds	16	r1,347	r29	17	1,421	26
Total	[1]31	4,685	100	[1]32	[2]5,466	100
Apparent consumption	XX	8,700	XX	XX	8,800	XX

rRevised. XX Not applicable.
[1]Nonadditive total because some plants produce more than one product.
[2]Data do not add to total shown because of independent rounding.

PRICES

At the beginning of the year, demand for crude iodine prompted U.S. importers of the Japanese and Chilean product to raise the discounted selling price from $6.35 to $6.53 per pound. The list price remained at $7.26 per pound. PPG Industries, Inc., listed crude iodine at $6.35 per pound for quantities greater than 4,700 pounds.[7]

In March, prices of U.S. Pharmacopeia (U.S.P.) and food chemical potassium iodide (KI) increased to a range between $8.80 and $9.54 per pound. Analytical reagent-grade KI listed at $10.27 per pound for truckloads. Resublimed crystals of U.S.P. increased to

$12.94 per pound for orders of 2,000 pounds. Sodium iodide was selling at $12.95 per pound for truckloads.[8]

By June, the price increases had caused decreased demand. Consumers used stocks of iodine that had been built up during the previous months in anticipation of a continuing tight market. Importers of Japanese and Chilean crude posted a price of $7.26 per pound. PPG listed prices of $8.00 per pound for orders less than 4,700 pounds and $7.00 per pound for shipments greater than 4,700 pounds.[9]

Feed-grade material, which listed at $7.95 per pound for orders over 500 pounds and $8.20 per pound for orders less than 500 pounds, was discounted in August. The quoted yearend U.S. prices for iodine and its primary compounds were as follows:

	Per pound[1]
Iodine, crude, drums	$7.00-$7.26
Resublimed iodine, U.S.P., granular, 100-pound drums, works	12.16-12.94
Calcium iodate, drums, delivered	7.38
Calcium iodide, 35-pound drums, works	5.98
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
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 negotiation and/or somewhat different price quotations.

Source: Chemical Marketing Reporter, v. 220, No. 26, Dec. 28, 1981, pp. 30-37.

FOREIGN TRADE

The United States continued to be dependent on imports primarily from Japan and Chile to supplement domestic production. Imports of crude iodine decreased from 6,234,000 pounds in 1980 to 6,099,000 pounds in 1981. U.S. exports are not available because they are grouped in many different categories with other halogens, but when last reported were small. Imports are approximately 75% of domestic consumption. Imports of crude iodine during 1981 were from the following countries: Japan, 81%; Chile, 17%; New Zealand, 1%; and Canada, 1%. Imports from Japan and Chile decreased between 1980 and 1981. The value declared for U.S. Customs increased from $4.63 per pound in 1980 to $5.94 per pound in 1981, a value growth rate of 28% during 1981.

Table 2.—U.S. imports for consumption of resublimed iodine in 1981, by country

(Thousand pounds and thousand dollars)

Country	Quantity	Value
Canada	(1)	1
Germany, Federal Republic of	(1)	1
Japan	32	238
Netherlands	(1)	(1)
Sweden	3	23
Total	35	263

[1]Less than 1/2 unit.

Source: U.S. Department of Commerce, Bureau of the Census.

Table 3.—U.S. imports for consumption of crude iodine, by country

(Thousand pounds and thousand dollars)

Country	1979		1980		1981	
	Quantity	Value	Quantity	Value	Quantity	Value
Canada	--	--	--	--	68	291
Chile	1,342	4,314	1,124	5,669	1,014	6,239
Germany, Federal Republic of	--	--	(1)	(1)	--	--
Indonesia	13	40	--	--	--	--
Japan	4,838	14,073	5,062	22,894	4,929	29,153
Korea, Republic of	--	--	42	253	--	--
Mexico	1	2	--	--	--	--
New Zealand	--	--	--	--	88	548
United Kingdom	7	25	6	31	--	--
Total	6,201	18,454	6,234	[2]28,848	6,099	36,231

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

Source: U.S. Department of Commerce, Bureau of the Census.

WORLD REVIEW

Chile.—Sociedad Química y Minera de Chile operated two nitrate mines, Pedro de Valdivia and Maria Elena, which produced crude iodine (99.6%). Production of iodine as a coproduct of nitrates increased as improved recovery techniques were applied and the iodine plant was expanded.[10]

Borax is recovered before iodine as a byproduct because it can interfere with the purification of the iodine. Recovery of the borax was being tested by pilot projects using solvent reaction.

The Maria Elena plant uses a modified Guggenheim process with a brine wash on the tailings and concentrating the weak solution by solar evaporation. The tailings solution contained 0.3 to 0.6 gram per liter of iodine. The process provided flexibility and increased iodine recovery.

The Pedro de Valdivia plant operates at a rate of 3.7 million pounds of iodine per year. The feed from the mine averages 0.04% iodine. Pedro de Valdivia (which started production of iodine in 1931) uses the Guggenhein process.

Reserves were estimated to total between 1.8 and 3.5 million pounds.[11] Reserves of iodine in overburden and wastedumps could contain close to 300 million pounds of iodine. Total iodine reserves in solid minerals could be as high as 9 million pounds of which about 2 million pounds is proven.[12]

A paper on the geology and origin of the nitrate deposits discussed the formation of the iodine. It is believed that local sources including the spray and evaporation from the Pacific Ocean and volcanic emission in the nearby Andes Mountains may have been a major source of iodine. The existence of the iodine is due to favorable accumulations and preservation of the deposit.[13]

France.—Pechiney Ugine Kuhlmann confirmed negotiations to sell its chemical division. One of the two consistently profitable parts of the company were the halide (including iodides) portion.[14]

Indonesia.—Ise Chemical Industries Co., Ltd., continued to be a producer of iodine in Indonesia. The primary problem with marketing was the low quality of the iodine. The iodine is produced in East Java at a plant located at Mojokerto. Iodine-bearing brines averaging 100 to 150 milligrams per liter have been found at many places in the oil belt of Neocene to Pleistocene Age sediments in East Java.

Japan.—Production of crude iodine in Japan, which produces approximately 55% of the world iodine requirements, continued to be affected by environmental and economic difficulties. Output in 1981 remained well below the 1972 record of 16.5 million pounds. Japan had a nameplate capacity of over 19 million pounds. During 1981, 83% of the world's iodine production came from the Southern Kanto Gasfield of the Chiba Prefecture. Ise Chemical has become Japan's leading iodine producer with a capacity of approximately 9 million pounds.

Five Japanese companies operated 17 plants to produce iodine. Six of the plants produced iodine by an ion-exchange process. The remaining plants used the air-blowout process.

The iodine produced in Japan is dissolved in brine accompanied by natural gas. The brine is believed to be derived from seawater and contains a maximum of 160 milligrams per liter of iodine. All of the iodine produced in Japan occurs in dry-type gases, natural gas associated with water.[15]

In 1981, exports of Japanese iodine declined to 12 million pounds. Export values increased to an average $5.40 per pound. Japan exported to 36 countries, of which the European Economic Community accounted for 47%; the United States, 38%; India, 4%; and Canada, 3%.[16]

United Resources announced an investment in Okinawa Natural Gas Development Co. (tentative name) to manufacture iodine. Plans were to produce 441,000 to 551,000 pounds per year of iodine by 1983.

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

(Thousand pounds)

Country[2]	1977	1978	1979	1980[p]	1981[e]
Chile	4,092	4,237	5,313	5,734	5,926
China	800	1,000	1,000	1,000	1,000
Indonesia	26	[r]15	55	55	55
Japan	13,448	13,228	13,779	14,332	15,136
U.S.S.R.[e]	[r]4,400	[r]4,400	4,400	4,400	4,400
United States	W	W	W	W	W
Total	[r]22,766	[r]22,880	24,547	25,521	26,517

[e]Estimated. [p]Preliminary. [r]Revised. W Withheld to avoid disclosing company proprietary data.
[1]Table includes data available through June 9, 1982.
[2]In addition to the countries listed, the Federal Republic of Germany is known to have produced elemental iodine in 1976 and may have continued to do so during 1977-81, but output is not officially reported and available information is inadequate for formulations of reliable estimates of output levels. New Zealand also produces elemental iodine, but production data are not available.

The iodine occurs in brines in gas reservoirs of Upper Miocene Age. Tests of the brines show iodine concentration between 40 and 110 parts per million. One test well had iodine concentrations between 76 and 91 parts per million over 350 feet of strata.[17]

New Zealand.—The largest iodine reserves in the world are in New Zealand. There is an extensive distribution of similar sediments to those producing iodine in Japan (post Middle Miocene).[18]

U.S.S.R.—Substantial deposits of salts were reported in the Inder salt dome of Western Kazakhstan. The dome is 6 miles deep and contains rock salt, potassium, magnesium, iodine, nitrates, and borates.

TECHNOLOGY

West Chemical Products, Inc., announced a major advance in using iodine as a microbiocide. The patented biocide permits smaller quantities of costly iodine in germicides, sanitizers, and disinfectants. Besides a reduction in cost, the lower quantities of iodine will reduce potential absorption of iodine by the skin of animals and humans. West Chemical has patented the low-iodine technology and intends to market the iodine product worldwide. The low-iodine product is now being marketed in hand-wash compositions and topical solutions. West Chemical expects to introduce other products by yearend.[19]

Tennessee Eastman Co. continued plans to produce acetic anhydride from coal using a new process that will bypass the formation of acetic acid. The plant was to be completed in 1982 and be onstream in 1983. The process makes methanol from syngas by the Lurgi process. The methanol reacts with acetic acid to produce methyl acetate. The methyl acetate is carbonylated to acetic anhydride. The catalyst, which was not identified, is modified by a picaline (group VIII metal) and is promoted by methyl iodide.[20]

The FDA requested submission of a new drug application for KI in oral form for use as a thyroid-blocking agent. The request was seriously considered after the release of radioactive iodine (I^{131}) on March 28, 1979, became the most severe nuclear accident in the Nation's history at Three Mile Island, Pa. Health problems which could be expected from the radioactive iodine release were investigated. The potential use of KI is to reduce the uptake of radioiodides. To be effective, it would be necessary to administer KI within 2 hours of exposure.[21]

Studies have shown that the iodine that escapes from light-water reactor accidents is not the elemental form but a metal iodide, probably cesium iodide.[22] Oxidation of the iodide can occur to yield the iodate ion, which is nonvolative. It is significant that the issuance of thyroid-blocking agents is not required.[23]

Other studies and research were conducted on iodine during 1981. Studies on iodine-125 showed selective concentration of triiodothyronine with excess triiodothyronine. Thyroid hormones may affect behavior and activity of the automatic nervous system.[24] Sodium iodide scintillation crystals on photomultiplier tubes can detect gamma rays, neutrons, and charged particles. A 72-tube unit was built for Oak Ridge National Laboratory.[25] Radiochemical damage from decaying iodine-125 occurred within 15 to 20 angstroms of the site. Deoxyribonucleic acid strand damage was detectable up to 70 angstroms from the decay site.[26] Sodium iodide-thalium doped crystals are used to change gamma rays to light in open or cased drill holes. The crystals usually last 2 to 3 years. The doped crystals are used to detect induced radiation to help in lithological interpretations in exploration of ore bodies.[27]

MEERSCHAUM[28]

Crude or block meerschaum was not imported in 1981. Imports of crude or block meerschaum in 1980, all from the United Kingdom, totaled 3,793 pounds with a customs declared value of $17,720. The unit value of this imported material was $4.67 per pound. Somalia and the Federal Republic of Germany have been the previous major suppliers to the United States. Crude or block meerschaum is mined chiefly in Somalia, Tanzania, and Turkey.

Although Turkey is a major producer of crude or block meerschaum, State laws have prohibited exports of uncarved material since 1975. The block material was used by companies in New York and Ohio for manufacturing of smokers' pipes.

QUARTZ CRYSTAL[29]

Production of natural quartz crystal in 1981 was estimated to be 175,000 pounds. Reported cultured quartz crystal production decreased from 757,000 pounds in 1980 to 660,000 pounds in 1981. Consumption of both natural and cultured electronic- and optical-grade quartz crystal decreased significantly in 1981 and totaled 296,000 pounds compared with 410,000 pounds in 1980. Imports of natural quartz crystal dropped to 389,000 pounds in 1981 compared with 816,000 pounds in 1980. Exports of natural quartz increased to 127,000 pounds compared with 91,000 pounds exported in 1980, while exports of cultured quartz decreased from 219,000 pounds in 1980 to 125,000 pounds in 1981.

Legislation and Government Programs.—At yearend 1981, the total defense materials inventory of natural electronic-grade quartz crystal was 2.1 million pounds, of which 1.49 million pounds of stockpile grade was excess to the stockpile goal. Sales of natural quartz crystal by GSA during 1981 totaled 48,000 pounds.

Table 5.—Salient electronic- and optical-grade quartz crystal statistics in the United States

(Thousand pounds and thousand dollars)

	1977	1978	1979	1980	1981
Production:					
Mine[1]	606	317	314	[e]400	[e]175
Cultured quartz	583	329	575	757	660
Imports of natural quartz crystal:[2]					
Quantity	265	165	428	816	389
Value	$394	$459	$216	$402	$233
Exports of electronic- and optical-grade quartz crystal:					
Natural:					
Quantity	370	NA	NA	91	127
Value	$1,371	NA	NA	$366	$490
Cultured:					
Quantity	133	NA	NA	219	125
Value	$2,634	NA	NA	$3,209	$4,600
Total:					
Quantity	[3]502	NA	NA	310	$252
Value	$4,005	NA	NA	$3,575	$5,090
Consumption of quartz crystal	280	261	284	[r]410	296
Natural (electronic and optical grade)	56	24	15	[r]17	14
Cultured	224	237	269	393	282

[e]Estimated. [r]Revised. NA Not available.
[1]Includes lasca and some specimen and jewelry material.
[2]Includes electronic grade, optical grade, and lasca (a feedstock for growing cultured quartz).
[3]Data do not add to total shown because of independent rounding.

DOMESTIC PRODUCTION

In 1981, various grades of natural quartz were produced in Arkansas by Coleman Crystal, Inc., Jessieville, Ark., and Burrows Mining Co. and Ocus Stanley, both in Mount Ida, Ark. Total natural quartz production was estimated to be 175,000 pounds in 1981, down significantly from the 1980 estimated production of 400,000 pounds.

In 1981, U.S. production of cultured quartz crystal, for use in the quartz-cutting industry, totaled 660,000 pounds from seven companies in five States, a decrease of 12.8% compared with 757,000 pounds produced by seven companies in 1980. The producers were Motorola, Inc., Chicago, Ill.; Electro Dynamics Corp. and Thermo Dynamics Corp., both in Shawnee-Mission, Kans.; Western Electric Co., Inc., North Andover, Mass.; Sawyer Research Products, Inc., Eastlake, Ohio; Bliley Electric Co., Cortland, Ohio (plant in Pennsylvania); and P. R. Hoffman Co., Carlisle, Pa.

CONSUMPTION AND USES

U.S. consumption of lasca (a grade of nonelectric natural quartz primarily used as a feedstock for growing cultured quartz crystal) by seven crystal growers in 1981 was 852,000 pounds, a 17% decrease from

1,026,000 pounds reported in 1980.

Reported consumption of both natural and cultured electronic- and optical-grade quartz crystal in 1981 totaled 296,000 pounds, 27.8% less than the 410,000 pounds consumed in the previous year. Of the total 1981 consumption, natural quartz was 14,000 pounds compared with 17,000 pounds in 1980, and cultured quartz was 282,000 pounds compared with 393,000 pounds in 1980.

In 1981, 37 companies in 15 States reported consumption of quartz crystal. Of the 1981 total, 33 companies consumed only cultured quartz crystal, 1 consumed natural quartz crystal only, and 3 consumed both natural and cultured material.

STOCKS

Reported industry stocks of quartz crystal (cultured and natural electronic- and optical-grade) totaled approximately 125,000 pounds at yearend 1981. Of this total, 61,000 pounds was natural and 64,000 pounds was cultured. Compared with yearend 1980 stocks, natural quartz crystal stocks had decreased by 9,000 pounds and cultured quartz had decreased by 18,000 pounds.

PRICES

The average reported value of lasca consumed for production of cultured quartz crystal in 1981 was $0.61 per pound. The average value for cultured quartz crystal, based on reported sales of 199,297 pounds in 1981, was $43.34 per pound. Of the total 1981 sales, the value of "as grown" crystal was $38.15 per pound, and that for "lumbered" crystal was $44.68 per pound.

FOREIGN TRADE

U.S. exports of cultured (electronic- and optical-grade) quartz crystal in 1981 totaled 125,000 pounds, a decrease of 43% from that of 1980. U.S. Customs value of the 1981 exports was $4.6 million or $36.80 per pound. Japan and the Federal Republic of Germany remained the principal recipients of high-quality cultured quartz crystal exports receiving 58,000 and 49,000 pounds, respectively. Approximately 36,000 pounds at an average value of $3.73 per pound was also exported under the cultured crystal classification.

U.S. exports of natural (electronic- and optical-grade) quartz crystal in 1981 were estimated to be 127,000 pounds, an increase of 40% over that of 1980. U.S. Customs value of the 1981 exports was $490,000 or $3.86 per pound. Approximately 65,000 pounds was valued at an average of $4.64 per pound. Leading countries receiving natural quartz crystal valued at over $4.00 per pound were, in descending order, Hong Kong, Japan, Switzerland, and the Federal Republic of Germany. Approximately 849,000 pounds at an average custom value of $2.57 per pound was also exported in 1981 under the classification of natural quartz crystal.

U.S. imports of natural quartz, all of which was designated as "Crude Brazilian Pebble" in 1981, totaled 389,000 pounds, a decrease of 52% from that of 1980. U.S. Customs value of the 1981 imports was $233,000 or $0.60 per pound. Brazil was the only principal source of imported natural quartz crystal. Canada was the only other source of imports providing 124 pounds valued at $1,700.

STAUROLITE[30]

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 was produced in the United States commercially in 1981 by E. I. du Pont de Nemours & Co. 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 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 rate of thermal expansion, high-thermal conductivity, and high-melting point. It is also used as an abrasive for impact finishing metallic shapes and sandblasting buildings under the trade names "Starblast" (80 mesh) and "Biasill" (90 mesh), as well as a coarser grade (55 mesh).

Quantitative production data are withheld to avoid disclosing company proprietary data, but the 1981 output of staurolite decreased 9% from that of 1980; shipments decreased 39% in tonnage and increased 1% in price per ton from those of 1980. Domestic productive capacity was 135,000 tons to 160,000 tons per year in 1981.

Staurolite was also produced in India in small quantities and had been produced sporadically by other nations.

STRONTIUM[31]

Domestic consumption of primary strontium on a carbonate basis was 28,188 short tons in 1981 compared with 23,940 short tons in 1980. Imports of strontium minerals were 49,699 tons in 1981 and 38,646 tons in 1980. Imports of various strontium compounds were 4,644 tons in 1981.

Legislation and Government Programs.—Government stockpiles contained 13,415 tons of nonstockpile-grade celestite (strontium sulfate) at yearend 1981, unchanged from that of 1980. This material was available for disposal throughout the year, but no sales were made.

DOMESTIC PRODUCTION

Strontium minerals have not been produced commercially in the United States since 1959. However, a number of firms produced strontium compounds from imported celestite.

Table 6.—Major producers of strontium compounds in 1981

Company	Location	Compounds
Barium and Chemicals, Inc	Steubenville, Ohio	Various.
Chemical Products Corp	Cartersville, Ga	Carbonate.
FMC Corp	Modesto, Calif	Carbonate and nitrate.
M & T Chemicals, Inc	Baltimore, Md	Various.
Mallinckrodt, Inc	St. Louis, Mo	Do.
Milwhite Co., Inc	Houston, Tex	Sulfate.
Mineral Pigments Corp	Beltsville, Md	Chromate.

CONSUMPTION AND USES

Domestic consumption of strontium in the manufacture of various primary strontium compounds increased to 28,188 short tons in 1981 on a strontium carbonate basis, of which 75% was consumed as strontium sulfate or processed celestite. Distribution of primary strontium compounds by end use is shown in table 7. In terms of end use in 1981, 65% of the total was consumed in television picture tubes, 15% in pyrotechnics, 5% in ferrites, 4% in purifying electrolytic zinc, and 4% in pigments. Additional amounts were consumed directly as crude celestite in all 3 years (1979-81), usually in pigments (white filler) or in purifying electrolytic zinc. Miscellaneous uses included plastics, toothpaste, pharmaceuticals, paint, florescent lights, electronic components, drilling mud, welding fluxes, and the making of electrolytic zinc metal. Small quantities of strontium metal were produced by research companies.

Table 7.—Distribution of primary strontium compounds, by end use

(Percent)

End use	1979	1980	1981
Ferrite ceramic magnets	10	5	5
Pigments and fillers	4	4	4
Purifying electrolytic zinc	7	5	4
Pyrotechnics and signals	16	12	15
Television picture tube faceplates	57	67	65
Other	6	7	7
Total	100	100	100

PRICES

Yearend prices for 1981 quoted in the Chemical Marketing Reporter[32] were as follows: Strontium carbonate—glass grade, bags, truckloads, works, 28 to 28.75 cents per pound; and strontium nitrate—bags, carlots, works, $24 per 100 pounds. Prices for strontium minerals are usually determined by direct negotiations between buyer and seller and are seldom published. The average value of imported strontium minerals at foreign ports was $64.51 per ton in 1981, up $8.95 from that of 1980.

FOREIGN TRADE

Imports of strontium minerals in 1981 increased from 38,646 tons in 1980 to 49,699 tons in 1981. Almost all of the material was imported from Mexico in both years. Imports of various strontium compounds increased to 4,644 tons in 1981. The Federal Republic of Germany was again the principal source of compounds, providing 2,775 tons to the United States in 1981, compared with 2,100 tons in 1980. Quantitative data on U.S. exports of strontium compounds were not available. During June 1981, the U.S. International Trade Commission made a final determination that an industry in the United States was being materially injured by reason of strontium nitrate imports from Italy, which were being sold at less than fair value (dumped).[33]

Table 8.—U.S. imports for consumption of strontium minerals,[1] by country

Country	1980		1981	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Mexico	37,817	$2,086	48,046	$2,937
Spain	829	60	1,653	269
U.S.S.R	(2)	1	--	--
Total	38,646	2,147	49,699	3,206

[1]Strontianite (strontium carbonate) and celestite (strontium sulfate).
[2]Less than 1/2 unit.

Table 9.—U.S. imports for consumption of strontium compounds and metal, by country

Country	1980		1981	
	Pounds	Value	Pounds	Value
Strontium carbonate, not precipitated:				
Germany, Federal Republic of	--	--	11,023	$2,571
United Kingdom	--	--	58	2,275
Total	--	--	11,081	4,846
Strontium carbonate, precipitated:				
Canada	317,462	$70,560	--	--
France	--	--	1,596,117	365,442
Germany, Federal Republic of	4,118,201	920,465	4,485,345	1,117,482
Netherlands	--	--	39,682	9,826
United Kingdom	2	364	3	886
Total	4,435,665	991,389	6,121,147	1,493,636
Strontium chromate:[1]				
Canada	483,525	525,411	867,750	1,041,755
France	--	--	6,070	7,939
Total	483,525	525,411	873,820	1,049,694
Strontium nitrate:				
Germany, Federal Republic of	--	--	2,334	7,920
Ireland	29	628	--	--
Italy	816,363	269,100	2,124,681	766,236
United Kingdom	--	--	5	886
Total	816,392	269,728	2,127,020	775,042
Strontium compounds, n.s.p.f.:				
Germany, Federal Republic of	82,460	66,421	51,749	16,501
Japan	45,205	32,922	68,342	49,475
United Kingdom	577	1,783	1,705	10,484
Total	128,242	101,126	121,796	76,460
Strontium metal, unwrought: Canada	38,651	334,653	33,382	330,571
Grand total	r5,902,475	r2,222,307	9,288,246	3,730,249

rRevised.
[1]Imported as strontium chromate pigment (TSUS 473.19).

WORLD REVIEW

Deposits of strontium minerals are numerous throughout the world, but over three-quarters of known world production is usually from five major producing countries. In the 1977-81 time period, Canada dropped from the ranks of major producers and Iran rose into the ranks. Mexico, Spain, Turkey, and Algeria have continued as major producers.

On a worldwide basis, it has been estimated that strontium compounds are used in the following percentages: 80% as carbonate, 15% as nitrate, and 5% for all other strontium compounds including chromate, phosphate, chloride, and many others in smaller quantities.[34]

Worldwide consumption of strontium compounds has also been estimated with the United States taking about 45%, Japan about 30%, Europe about 20%, and others about 5%. Distribution of strontium compounds by end use has been reported as color televisions about 50%, ferrite magnets about 20%, pyrotechnics about 15%, and other uses the remaining 15%.[35]

Japan.—It has been reported that Japanese demand for strontium compounds increased markedly from 16,645 short tons in 1976 to 36,210 short tons in 1980.[36] Ninety-nine percent of this increase in demand was accounted for by strontium carbonate, primarily for use in television tubes and ferrite magnets.

Qatar.—The Qatar Industrial Development Centre (QIDC) announced the discovery of a large celestite deposit in Qatar. According to QIDC, the discovery followed a comprehensive geological survey of the area.[37]

Table 10.—Strontium minerals: World production, by country[1]

(Short tons)

Country[2]	1977	1978	1979	1980[p]	1981[e]
Algeria	5,622	6,418	[e]6,000	6,000	6,000
Argentina	925	1,317	134	295	295
Iran[e 3]	11,000	16,535	8,818	5,516	5,520
Italy	[e]770	402	1,866	1,160	1,100
Mexico	50,302	[r]37,725	43,562	[4]41,356	40,785
Pakistan	402	239	680	551	330
Spain	12,120	15,430	19,840	20,945	22,000
Turkey	[e]18,300	[r]19,290	[e]19,840	17,637	16,535
United Kingdom	5,622	4,740	6,615	1,100	1,100
Total	105,063	[r]102,096	107,355	94,560	93,665

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through June 2, 1982.
[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]Year beginning March 21 of that stated.
[4]Reported figure.

TECHNOLOGY

In some applications, alloys are being used instead of steel to reduce the weight of the final product. A strontium additive is now being used in Japan to improve the casting properties of an aluminum-silicon alloy.[38] Strontium increases the strength and heat resistance of the final material. Japan Metals and Chemicals are marketing this alloy under the name of Sutoal. The new alloy was developed using techniques that Union Carbide Corp. first used in 1972. The alloy composition is approximately 10% Sr, 18% Si, 65% to 70% Al, and less than 3% Fe. This alloy was developed for vehicle wheels, but may have many other applications.

WOLLASTONITE[39]

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, and various other applications.

U.S. wollastonite shipments in 1981 were 14% higher in tonnage than in the previous year. Actual data are withheld to avoid disclosing company proprietary data. The two continuing producers were NYCO, a division of Processed Minerals, Inc., Essex County, N.Y.; and R. T. Vanderbilt Co., Inc., Lewis County, N.Y. In 1981, Pfizer, Inc., reported wollastonite production in southern California after a lull in activity.

Silicas and silicates, such as wollastonite, received increased attention in house paint in 1981, as they reduce the need of more costly ingredients such as titanium dioxide. Also, they are more versatile than more traditional extenders and improve flowability and hiding power of the paint.[40]

A survey by C. H. Kline & Co., an industrial market-research company, reported a continuing shift to compounded plastic materials in place of all-resin systems. Growth for wollastonite as a filler in polypropylene was forecast at 10% or more per year. Growth for other minerals and fiberglass was forecast at from 5% to 8.5%.[41]

A journal article discussed production of wollastonite in Finland, India, Mexico, and the United States. Also discussed were its uses in ceramics, sanitary ware, tile bodies, plastics, paints, etc.; synthetic wollastonite production; the wollastonite market in the United States and Western Europe; and the future of wollastonite.[42]

In Lappeenranta, Finland, at the open pit mine of Paraisten Kalkki Oy, a model 16 photometric sorting machine had been separating wollastonite from limestone and amphibolite since August 1978. The machine had been handling material in the size range of 45 to 85 millimeters. Two new machines, which were to enable the company to treat all run-of-mine ore in the 20- to 140-millimeter size, were on order from Ore Sorters (Canada) Ltd., a subsidiary of the RTZ Ore Sorters Group.[43]

A $21,000 grant to study the feasibility of using wollastonite in the manufacture of whitewares was awarded to Alfred University by the New York State Science and Technology Foundation. The study will attempt to determine if wollastonite can be used, instead of quartz, to improve the properties of whitewares.[44]

Chemical Marketing Reporter, December 21, 1981, quoted the price of paint-grade wollastonite, 400-mesh, bagged, in carload lots, f.o.b. works, as $106 per ton, and 325-mesh material as $90 per ton. The American Paint & Coatings Journal, December 28, 1981, quoted the price of paint-grade wollastonite, 400-mesh, in carload lots, f.o.b. plant, as $116 per ton, and 325-mesh material as $90 to $100 per ton.

ZEOLITES[45]

Production of natural zeolites in the United States in 1981 was estimated to have approximately doubled the 5,000 tons of 1980. The 4,000 tons produced and processed by newcomer Teague Minerals Co. of Adrian, Oreg., was the large reason for the surge. There were other indications of continued growth including the Anaconda Co.'s conversion of a copper facility in Weed Heights, Nev., to a zeolite-processing plant.

A national business publication wrote about zeolites for the first time.[46] It described the present $400 million market, mostly synthetic zeolites, projected to $2 billion within 10 years, and cited the natural zeolite producers as expecting one-half of that market for their less pure and less costly products. It stated that Anaconda had identified 170 potential applications for the natural zeolites and that Occidental Minerals Corp. has an extensive test program underway exploring the use of zeolites as soil amendments. Occidental wants to prevent the loss to the atmosphere or water of plant nutrients, especially ammonia. They are also exploring the utility of zeolites as a pesticide carrier that would extend the effective use time after application.

The article also indicated that Pfizer had obtained permission from the FDA to use a synthetic zeolite as an antibiotic carrier in animal feeds. The industry feels that this probably presages permission for other uses of synthetic and possibly natural zeolites. Apparently, synthetics sold for $500 to $6,000 per ton and natural zeolites were being priced at $300 to $400 per ton. The lower priced synthetic zeolites ($500 per ton) were being used to replace some of the phosphates in detergents, at a 30% savings over the phosphates. Proctor & Gamble Co. is using them in Tide, Oxydol, and Bold detergents.

A Canadian periodical reported the imminent startup of two different manufacturing companies using zeolites as an integral part of their products.[47] The previously reported Zeopower Co. is finalizing plans for a joint venture solar collector plant with Toyo Sash Co., a major Japanese aluminum product manufacturer. The plant would be situated in the Phoenix, Ariz., area. Woods Solar Systems, Ltd., of Calgary, Alberta, Canada, was to start the manufacturing in October 1981 of zeolite heat-storage systems reportedly able to store solar or other heat at efficiencies greater than current systems. The company was designing mobile systems that can capture waste industrial energy and transport it to such use sites as greenhouses, lumber kilns, schools, and other light industry or commercial plants. They predict that the system can be used to store off-peak electricity.

The largest of the "methane from landfill" companies objected strenuously to the U.S. Department of Energy (DOE) grants for research on its already proven technology. The Getty Oil Co., through its subsidiary, Getty Synthetic Fuels, operates three of the nine functional methane recovery units using zeolites. A potential of 55 billion cubic feet per year of gas is available from just the 200 largest U.S. landfills.[48]

The market for synthetic zeolites continues to grow. The newest U.S. producer, PQ Corp., broke ground in Kansas City, Kans., for its 65,000-ton-per-year facility aimed at the merchant market for replacing phosphates in detergent. PQ estimated the domestic market will be at 125,000 to 135,000 tons per year within the next 10 years. Large-scale production of the detergent zeolites had reduced the price to $500 per ton, making them cost effective with reference to the replaced sodium tripolyphosphate at $700 to $710 per ton.

Italy had the highest concentration of new plant activity based on the belief that legislation would be forthcoming requiring reduction in the phosphate content of detergents. Published market estimates varied widely, with three reports citing respectively a 40,000- to 60,000-metric-ton market, a 20,000-ton market, and a 1,000-ton market.[49] Regardless of market size, Degussa GmbH of the Federal Republic of Germany planned to construct a new plant of initial capacity of 30,000 tons per year with expansion capability to 60,000 tons per year. Montedison announced plans to construct a $15 million plant, and Caffaro announced plans to import zeolites from France's Produits Chimique Ugine Kuhlmann while actively considering plant construction.

Several research projects were underway to improve the Fischer-Tropsch reaction that is used by South African Coal, Oil, and Gas Corp., Ltd. (SASOL), the energy company owned by the Government of the Republic of South Africa, to make gasoline from synthesis gas produced from coal. Mobil Oil Co. proposed to use Fischer-Tropsch chemistry to produce the feedstock for its ZSM-5 zeolite catalyst route to gasoline. Mobil postulated that 65% of its product would be 90-octane gasoline; the SASOL process produces a product containing 42% of 55-octane gasoline. A mining magazine reported that DOE had entered into a cooperative agreement with Mobil for 50-50 sharing of the cost of a plant to use the technology.[50]

Use of zeolites for hydrogen storage has been postulated.[51] The article indicated that at elevated temperature and pressure the hydrogen molecules can be forced into the beta cages of zeolites and that they will remain there under ambient conditions. Some advantages over the metal-hydride storage method were detailed.

Zeolites played a large part in the radioactive materials clean up at Three Mile Island.[52] The main water contaminants were cesium 134, cesium 137, and strontium 90. The consensus was that, using a homogenous mixture of 4.8 cubic feet per vessel of Union Carbide's IONSIV IE 96 and 3.2 cubic feet of their Linde A, a workable unit was made. Operating reports by the Nuclear Regulatory Commission during decontamination showed effective removal of 99.999% of cesium (both isotopes) and 99.59% of the strontium 90.

An engineering magazine article detailed the use of molecular sieves to separate paraffin isomers from a light naphtha feed.[53] This technique allows refinery upgrading of the gasoline octane number in an economical manner.

The zeolite literature continued to proliferate at a high rate. Chemical Abstracts Service has a selective pick on zeolite related publications and patents and has been producing several hundred abstracts per year. The October 1981 issue of Clays and Clay Minerals was devoted exclusively to zeolite papers. A quarterly on zeolites appeared.[54]

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