SULFUR

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Through its major derivative sulfuric acid, sulfur ranks as one of the more important elements used as an industrial raw material. It is of prime importance to every sector of the world's industrial and fertilizer complexes. Sulfuric acid production is the major end use for sulfur, and consumption of sulfuric acid has been regarded as one of the best indexes of a nation's industrial development. More sulfuric acid is produced in the United States every year than any other chemical; nearly 48 million metric tons, equivalent to about 16 million tons of elemental sulfur, were produced, slightly more than that of 1995 (Chemical and Engineering News, 1997).

Domestic production of sulfur remained level, although shipments, consumption, U.S. trade, and prices decreased. The United States maintained its position as the leading producer and consumer of sulfur and sulfuric acid. The quantity of sulfur recovered during the refining of petroleum and the processing of natural gas continued the upward trend established in 1939, the second year the U.S. Bureau of Mines (USBM) published data on the production of this type of sulfur in its Minerals Yearbook. This data series has continued at the U.S. Geological Survey (USGS) since the minerals information activities of the USBM were transferred in 1996. The production of sulfur by using the Frasch process was about 8% lower than that of 1995, which was due to intentional cutbacks to improve the balance between supply and demand. Frasch production data were estimated on the basis of company reports published by the single company that continues to produce Frasch sulfur. Total production of sulfur from all sources was level, shipments declined, and stocks increased.

Byproduct sulfuric acid from the Nation's nonferrous smelters and roasters, essentially mandated by laws concerning sulfur dioxide emissions, supplied a significant quantity of sulfuric acid to the domestic merchant (commercial) acid market. Production increased slightly.

World sulfur production was slightly lower than that of 1995. Frasch production was significantly lower because of production decreases in Poland and the United States. Elemental sulfur production from recovered sources, primarily during the processing of natural gas and petroleum products, increased slightly. More than three-quarters of the world's elemental sulfur production came from recovered sources; the quantity of sulfur supplied from these sources was dependent on the world demand for fuels and petroleum products, not on the demand for sulfur.

World sulfur consumption remained about the same with no change in the way it was divided among fertilizer production and in a myriad of industrial uses. World trade of elemental sulfur decreased about 3% from the levels recorded in 1995. U.S. sulfur inventories increased nearly 10%, as did worldwide inventories of elemental sulfur. *(See table 1 and figure 1.)*

Production

***Elemental Sulfur.*—**Production was slightly lower than that of 1995. Shipments were slightly lower in quantity and 23% lower in value owing to a substantial decrease in the average price of elemental sulfur.

Production statistics are collected on a monthly basis and published in the USGS sulfur monthly Mineral Industry Surveys. Of the 139 operations to which survey requests were sent, all but 1 responded, representing nearly 100% of the total production shown in table 1. Production data for the nonrespondent was obtained from the State of Texas (Texas Comptroller of Public Accounts, 1997).

Frasch.—Native sulfur associated with the caprock of salt domes and in sedimentary deposits is mined by the Frasch hot-water method, in which the native sulfur is melted underground and brought to the surface by compressed air. Freeport Sulphur Co. operated two Frasch mines, one each in Louisiana and Texas. Freeport's operations included the Culberson Mine in west Texas; sulfur-forming and sulfur-loading facilities in Galveston, TX, and Tampa, FL; and the Main Pass Mine, 27 kilometers offshore Louisiana in the Gulf of Mexico. Production at Main Pass and Culberson averaged about 5,440 and 2,490 tons per day, respectively, throughout the year (Freeport McMoRan Resource Partners, 1997, p. 4).

Recovered.—Recovered elemental sulfur, a nondiscretionary byproduct from petroleum refining, natural gas processing, and coking plants, was produced primarily to comply with environmental regulations that were applicable directly to emissions from the processing facility or indirectly by restricting the sulfur content of the fuels sold or used by the facility. Recovered elemental sulfur was produced by 59 companies at 137 plants in 26 States, 1 plant in Puerto Rico, and 1 plant in the U.S.Virgin Islands. Most of these plants were of relatively small size, with only 26 reporting annual production exceeding 100,000 tons. By source, 72% was produced at petroleum refineries or satellite plants treating refinery gases and coking plants. The remainder was produced at natural gas treatment plants. The largest recovered-sulfur producers were Exxon Co. U.S.A., Standard Oil Co. (Indiana), Standard Oil Co. (California), Mobil Oil Corp., Star Enterprises, and Shell Oil Co. The 47 plants owned by these companies accounted for 58% of recovered elemental sulfur output during the year. *(See tables 2 and 3.)*

Byproduct Sulfuric Acid.—Production at copper, lead,

molybdenum, and zinc roasters and smelters amounted to 12% of the total domestic production of sulfur in all forms. Seven acid plants operated in conjunction with copper smelters, and six were accessories to lead, molybdenum, and zinc smelting and roasting operations. The seven largest acid plants (all at copper mines) accounted for 87% of the output. The largest producers—Phelps Dodge Corp., Broken Hill Proprietary Co., Ltd. (formerly Magma Copper Co.), ASARCO Incorporated, Cyprus Miami Mining Corp., and Kennecott Corp.—operated seven copper plants. *(See table 4 and figure 2.)*

Consumption

Domestic consumption of sulfur in all forms was about 8% lower than that of 1995. Of the sulfur consumed, 83% was obtained from such domestic sources as elemental sulfur (72%) and byproduct acid (11%) compared with 78% in 1995 and 77% in 1994. The remaining 17% was supplied by imports of recovered elemental sulfur (12%) and sulfuric acid (5%). The USGS collected end-use data on sulfur and sulfuric acid according to the Standard Industrial Classification of industrial activities.

Sulfur differs from most other major mineral commodities in that its primary use is as a chemical reagent rather than as a component of a finished product. This use generally requires that it be converted to an intermediate chemical product prior to its initial use by industry. The largest sulfur end use, sulfuric acid, represented 86% of reported consumption with an identified end use. Some identified sulfur end uses were tabulated in the "Unidentified" category because these data were proprietary. Data collected from companies that did not identify shipment by end use also were tabulated as "Unidentified." Although there are no supporting data, it could be reasonably assumed that a significant portion of the sulfur in the "Unidentified" category was shipped to sulfuric acid producers or was exported.

Because of its desirable properties, sulfuric acid retained its position as the most universally used mineral acid and the most produced and consumed, by volume, inorganic chemical. Reported U.S. consumption of sulfur in sulfuric acid (100% basis) decreased in 1996, primarily owing to the decrease in sulfur used in the production of phosphatic fertilizers. Although reported data for total sulfur consumption indicated a slight increase, apparent consumption figures indicate that actual consumption was probably lower than that of 1995.

Agriculture was the largest sulfur-consuming industry despite a decrease to 8.4 million tons compared with 9 million tons reported in 1995. Reported consumption in phosphatic fertilizers was 10% lower than that of 1995, reflecting decreased production and temporary shutdowns at a number of phosphoric acid plants. Actual consumption for phosphate fertilizer probably did not decrease that much because some or most of the "Unidentified" sulfur consumption is believed to have been for that end use. On the basis of export data from the Bureau of the Census, the estimated quantity of sulfur needed to manufacture exported phosphatic fertilizers decreased 14% to 4.9 million tons; reports from the Fertilizer Institute, however, stated that the reported phosphate fertilizer exports were believed to be understated, and the Department of Commerce was conducting an investigation to resolve the problem (Vrooman, 1997).

The second largest end use for sulfur was in petroleum refining and other petroleum and coal products. On the basis of events in the petroleum refining industry, an increase in petroleum refining uses would be expected; the significant increases reported for the use of elemental sulfur in this category, however, indicate inconsistencies in reporting. Demand for sulfuric acid in copper ore leaching, the third largest end use, decreased 8%. *(See tables 5, 6, and 7.)*

According to the 1996 canvass reports, company receipts of spent or contaminated sulfuric acid for reclaiming totaled 1.8 million tons. This figure was believed to be significantly higher than reported; most of the acid is, however, recycled by companies that produce acid for consumption in their own operations and also recycle acid used in their plants. Because it does not involve sales or shipments of the spent sulfuric acid, many companies do not handle the acid recycling as a separate process and thus do not report it in the USGS consumption survey. The petroleum refining industry is believed to be the largest source and consumer of recycled acid for use in its alkylation process.

Stocks

Yearend inventories held by Frasch and recovered elemental sulfur producers increased nearly 10% from those of 1995. On the basis of apparent consumption of all forms of sulfur, combined yearend stocks amounted to approximately an 18-day supply compared with a 15-day supply in 1995 and a 32-day supply in 1994. *(See table 1.)*

Prices

The reported contract prices for elemental sulfur, exterminal Tampa, FL, began the year at $74 to $77 per ton, decreased incrementally until they reached a low of $59 to $61 in early July, rose to $61 to $63 per ton at the end of October, and remained steady through the remainder of the year. On the basis of total shipments and value reported to the USGS, the average value of shipments for all elemental sulfur was $34.48 per ton, which was 21% lower than that of 1995.

Foreign Trade

Exports of elemental sulfur from the United States, including the U.S. Virgin Islands, were about 6% lower than those of 1995 and 22% lower in value because of significant price decreases for U.S. material. The average unit value of exported elemental sulfur decreased from $73 per ton to $65, a decrease of 17%. According to the Bureau of the Census, exports from the west coast were 685,000 tons, or 80% of total U.S. exports.

The United States continued to be a net importer of sulfur—

imports exceeded exports by 765,000 tons. Recovered sulfur from Canada and Mexico delivered to U.S. terminals and consumers in the liquid phase furnished about 93% of all U.S. sulfur import requirements. Total elemental sulfur imports decreased about 35% in quantity; imports by rail from Canada decreased 35%, and waterborne shipments from Mexico were 11% lower than those of 1995. Imports from several other countries comprised about 17% of all imported sulfur. The value of elemental sulfur imports decreased 58%.

Imports from Canada were significantly lower because of the low prices. In such a situation, Canadian producers may limit their shipments to the United States to avoid the possibility of an antidumping complaint. The U.S. Department of Commerce (DOC) completed an investigation concerning a complaint of this type against Canadian sulfur producers filed by Pennzoil Sulphur Co. in 1994 regarding the period from December 1, 1992, to November 30, 1993. DOC found that sales were made at discounts ranging from 11.79% to 42.8%. Antidumping duties were assessed against the companies in question (Green Markets, 1996).

The United States also had significant trade in sulfuric acid. Sulfuric acid exports decreased 31% from those of 1995. Acid imports were 10 times greater than exports. Canada was the source of 77% of U.S. acid imports, most of which were probably byproduct acid from smelters. Canadian shipments to the U.S. were shipped by rail. The remainder came primarily by ship from Europe, Latin America, and Japan. The tonnage increased 8% from that of 1995; the value of imported sulfuric acid decreased by 16%. *(See tables 8, 9, 10, and 11.)*

World Review

World production was slightly lower than that of 1995; consumption was believed to be about the same. Prices were down. Cutbacks were made at U.S. and Polish Frasch operations to maintain a better supply/demand balance worldwide. Recovered sulfur production and byproduct sulfuric acid production were virtually unchanged. Even with slightly decreased production, supply surpassed demand; worldwide sulfur inventories increased to 16.2 million tons, of which 60% was stockpiled in Canada.

Industry Structure.—The global sulfur industry remained divided into two sectors. In the discretionary sector, the mining of sulfur or pyrites is the sole objective; this voluntary production of native sulfur or pyrites is based on the orderly mining of discrete deposits, with the objective of obtaining as nearly a complete recovery of the resource as economic conditions permit. In the nondiscretionary sector, sulfur or sulfuric acid is recovered as an involuntary byproduct, the quantity of output subject to demand for the primary product irrespective of sulfur demand. Nondiscretionary sources represented about 76% of the sulfur in all forms produced worldwide.

Poland and the United States were the only countries that produced 1 million tons or more of native sulfur by using either the Frasch method or conventional mining methods. Small quantities of native sulfur were produced in Asia, Europe, North America, and South America. The importance of pyrites to the world sulfur supply has significantly decreased; China and Spain were the only countries in the top 15 sulfur producers whose primary sulfur source was pyrites. About 71% of all pyrites production was in these countries.

Recovered elemental sulfur was the predominant source of sulfur in Canada, France, Germany, Iran, Russia, Saudi Arabia, and the United States. Additionally, recovered elemental sulfur was an important source in Japan and Mexico.

International sulfur trade was dominated by a limited number of exporting countries. Canada, Saudi Arabia, Poland, and Germany, in descending order of importance, exported more than 1 million tons of elemental sulfur each and accounted for 64% of sulfur trade. Major sulfur importers, in descending order, were Morocco, the United States, India, Tunisia, and Brazil, all with imports of more than 1 million tons.

Australia.—Sulfuric acid production in Australia in 1996 was more than 1.2 million tons from smelters and 330,000 tons from one plant burning elemental sulfur. Most of the acid was used for the production of fertilizers, and additional sulfuric acid requirements were met through imports. Metal leaching was expected to be a growth area for sulfur consumption, especially in Western Australia. Three nickel-leaching projects were under consideration. Two of the projects would use acid purchased from a sulfuric acid plant that was completed in late 1996 at a nickel smelter in Kalgoorlie, and the other would produce its own acid from elemental sulfur. Initial production from the Kalgoorlie plant was expected to be exported (Wellington, 1996).

A large sulfuric acid plant was planned in conjunction with the Mount Isa Mines Ltd. copper smelter in Queensland. Upon completion, the operation will have the capacity to recover 1.2 million tons of sulfuric acid per year with an expected annual production of 800,000 tons. Full commissioning of the sulfuric acid plant was expected in early 2000. The acid will provide the necessary acid imports for the new Queensland Fertilizer Project about 150 kilometers south of Mount Isa (Sulphur, 1997).

The Queensland plant was not considered to be a possible source of acid for the Western Australia nickel projects because the cost of shipping across the country would be prohibitive.

Canada.—Second only to the United States in sulfur production in all forms, Canada led the world in the production of byproduct sulfur, exports of elemental sulfur; and stockpiled material. Canadian stocks were 9.7 million tons at the end of 1996, an increase of 15% from those of the previous year (Prud'homme, 1997).

There were 48 sulfur recovery operations at natural gas processing plants in Alberta and 5 in British Columbia. Most Canadian sulfur production was in these provinces, and production continued to expand. The capacity for sulfur recovery in these provinces was nearly 35,000 tons per day, a figure that translates into an annual capacity of almost 16 millions tons per year of sulfur from natural gas processing alone. Additional sulfur was recovered from oil sands in these provinces. Although sulfur recovery from oil sands is less than

10% of total Canadian sulfur production, the potential of further development of the vast oil sands reserves presents the possibility of a further 10 million tons per year of Canadian supply. Investigations were being conducted into alternative methods of dealing with the sulfur from these processes in the hope of finding a technology, perhaps reinjection, that reduces the amount of sulfur that results from sour gas and oil sands processing (Horseman, 1996).

Byproduct sulfuric acid from metal smelters was a predominant source of sulfur in other forms. Small in comparison to the quantity of sulfur produced in elemental form, smelter acid represents further growth for sulfur production in all forms. Increases in smelter acid production were expected from improvements at existing operations and a new nickel smelter in Newfoundland to be completed in 2000 or 2001 (Prud'homme, 1997).

China.—China was the leading producer and consumer of pyrites as the source of sulfur for sulfuric acid production. Indications were, however, that China was beginning to turn to imported elemental sulfur as an alternative raw material. Canada and Japan were the primary suppliers of the elemental sulfur. Continued growth was expected in this market (Sulphur, 1996a).

Iraq.—Although Iraqi sulfur production did not have an impact on the world market, the potential exists for the country to return to its role as a leading exporter when the United Nations sanctions are lifted. Sulfur production capacity at the Mishraq Mine was believed to be more than 1 million tons per year. When sanctions are lifted, production, much of which would be exported, is expected to approach full capacity quickly.

Kazakstan.—Tengizchevroil, established in 1993 as a joint oil and gas venture of Tengizmunaigaz, the government-owned gas and oil company, and Chevron Overseas Co., a division of Chevron Corp., developed the Tengiz oil field, the largest oil field discovered in the world in the last 20 years. Mobil became a 25% partner in the project in 1996.

Located on the southern side of the North Caspian Basin, Tengiz reserves were estimated to be more than 3 billion tons of crude oil and 1,800 billion cubic meters of associated gas, both of which have high hydrogen sulfide contents, thus necessitating sulfur removal. The field was discovered in 1979, but the high sulfur content delayed its development until technology was developed that could successfully treat the high sulfur-content gas concentrates. In late 1996, the fourth 250,000-ton-per-year sulfur recovery unit was completed, bringing the sulfur recovery capacity to 1 million tons per year. Total sulfur recovery at the project is 99% or higher.

Marketing Tengiz products was difficult because Kazakstan's infrastructure was inadequate to support full production at the oil field. The situation had improved by the end of 1996, and much of the oil was reaching markets in Russia and Finland. Sulfur was shipped via Tengizchevroil's fleet of rail tank cars or stockpiled. Sulfur-crushing operations were suspended because of safety and environmental concerns (Freter, 1997). Agreements were reached between the governments of Kazakstan, Oman, and Russia and a number of international oil companies to expand the Russian oil pipeline system to transport Tengiz oil to the port of Novorossiisk on the Black Sea. Tengiz oil production was estimated to be 4.4 million tons, and the partnership planned to expand production to 50 million tons by 2000. The pipeline from Tengiz was essential to fulfilling these expectations. Sulfur production in 1996 was estimated to be about 500,000 tons (Sulphur, 1996b).

Because sulfur sales from Tengiz have been difficult owing to the distances the material must be transported to reach major markets, research was being conducted to identify domestic markets. Possible markets were toxic and hazardous waste stabilization, transportation infrastructure improvements with sulfur paving materials, other construction applications, and reclamation of sodic soils to improve agricultural productivity (Kalb and others, 1996).

Poland.—One of the few remaining producers of native sulfur, Polish Frasch production was 45% lower than that of 1992, the year when production was highest. Further cuts were planned for 1997, which could reduce planned production to 1.2 million tons. These reductions were necessary because the high cost of Frasch production made Polish sulfur prices uncompetitive in world markets. Plans were progressing for privatization of Ciech AgroSulphur, the government-owned sulfur trading company (Sulphur, 1997). *(See table 12.)*

Outlook

The longer term outlook for the sulfur industry was unchanged—increased output with slower growth in consumption resulting in variable prices and growing inventories. Specific details are much more difficult to predict. Which producers will suffer most from the oversupply situation is a question that can be answered only over time.

World sulfur demand is forecast to increase at an annual rate of about 2% per year for the next 10 years. World demand is projected to approach 60 million tons in 2001 and increase to nearly 67 million tons in 2006. Growth of sulfur consumption in the United States is expected to be modest. The phosphate fertilizer industry has not announced expansions; expectations for growth will reflect only slight improvements in efficiency at operating plants and periodic changes in production caused by opening and closing of marginal facilities in response to market conditions. Industrial consumption should remain fairly steady with the only serious possibility of increases in nonferrous ore leaching.

Almost 66% of sulfur consumption in the United States was for agricultural uses. More than 80% of U.S. agricultural sulfur demand and almost 60% of world agricultural sulfur consumption were for the manufacture of phosphoric acid. World demand for phosphate fertilizers is forecast to increase at a rate of about 2.7% per year for the next 10 years. It is assumed that more than 80% of the growth will be for the production of phosphoric acid to produce high-analysis fertilizers; the increased production will directly affect world sulfur demand. Consumption of sulfur for phosphate fertilizer

manufacture in the United States is divided into two components—demand for phosphate fertilizers consumed by domestic farmers and demand for exported phosphate fertilizers. Fertilizer consumption is reasonably stable, and exports are expected to remain strong.

The broad-spectrum industrial or nonagricultural sulfur use category accounted for less than 33% of U.S. sulfur consumption and about 40% of world sulfur demand. Although significant variations in demand for the diverse elements within this broad category are expected in the United States and other geographic areas, world industrial demand is expected to grow at an average rate of 1.1% per year during the next 10 years, reaching about 29 million tons.

The necessity for the removal of sulfur from solid, liquid, and gaseous effluents for environmental protection has caused the production of sulfur and sulfur compounds from these sources to exceed production from primary sources of supply. The long-term prospect is that 85% or more of the world sulfur supply will come from environmentally regulated sources and that output from these sources will be produced regardless of world sulfur demand. As a result, it is probable that no new operation that produces sulfur as its primary product will be developed and that more voluntary operations will be curtailed. In 1980, voluntary sources of production—Frasch, native sulfur, and pyrites—accounted for 50% of the world output of about 55 million tons. In 1996, these same sources supplied only 24% of the world production of 52.4 million tons.

Voluntary production of sulfur should continue to decline while recovered sulfur production will continue to expand at a faster pace than demand. As more countries enact and enforce environmental legislation on a par with North American and European laws, tremendous new quantities of sulfur could be recovered. More-stringent regulation and compliance will be long-term developments and cannot be quantified at the current time, but changes are inevitable. In fact, the impact of projects to improve sulfur recovery, especially at copper smelters, is already being felt. World sulfur production is predicted to reach nearly 64 million tons in 2001 and 68 million tons in 2006.

References Cited

Chemical and Engineering News, 1997, Production—Mixed in 1996: Chemical and Engineering News, v. 75, no. 25, p. 42.

Freeport McMoRan Resource Partners, Limited Partnership, 1997, Freeport McMoRan Resource Partners 10-K Report 1996: Securities and Exchange Commission, 21 p.

Freter, G.P., 1997, Potential of Tengizchevroil partnership: Sulphur, no. 248, p. 18-23.

Green Markets, 1996, U.S. DOC determines preliminary margins for Canadian sulfur shipments to the U.S.: Green Markets, v. 20, no. 35, p. 8-9.

Horseman, Martin, 1996, West Canadian sulphur—Lots more on the horizon: Sulphur, no. 246, p. 29-39.

Kalb, P.D., Michaud, W.R., Dyer, R.S., Diamante, J.M., Hecht, A.D., and McBee, W.C., 1996, Kazakstan–Opportunities for cleaning the environment and expanding the use of sulphur in construction materials and agricultural applications: Sulphur Markets Today and Tomorrow, International Symposium, Washington, DC, March 27-19, 1996, Proceedings, sec. 3, p. 1-17.

Prud'homme, Michel, 1997, Sulphur: Natural Resources Canada Canadian Minerals Yearbook 1996, 15 p.

Sulphur, 1996a, China's sulphur imports: Sulphur, no. 246, p. 9.

———1996b, Kazakhstan–Mobil joins Tengiz as Caspian pipeline agreement signed and sulphur production grows: Sulphur, no. 244, p. 11-13.

———1997, Australia–MIM and WMCF to develop Mount Isa acid: Sulphur, no. 248, p. 11.

Texas Comptroller of Public Accounts, 1997, Sulphur tax for 1996–Taxable long tons produced: Texas Comptroller of Public Accounts, 3 p.

Vrooman, H.L., 1997, July 1997 import/export data: Fertilizer Record, September 18, p. 1.

Wellington, V.S., 1996, Development of sulfuric acid production and demand in Australia, *in* Sulphur 96 Vancouver, Preprints, October 20-23, 1996: London, British Sulphur Publishing, p. 55-61.

SOURCES OF INFORMATION

U. S. Geological Survey Publications

Sulfur. Ch. in United States Mineral Resources, U.S. Geological Survey Professional Paper 820, 1973.

Sulfur. Ch. in Mineral Commodity Summaries, annual.

Sulfur. Ch. in Minerals Yearbook, annual.[1]

Sulfur. Mineral Industry Surveys, monthly.[1]

Other

Chemical and Engineering News, weekly.

Chemical Engineering, weekly.

Chemical Market Reporter, weekly.

Chemical Week, weekly.

European Chemical News (London), weekly.

Fertilizer Focus (London), monthly.

Fertilizer International (London).

Fertilizer Markets, weekly.

Green Markets, weekly.

Industrial Minerals (London).

The Oil and Gas Journal, weekly.

Phosphorus & Potassium (London), bimonthly.

Sulfur. Ch. in Mineral Facts and Problems, U.S. Bureau of Mines Bulletin 675, 1985.

Sulphur (London), bimonthly.

Sulphur Newsletter—Fertecon North America Sulfur Service.

[1]Prior to January 1996, published by U.S. Bureau of Mines.

TABLE 1
SALIENT SULFUR STATISTICS 1/

(Thousand metric tons, sulfur content, and thousand dollars unless otherwise specified)

	1992	1993	1994	1995	1996
United States:					
Production:					
Frasch	2,320	1,900 2/	2,960 e/	3,150 e/	2,900 e/
Recovered 3/	7,050	7,720 4/	7,160 e/	7,250	7,470
Other forms	1,300	1,430	1,380	1,400	1,430
Total	10,700	11,100	11,500 e/	11,800 e/	11,800 e/
Shipments:					
Frasch	2,600	1,480 2/	W	W	W
Recovered 3/	7,090	7,580 4/	10,300 5/	10,700 5/	10,400 5/
Other forms	1,300	1,430	1,390	1,400	1,430
Total	11,000	10,500	11,700	12,100	11,800
Exports:					
Elemental 6/	966	656	899	906	855
Sulfuric acid	46	46	46	56	38
Imports:					
Elemental	2,730	2,040	1,650	2,510	1,620
Sulfuric acid	649	797	696	628	678
Consumption, all forms	13,400	12,600	13,100	14,300 r/	13,200
Stocks, Dec. 31: Producer, Frasch and recovered	809	1,380	1,160	583	639
Value:					
Shipments, f.o.b. mine or plant:					
Frasch	$151,000	$101,000	W	W	W
Recovered 3/	$315,000	$189,000	$293,000 5/	$469,000 5/	$359,000 5/
Other forms	$76,100	$63,100	$86,100	$85,500	$85,900
Total	$543,000	$335,000	$379,000	$555,000	$445,000
Exports, elemental 6/ 7/	$69,700	$39,700	$48,400	$66,200	$51,700
Imports, elemental	$130,000	$49,800	$62,000	$143,000	$60,500
Price, elemental, dollars per metric ton, f.o.b. mine or plant	$48.14	$31.86	$28.60	$43.74	$34.48
World: Production, all forms (including pyrites)	50,700	51,200 r/	53,700 r/	53,200 r/	52,400 e/

e/ Estimated. r/ Revised. W Withheld to avoid disclosing company proprietary data; included with "Recovered."

1/ Data are rounded to three significant digits except prices.

2/ Includes 10 months of Frasch sulfur data. Two remaining months of Frasch data included with "Recovered" to avoid disclosing company proprietary data.

3/ Includes Puerto Rico and the U.S. Virgin Islands.

4/ Includes corresponding Frasch sulfur data for November and December.

5/ Includes corresponding Frasch sulfur data.

6/ Includes exports from the U.S. Virgin Islands to foreign countries.

7/ Includes value of exports from the U.S. Virgin Islands to foreign countries.

TABLE 2
RECOVERED SULFUR PRODUCED AND SHIPPED IN THE UNITED STATES, BY STATE 1/

(Thousand metric tons and thousand dollars)

State	1995			1996		
		Shipments			Shipments	
	Production	Quantity	Value	Production	Quantity	Value
Alabama	396	396	17,500	398	400	14,100
California	800	804	13,200	828	834	6,080
Illinois	331	331	14,700	353	351	8,700
Louisiana	789	W	W	877	W	W
Michigan and Minnesota	258	258	7,060	254	255	749
Mississippi	550	557	12,100	471	468	10,800
New Mexico	41	41	576	44	44	252
North Dakota	57	57	538	50	50	288
Ohio	60	60	2,090	68	68	1,680
Pennsylvania	51	51	1,360	W	W	W
Texas	2,090	2,970 2/	144,000 2/	2,230	3,180 2/	122,000 2/
Washington	114	113	1,330	112	113	899
Wyoming	1,030	1,020	13,700	1,080	1,060	23,600
Other 3/	682	4,060	241,000	706	3,590	170,000
Total	7,250	10,700	469,000	7,470	10,400	359,000

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

1/ Data are rounded to three significant digits; may not add to totals shown.

2/ Includes corresponding Frasch sulfur data.

3/ Includes Arkansas, Colorado, Delaware, Florida, Indiana, Kansas, Kentucky, Louisiana (shipments and value), Montana, New Jersey, Utah, Virginia, Wisconsin, Puerto Rico, and the U.S. Virgin Islands.

TABLE 3
RECOVERED SULFUR PRODUCED AND SHIPPED IN THE UNITED STATES,
BY PETROLEUM ADMINISTRATION FOR DEFENSE (PAD) DISTRICT 1/

(Thousand metric tons)

District and source	1995		1996	
	Production	Shipments	Production	Shipments
PAD 1:				
Petroleum and coke	245	238	217	225
Natural gas	50	50	51	51
Total	295	288	267	276
PAD 2:				
Petroleum and coke	904	899	927	925
Natural gas	58	58	50	49
Total	962	957	977	975
PAD 3: 2/				
Petroleum and coke	2,860	W	3,140	W
Natural gas	1,100	W	982	W
Total	3,970	7,400 3/	4,120	7,070 3/
PAD 4 and 5:				
Petroleum and coke	1,030	1,030	1,090	1,100
Natural gas	999	994	1,010	992
Total	2,030	2,030	2,100	2,090
Total petroleum	5,040	W	5,370	W
Total natural gas	2,210	W	2,090	W
Grand total	7,250	10,700 3/	7,470	10,400 3/

W Withheld to avoid disclosing company proprietary data.

1/ Data are rounded to three significant digits; may not add to totals shown.

2/ Includes Puerto Rico and the U.S. Virgin Islands.

3/ Includes corresponding data from Frasch producers.

TABLE 4
BYPRODUCT SULFURIC ACID 1/ PRODUCED
IN THE UNITED STATES 2/

(Thousand metric tons, sulfur content, and thousand dollars)

Type of plant	1995	1996
Copper 3/	1,210	1,240
Zinc 4/	118	118
Lead and molybdenum 4/	70	68
Total	1,400	1,430
Value	85,500	85,900

1/ Includes acid from foreign materials.
2/ Data are rounded to three significant digits; may not add to totals shown.
3/ Excludes acid made from pyrites concentrates.
4/ Excludes acid made from native sulfur.

TABLE 5
CONSUMPTION OF SULFUR 1/ IN THE UNITED STATES 2/

(Thousand metric tons)

	1995	1996
Total elemental:		
Shipments 3/	10,700	10,400
Exports	906	855
Imports	2,510 r/	1,620
Total	12,300 r/	11,200
Byproduct sulfuric acid:		
Shipments 3/	1,400	1,430
Exports 4/	56	38
Imports 4/	628	678
Total, all forms	14,300 r/	13,200

r/ Revised.
1/ Crude sulfur or sulfur content.
2/ Data are rounded to three significant digits; may not add to totals shown.
3/ Includes Puerto Rico and the U.S. Virgin Islands.
4/ May include sulfuric acid other than byproduct.

TABLE 6
SULFUR AND SULFURIC ACID SOLD OR USED IN THE UNITED STATES, BY END USE 1/

(Thousand metric tons, sulfur content)

SIC 3/	End use	Elemental sulfur 2/ 1995	Elemental sulfur 2/ 1996	Sulfuric acid (sulfur equivalent) 1995	Sulfuric acid (sulfur equivalent) 1996	Total 1995	Total 1996
102	Copper ores	--	--	864 r/	798	864 r/	798
1094	Uranium and vanadium ores	--	--	2 r/	2	2 r/	2
10	Other ores	--	--	93	57	93	57
26, 261	Pulpmills and paper products	W	W	319 r/	343	319 r/	343
28, 285, 286, 2816	Inorganic pigments, paints and allied products, industrial organic chemicals, other chemical products 4/	34	67	170 r/	152	204 r/	219
281	Other inorganic chemicals	132	128	167 r/	154	299 r/	282
282, 2822	Synthetic rubber and other plastic materials and synthetics	W	W	245 r/	270	245 r/	270
2823	Cellulosic fibers, including rayon	--	--	50	47	50	47
283	Drugs	--	--	4	4	4	4
284	Soaps and detergents	9	9	12	19	21	28
286	Industrial organic chemicals	--	--	57 r/	48	57 r/	48
2873	Nitrogenous fertilizers	--	--	88	142	88	142
2874	Phosphatic fertilizers	--	--	8,200	7,380	8,200	7,380
2879	Pesticides	--	--	10	10	10	10
287	Other agricultural chemicals	673	824	29	27	702	851
2892	Explosives	--	--	3	5	3	5
2899	Water-treating compounds	--	--	74 r/	91	74 r/	91
28	Other chemical products	--	--	41	41	41	41
29, 291	Petroleum refining and other petroleum and coal products	395	739	479 r/	525	874 r/	1,260
30	Rubber and miscellaneous plastic products	W	W	--	--	W	W
331	Steel pickling	--	--	7	8	7	8
333	Nonferrous metals	--	--	8	7	8	7
33	Other primary metals	--	--	1	1	1	1
3691	Storage batteries (acid)	--	--	25	33	25	33
	Exported sulfuric acid	--	--	10	6	10	6
	Total identified	1,240	1,770	11,000 r/	10,200	12,200 r/	11,900
	Unidentified	533	807	508 r/	780	1,040 r/	1,590
	Grand total	1,780	2,570	11,500 r/	11,000	13,200 r/	13,500

r/ Revised. W Withheld to avoid disclosing company proprietary data; included with "Unidentified."
1/ Data are rounded to three significant digits; may not add to totals shown.
2/ Does not include elemental sulfur used for production of sulfuric acid.
3/ Standard Industrial Classification.
4/ No elemental sulfur was used in inorganic pigments and paints and allied products.

TABLE 7
SULFURIC ACID FROM SMELTERS SOLD OR USED IN THE UNITED STATES,
BY END USE 1/

(Thousand metric tons of 100% H2SO4)

SIC 2/	Use	1995	1996
102	Copper ores	2,250	2,360
10	Other ores	W	W
26, 261	Pulp mills and other paper products	52 r/	47
28, 281, 282, 283, 286, 2816	Miscellaneous chemicals	143	87
2873	Nitrogenous fertilizers	48	58
2874	Phosphatic fertilizers	505 r/	417
287, 2879	Pesticides and other agricultural chemicals	84	86
2899	Water-treating compounds	76	80
291	Petroleum refining	W	W
3691	Storage batteries (acid)	W	W
33, 331, 333, 1094	Miscellaneous metal usage	23	25
	Unidentified 3/	881 r/	1,190
	Total	4,060 r/	4,340

r/ Revised. W Withheld to avoid disclosing company proprietary data; included with "Unidentified."
1/ Data are rounded to three significant digits; may not add to totals shown.
2/ Standard Industrial Classification.
3/ Includes exports.

TABLE 8
U.S. EXPORTS 1/ OF ELEMENTAL SULFUR, BY COUNTRY 2/

(Thousand metric tons and thousand dollars)

	1995		1996	
Country	Quantity	Value	Quantity	Value
Argentina	36	2,130	4	537
Australia	23	3,250	29	3,450
Bangladesh	26	1,280	--	--
Brazil	116	6,690	50	2,260
Canada	29	4,070	65	6,010
Colombia	9	721	9	668
India	178	9,020	(3/)	4
Indonesia	85	4,530	(3/)	11
Korea, Republic of	27	9,750	4	5,690
Mexico	64	4,540	139	7,370
Morocco	33	1,460	--	--
Senegal	187	9,980	194	7,300
South Africa	1	185	1	302
Tunisia	33	1,320	97	3,280
Other	59	7,240	263	14,900
Total	906	66,200	855	51,700

1/ Includes exports from the U.S. Virgin Islands.
2/ Data are rounded to three significant digits; may not add to totals shown.
3/ Less than 1/2 unit.

Source: Bureau of the Census.

TABLE 9
U.S. EXPORTS OF SULFURIC ACID (100% H2SO4), BY COUNTRY 1/

	1995		1996	
Country	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Argentina	1,000	$116	28	$3
Canada	64,300	4,890	70,200	5,280
China	1,250	225	2,160	464
Costa Rica	697	141	361	18
Dominican Republic	4,570	280	2,550	178
Israel	13,300	858	1,460	433
Japan	630	182	462	144
Korea, Republic of	914	44	204	36
Mexico	45,000	2,310	6,550	930
Netherlands	2,270	78	4,580	245
Netherlands Antilles	5,650	237	12	4
Panama	3,900	156	1,180	57
Saudi Arabia	1,200	64	143	18
Singapore	1,910	380	734	437
Taiwan	3,530	814	497	293
Trinidad and Tobago	5,110	365	7,270	430
United Kingdom	(2/)	3	237	39
Uruguay	3,500	158	--	--
Venezuela	7,550	325	1,520	173
Other	3,880	1,210	17,300	3,170
Total	170,000	12,800	117,000	12,400

1/ Data are rounded to three significant digits; may not add to totals shown.
2/ Less than 1/2 unit.

Source: Bureau of the Census.

TABLE 10
U.S. IMPORTS OF ELEMENTAL SULFUR, BY COUNTRY 1/

(Thousand metric tons and thousand dollars)

Country	1995		1996	
	Quantity	Value 2/	Quantity	Value 2/
Canada	1,630	63,200	1,060	30,400
Mexico	506	29,300	448	21,200
Other	377	50,000	112	8,970
Total	2,510	143,000	1,620	60,500

1/ Data are rounded to three significant digits; may not add to totals shown.
2/ Declared customs valuation.

Source: Bureau of the Census.

TABLE 11
U.S. IMPORTS OF SULFURIC ACID (100% H2SO4), BY COUNTRY 1/

Country	1995		1996	
	Quantity (metric tons)	Value 2/ (thousands)	Quantity (metric tons)	Value 2/ (thousands)
Argentina	3,600	$1,660	2,840	$373
Canada	1,660,000	75,600	1,600,000	59,600
Chile	20,900	462	--	--
Germany	94,400	4,720	167,000	5,630
Japan	23,600	1,930	127,000	5,220
Mexico	95,300	8,540	138,000	5,760
Netherlands	(3/)	10	16,800	400
Spain	--	--	25,800	889
United Kingdom	670	--	78	23
Other	22,700	40	673	123
Total	1,920,000	92,900 r/	2,070,000	78,000

r/ Revised.
1/ Data are rounded to three significant digits; may not add to totals shown.
2/ Declared c.i.f. (cost, insurance, and freight paid by shipper) valuation.
3/ Less than 1/2 unit.

TABLE 12
SULFUR: WORLD PRODUCTION IN ALL FORMS, BY COUNTRY AND SOURCE 1/ 2/

(Thousand metric tons)

Country and source 3/	1992	1993	1994	1995	1996 e/
Canada: Byproduct:					
Metallurgy	931	900	870	860	883 p/
Natural gas	5,769	6,600	7,000	7,100	7,070
Petroleum	235	340	350	380	650
Tar sands	552	590	630	670	407
Total	7,487	8,430	8,850	9,010	9,014 p/
China: e/					
Native	320	330	330	160 r/	170
Pyrites	4,930	5,330	5,870	4,570 r/	4,600
Byproduct, all sources	650	700	700	700	700
Total	5,900	6,360	6,900	5,430 r/	5,470
France: Byproduct:					
Natural gas	770	829	865	825 r/	850
Petroleum	230	278	219	240 r/	250
Unspecified e/	150	150	100	100	100
Total e/	1,150	1,260	1,180	1,170 r/	1,200
Germany:					
Pyrites e/	25	--	--	--	--
Byproduct:					
Metallurgy	23	33	35 e/	20 r/	20
Natural gas and petroleum	1,016	1,137	880 r/	1,000 r/	1,000
Unspecified e/ 4/	100 5/	90	90	90	90
Total e/	1,160	1,261 r/ 5/	1,010 r/	1,110 r/	1,110
Iran: Byproduct: e/					
Metallurgy	50	50	50	50	50
Natural gas and petroleum	700	750	830	840	840
Total	750	800	880 5/	890	890
Iraq: e/					
Frasch	250	250	250	250	250
Byproduct, natural gas and petroleum	100	200	225	225	225
Total	350	450	475	475	475
Japan:					
Pyrites	31	29	4	2 e/	2
Byproduct:					
Metallurgy	1,374	1,383	1,269	1,310 r/	1,300
Petroleum	1,340	1,510	1,550 e/	1,500 e/	1,500
Total	2,745	2,922	2,820 e/	2,810 r/ e/	2,800
Mexico:					
Frasch	710	102	--	--	--
Byproduct:					
Metallurgy e/	817	730	2,014 5/	2,000	2,000
Natural gas and petroleum	775	804	877	882	885
Total e/	2,300	1,640	2,890	2,880	2,890
Poland: 6/					
Frasch	2,329 r/	1,861 r/	2,163 r/	2,425 r/	1,530
Native	562	--	--	--	--
Byproduct:					
Metallurgy	207	220	200 e/	200 e/	200
Petroleum	26	29	25 e/	25 e/	25
Gypsum e/	10	10	10	10	10
Total	3,134 r/	2,120 r/	2,398 r/	2,660 r/ e/	1,769 5/
Russia: e/ 7/					
Native	100	100	80	80	70
Pyrites	390	640	700	750	750
Byproduct, natural gas	2,830	2,680	2,550	2,970	3,000
Other	175	180	175	200	200
Total	3,500	3,600	3,510	4,000	4,020
Saudi Arabia: Byproduct, all sources	2,370	2,400	2,300	2,200	2,000
South Africa:					
Pyrites	296	323	252	159	193
Byproduct:					
Metallurgy	56 e/	81 e/	118	67 r/	80
Petroleum 8/	166	171	209	233	196
Total	518	575	579	459 r/	469

See footnotes at end of table.

TABLE 12--Continued
SULFUR: WORLD PRODUCTION IN ALL FORMS, BY COUNTRY AND SOURCE 1/ 2/

(Thousand metric tons)

Country and source 3/	1992	1993	1994	1995	1996 e/
Spain:					
Pyrites	535 r/	408 r/	436 r/	404 r/	400
Byproduct: e/					
Coal (lignite) gasification	2	2	2	2	2
Metallurgy	258	258	250	250	250
Petroleum	90	100	100	100	100
Total e/	885 r/	768 r/	788 r/	756 r/	752
United States:					
Frasch	2,320	1,900 9/	2,930 e/	3,150 e/	2,900
Pyrites	W	W	(10/)	(10/)	(10/)
Byproduct:					
Metallurgy	1,290	1,430	1,380	1,400	1,430 5/
Natural gas	2,530	2,910 r/ 11/	2,240	2,210	2,100 5/
Petroleum	4,520	4,820	4,920	5,040	5,370 5/
Unspecified	3	3	(10/)	(10/)	(10/)
Total	10,700	11,100 r/	11,500 e/	11,800 e/	11,800
Other countries:	7,778 r/	7,622 r/	7,619 r/	7,526 r/	7,550
Of which:					
Frasch	18	22 r/	21 r/	22 r/	23
Native	1,000	789	618 r/	503 r/	493
Pyrites	1,649 r/	1,297 r/	1,202 r/	1,097 r/	1,060
Byproduct:					
Metallurgy	2,154 r/	2,249 r/	2,213 r/	2,225 r/	2,200
Natural gas	385	390 r/	348	397 r/	398
Natural gas and petroleum, undifferentiated	355	455	794	888	962
Petroleum	1,360 r/	1,542 r/	1,548 r/	1,513 r/	1,540
Unspecified sources	857	879	876 r/	881 r/	875
Grand total	50,700	51,300 r/	53,700 r/	53,200 r/	52,200
Of which:					
Frasch	5,630 r/	4,140	5,360 r/	5,850 r/	4,710
Native	1,980	1,220	1,030	743 r/	733
Pyrites	7,860 r/	8,030 r/	8,460 r/	6,980 r/	7,000
Byproduct:					
Coal (lignite) gasification e/	2	2	2	2	2
Metallurgy	7,160 r/	7,330 r/	8,400 r/	8,380 r/	8,410
Natural gas	12,300	13,400 r/	13,000	13,500 r/	13,400
Natural gas and petroleum, undifferentiated	2,950	3,350	3,610 r/	3,840 r/	3,910
Petroleum	7,970 r/	8,790 r/	8,930 r/	9,030 r/	9,630
Tar sands	552	590	630	670	407
Unspecified sources	4,300	4,400 r/	4,240 r/	4,170 r/	3,970
Gypsum e/	10	10	10	10	10

e/ Estimated. p/ Preliminary. r/ Revised. W Withheld to avoid disclosing company proprietary data; included with "Byproduct: Unspecified sources."

1/ World totals, U.S. data, and estimated data are rounded to three significant digits; may not add to totals shown.

2/ Table includes data available through June 4, 1997.

3/ The term "Source" reflects 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 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 materials. In contrast, byproduct recovery from metallurgical operations, petroleum refineries, and spent oxides are credited to the nation where the recovery takes place, which, in some instances, is not the original source country of the crude product from which the sulfur is extracted.

4/ Data for 1992 represent byproduct production from the eastern states. Production data for 1993-96 represent those of the unified country.

5/ Reported figure.

6/ Official Polish sources report total Frasch and native mined elemental sulfur output annually, undifferentiated; this figure has been divided between Frasch and other native sulfur on the basis of information obtained from supplementary sources.

7/ Sulfur is believed to be produced from Frasch and pyrite and as a petroleum byproduct; however, information is inadequate to formulate estimates.

8/ Includes byproduct production from synthetic fuels.

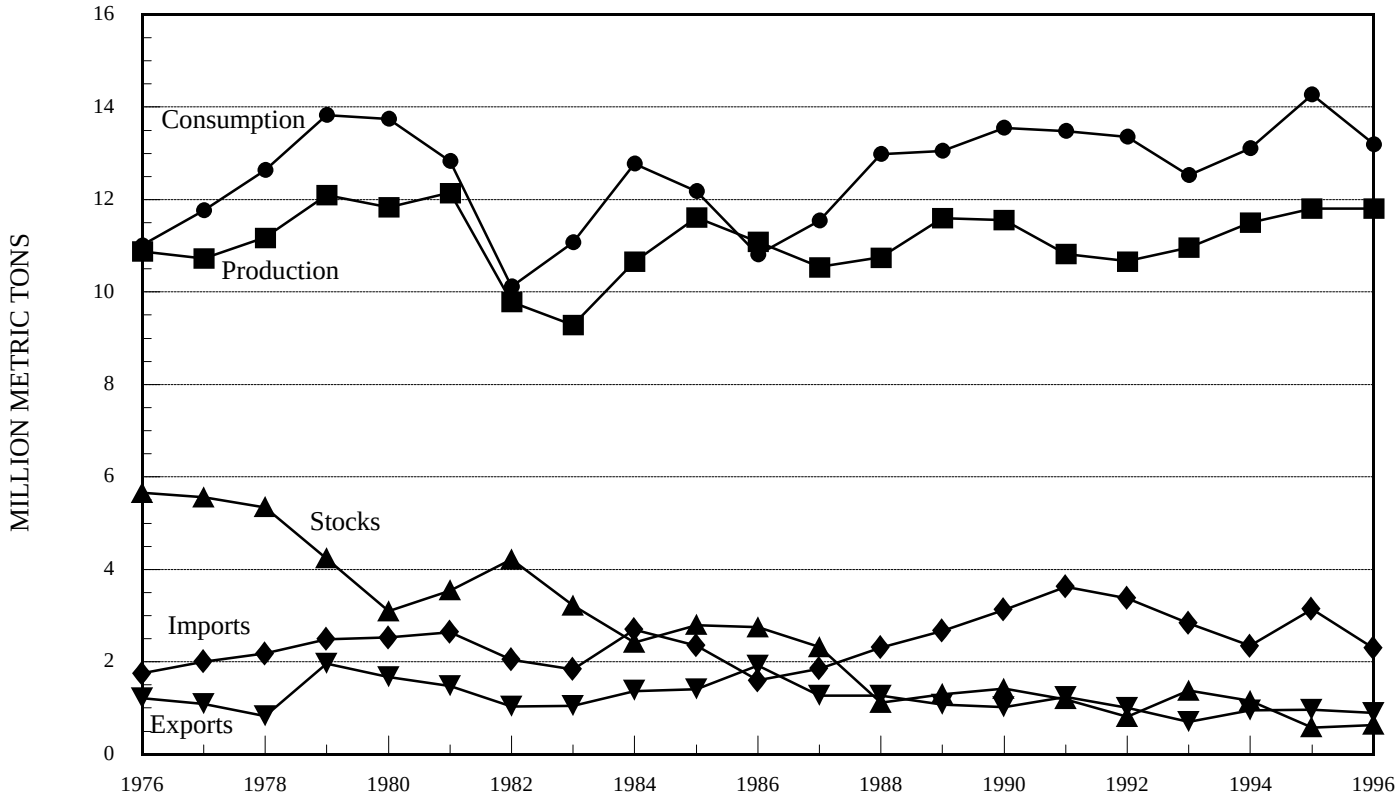
9/ Includes 10 months of Frasch sulfur production data. Two remaining months of Frasch data included with byproduct natural gas data to conform with proprietary data requirements.

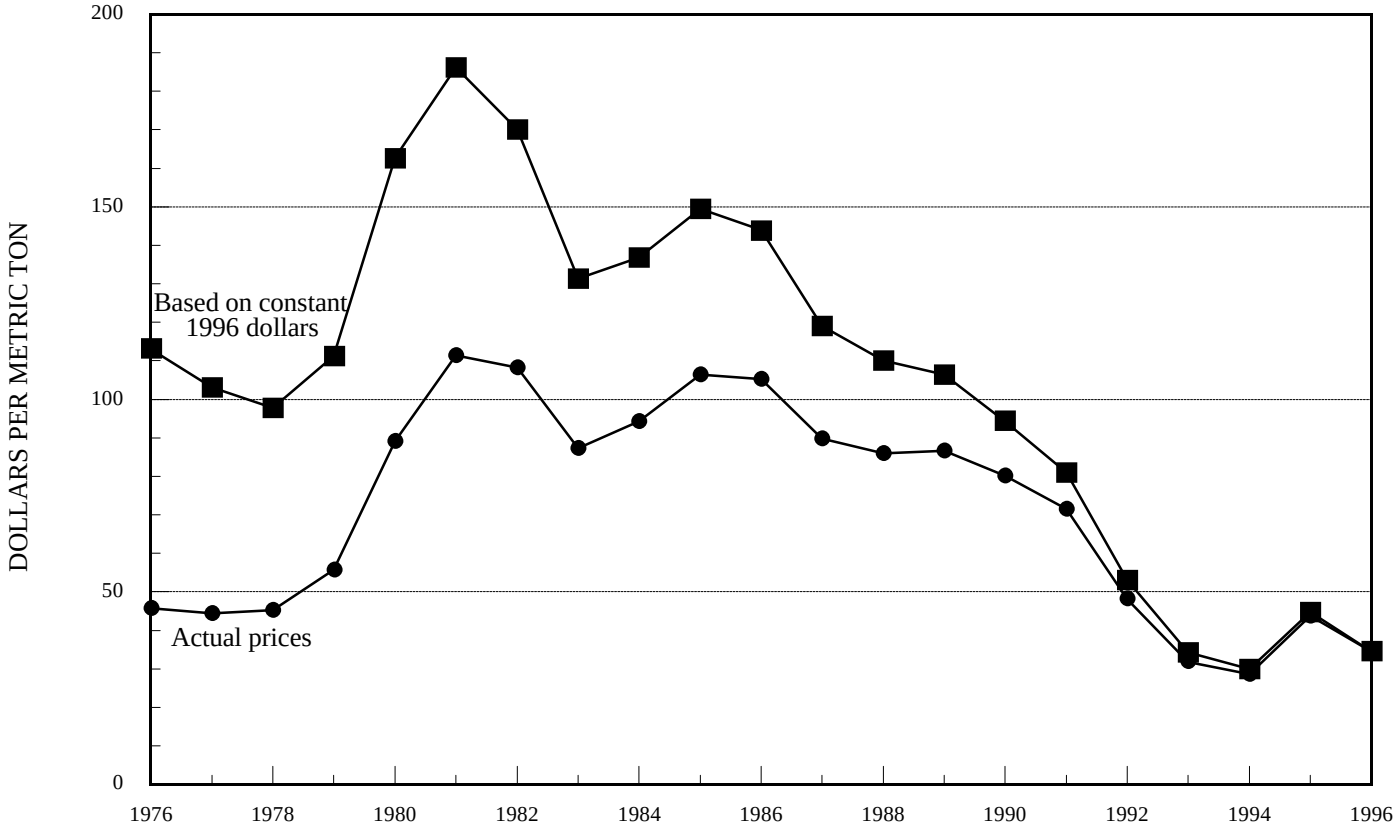
10/ Survey discontinued in 1994; data not available.

11/ Includes Frasch sulfur production data for November and December.

Figure 1

TRENDS IN THE SULFUR INDUSTRY IN THE UNITED STATES

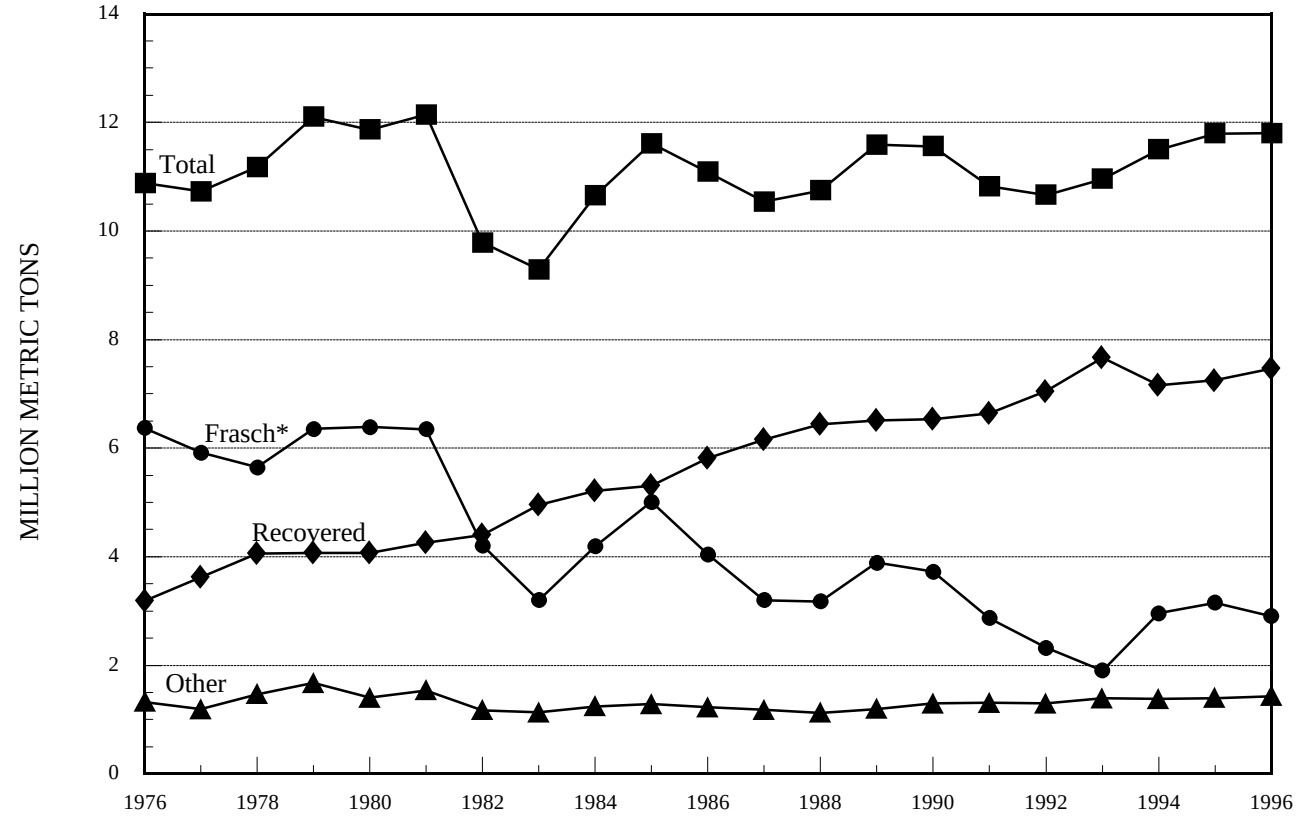


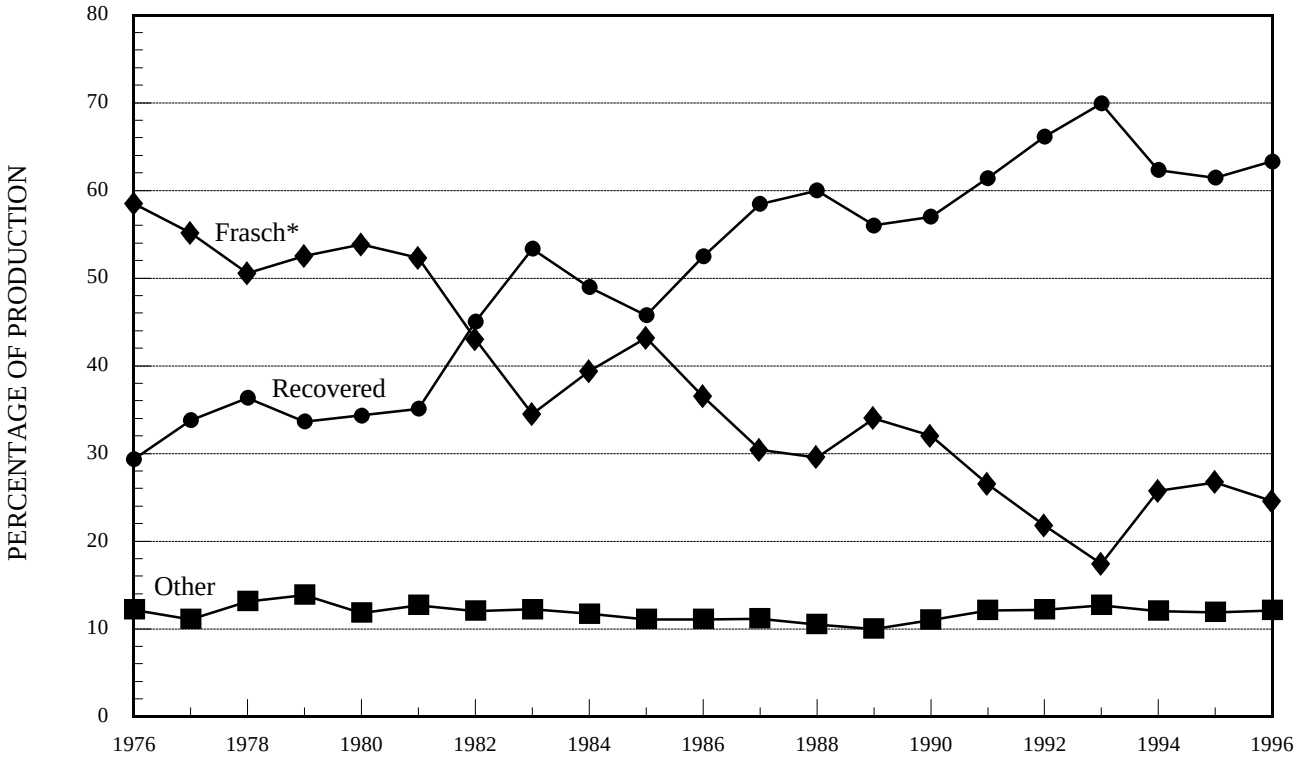


Based on the average reported values for elemental sulfur (Frasch and recovered), f.o.b. mine and/or plant, these prices reflect about 90% of the shipments of sulfur in all forms from 1976 through 1996.

FIGURE 2

TRENDS IN THE PRODUCTION OF SULFUR IN THE UNITED STATES





*Includes 10 months of Frasch data for 1993; the other 2 months are included with recovered sulfur data to conform with proprietary data requirements. Data for 1994-96 are estimates.