SULFUR

By Joyce A. Ober

Domestic survey data and tables were prepared by Maria Arguelles, statistical assistant, and the world production table was prepared by Glenn J. Wallace, international data coordinator.

The U.S. sulfur industry was characterized by company mergers, fluctuating prices, and supply constraints in 1998. The only remaining Frasch sulfur producer merged with an oil and gas producer. Several mergers of major oil producers who were also sulfur producers took place during the year, and more were expected in 1999. Prices varied significantly geographically, and trends to increased prices in the United States were contradicted with falling prices in international markets. Intentional production cutbacks at sulfur mines and adverse weather conditions in the Gulf of Mexico reduced native sulfur production significantly; to a lesser degree, weather negatively affected production at oil refineries in the area also. These factors combined to limit sulfur availability in the U.S. Gulf Coast region.

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; more than 43 million metric tons (Mt), equivalent to about 14 Mt of elemental sulfur, were produced, slightly less than that of 1997 (Chemical and Engineering News, 1998).

Domestic sulfur production was slightly lower, shipments and consumption were slightly higher, imports increased, and prices decreased (table 1, figures 1 and 2). 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. Sulfur produced by using the Frasch process was significantly lower than that of 1997. The reasons for the decrease were the intentional cutbacks by Freeport-McMoRan Sulphur Inc., the only domestic Frasch producer, to improve the balance between supply and demand (Fertilizer Markets, 1998a) and the technical problems at the company's off-shore Frasch operation as a result of a hurricane in the Gulf of Mexico (McMoRan Exploration Co., 1999, p. 21-22); Frasch production data were estimated on the basis of company reports published by Freeport and other public information. Because total production of sulfur from all sources was lower as a result of the severe decrease in Frasch production, increased shipments resulted in a sharp reduction in stocks.

Byproduct sulfuric acid from the Nation's nonferrous smelters and roasters, produced as a result of laws restricting sulfur dioxide emissions, supplied a significant quantity of sulfuric acid to the domestic merchant (commercial) acid market. Production from this sector increased.

World sulfur production decreased slightly in 1998 (table 1). Frasch production was significantly lower because of production cutbacks in Poland and the United States. Elemental sulfur production from recovered sources, primarily during the processing of natural gas and petroleum products, increased. 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, nonferrous metals, and petroleum products, not for sulfur.

World sulfur consumption remained about the same with no change in the way it was divided among fertilizer production and a myriad of other industrial uses. World trade of elemental sulfur increased slightly from the levels recorded in 1997. U.S. sulfur inventories decreased, but worldwide inventories of elemental sulfur were slightly higher.

Production

Elemental Sulfur.—Production statistics are collected on a monthly basis and published in the U.S. Geological Survey (USGS) sulfur monthly Mineral Industry Surveys. Of the 136 operations to which survey requests were sent, all responded, representing 100% of the total production shown in table 1. In 1998, production was 4% lower than that of 1997. Shipments were up slightly, but the value of shipments was lower owing to a decrease in the average unit value of elemental sulfur. Trends in sulfur production are shown in figure 2.

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'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 was intentionally curtailed at both mines in an attempt to balance supply and demand and to maintain prices. Freeport announced plans to close Culberson permanently in September (Fertilizer Markets, 1998a); the plans, however, were delayed as a result a hurricane that passed through the Gulf of Mexico in September prompting the evacuation of the platform at Main Pass for 3 days. When production restarted, nine of the previously producing wells required redrilling because they had frozen during the shut down. Only four of the nine wells had been replaced by yearend. Because of the problems at Main Pass, production was maintained at Culberson into 1999. Late in the year, Freeport merged with McMoRan Oil and Gas Co. to become Freeport-McMoRan Sulphur Inc., a wholly owned subsidiary of McMoRan Exploration Co. (McMoRan Exploration Co., 1999, p. 21-22).

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 sulfur was produced by 52 companies at about 120 plants in 26 States and 1 plant in the U.S. Virgin Islands; most of these plants were small, with 28 reporting annual production exceeding 100,000 metric tons (t). By source, 74% of recovered elemental sulfur production came from 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, by descending order of production, were Exxon Corp., Amoco Corp., Chevron Corp., Mobil Oil Corp., Citgo Petroleum Corp., and Motiva Enterprises L.L.C. The 31 plants owned by these companies accounted for 55% of recovered sulfur output during the year. As a result of the same storm that affected sulfur production at the off-shore Frasch operation, a refinery in Pascagoula, MS, one of several owned by Chevron Corp., was damaged, causing the refinery and its sulfur recovery facilities to be inactive for most of the fourth quarter of 1998 (Chevron Corp., 1999, p. 17). Recovered sulfur production by state and regional are shown in tables 2 and 3.

During the past few years, the oil and gas industry has undergone significant consolidation—a trend continued in 1998. On January 1, 1998, Marathon Oil Co. and Ashland Inc. merged their marketing, refining, and transportation capabilities to create Marathon Ashland Petroleum L.L.C. (Marathon Ashland L.L.C., New company, accessed October 18, 1999, at URL http://www.mapllc.com/who/newcomp.htm).

In early 1998, Shell Oil Co. and Texaco Inc. combined their Midwestern and Western marketing and refining operations and created Equilon Enterprises L.L.C. Motiva Enterprises comprised the Eastern and Gulf Coast operations of Shell, Texaco, and Star Enterprise Inc., a joint venture of Texaco and Saudi Aramco (Texaco Inc., 1999, p. 12-13). To obtain regulatory approval from the Federal Trade Commission (FTC), Shell sold its Anacortes, WA, refinery. Shell's Deer Park, TX, refinery was not included in the new alliance because it was part of a joint venture arrangement with a Mexican company formed in 1993 (Shell Oil Co., 1999, p. 19).

On December 31, 1998, Amoco and British Petroleum Co., P.L.C. merged to form BP Amoco P.L.C. (BP Amoco P.L.C., 1999). The merger, valued at nearly $50 billion, created the world's third largest oil, gas, and chemical producer. The new conglomerate was headquartered in London (Thayer and Layman, 1998). The FTC required the two companies to sell about 150 retail sites and to offer termination rights for some gasoline supply contracts in Ohio and the Southeastern United States as condition for the approval of the merger (BP Amoco P.L.C., 1998).

Another merger, slated for completion in 1999, was expected to create the largest oil company in the world and the largest company in the United States. On December 1, 1998, Exxon and Mobil announced an agreement to form Exxon Mobil Corp. with an estimated value of $80 billion. Regulatory and shareholder approvals and completion of the merger were expected in 1999 (Chang, 1998).

Byproduct Sulfuric Acid.—Sulfuric acid production at copper, lead, molybdenum, and zinc roasters and smelters (table 4) accounted for 14% 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 88% of the output. The largest producers—ASARCO Incorporated; Broken Hill Proprietary Co., Ltd. (BHP); Cyprus Miami Mining Corp.; Kennecott Corp.; and Phelps Dodge Corp.—operated a total of seven copper smelters (figure 2).

Consumption

Domestic consumption of sulfur in all forms was slightly higher than that of 1997 (table 5). Of the sulfur consumed, 79% was obtained from domestic sources, such as elemental sulfur (68%) and byproduct acid (11%), compared with 80% in 1997 and 1996. The remaining 21% was supplied by imports of recovered elemental sulfur (16%) and sulfuric acid (5%). The USGS collected end-use data on sulfur and sulfuric acid according to the Standard Industrial Classification of industrial activities (tables 6 and 7).

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 80% 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." A significant portion of the sulfur in the "Unidentified" catagory may have been shipped to sulfuric acid producers or exported, although data to support such an assumption were not available.

Because of its desirable properties, sulfuric acid retained its position as the most universally used mineral acid and the most produced and consumed inorganic chemical, by volume. Based on USGS surveys, reported U.S. consumption of sulfur in sulfuric acid (100% basis) was virtually unchanged from 1997. Reported data for total sulfur consumption and apparent consumption figures indicate that actual consumption was slightly higher than that of 1997.

Agriculture was the largest sulfur-consuming industry, increasing to 8.9 Mt compared with 8.2 Mt reported in 1997. Reported consumption in phosphatic fertilizers was 7.5% higher than that of 1997. This increase was consistent with the Bureau of the Census's reported 8% increase in the production of phosphoric acid, a precursor for many phosphatic fertilizers

(Bureau of the Census, 1999). On the basis of export data from Census, the estimated quantity of sulfur needed to manufacture exported phosphatic fertilizers increased slightly to 5.8 Mt.

The second largest end use for sulfur was in petroleum refining and other petroleum and coal products. On the basis of the strong performance in the petroleum refining industry, an increase in petroleum refining uses would be expected; the 14% increase reported for the use of elemental sulfur in this category was probably higher than the actual growth in the industry. Demand for sulfuric acid in copper ore leaching, the third largest end use, increased by 7%; this use of sulfuric acid in copper ore leaching has increased steadily since 1995.

According to the 1998 canvass reports, company receipts of spent or contaminated sulfuric acid for reclaiming totaled 208,000 t. This figure was believed to be significantly higher than reported in USGS surveys; most of the acid, however, is recycled by companies that produce acid for consumption in their own operations and also recycle acid used in their plants. Because the recycling of acid 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 thought 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 decreased to 283,000 t, about 63% less than that of 1997 (table 1). On the basis of apparent consumption of all forms of sulfur, combined yearend stocks amounted to about a 7-day supply compared with a 20-day supply in 1997 and a 17-day supply in 1996. Sulfur inventories were at the lowest levels seen since Frasch production became profitable early in the 20th century (Haynes, 1959, p. 61). Stocks at the end of 1998 represented 5% of the quantity held in inventories at the end of 1976, when sulfur stocks peaked at 5.65 Mt, a 7.4-month supply at that time (Shelton, 1978).

Prices

The contract prices for elemental sulfur, at terminals in Tampa, FL, reported weekly in Green Markets, began the year at $66 to $68 per metric ton. In early February, prices decreased to $63 to $66 and remained steady until October when they increased to $66 to $69 per ton and where they remained throughout the rest 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 $29.14 per ton, which was 19% lower than that of 1997. Prices varied greatly on a regional basis, causing the discrepancies between Green Markets prices and USGS prices. Tampa prices are usually the highest prices reported because of the large sulfur demand in the central Florida area. U.S. West Coast prices are frequently $0 to $1 per ton; and in reality, however, West Coast producers may face negative values as a result of costs incurred at forming plants. These costs are necessary to make solid sulfur in acceptable forms to be shipped overseas.

Foreign Trade

Exports of elemental sulfur from the United States, including the U.S. Virgin Islands, were about 26% higher in quantity than those of 1997 but slightly lower in value, as shown in table 8, because the average unit value of U.S. export material decreased even more than the value of material used for domestic consumption. The average unit value of exported elemental sulfur decreased from $51 to $40 per ton, which was 22% lower than in 1997. Exports from the West Coast were 819,000 t, or 92% of total U.S. exports.

The United States continued to be a net importer of sulfur—imports of elemental sulfur exceeded exports by 1.38 Mt. Recovered elemental sulfur from Canada and Mexico delivered to U.S. terminals and consumers in the liquid phase furnished about 88% of all U.S. sulfur import requirements. Total elemental sulfur imports increased about 10% in quantity; imports by rail from Canada were about the same, and waterborne shipments from Mexico were 16% higher than those of 1997 (table 10). Imports from Venezuela comprised about 12% of all imported sulfur. The value of elemental sulfur imports decreased 10%.

The U.S. Tariff Commission (1973, p. 3) determined that “an industry in the United States is likely to be injured by reason of the importation of elemental sulfur from Canada which is being, or is likely to be, sold at less than fair value within the meaning if the Antidumping Act, 1921, as amended.” Since that time, several complaints against imports of Canadian sulfur have been filed by U.S. sulfur producers. In at least some instances, the findings went against the Canadian producers, and antidumping duties were assessed. An example of such a case was the U.S. Department of Commerce (DOC) investigation concerning an antidumping complaint against Canadian sulfur producers regarding the period from December 1, 1994, to November 30, 1995. The DOC determined that sales were made at discounts ranging from 0.33% to 40.38% for the companies involved. Antidumping duties were assessed against any material imported from these firms (Fertilizer Markets, 1998b).

As part of the Uruguay Round Agreements Act, the DOC was required “to revoke an antidumping or countervailing duty order, or terminate a suspension agreement, after five years unless the Department of Commerce and the International Trade Commission (ITC) determine that revoking the order or terminating the suspension agreement would be likely to lead to continuation or recurrence of dumping or subsidies (Commerce) and of material injury (ITC)” (International Trade Commission, 1998, p. 1). Reviews of such cases began in July 1998. Because the response to requests for comments from interested parties concerning sulfur from Canada were determined to be inadequate, the review of sulfur antidumping orders was expedited, and a full review, including public hearings, was not held (International Trade Commission, 1998).

On the basis of the expedited 5-year review, ITC determined that “under section 751(c) of the Tariff Act of 1930, as amended, the revocation of the antidumping finding concerning elemental sulfur from Canada is not likely to lead to continuation of material injury to an industry in the United States within a reasonably foreseeable time" (International Trade Commission, 1999, p. 3). As a result of the ITC's recommendations, the DOC was to revoke the existing antidumping finding on elemental sulfur from Canada, effective January 1, 2000 (International Trade Commission, 1998).

The United States also had significant trade in sulfuric acid. Sulfuric acid exports were 32% higher compared with those of 1997 (table 9). Acid imports were 13 times greater than exports (tables 9 and 11). Canada was the source of 76% of U.S. acid imports, most of which were probably byproduct acid from smelters. Canadian shipments to the United States came by rail and the remainder of imports came primarily by ship from Europe, Latin America, and Japan. Although the tonnage of imports of sulfuric acid was nearly the same as that of 1997, the value of imported sulfuric acid increased by 3%.

World Review

The global sulfur industry remained divided into two sectors—discretionary and nondiscretionary. 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 more than 80% of the sulfur in all forms produced worldwide as shown in table 12.

Poland and the United States were the only countries that produced 1 Mt or more of native sulfur by using either the Frasch or conventional mining methods (table 12). 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 was the only country in the top 15 sulfur producers whose primary sulfur source was pyrites. About 69% of all pyrites production was in this country.

Recovered elemental sulfur was the predominant source of sulfur in Canada, France, Germany, Iran, Japan, Mexico, Russia, Saudi Arabia, South Africa, and the United States. The international sulfur trade was dominated by a limited number of exporting countries, in descending order of importance–Canada, Saudi Arabia, Russia, Japan, and Germany; these countries exported more than 1 Mt of elemental sulfur each and accounted for 67% of sulfur trade. Major sulfur importers, in descending order, were Morocco, the United States, India, Tunisia, Brazil, and China, all with imports of more than 1 Mt.

World production of sulfur was slightly lower in 1998 than that of 1997; consumption was believed to be slightly higher. Prices in most of the world were believed to be lower. Production of Frasch was 30% lower than that of 1997 as a result of curtailments in Poland and the United States. Recovered sulfur production and byproduct sulfuric acid production were 5% higher than those of 1997. Supply continued to exceed demand; worldwide sulfur inventories increased, most of which was stockpiled in Canada. Globally, sulfur from pyrites decreased by 19%; the largest decrease was in China.

Australia.—Not a major producer of sulfur in any form, the completion of four new nonferrous metal smelter projects was expected to raise byproduct sulfuric acid capacity to 3.4 million metric tons (Mt/yr) by 2000; this is equivalent to more than 1 Mt of sulfur. WMC Fertilizer Ltd. was building a new 1.2-Mt/yr sulfuric acid plant adjacent to Mount Isa Mines Ltd.'s copper smelter at Mount Isa, Queensland. To reach full capacity, off-gases from the smelter were likely to be supplemented with the burning of additional elemental sulfur. Acid from the Mount Isa plant was earmarked for WMC's Queensland phosphate project, which was designed to produce phosphoric acid from phosphate rock mined at Phosphate Hill (Stevens, 1998d, p. 34).

Korea Zinc Co. Ltd. was building a 373,000-metric-ton-per-year (t/yr) plant at its Townsville, Queensland, project. This acid was expected to supply the Queensland phosphate project, to provide sulfuric acid for industrial uses in the eastern portion of the country, and to boost export volumes. Sulfuric acid production was to triple at Port Kembla Copper Co.'s smelter; a Japanese consortium financed the expansion to 350,000 t/yr for the export market. Western Mining Corp. was completing a 200,000-t/yr sulfuric acid plant at its Olympic Dam copper and uranium project for use in its metallurgical operations (Stevens, 1998d, p. 36).

As a result of these expansions and other byproduct acid production in Western Australia, Australia has eliminated most elemental sulfur imports. Several large nickel leaching operations were under development that could consume huge quantities of acid. Upon completion, these projects were expected to increase Australian demand for elemental sulfur from which to produce the additional acid requirements. The combination of smelter acid projects and sulfur-burning acid plants held the potential to increase Australia's installed sulfuric acid production capacity to 5.87 Mt/yr in 2000 from 1.36 Mt/yr in 1996 (Stevens, 1998d).

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. The majority of the sulfur production came from natural gas plants in Alberta where sulfur inventories reached nearly 11 Mt. The Alberta producers were stockpiling material in an attempt to raise prices in international markets (Green Markets, 1998).

In addition to the large sour gas deposits, Alberta contains the huge oil sand deposits known as the Athabascan Oil Sands with estimated reserves of 1.7 billion to 2.5 billion barrels of crude oil, 300 million barrels of which are recoverable. In 1997, about 20% of Canadian crude oil production came from oil sands. These deposits also contain 4% to 5% sulfur that must be removed during processing. Sulfur production from oil sands contributed nearly 700,000 t to total Canadian output in 1997 (Stevens, 1998b). No similar data were available for 1998.

Low crude oil prices in 1998 caused the reassessment of some of the proposed projects and expansions at Canadian oil sand deposits. Suncor Energy Inc. planned to double sulfur production at its Project Millennium near Fort McMurray to almost 440,000 t/yr by 2002 from about 220,000 t/yr in 1998; further expansions would take sulfur recovery to 1.5 Mt/yr by 2005. Syncrude Canada Ltd. moved forward with its Aurora Mine and Husky Oil Ltd. announced an expansion at its heavy oil upgrader at Lloydminster that would double sulfur recovery. Shell Canada Ltd. and BHP sponsored a feasibility study on another oil sands project near Edmonton that could produce 1,000 tons per day (t/d) of sulfur; completion of the study was expected in early 1999. Several other companies delayed further activity in oil sands projects until crude oil prices stabilized, but the projects that were progressing despite the set back in oil prices represented the potential for an additional 1 to 2 Mt of Canadian sulfur production in Alberta (Stevens, 1998a).

Chile.—The world's largest producer of copper, Chile's sulfur production came entirely in the form of byproduct sulfuric acid from seven copper smelters and one molybdenum smelter. Environmental concerns prompted significant improvements in desulfurization capabilities at the smelters, and production of byproduct acid has increased significantly in recent years, approaching the equivalent of 1 Mt of sulfur production in 1998.

The capture of sulfur emissions from Chilean smelters ranged from a meager 5% to 70%. Modernization projects were designed to increase recovery up to 95% at some operations and to improve environmental conditions. Increased Chilean sulfuric acid was expected to enter the world market; increases at copper ore leaching operations, however, absorbed most of the acid, and future growth of leaching operations could necessitate acid imports (Horseman, 1997).

One example of an environmental improvement project was Corporación National del Cobre's (Codelco) installation of a new 1,500 t/d-sulfuric acid plant at its El Teniente smelter. Codelco experienced some technical problems during initial production, but the company expected to have the new acid plant fully operational in early 1999. A second larger sulfuric acid plant was planned for the site that would bring sulfuric acid capacity to 3,200 t/d (Fertilizer Week, 1998). In addition to Codelco's environmental improvements, Noranda Inc., a Canadian company, was conducting an environmental impact study prior to expanding its Altonorte smelter. The project called for an 80% increase in copper capacity, to 290,000 t/yr, and an increase of 180% in sulfuric acid capacity, to 700,000 t/yr (Fertecon North America Sulphur Service, 1998d).

China.—Sulfuric acid production in China more than doubled in the 10 years prior to 1996 in conjunction with the growth of the country's chemical industry, especially agricultural chemicals. China is the one of the few remaining countries to use pyrites as the dominant raw material for sulfuric acid production. In 1994, China began importing elemental sulfur for sulfuric acid production. The primary reasons for this change were environmental concerns including the waste disposal problems associated with burning pyrites; poor air quality caused by the pyrites acid plants; and particulate emissions during material handling. Lesser considerations were the inability to obtain consistent high-quality pyrites and the lack of capacity to transport large quantities of material long distances.

As the result of a study completed in 1995, the Chinese Government continued to import elemental sulfur to meet a portion of the country's demand for sulfuric acid production (Hasegawa, 1997). China imported 1.3 Mt of elemental sulfur in 1998 and nearly 800,000 t in 1997, mostly from Canada and Japan.

Mexico.—A former Frasch producer from 1954 when mining began at San Cristobal (Larson and Marks, 1955) until 1993 when the Texistepec Mine closed (Ober, 1994), Mexico was the second largest supplier of imported recovered sulfur to the United States. Petróleos Mexicanos (Pemex), the Mexican Government's oil company and a producer of high-sulfur crude oil, ensured markets for its Maya crude by entering long-term supply contracts with U.S. refiners, especially in Texas. Pemex agreed to supply Clark Refining and Marketing Inc.'s Port Arthur refinery. Clark was to install a new coker to allow it to handle the heavy Mexican crude. Refining Mexican crude was expected to increase sulfur recovery by 50% to 60% at Port Arthur. Pemex was negotiating a similar deal with Mobil for its Beaumont refinery. The Mexican company has been a partner in Shell's Deer Park, refinery for several years (Fertecon North America Sulphur Service, 1998c). Exxon also agreed to build a coker to enable it to process Mayan crude at its Baytown, refinery (Fertecon North America Sulphur Service, 1998a).

Peru.—Never a large sulfur producer, Peru was proceeding with a multiphase improvement project at Southern Peru Copper Corp.'s (SPCC) copper smelter at Ilo. For nearly 30 years after the smelter opened in 1960, all sulfur dioxide emitted at the smelter was released into the atmosphere. In 1989, SPCC began to investigate processes for cutting emissions. In 1995, during the first phase, 18% of the site's sulfur emissions were captured. In 1998, during the second phase, sulfur recovery was increased to 30%. The final phase of the project, slated for completion in 2003, was designed to raise recovery to about 95% of sulfur emissions (More, 1998).

Although completion of this project will not move Peru into the upper echelon of sulfur producers, it is a very good example of how increasing environmental awareness in developing countries is influencing the sulfur market. The equivalent of about 500,000 t of sulfur represents less than 1% of global sulfur production; similar increases in a number of countries, however, could quickly alter the worldwide supply and demand balance, exacerbating the normal over-supply situation, especially for discretionary producers.

Poland.—Rich sulfur deposits were discovered in Poland in 1954, and production began at the first surface mine late in that decade. Since that time, five native sulfur mines have been developed in Poland. The first two, Piaseczno and Machów, were surface mines using conventional mining methods. The other three mines, Grzybów, Jezióko, and Osiek, used the Frasch method with modifications to meet the geologic conditions in Poland. At the peak of Polish sulfur production in 1980, more than 5 Mt of sulfur could be produced from three mines, Grzybów, Jeziórko, and Machów. Three of the mines closed and were being recultivated as lakes and other recreation areas, leaving Jeziórko and Osiek operating in 1998.

Polish sulfur entered the global market in 1961, when the sulfur shipping facilities in Gdańsk were completed. In 1980, about 3.8 Mt (nearly 75%) of Polish production was exported, mostly to other European countries. Since the early 1990's, low global prices have made it extremely difficult for the discretionary sulfur producers to compete in the global market, and those markets have dwindled for the Polish industry (Karolak, 1997). Frasch production in Poland has decreased rapidly during the past few years, with only 1.3 Mt produced in 1998 and little expectation for improvement.

Saudi Arabia.—Already 1 of the top 15 sulfur producers in the world, plans to expand Saudi Arabia's Master Gas Gathering System were in the works that would result in an additional 1.1 Mt/yr of sulfur recovery capacity. Production could exceed 2.2 Mt/yr by 2002 when a new natural gas processing plant was scheduled for completion. Most of Saudi Arabia's sulfur production was linked to its processing of sulfur-containing natural gas; but expansions of sulfur recovery capacity at oil refineries were also under construction. Most Saudi sulfur was exported. Traditionally, India has been the primary recipient of Saudi sulfur, but recent efforts to expand markets resulted in sales to Jordan and Morocco (Stevens, 1998c).

Venezuela.—A producer of high-sulfur crude oil, Venezuela became an increasingly important sulfur producer from its petroleum refineries and upgraders and an increasingly important direct and indirect supplier of sulfur to the U.S. market. As a direct sulfur supplier in 1997, Lagoven, SA, a Venezuelan company agreed to a long-term contract to supply molten sulfur from its Amuay refinery to PCS Phosphate Inc.'s Aurora, NC, phosphoric acid plant. During the 10-year contract, shipments were to increase from 140,000 t/yr in 1998 to 260,000 t/y in 2007. Lagoven revamped its desulfurization complex to enable it to meet the contract commitments (Fertilizer Markets, 1997).

Several new proposals for developing extra heavy oil projects in central Venezuela's Orinoco Belt by Petróleos de Venezuela S.A. (PdVSA) and its partners from other countries included plans for sulfur production at crude oil upgraders within Venezuela and increased sulfur production at refineries processing Venezuelan upgraded crude. Orinoco crude averages about 4% sulfur. One British and four U.S. companies were negotiating individual projects with PdVSA. If all the proposals were agreed upon, then sulfur production in Venezuela could increase by nearly 700,000 t/yr; and exports of crude oil to other countries would result in an additional 640,000 t/yr of sulfur recovered from the material. The United States was expected to be the recipient of most of the Venezuelan oil (Fertecon North America Sulphur Service, 1998b).

PdVSA became a partner with Amerada Hess Corp. in Hess's St. Croix, U.S. Virgin Islands, refinery. The refinery, owned equally by Hess and PdVSA, was renamed HOVENSA L.L.C. As part of the deal, HOVENSA immediately began purchasing crude oil from PdVSA. The refinery was to install a coking unit to enable it to handle the high-sulfur raw material better. Upon completion of the coker, HOVENSA will increase its intake of PdVSA oil (Amerada Hess Corp., 1998).

Outlook

The long-term outlook for the sulfur industry has not changed for several years—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 with time; although discretionary producers are becoming more vulnerable.

World sulfur demand for fertilizer is forecast to increase at a rate of about 3% per year for the next 10 years, and industrial demand is predicted to grow at a more modest 1.7%. Growth of sulfur consumption in the United States will probably be slower than in many other parts of the world. The U.S. phosphate fertilizer industry has announced no expansions, and none are expected; 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.

In 1998, about 65% of U.S. sulfur consumption was for agricultural uses, and almost 85% 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 2.5% per year for the next 10 years. More than 80% of the growth will probably 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. Although expected to remain strong, exports are dependent upon the economies of the importing countries. Serious economic problems in much of the world, especially Asia, could continue to have a negative impact on fertilizer trade.

The broad-spectrum industrial or nonagricultural sulfur use category accounted for less than 31% of U.S. sulfur consumption and about 40% of world sulfur consumption. 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 continue to grow very slowly.

The necessity for the removal of sulfur from liquid, gaseous, and solid 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 90% 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, new operations that produce sulfur as the primary product will probably not be developed, and more voluntary operations will be curtailed. In 1998, voluntary sources of production—Frasch, native sulfur, and pyrites—accounted for only 18% of the world output of about 57.8 Mt; in 1980, these same sources supplied 50% of the world production of 55.0 Mt.

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

References Cited

Amerada Hess Corp., 1998, Amerada Hess announces establishment of refinery joint venture with Petróleos de Venezuela: New York, Amerada Hess Corp. press release, October 30, 1 p.

BP Amoco P.L.C., 1998, Federal Trade Commission approves BP Amoco merger: London, BP Amoco P.L.C. press release, December 30, 1 p.

———1999, BP Amoco merger completed: London, BP Amoco P.L.C. press release, January 1, 1 p.

Bureau of the Census, 1999, Fertilizer materials (MQ28B(98)-4), fourth quarter 1998: Bureau of the Census, March 11, 5 p.

Chang, Joseph, 1998, Exxon, Mobil merge into $200 Bn power forming largest petrochemical producer: Chemical Market Reporter, v. 254, no. 23, December 1, p. 1 and 18.

Chemical and Engineering News, 1999, Production—Modest gain: Chemical and Engineering News, v. 77, no. 26, June 28, p. 35.

Chevron Corp., 1999, 1998 Form 10-K—Fiscal Year 1998: Securities and Exchange Commission, 38 p.

Fertecon North America Sulphur Service, 1998a, In brief: Fertecon North America Sulphur Service, v. 9, no. 10, October, p. 3.

———1998b, Keynote—Scale and timing of heavy-oil sulphur production in Venezuela becomes clearer: Fertilizer North America Sulphur Service, v. 9, no. 10, p. 1-2.

———1998c, News and developments: Fertecon North America Sulphur Service, v. 9, no. 3, March, p. 2.

———1998d, News and developments: Fertecon North America Sulphur Service, v. 9, no. 11, November, p. 3-4.

Fertilizer Markets, 1997, PCS Phosphate awarded sulphur contract in Venezuela: Fertilizer Markets, v. 8, no. 19, December 1, p. 3.

———1998a, Freeport shutters Culberson S mine: Fertilizer Markets, v. 8, no. 49, July 6, p. 1-2.

———1998b, Husky, Mobil continue to face S duties for Canada-U.S. trade: Fertilizer Markets, v. 7, no. 51, July 21, p. 2-3.

Fertilizer Week, 1998, Chile's El Teniente H_2SO_4 plant down for 2 months: Fertilizer Week, v. 12, no. 20, September 28, 1998, p. 2-3.

Green Markets, 1998, Freeport Sulphur supports antidumping order—Florida Phosphate Council advocated free enterprise: Green Markets, v. 22, no. 41, October 12, p. 1 and 11.

Haynes, Williams, 1959, Brimstone—The stone that burns: Princeton, NJ, D. Van Nostrand Co., Inc., 293 p.

Hasegawa, Tamikiyo, 1997, Chinese sulfur supply and demand: Sulphur, no. 250, p. 19-21.

Horseman, Martin, 1997, Copper projects boost sulphuric acid industry in Chile: Sulphur, no. 251, p. 31-36.

International Trade Commission, 1998, In its first five-year review, ITC determines that continuation or recurrence of material injury not likely if antidumping duty finding on elemental sulfur from Canada is revoked: Washington, DC, International Trade Commission news release, December 21, 2 p.

———1999, Elemental sulfur from Canada—Investigation No. AA1921-127 (Review): Washington, DC, International Trade Commission Publication 3152, January, 27 p.

Karolak, Jozef, 1997, The Polish sulphur industry: International Fertilizer Industry Association Production and International Trade Committee Meeting, Warsaw, October 14-15, 1997, Proceedings, v. III, p. 85-92.

Larson, L.P., and Marks, A.L., 1955, Sulfur: U.S. Bureau of Mines Minerals Yearbook 1954, v. I, p. 1136-1137.

McMoRan Exploration Co., 1999, McMoRan Exploration Co. 1998 annual report and Form 10-K.: McMoRan Exploration Co., 44 p.

More, Alexander, 1998, Forward looking at SPCC: Sulphur, no. 259, p. 47-55.

Ober, J.A., 1994, Sulfur: U.S. Bureau of Mines Minerals Yearbook 1993, v. I, p. 1172.

Shell Oil Co., 1999, Form 10-K—Fiscal Year 1998: Securities and Exchange Commission, 109 p.

Shelton, J.E., 1978, Sulfur: U.S. Bureau of Mines Minerals Yearbook 1976, v. I, p. 1296.

Stevens, Jason, 1998a, Big "heavy" projects going ahead: Sulphur, no. 257, p. 25-31.

———1998b, Oil sands projects gather pace: Sulphur, no. 254, p. 27-30.

———1998c, Saudis expand their sulphur horizons: Sulphur, no. 259, p. 20-24.

———1998d, Up, up, and away: Sulphur, no. 259, p. 34-37.

Texaco Inc., 1999, Form 10-K—Fiscal Year 1998: Securities and Exchange Commission, 32 p.

Thayer, Ann, and Layman, Patricia, 1998, BP, Amoco to merge: Chemical and Engineering News, v. 76, no. 33, August 17, p. 6.

U.S. Tariff Commission, 1973, Determination of likelihood of injury in investigation no. AA1921-127 under the Antidumping Act, 1921, as amended: Washington, DC, U.S. Tariff Commission Publication 617, 12 p.

SOURCES OF INFORMATION

U.S. Geological Survey Publications

Sulfur. Ch. in Mineral Commodity Summaries, annual.[1]

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

Sulfur. Ch. in United States mineral resources, U.S. Geological Survey Professional Paper 820, 1973.

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), monthly.

Fertilizer Markets, weekly.

Green Markets, weekly.

Industrial Minerals (London), monthly.

The Oil & 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, monthly.

---

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

TABLE 1
SALIENT SULFUR STATISTICS 1/

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

	1994	1995	1996	1997	1998
United States:					
Production:					
Frasch e/	2,960	3,150	2,900	2,820	1,800
Recovered 2/	7,160 e/	7,250	7,480	7,650	8,220
Other forms	1,380	1,400	1,430	1,550	1,610
Total e/	11,500	11,800	11,800	12,000	11,600
Shipments:					
Frasch	W	W	W	W	W
Recovered 2/ 3/	10,300	10,700	10,400	10,400	10,500
Other forms	1,390	1,400	1,430	1,550	1,610
Total	11,700	12,100	11,800	11,900	12,100
Exports:					
Elemental 4/	899	906	855	703	889
Sulfuric acid	46	56	38	39	51
Imports:					
Elemental	1,650	2,510	1,960	2,060	2,270
Sulfuric acid	696	628	678	659	668
Consumption, all forms	13,100	14,300	13,600	13,900	14,100
Stocks, December 31: Producer, Frasch and recovered	1,160	583	646 r/	761	283
Value:					
Shipments, f.o.b. mine or plant:					
Frasch	W	W	W	W	W
Recovered 2/ 3/	$310,000 r/	$476,000 r/	$355,000 r/	$375,000 r/	$306,000
Other forms	$82,800	$86,400	$85,800	$98,100	$68,300
Total	$393,000 r/	$562,000 r/	$441,000 r/	$473,000 r/	$375,000
Exports, elemental 4/ 5/	$48,400	$66,200	$51,700	$36,000	$35,400
Imports, elemental	$62,000	$143,000	$70,200	$64,900	$58,400
Price, elemental, dollars per metric ton, f.o.b. mine or plant	$30.08	$44.46	$34.11	$36.06	$29.14
World: Production, all forms (including pyrites)	53,400 r/	54,800 r/	55,700 r/	58,300 r/	57,800 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; may not add to totals shown.
2/ Includes Puerto Rico and the U.S. Virgin Islands.
3/ Includes corresponding Frasch sulfur data.
4/ Includes exports from the U.S. Virgin Islands to foreign countries.
5/ 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)

	1997			1998		
		Shipments			Shipments	
State	Production	Quantity	Value	Production	Quantity	Value
Alabama	366	363	12,600	358	362	11,800
California	845	839	4,200	1,100	1,090	6,960
Illinois	400	400	13,200	404	414	5,810
Louisiana	853	W	W	914	2,600	W
Michigan and Minnesota	123	122	684	126	126	2,600
Mississippi	552	538	11,300	460	482	11,000
New Mexico	51	49	335	51	50	302
North Dakota	42	41	180	54	54	208
Ohio	57	57	1,590	47	48	1,670
Texas	2,510	3,410 2/	132,000 r/ 2/	2,750	3,340 2/	107,000 2/
Washington	109	109	331	114	114	1,100
Wyoming	1,060	1,040	19,700	1,070	1,060	12,100
Other 3/	684	3,420	179,000 r/	788	771	145,000
Total	7,650	10,400	375,000 r/	8,220	10,500	306,000

r/ Revised. 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, Pennsylvania, 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)

	1997		1998	
District and source	Production	Shipments	Production	Shipments
PAD 1:				
Petroleum and coke	224	223	233	231
Natural gas	50	50	47	47
Total	274	273	280	278
PAD 2:				
Petroleum and coke	826	826	889	891
Natural gas	42	41	55	56
Total	868	867	944	946
PAD 3: 2/				
Petroleum and coke	3,120	W	3,620	W
Natural gas	1,280	W	1,000	W
Total	4,410	7,180 3/	4,630	6,930 3/
PAD 4 and 5:				
Petroleum and coke	1,060	1,050	1,320	1,300
Natural gas	1,040	1,030	1,060	1,060
Total	2,100	2,080	2,380	2,360
Total petroleum	5,230	W	6,060	W
Total natural gas	2,420	W	2,160	W
Grand total	7,650	10,400 3/	8,220	10,500 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 Frasch sulfur data.

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

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

Type of plant	1997	1998
Copper 3/	1,370	1,430
Zinc 4/	120	121
Lead and molybdenum 4/	66	68
Total	1,550	1,610
Value	105,000	77,100

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 IN THE UNITED STATES 1/ 2/

(Thousand metric tons)

	1997	1998
Total elemental:		
Shipments 3/	10,400	10,500
Exports	703	889
Imports	2,060	2,270
Total	11,800	11,900
Byproduct sulfuric acid:		
Shipments 3/	1,550	1,610
Exports 4/	39	51
Imports 4/	659 r/	668
Total, all forms	13,900 r/	14,100

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/ 1997	Elemental sulfur 2/ 1998	Sulfuric acid (sulfur equivalent) 1997	Sulfuric acid (sulfur equivalent) 1998	Total 1997	Total 1998
102	Copper ores	--	--	763	818	763	818
1094	Uranium and vanadium ores	--	--	5	3	5	3
10	Other ores	--	--	108 r/	126	108 r/	126
26, 261	Pulpmills and paper products	84	W	334	134	418	134
28, 285, 286, 2816	Inorganic pigments, paints and allied products, industrial organic chemicals, other chemical products 4/	94	80	232 r/	174	326 r/	254
281	Other inorganic chemicals	30	W	271 r/	202	301 r/	202
282, 2822	Synthetic rubber and other plastic materials and synthetics	W	W	85 r/	69	85 r/	69
2823	Cellulosic fibers, including rayon	--	--	33 r/	5	33 r/	5
283	Drugs	--	--	3	3	3	3
284	Soaps and detergents	W	--	17	1	17	1
286	Industrial organic chemicals	--	--	104 r/	93	104 r/	93
2873	Nitrogenous fertilizers	--	--	161	213	161	213
2874	Phosphatic fertilizers	--	--	7,000	7,530	7,000	7,530
2879	Pesticides	--	--	18 r/	17	18 r/	17
287	Other agricultural chemicals	998	1,070	37 r/	31	1,040 r/	1,100
2892	Explosives	--	--	5 r/	5	5	5
2899	Water-treating compounds	--	--	64 r/	75	64 r/	75
28	Other chemical products	--	--	107	38	107	38
29, 291	Petroleum refining and other petroleum and coal products	1,270	1,450	610 r/	632	1,880	2,080
30	Rubber and miscellaneous plastic products	(5/)	--	--	--	(5/)	--
331	Steel pickling	--	--	12	14	12	14
333	Nonferrous metals	--	--	78	38	78	38
33	Other primary metals	--	--	12	45	12	45
3691	Storage batteries (acid)	--	--	35 r/	12	35 r/	12
	Exported sulfuric acid	--	--	53 r/	6	53 r/	6
	Total identified	2,470	2,600	10,200 r/	10,300	12,600 r/	12,900
	Unidentified	1,000 r/	1,320	559	236	1,560	1,550
	Grand total	3,470	3,920	10,700	10,500	14,200 r/	14,400

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.

5/ Revised to zero.

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

(Thousand metric tons of 100% H_2SO_4)

SIC 2/	Use	1997	1998
102	Copper ores	2,250	2,400
10	Other ores	W	W
26, 261	Pulp mills and other paper products	W	W
28, 281, 282, 283, 286, 2816	Miscellaneous chemicals	392	265
2873	Nitrogenous fertilizers	97	W
2874	Phosphatic fertilizers	625	W
287, 2879	Pesticides and other agricultural chemicals	98	97
2899	Water-treating compounds	117	195
291	Petroleum refining	W	W
3691	Storage batteries (acid)	W	W
33, 331, 333, 1094	Miscellaneous metal usage	196	158
	Unidentified 3/	1,110	1,780
	Total	4,880	4,890

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 OF ELEMENTAL SULFUR, BY COUNTRY 1/ 2/

(Thousand metric tons and thousand dollars)

	1997		1998	
Country	Quantity	Value	Quantity	Value
Argentina	20	684	18	555
Australia	32	1,130	(3/)	10
Brazil	148	4,830	356	9,800
Canada	40	3,790	35	4,170
Colombia	7	443	5	510
India	79	2,720	--	--
Indonesia	24	986	(3/)	33
Korea, Republic of	2	3,380	3	3,350
Mexico	80	4,590	57	2,540
Morocco	34	1,140	85	2,250
Senegal	145	4,840	176	4,170
South Africa	1	267	(3/)	118
Tunisia	35	1,180	--	--
Other	56	6,090	154	7,940
Total	703	36,000	889	35,400

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% H_2SO_4), BY COUNTRY 1/

Country	1997 Quantity (metric tons)	1997 Value (thousands)	1998 Quantity (metric tons)	1998 Value (thousands)
Canada	85,200	$5,600	122,000	$6,870
China	957	369	2,520	474
Costa Rica	207	7	3	5
Dominican Republic	1,510	118	5,110	302
Israel	2,250	502	3,830	606
Japan	333	158	32	50
Korea, Republic of	10	12	47	28
Mexico	7,160	849	8,940	3,540
Netherlands	--	--	74	66
Netherlands Antilles	2,910	212	2,860	211
Panama	176	20	1,000	42
Saudi Arabia	1,140	684	1,210	2,490
Singapore	697	591	451	247
Taiwan	2,000	635	1,640	537
Trinidad and Tobago	2,620	181	13	23
United Kingdom	296	34	150	29
Venezuela	1,060	126	233	623
Other	9,280	2,560	5,360	2,010
Total	118,000	12,700	155,000	18,100

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

Source: Bureau of the Census.

TABLE 10

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

(Thousand metric tons and thousand dollars)

Country	1997 Quantity	1997 Value 2/	1998 Quantity	1998 Value 2/
Canada	1,470	31,000	1,440	16,900
Mexico	480	24,400	559	26,900
Other	110	9,460	268	14,600
Total	2,060	64,900	2,270	58,400

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

2/ Declared customs valuation.

Source: Bureau of the Census; as adjusted by the U.S. Geological Survey.

TABLE 11

U.S. IMPORTS OF SULFURIC ACID (100% H_2SO_4), BY COUNTRY 1/

Country	1997 Quantity (metric tons)	1997 Value 2/ (thousands)	1998 Quantity (metric tons)	1998 Value 2/ (thousands)
Argentina	--	--	859	$117
Canada	1,600,000	$60,500	1,550,000	60,800
Germany	32,900	872	30,700	1,060
Japan	80,600	5,760	203,000	11,400
Mexico	215,000	6,420	50,100	2,930
Spain	7,330	186	10,200	288
Other	79,200	10,300	194,000	10,200
Total	2,010,000	84,000	2,040,000	86,800

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.

Source: Bureau of the Census.

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

(Thousand metric tons)

Country and source 3/	1994	1995	1996	1997	1998 e/
Canada: Byproduct:					
Metallurgy	870	860	789	801	838 p/
Natural gas	7,980 r/ 4/	8,150 r/ 4/	8,327	8,280	8,410 p/
Total	8,850	9,010	9,116 r/	9,081 r/	9,250
China: e/					
Elemental	330	160	170	200 r/	210
Pyrites	5,870	5,930	5,990	6,040 r/	4,490
Byproduct, metallurgy	820 r/	940 r/	1,100 r/	1,400 r/	1,450
Total	7,020 r/	7,030 r/	7,260 r/	7,640 r/	6,150
France: Byproduct:					
Natural gas	865	825	755 e/	697 r/	700
Petroleum	219	240	235 e/	263 r/	250
Unspecified e/	100	100	99	100	100
Total e/	1,180	1,170	1,090	1,060 r/	1,050
Germany: Byproduct: e/					
Metallurgy	35	20 5/	20	25	25
Natural gas and petroleum	880 5/	1,000	1,000	1,085 r/ 5/	1,100
Unspecified	90	90	90	50 r/	50
Total	1,005 5/	1,110	1,110	1,160 r/	1,180
Iran: Byproduct: e/					
Metallurgy	50	50	50	50	50
Natural gas and petroleum	830	840	840	850	850
Total	880 5/	890	890	900	900
Iraq: e/					
Frasch	250	250	250	250	250
Byproduct, natural gas and petroleum	225	225	225	200	200
Total	475	475	475	450	450
Japan:					
Pyrites e/	4 5/	2	2	2	2
Byproduct:					
Metallurgy	1,269	1,312	1,285	1,301 r/	1,310
Petroleum e/	1,630 r/	1,680 r/	1,790 r/	2,010 r/	2,080
Total e/	2,900 r/	3,000 r/	3,080 r/	3,320 r/	3,400
Kazakhstan: e/					
Pyrites	200	71	71	--	--
Byproduct:					
Metallurgy	261	131	139	139	212
Natural gas and petroleum	219	255	515	778 r/	933
Total	680	457	725	917 r/	1,150
Mexico: Byproduct:					
Metallurgy	300 r/	359 r/	359 r/	417 r/	474
Natural gas and petroleum	877	882	921	923	913 5/
Total	1,177 r/	1,241 r/	1,280 r/	1,340 r/	1,390
Poland: 6/					
Frasch	2,163	2,425	1,783 r/	1,719 r/	1,300
Byproduct: e/					
Metallurgy	127 r/	131 r/	98 r/	229 r/	261
Petroleum	25	25	25	10	10
Gypsum e/	10	10	10	4	5
Total	2,325 r/	2,591 r/	1,916 r/	1,962 r/	1,570
Russia: e/ 7/					
Native	80	80	70	50	50
Pyrites	700	450	400	400	400
Byproduct, natural gas	2,550	2,970	3,000	2,950	3,700
Other	320	335	325	350	325
Total	3,650	3,840	3,800	3,750	4,480
Saudi Arabia: Byproduct, all sources	1,630 r/	1,650 r/	1,750 r/	2,000 e/	2,000
South Africa:					
Pyrites	252	159	184	167	152
Byproduct:					
Metallurgy	118	67	91	110 e/	100
Petroleum 8/	209	233	200	293	280
Total	579	459	475	570 e/	532

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/	1994	1995	1996	1997	1998 e/
Spain:					
Pyrites	342 r/	404	438 r/	424 r/	430
Byproduct: e/					
Coal (lignite) gasification	2	2	2	2	2
Metallurgy	250	305 r/	428 r/	456 r/	461
Petroleum	100	75 r/	75 r/	85 r/	100
Total e/	694 r/	786 r/	943 r/	967 r/	993
United States:					
Frasch e/	2,930	3,150	2,900	2,820	1,800
Byproduct:					
Metallurgy	1,380	1,400	1,430	1,550	1,610 5/
Natural gas	2,240	2,210	2,100	2,420	2,160 5/
Petroleum	4,924	5,040	5,370	5,230	6,060 5/
Total e/	11,500	11,800	11,800	12,000	11,600
Other:					
Frasch	21	22	25	20 r/	21
Native	504 r/	333 r/	225 r/	161 r/	153
Pyrites	1,193 r/	1,155 r/	1,113 r/	1,012 r/	1,070
Byproduct:					
Metallurgy	2,208 r/	2,508 r/	2,642 r/	2,983 r/	3,140
Natural gas	123 r/	155 r/	150 r/	130 r/	206
Natural gas, petroleum, and tar sands, undifferentiated	1,588 r/	1,709 r/	2,014 r/	2,363 r/	2,500
Petroleum	1,517 r/	1,557 r/	1,661 r/	1,884 r/	1,850
Unspecified sources	893 r/	970 r/	1,098 r/	1,189 r/	1,260
Total	8,046	8,410	8,929	9,742	10,200
Grand total	53,400 r/	54,800 r/	55,700 r/	58,300 r/	57,800
Of which:					
Frasch	5,360	5,850	4,960 r/	4,810	3,370
Native 9/	914 r/	573 r/	465 r/	411 r/	413
Pyrites	8,560 r/	8,170 r/	8,200 r/	8,050 r/	6,550
Byproduct:					
Coal (lignite) gasification e/	2	2	2	2	2
Metallurgy	7,690 r/	8,080 r/	8,430 r/	9,460 r/	9,940
Natural gas	5,780 r/	6,160 r/	14,300 r/	14,500 r/	15,200
Natural gas, petroleum, and tar sands, undifferentiated	12,600 r/	13,100 r/	5,520 r/	6,200 r/	6,500
Petroleum	8,620 r/	8,850 r/	9,360 r/	9,780 r/	10,600
Unspecified sources	3,850 r/	4,080 r/	4,460 r/	5,090 r/	5,180
Gysum e/	10	10	10	4	5

e/ Estimated. p/ Preliminary. r/ Revised.

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 August 6, 1999.

3/ The term "Source" reflects the means of collecting sulfur and the type of raw material. Sources listed include the following: Frasch recovery; native, comprising all production of elemental sulfur by traditional mining methods (thereby excluding Frasch); pyrites (whether or not the sulfur is recovered in the elemental form or as acid); 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 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. Production of Frasch sulfur, other native sulfur, pyrites-derived sulfur, mined gysum-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 material. In contrast, byproduct recovery from metallurgical operations, petroleum refineries, and spent oxides are credited to the nation where the recovery takes place, which is not the originial source country of the crude product from which the sulfur is extracted.

4/ Includes petroleum and tar sands.

5/ Reported figure.

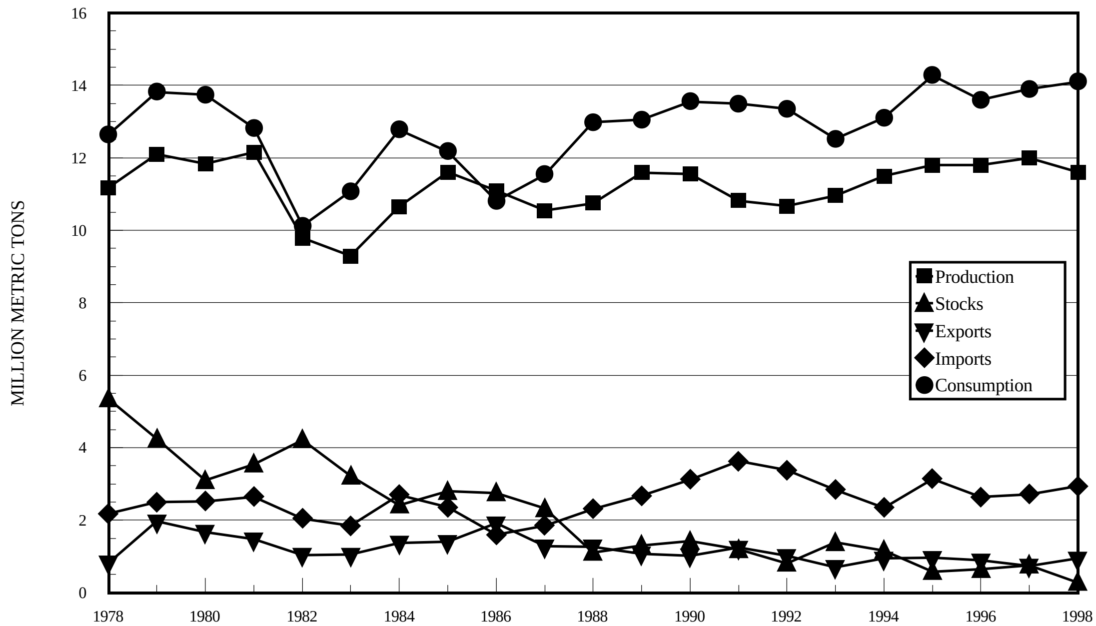
6/ Official Polish sources report total Frasch and native mined elemental sulfur output annually, undifferentiated; this figure has been divided between Frasch and other native sulfur on the basis of information obtained from supplementary sources.

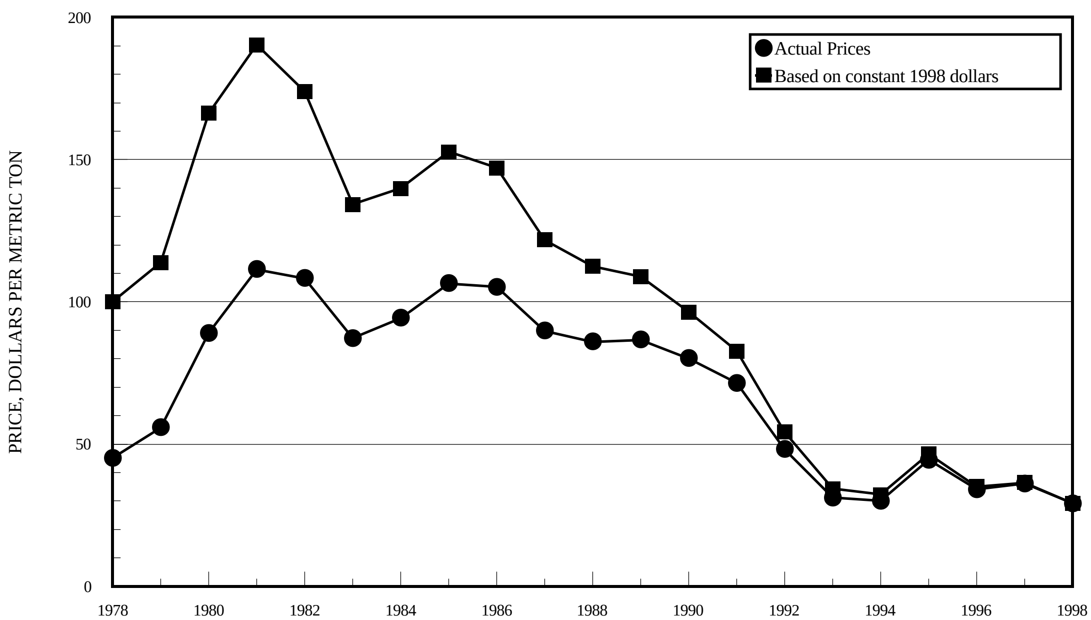
7/ Sulfur is believed to be produced from Frasch and as a petroleum byproduct; information, however, is inadequate to formulate estimates.

8/ Includes byproduct production from synthetic fuels.

9/ Includes "China: Elemental."

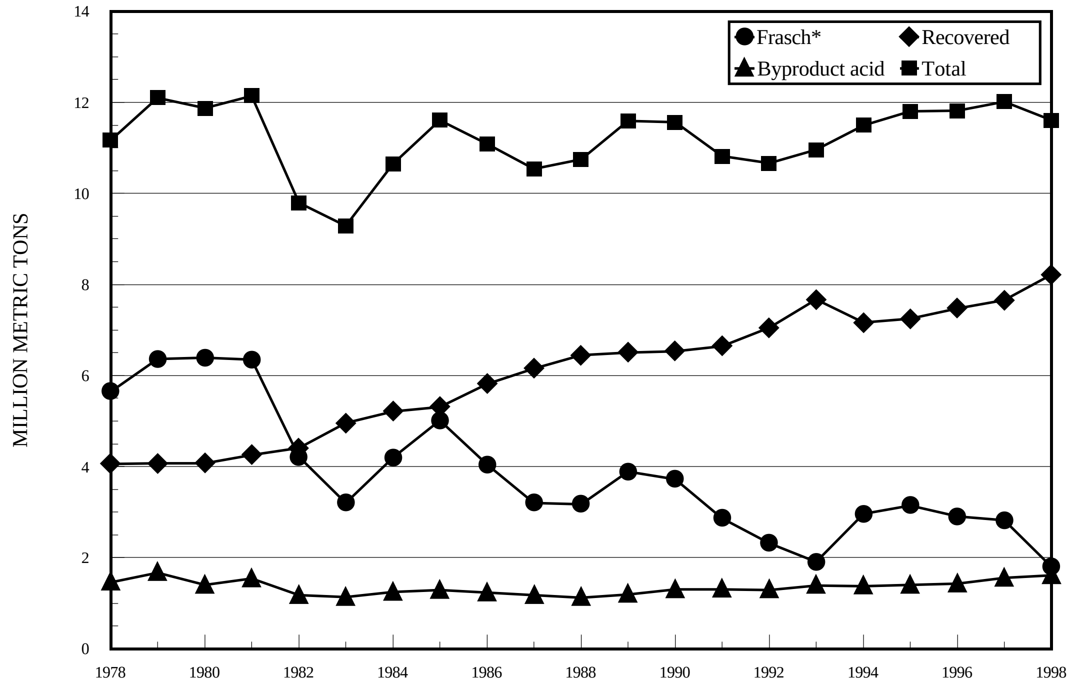
FIGURE 1
TRENDS IN THE SULFUR INDUSTRY IN THE UNITED STATES

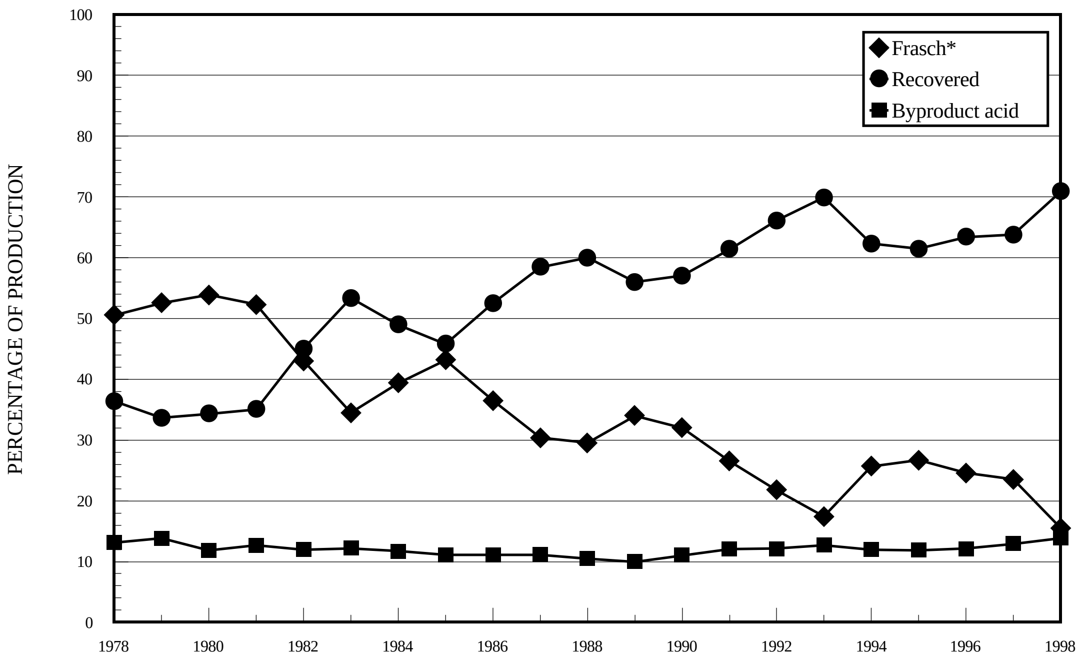




Based on the average reported values for elemental sulfur (Frasch and recovered), f.o.b. mine and/or plant, these prices reflect about 90% of the shipments of sulfur in all forms from 1978 through 1998.

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 the recovered sulfur data to conform with proprietary data requirements. Data are estimates for 1994 through 1998.