SODIUM SULFATE

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There are two types of sodium sulfate—natural and byproduct, also known as synthetic. Natural sodium sulfate is produced from naturally occurring brines and crystalline deposits found in California and Texas. It is also found as a constituent of saline lakes, such as the Great Salt Lake in Utah. Synthetic sodium sulfate is recovered as a byproduct from various manufacturing processes. Both types of sodium sulfate have several important and useful applications in various consumer products. In a survey of the top 50 basic organic and inorganic chemicals made in the United States, sodium sulfate ranked 47th in terms of quantity produced.[1]

Continuing with this report, all data will be reported in metric units to comply with Public Law 100-418 of August 23, 1988. This Federal law required all Federal agencies to use the metric system of measurement by the end of fiscal year 1992. Although the use of the metric measurement standards was authorized by law since 1866 (Act of July 28, 1866; 14 Statue 339) and the United States was an original signatory party to the 1875 Treaty of the Meter (20 Statue 709), the United States has been the only industrially developed nation that has not universally converted to the metric system from the English system of measurements. As foreign trade of soda ash increases and foreign participation in U.S. joint mining ventures continues, communicating information with an international standard of measurement becomes more important. Two of the three natural sodium sulfate producers have foreign partners and some of the byproduct producers do also.

DOMESTIC DATA COVERAGE

Domestic production and inventory data for natural sodium sulfate are developed by the U.S. Bureau of Mines from monthly and annual surveys of U.S. operations. Of the three natural sodium sulfate operations to which a survey request was sent, all responded, representing 100% of the natural sodium sulfate data used in this report.

Synthetic sodium sulfate data were collected by the U.S. Department of Commerce, Bureau of the Census, from monthly and annual surveys (aggregate data published in Current Industrial Reports, Inorganic Chemicals, M28A and MA28A) of companies engaged in recovering and selling byproduct sodium sulfate. Any revised Census Bureau data have been included using most recent Census Bureau statistics. These data are aggregated with U.S. Bureau of Mines natural sodium sulfate data and included in several tables. *(See table 1.)*

BACKGROUND

Natural sodium sulfate was known to have been used as a medicine as early as the 16th century. It was first accurately described in 1658 by Johann Rudolf Glauber, a German chemist whose name is still associated with the hydrated crystal, Glauber's salt ($Na_2SO_4 \cdot 10H_2O$), and the anhydrous mixed sulfate, Glauberite ($Na_2SO_4 \cdot CaSO_4$).

Glauber and other researchers prepared sodium sulfate by reacting common salt with sulfuric acid. The invention of the Kraft process for making pulp and paper in 1880 provided the first major industrial market for sodium sulfate.

Definitions, Grades, and Specifications

The following terms are used in the sodium sulfate industry:

Anhydrous Sodium Sulfate.—Refined sodium sulfate or the mineral thenardite (Na_2SO_4). Named for the French chemist, Louis Jacques Thenard, thenardite is a colorless to white mineral with a specific gravity of 2.67 and a hardness of 2.5 to 3. Because of its whiteness and purity, it is used in detergents, pharmaceuticals, dyestuffs, glass, and ceramic glazes. Commercial-grade material has a bulk density of about 1.23 grams per cubic centimeter (77 pounds per cubic foot).

Byproduct Sodium Sulfate.—Synonymous with synthetic sodium sulfate. It is recovered as a byproduct from various chemical and textile manufacturing processes.

Glauber's Salt.—Same as the mineral mirabilite (Latin "sal mirabile" or "wonderful salt"), sodium sulfate decahydrate ($Na_2SO_4 \cdot 10H_2O$). The mineral contains 55.9% water of crystallization and forms opaque to colorless needlelike crystals.

High Purity.—Refers to anhydrous sodium sulfate with a purity of 99% or greater. Usually sold to detergent, glass, and textile industries.

Low Purity.—Some processes occasionally produce sodium sulfate that does not meet certain physical or color specifications required by certain consumers despite being a chemically pure product. This grade of sodium sulfate is generally sold to sectors that are not as concerned about whiteness or particle size, such as the pulp and paper industry, at reduced prices.

Natural Sodium Sulfate.—Sodium sulfate obtained from mining crystalline sodium sulfate-bearing minerals or from sodium sulfate-bearing brines.

Salt Cake.—Normally refers to impure sodium sulfate containing 90% to 99% Na_2SO_4. Because of its impurity or possible discoloration, it usually is sold only to the pulp and paper industry.

Synthetic Sodium Sulfate.—Same as byproduct sodium sulfate.

Sodium sulfate made from natural brine usually contains less than 0.5% total impurities, but that produced as a byproduct of other manufacturing may contain much larger quantities. The material meeting U.S. Pharmacopeia (U.S.P.) specifications and that intended for glassmaking must contain at least 99% sodium sulfate. In addition, glassmakers' grade must be low in iron and heavy metals. Technical grades of sodium sulfate may have from 2% to 6% impurities. Purchases of detergent or rayon-grade sodium sulfate are based primarily on whiteness. Its sodium chloride content may be between 1.5% and 2.0%, and its iron content between 60 and 100 parts per million.

Industry Structure

Three companies produced natural sodium sulfate from a total of three plants in California, Texas, and Utah. The domestic natural sodium sulfate industry supplied about one-half of the total output of U.S. sodium sulfate. Because of the location of these plants, most natural sodium sulfate is marketed in the West and southern gulf areas. Byproduct material was supplied by 14 companies operating 15 plants primarily in the Midwest and Mid-Atlantic regions. Total rated production capacity in 1991 was 822,000 tons, and the industry operated at 85% of this capacity. *(See table 2.)*

Geology—Resources

Sodium is the sixth most abundant element in the Earth's crust. Sodium sulfate-bearing mineral deposits are geologically young, mainly of post-glacial age. Sodium sulfate is widespread in occurrence and is a common component of seawater and many saline or alkaline lakes. Economic reserves of natural sodium sulfate are estimated at 3.3 billion tons worldwide. With world production of natural sodium sulfate averaging about 2.6 million tons per year, supplies are sufficient to meet anticipated demand for several centuries. The quantity of synthetic sodium sulfate is dependent on the longevity of the manufacturing firms recovering byproduct sulfate.

Surface depressions or lakes that have no outlets and are fed by spring waters flowing over volcanic rocks containing sulfide minerals often yield soluble sulfide salts that are oxidized by contact with the air to produce sulfates. Some minerals over which the spring water may flow contain the sulfates directly, such as bentonite or gypsum. When an inland lake of this type evaporates and becomes highly concentrated in salts, one of the first salts to precipitate would be mirabilite, also known as Glauber's salt, which has very poor solubility at low temperatures. During seasonal temperature variations, the sulfate will precipitate preferentially to the lake bottom.

Thenardite and mirabilite are the only sodium sulfate minerals that are commercially important. Many economic deposits of sodium sulfate are in the form of crystalline beds of mirabilite such as those found in Canada and the U.S.S.R., which has the world's largest sodium sulfate resource in the Kara-Bogaz-Gol Gulf. Because mirabilite converts to thenardite when exposed to air, its outer surface may develop a thenardite crust. Some buried sedimentary formations contain very large deposits of thenardite and glauberite, such as the deposit in Villarrubia de Santiago in Spain.

Sodium sulfate is also found dissolved in underground brines in California, Texas, and other parts of the world. The sulfate is usually converted to mirabilite when extracted from the brine by mechanical refrigeration techniques. *(See table 3.)*

Technology

The technology to mine and process natural sodium sulfate involves mechanical refrigeration or natural chilling to induce crystallization followed by dissolution, filtration, evaporation, and drying. Recovery of byproduct sodium sulfate from chemical processes involves various techniques.

Mining.—Sodium sulfate is extracted from the upper level of the Searles Lake brine in California and is treated separately from the carbonate-rich lower level and mixed layer brines. The subterranean sodium sulfate-bearing brines in western Texas are the simplest of the domestic brine deposits. Mechanical refrigeration is used to extract Glauber's salt crystals from the brine. The Great Salt Lake in Utah also contains valuable quantities of sodium sulfate. Brine from the most concentrated northwest segment of the lake is pumped into solar evaporation ponds on the eastern shore of the lake where sodium chloride first precipitates as the water evaporates. Sodium sulfate crystals precipitate in a fairly pure state when winter weather cools the brine to -1° to 4° C (30° to 40° F). The crystals are picked up by large earth-moving machinery and stored outdoors until further processing to anhydrous sodium sulfate can take place.

Processing.—At Searles Lake, the brine is first cooled at about 16° C (60° F) to precipitate borax crystals, which are removed from the system for subsequent further processing and sale. A second cooling to about 4° C (40° F) precipitates

the sodium sulfate in the form of Glauber's salt. These crystals are separated from the brine on a rotating drum filter. They are then redissolved in fresh water in a vacuum crystallizer. After the second separation and drying, the crystals are about 98.2% sodium sulfate. Additional treatment can obtain a 99.3% purity. Major impurities remaining are sodium chloride, sodium carbonate, and boron.

In Texas, after the crystals are processed in rotary drum vacuum filters and washed, they are melted and dehydrated using mechanical vapor recompression evaporators, which are more energy efficient than triple effect evaporators or submerged gas burners. Final classifying, centrifuging, drying in rotary kilns, and screening converts the Glauber's salt to marketable anhydrous sodium sulfate of 99.7% purity.

Purification and dehydration procedures at the facility on the Great Salt Lake are similar to those of other sodium sulfate plants. The final product results in a purity between 99.5% to 99.7%.

Sodium sulfate is also produced as a byproduct of the production of ascorbic acid, boric acid, cellulose, chromium chemicals, lithium carbonate, rayon, resorcinol, and silica pigments. It is also recovered from certain flue gas desulfurization operations. The Mannheim and Hargreaves furnace processes also produce byproduct sodium sulfate. In the Mannheim furnace, salt and sulfuric acid are reacted to form hydrogen chloride (HCl) and sodium sulfate. The Hargreaves furnace produces HCl and sodium sulfate by the reaction of sulfur dioxide, sodium chloride, air, and water. The Mannheim process is the major method used in Europe, but its use in the United States has decreased considerably since less expensive methods to produce HCl became available.

Recycling.—Because of environmental concerns regarding sulfur emissions from pulp and paper mills, many Kraft pulpers were installing pollution abatement equipment to reduce sulfur losses in the pulping process. This will result in more sodium sulfate being recycled and less used in batch makeup solutions.

Byproducts and Coproducts

The brines of Searles Lake in California contain sodium sulfate as well as coproduct borax, potassium chloride, sodium chloride, and soda ash. The Great Salt Lake in Utah is a source of magnesium compounds, potassium sulfate, sodium chloride, as well as sodium sulfate.

Some manufacturers of ascorbic acid, boric acid, cellulose, chromium chemicals, lithium carbonate, rayon, resorcinol, and silica pigments produce sodium sulfate as a byproduct of the process. The sodium sulfate is considered a waste product but has marketability.

Economic Factors

Prices.—Producers of natural sodium sulfate tend to market and sell most of their own product, but most synthetic producers use major chemical distributors or chemical supply companies as sales agents. The principal product made and sold by the synthetic sodium sulfate producer is the primary economic factor. Because sodium sulfate is considered a waste product, it will be sold at a price that ensures prompt sales. This practice tends to set the rates at which the natural product can be sold.

The list prices quoted in trade journals or by producers of all grades of sodium sulfate differ from the annual average values reported by the U.S. Bureau of Mines. The value represents the combined amount of total revenue of domestic natural sodium sulfate sold at list prices, spot prices, long-term contracts, discounts, and export divided by the aggregated quantity of sodium sulfate sold. The published value does not necessarily correspond to the posted list price. *(See table 4.)*

Tariffs.—Import tariffs serve to protect the interests of domestic producers for particular products. For sodium sulfate, a 32.5-cents-per-ton tariff is imposed on imported anhydrous sodium sulfate from countries having most favored nation (MFN) status and $2.95 per ton from those with non-MFN status. There are no import tariffs on imported salt cake, regardless of the country of origin.

Royalties.—Sodium sulfate mined on Federal lands is subject to the Mineral Leasing Act of 1920, which provides for royalty payments to the U.S. Government. The royalty is 5% of the quantity or gross value of the output of the product at the point of shipment to market. Each Federal lease also has other costs, such as bonds, acreage rental fees, sodium prospecting permit application fees, and permit bonds. The Searles Lake sodium sulfate deposit is the only resource with active operations that has any Federal leases. Because of the variety of the brine constituents, the operator has a commingling agreement with the U.S. Government to compute royalties.

Depletion Provisions.—Legislation passed by the U.S. Government provides an allowance for the depletion of natural resources, notably timber and minerals. The depletion allowance is an important inducement for companies willing to accept the risk and high cost of mining development. The concept of depletion allowances for minerals is similar to the depreciation of other assets. Although cost depletion and percentage depletion are two methods used to compute depletion deductions, most companies prefer to use the latter. About 100 mineral categories are entitled to percentage depletion. The rates range between 5% and 22% of the gross income from the mineral property, depending on the mineral and location (foreign or domestic), and are subject to a limitation of 50% of the net income of the property. The mineral depletion allowance for natural sodium sulfate is 14% for U.S. companies mining from domestic or foreign sources.

Operating Factors

Operating factors are different for mining companies producing natural

sodium sulfate compared with manufacturing facilities recovering byproduct sodium sulfate. The quantity of synthetic sodium sulfate recovered is directly associated with the production capabilities of the primary industry (e.g., rayon, lithium carbonate, etc.) and the sulfate recovery rates.

Environmental Requirements.—Land usage may become a problem when sodium sulfate is obtained by solar evaporation, as in the case of the Great Salt Lake brines. Large areas of relatively flat land are required to allow for adequate concentration and evaporation. When land values are high, the capital required for land acquisition may increase operating costs. Disposal of the waste liquors from which sodium sulfate was extracted may develop into a major ground water discharge problem in some areas. Reinjection of spent solutions into underground source strata is expensive but often is the only acceptable method of disposal.

Because sodium sulfate is water-soluble, most releases of sodium sulfate to the environment affect water quality rather than air or land quality. These releases are mainly from Kraft pulp mills, which typically discharge between 5 to 15 million kilograms (11 to 33 million pounds) of sodium sulfate per year per site. The resulting drinking water concentrations have been estimated as high as 38.8 milligrams per liter, which is significantly below the maximum concentration level of 250 milligrams per liter set by the National Secondary Drinking Water Standard.

Problems associated with chemical effluents discharged from manufacturing plants that recover sodium sulfate have also caused environmental concerns not attributed to sodium sulfate. The second largest byproduct sodium sulfate facility in the United States at Front Royal, VA, owned by Avtex Fibers Inc., was closed in late 1989 by Federal and State regulatory agencies because of contaminated water discharges containing carbon disulfide and polychlorinated biphenyls (PCB's). These toxic chemicals were produced from rayon manufacture, not sodium sulfate recovery.

Toxicity.—Sodium sulfate was deleted in early 1989 from the list of toxic chemicals under section 313 of title III of the Superfund Amendments and Reauthorization Act of 1986. The U.S. Environmental Protection Agency determined that there was no evidence that sodium sulfate caused, or could reasonably be anticipated to cause, adverse human health or environmental effects as specified in the act.

Employment.—According to the Bureau of Labor Statistics and industry sources, approximately 300 persons are employed in mining and processing natural sodium sulfate in the United States. Data are not available on the number of personnel employed in recovering byproduct sodium sulfate.

Energy Requirements.—The energy requirements to mine natural sodium sulfate are minimal compared to the amount of energy required to process it. An early U.S. Bureau of Mines energy survey reported that 4.5 million British thermal units (Btu's) was required to produce 1 ton of natural sodium sulfate. With the interest in conserving energy, some technical improvements, such as the installation of mechanical vapor recompression crystallizers, have reduced the overall energy requirement to slightly less than 2 million Btu's per ton of sulfate produced.

Transportation.—All natural sodium sulfate is shipped in bulk or in bags by either rail or truck. The mode of transportation depends on the location of the customer, quantity purchased, and difference in freight rates. Because of the location of the natural producers in the West and Southwest, very little natural sodium sulfate is shipped to the East because transportation rates reduce its competitiveness with synthetic sodium sulfate. Consumers in the Midwest and East tend to rely on synthetic sodium sulfate produced in various Midwest and Southern locations.

ANNUAL REVIEW

Domestic sodium sulfate production decreased about 2% in 1991 while overall U.S. apparent consumption declined 6%. The slight downturn in production was attributed to the national economic recession that affected some of the industries that recover byproduct sodium sulfate. Although the United States is one of the largest producers in the world of natural and synthetic sodium sulfate, its share has decreased from 23% of world production total in 1980 to 14% in 1991. Figure 1 graphically shows the trend of U.S. production since 1970. Total production has declined 44% since 1970. *(See figure 1.)*

Issues

The environmental movement in North America continued to adversely affect the North American sodium sulfate industry. Changes toward oxygen-base bleaching chemicals by the pulp and paper industry have reduced the sales by several sodium sulfate suppliers. Some of the chemicals can be produced on-site at various pulp mills. One of the chosen bleaching chemicals, chlorine dioxide, produces sodium sulfate as a byproduct that can be used and partially recycled by the pulp mills. By producing their own sodium sulfate, certain pulp mills would not have to purchase any sodium sulfate.[2]

Sodium sulfate consumption by the soap and detergent industry, which has been the largest consumer of sodium sulfate, remained stagnant because of product reformulations. In addition, the growing national environmental awareness regarding the volume of packaging material discarded to landfills prompted certain detergent manufacturers to begin making superconcentrated or compact products that are packaged in smaller containers. This reduction in package size minimizes the amount of landfill waste but also reduces the quantity of sodium sulfate used in powdered detergents. Sodium sulfate is

used as a filler in powdered home laundry detergents. *(See figure 2.)*

Production

U.S. production of sodium sulfate decreased about 2% in 1991 primarily because of stagnant market conditions. Problems in byproduct production in the Southeast cause some tightness in the market. Production was temporarily down at the Bessemer City, NC, plant of Lithium Corp. of America, and a late startup at Cortauld's Le Moyne, AL, plant also caused supply disruptions.[3] Reportedly, the Hoffman-LaRoche pharmaceutical plant at Belvidere, NJ, ceased recovering sodium sulfate. Green Bay Packaging Inc., of Green Bay, WI, converted to using recycled paper that eliminated the sodium sulfate recovery operation. W. R. Grace and Co. changed its chelate agent process technology that reduced the quantity of sodium sulfate recovered. The plant is at Nashua, NH.

The United States and Mexico were the largest producers of total sodium sulfate, each representing about 13% of the world total. Spain produced 12%, followed by the U.S.S.R., 11%, and Canada and Germany, 7% each. These six countries accounted for approximately 65% of the world's output of total sodium sulfate, based on obtainable production data. *(See tables 5 and 6.)*

Consumption and Uses

U.S. sodium sulfate apparent consumption decreased 6% from that of the previous year. Most of the same conditions that affected demand in 1990 remained in 1991. Concern for the environment was the paramount reason behind the stagnant supply and demand situation. Imports for consumption of sodium sulfate, primarily from Canada and Mexico, also declined because of the depressed U.S. markets in which sodium sulfate is consumed.

An estimated 53% of the total sodium sulfate consumed in the United States is for use as a filler in powdered laundry detergents. Many areas in the country have adopted phosphate bans or limitations because phosphatic detergents contribute to the environmental problems of eutrophication. The affected areas represent about 33% of the U.S. population. In response to this environmental issue, detergent manufacturers have reformulated many of their detergents by switching from sodium tripolyphosphate (STPP) to tetrasodium pyrophosphate, which has the same building power as STPP but requires less to be used, thereby reducing the amount of phosphate released into the environment. These reformulations used more sodium sulfate as filler, which was beneficial to the sodium sulfate industry.

Sodium sulfate consumption decreased in the Kraft pulping industry because of the economic recession affecting the paper industry and recycling of paper products. Kraft pulping represented about 83% of the domestic pulp market in 1991. Public awareness about the environmental issue of nondegradable plastic packaging made many people prefer brown paper grocery bags (produced by the Kraft process), which degrade in landfills much more readily than plastic bags. Kraft pulping represents about 27% of the total demand for sodium sulfate. *(See figure 3.)*

Stocks

Yearend inventories of natural sodium sulfate stored by the three producers were 35,436 tons, which was a 9% decrease over that of the previous year. The material stockpiled was anhydrous sodium sulfate. Synthetic sodium sulfate was marketed mainly through major chemical distributors, which have separate storage facilities from the producers.

Atochem North America Inc. installed a new bagging system to handle its natural sodium sulfate supplies. The operation is at Charlotte, NC, and has a capacity to package more than 40,000 tons of product annually. Sodium sulfate can be packaged and stockpiled at the facility, which is closer to several of Atochem's customers.

Markets and Prices

The average value declined from $96.63 per metric ton ($87.66 per short ton) to $87.34 per metric ton ($79.23 per short ton) for bulk sodium sulfate, f.o.b. mine or plant.

As of December 1, Atochem North America increased it prices for natural sodium sulfate by $5 per ton. The new prices, per short ton, are: bulk detergent grade, $110; bulk glass grade, $110; bulk paper grade, $105; 100-pound bags detergent grade, $137; 50-pound bags detergent grade, $144; SS 2,000 pounds, $137.50; and SS 1,350 pounds, $144.45.[4] *(See table 7.)*

Foreign Trade

U.S. exports of 103,000 tons were 66% higher in 1991 when compared with those of the previous year. The Republic of South Korea received almost 3 times the quantity of sodium sulfate in 1991 than it imported in 1990. This increase was because of Oriental Chemical Industries (OCI), which became a joint-venture partner with North American Chemical Co. at Searles Lake, CA. OCI was taking its share of product back to Korea for consumption.

Canada and Mexico supplied about 98% and about 2%, respectively, of total U.S. sodium sulfate imports. Small shipments were sent to the United States from Brazil, Finland, Germany, and Japan. Although the United States had a net import reliance of about 8%, most imports were less expensive to consumers than products from domestic sources, especially when overland shipping costs are considered.

Approximately 33% of the total quantity was shipped to Australia; Chile, 15%; Colombia, 14%; and New Zealand, 8%. Most was in the form of low-purity salt cake. *(See tables 8, 9, 10, 11, and figure 4.)*

World Review

Industry Structure.—About 52% of the world sodium sulfate production in 1991 was from natural sources; the balance

was represented by synthetic sodium sulfate recovered from various chemical and manufacturing processes. Although the U.S. Bureau of Mines collects or estimates data from 28 sodium sulfate-producing countries, other countries are known or assumed to have produced synthetic sodium sulfate, but production statistics are not reported, and available information is inadequate to make reliable estimates of output. *(See table 12.)*

Capacity.—The data in table 2 are rated capacities for domestic natural operations and byproduct recovering facilities in 1991. Rated capacity is defined as the maximum quantity of product that can be produced in a period of time on a normally sustainable long-term operating rate, based on the physical equipment of the plant, and given acceptable routine operating procedures involving labor, energy, materials, and maintenance. Capacity includes both operating plants and plants temporarily closed that, in the judgment of the author, can be brought into production within a short period of time with minimum capital expenditure.

Mine capacity for natural sodium sulfate is derived from available company data on ore throughput to the refinery. The ore refers to mined crystalline sodium sulfate, harvested precipitate, or sodium sulfate-bearing brines. Refinery capacity for natural sodium sulfate pertains to the total amount of anhydrous sodium sulfate that the plant is capable of processing from the ore. Synthetic sodium sulfate refining capacity is dependent on the production capabilities of the primary industry and the sodium sulfate recovery rates.

Canada.—Agassiz Resources Ltd., which is the second largest natural sodium sulfate producer in Canada, closed its Hardene, Saskatchewan, facility in April. By July, Agassiz's plants at Cabri, Saskatchewan, and Metiskow, Alberta, had suspended operations because of economic conditions.[5]

Iran.—A 20,000-ton-per-year synthetic sodium sulfate plant is under construction near Ghazvin, 250 kilometers west of Teheran. Alborz Chemical Complex Co., a subsidiary of Alborz Investment Corp., the owner, planned to sell the sodium sulfate primarily to the local detergent industry. Startup of the facility was planned for 1992 or 1993.[6]

United Kingdom.—Imperial Chemical Industries licensed a new electrolytic process that recycles sulfuric acid and caustic soda from liquid wastes containing sodium sulfate. The sodium sulfate had been discharged as effluent to streams and rivers, which were becoming environmentally contaminated. Instead of purifying and selling the sodium sulfate byproduct, which had declining markets, the material could now be converted to salable acids.[7]

OUTLOOK

U.S. natural and synthetic sodium sulfate production and consumption decreased 44% and 48%, respectively, from those of 1980 to 1991. The decreases were because of changes in the recovery operations of consuming industries mandated by environmental legislation requiring reductions in sulfate emissions and declining use of sodium sulfate in powdered laundry detergents. Although production has been relatively flat since about 1982, domestic consumption of sodium sulfate has fluctuated primarily due to detergent reformulations that contain reduced quantities of sodium sulfate. U.S. consumption is expected to decline further, or less pessimistically remain flat, in the next few years.

The United States is a very important market for Canadian sodium sulfate. In 1991, 45% of Canadian output was exported to the United States. If domestic markets continue to decline, Canadian producers would encounter financial hardships and would be forced to look for more distant export opportunities. Sodium sulfate imports from Mexico are relatively minor compared to its total production capability; therefore, any erosion of U.S. domestic consumption would not affect Mexican producers significantly.

Production

The changes in the domestic demand situation has prompted several byproduct sodium sulfate producers to consider changing their process technology that would alter the composition of byproduct wastes. For example, hydrochloric acid plants could use potash, rather than salt, to recover potassium sulfate instead of sodium sulfate. Potassium sulfate is a fertilizer used for tobacco, fruits, nuts, and other crops.

A new method to produce byproduct sodium sulfate began in mid-1991. Tonolli Canada Ltd. started to produce about 7,000 tons per year of sodium sulfate from its battery recycling operation in Mississauga, Ontario, Canada. Its technology will be used by Doe Run Co., at Boss, MO. This facility will recover about 12,000 tons of sodium sulfate annually.[8] Reportedly, other battery recycling plants are planned that will also recover sodium sulfate. They include GNB Batteries Inc. of Fort Valley, GA, and Asarco. BASF Corp. is reportedly evaluating recovering sodium sulfate from one of its chemical operations. Formosa Plastics Corp. planned to construct a rayon plant near Wallace, LA, that would produce about 75,000 tons of synthetic sodium sulfate annually. These new byproduct operations will have an effect on the other byproduct plants and natural sodium sulfate producers that market sodium sulfate into those regions.

Detergents

The use of sodium sulfate as a filler appears to have peaked in 1989. In 1991, major detergent manufacturers continued making more superconcentrated detergent products rather than the traditional large boxes filled with bulk detergents containing up to 20% sodium sulfate as filler. This change, initiated by environmental considerations, will further reduce sales of sodium sulfate in the near future unless consumers do not purchase

the more expensive superconcentrate detergents because of the higher cost. If the economic recession continues, which affects consumer spending, less expensive powdered detergents containing sodium sulfate may be reintroduced at the expense of the more expensive concentrated and liquid products. In addition, liquid laundry detergents that do not contain any sodium sulfate continued to make up about 40% of the home laundry market.

Pulp and Paper

The economic recession that began in late 1990 and lasted throughout 1991 affected sodium sulfate sales to the pulp and paper sector, resulting in reduced sodium sulfate consumption. Environmental concerns regarding sulfur emissions prompted many Kraft pulpers to install pollution control equipment to reduce sulfur losses in the pulping process. Furthermore, many Kraft pulpers are changing their bleaching chemicals to abide by the new environmental regulations. Production of sodium chlorate, which is used to make chloride dioxide, will increase as the demand for oxygen-base bleaching chemicals rises. The process will produce sodium sulfate as a byproduct, thereby reducing the demand for saltcake. Recycling of brown paper bags made by the Kraft process will also reduce sodium sulfate consumption in the future.

[1]Chemical and Engineering News. Facts and Figures for the Chemical Industry. V. 69, No. 25, p. 31.
[2]———. Paper Industry Changes Shake Supplier Lineup. V. 69, No, 45, pp. 15-16.
[3]Chemical Marketing Reporter. Sodium Sulfate. V. 240, No. 12, p. 30.
[4]———. Bases and Salts, Sodium Sulfate. V. 240, No. 25, p. 29.
[5]———. Detergent Compact Shift Makes Sulfate Outlook Grim. V. 239, No. 17, p. 5.
[6]Industrial Minerals. New Synthetic Sodium Sulfate Plant. No. 286, p. 29.
[7]———. Company News. ICI Cleans Up Na_2SO_4 Waste. No. 286, p. 28.
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TABLE 1
SALIENT SODIUM SULFATE STATISTICS

(Thousand metric tons and thousand dollars)

	1987	1988	1989	1990	1991
United States:					
Production[1]	725	743	685	r713	696
Value[2]	$69,289	$64,545	$62,703	$64,244	$60,825
Exports	111	77	62	62	103
Value	$10,554	$8,737	$6,241	$6,704	$11,495
Imports for consumption	125	136	173	162	157
Value	$10,363	$11,962	$13,990	$13,155	$13,807
Stocks, Dec. 31: Producers	50	54	24	39	35
Apparent consumption	755	798	825	798	754
World: Production	r4,895	r4,943	r4,931	r4,870	e4,837

eEstimated. rRevised.
[1]Includes natural and synthetic. Total production data for synthetic sodium sulfate, obtained from the Bureau of the Census, was revised in Dec. 1990 M28A Inorganic Chemicals, Current Industrial Report.
[2]The value for synthetic sodium sulfate is based upon the average value for natural sodium sulfate.

TABLE 2
PRODUCERS OF NATURAL AND SYNTHETIC SULFATE, IN 1991

Product and company	Plant nameplate capacity (thousand metric tons)	Plant location	Source
Sodium sulfate, natural:			
Great Salt Lake Minerals & Chemicals Corp.	45	Ogden, UT	Salt lake brine.
North American Chemical Co.,[1] Westend plant	218	Trona, CA	Dry lake brine.
Ozark-Mahoning Co.[2]	141	Seagraves, TX	Do.
Total	404		
Sodium sulfate, synthetic:			
BASF	34	Lowland, TN	Rayon manufacture.
Climax Chemical Co.	45	Hobbs, NM	Hydrochloric acid manufacture.
Courtaulds North America Inc.	45	La Moyne, AL	Rayon manufacture.
Cyprus Specialty Metals	16	Kings Mountain, NC	Lithium carbonate.
W. R. Grace & Co. Organic Chemicals Div.	8	Nashua, NH	Chelating agents.
J. M. Huber	32	Etowah, TN	Silica pigment.
Do.	14	Havre de Grace, MD	Do.
Indspec Chemical Corp.	35	Petrolia, PA	Resorcinol manufacture.
Lithium Corp. of America	41	Bessemer City, NC	Lithium carbonate.
North American Rayon Corp.	14	Elizabethton, TN	Rayon manufacture.
Occidental Chemical Corp.	109	Castle Hayne, NC	Sodium dichromate manufacture.
Public Service of New Mexico	6	Waterflow, NM	Flue gas desulfurization.
Teepak, Inc.	6	Danville, IL	Cellulose manufacture.
Texaco Chemical Co.	3	Delaware City, DE	Flue gas desulfurization.
Total	408		
Grand total	812		

[1]Purchased Nov. 30, 1990, from Kerr-McGee Chemical Corp.
[2]Ozark's Brownfield plant, owned by Atochem North America (formerly Pennwalt), was placed on standby in Sept. 1987; 64,000 tons of capacity is not included in total industry capacity.

TABLE 3

WORLD NATURAL SODIUM SULFATE RESERVES AND RESERVE BASE

(Million metric tons)

	Reserves	Reserve base[1]
North America:		
Canada	84	272
Mexico	165	227
United States	857	1,361
Total	1,106	1,860
Europe:		
Spain	180	272
U.S.S.R.	1,814	2,268
Total	1,994	2,540
Africa:		
Botswana	188	227
World total[2]	3,300	4,600

[1]The reserve base includes demonstrated resources that are currently economic (reserves), marginally economic (marginal reserves), and some of those that are currently subeconomic (subeconomic resources). These definitions of reserves and reserve base are published in U.S. Geological Survey Circular 831, "Principles of a Resource/Reserve Classification for Minerals."
[2]Data do not add to total shown because of independent rounding.

NOTE.—Resources of sodium sulfate are known to also exist in Antarctica, Argentina, Chile, India, Iran, Italy, Mongolia, Romania, the Republic of South Africa, and Turkey. Production of synthetic sodium sulfate is dependent on the supply and demand of the primary product.

TABLE 4

TIME-VALUE RELATIONSHIPS FOR SODIUM SULFATE

Year	Average annual value,[1] dollars per ton			
	Natural sodium sulfate			
	Actual value		Based on constant 1991 dollars[2]	
	Short ton	Metric ton	Short ton	Metric ton
1970	18.28	20.15	60.93	67.16
1971	16.00	17.64	50.59	55.77
1972	16.26	17.92	49.03	54.05
1973	17.26	19.03	48.90	53.90
1974	23.99	26.44	62.51	68.91
1975	41.48	45.72	98.64	108.73
1976	49.25	54.29	110.18	121.45
1977	46.09	50.81	96.47	106.34
1978	46.06	50.77	89.37	98.51
1979	55.69	61.39	99.48	109.66
1980	62.42	68.81	101.86	112.28
1981	71.03	78.30	105.33	116.11
1982	83.00	91.49	115.88	127.74
1983	93.30	102.85	125.18	137.99
1984	92.16	101.59	118.49	130.61
1985	92.19	101.62	114.26	125.95
1986	86.11	94.92	103.97	114.61
1987	86.72	95.59	101.46	111.84
1988	78.81	86.87	88.75	97.83
1989	83.05	91.55	89.64	98.81
1990	87.66	96.63	90.84	100.13
1991	79.23	87.34	79.23	87.34

[1]Based on the average valuation by producers of their annual total production and reported sales. The values incorporate the price differences changed by producers for the same finished product sold in bulk at the plant.
[2]Final 1991 implicit price deflators for 1991 are based on gross domestic product and not gross national product, which was used previously. Based on 1987=100.

TABLE 5

SODIUM SULFATE SUPPLY-DEMAND RELATIONSHIPS[1]

(Thousand metric tons)

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
World Production											
United States	1,008	784	776	791	736	763	725	743	685	r713	696
Rest of world	3,693	3,337	3,306	3,611	3,773	3,846	r4,170	r4,200	r4,246	r4,157	e4,141
Total	4,701	4,121	4,082	4,402	4,509	4,609	r4,895	r4,943	r4,931	r4,870	e4,837
COMPONENTS AND DISTRIBUTION OF U.S. SUPPLY											
Domestic sources	1,008	784	776	791	736	763	725	743	685	713	696
Imports	249	357	311	240	177	171	125	136	172	162	157
Industry stocks, Jan. 1[2]	30	60	27	44	54	28	65	50	54	24	39
Total U.S. supply	1,287	1,201	1,114	1,075	967	962	915	929	911	r899	892
Distribution of U.S. supply:											
Industry stocks, Dec. 31[2]	60	27	44	54	28	65	50	54	24	39	35
Exports	112	101	83	69	108	101	111	77	62	62	103
Industrial demand	1,115	1,073	987	952	831	796	754	798	r825	r798	754
U.S. DEMAND PATTERN[e]											
Glass	62	54	50	49	48	48	45	48	33	r32	36
Pulp and paper	508	490	464	454	445	239	226	239	231	r223	200
Soaps and detergents	435	426	425	363	318	414	392	415	495	r479	400
Other[3]	110	103	48	86	20	95	91	96	66	r64	118
Total U.S. primary demand	1,115	1,073	987	952	831	796	754	798	r825	r798	754
VALUES[4]											
Average annual value per short ton[5]	$71.03	$83.30	$93.30	$92.16	$92.19	$86.11	$86.72	$78.81	$83.05	$87.66	$79.23
Average annual value per metric ton	$78.30	$91.49	$102.85	$101.59	$101.62	$94.92	$95.59	$86.87	$91.55	$96.63	$87.34

eEstimated using data from "Chemical Profile" issues on sodium sulfate by Chemical Marketing Reporter for 1980, 1983, 1986, and 1989. rRevised.

[1]Natural and synthetic except where noted. Synthetic sodium sulfate data obtained from the Bureau of the Census are revised periodically and may differ from previous published reports by the U.S. Bureau of Mines. World production data also are periodically revised on receipt of updated information.

[2]Natural sodium sulfate only.

[3]Includes ceramics, chemicals (potassium sulfate, sodium hyposulfite, sodium sulfide, sodium silicate, and sodium aluminum sulfate), feed supplements, printing inks, sulfonated oils, textile dyeing, veterinary medicines, and viscose sponges.

[4]Dollars per ton for natural sodium sulfate, f.o.b. mine or plant.

[5]Although data from 1990 and thereafter will be published in metric units, historical values based on short will continue to be published for reference.

TABLE 6

SYNTHETIC AND NATURAL SODIUM SULFATE[1] PRODUCED IN THE UNITED STATES

(Thousand metric tons and thousand dollars)

Year	Synthetic and natural[2] (quantity)			Synthetic	Natural	
	Lower purity[3] (99% or less)	High purity	Total[4]	Quantity	Quantity	Value
1970	509	737	1,246	703	543	10,932
1971	466	765	1,231	607	624	11,008
1972	477	727	1,204	568	636	11,396
1973	481	824	1,305	695	610	11,597
1974	513	710	1,223	602	621	16,411
1975	391	722	1,113	508	605	27,667
1976	422	695	1,117	516	601	32,655
1977	614	474	1,088	511	577	29,313
1978	599	461	1,060	511	549	27,865
1979	555	462	1,017	533	484	29,689
1980	613	421	1,033	504	529	36,389
1981	604	404	1,008	456	552	43,186
1982	420	364	784	W	W	W
1983	388	388	776	392	384	39,425
1984	388	403	791	396	395	40,125
1985	340	396	736	383	353	35,860
1986	328	435	763	404	359	34,102
1987	312	r413	725	379	346	33,086
1988	312	431	743	382	361	31,377
1989	291	394	685	345	340	31,104
1990	r345	r368	r713	364	349	33,748
1991	354	342	696	342	354	30,904

rRevised. W Withheld to avoid disclosing company proprietary data.

[1]All quantities converted to 100% Na_2SO_4 basis.

[2]Current Industrial Reports, Inorganic Chemicals, Bureau of the Census. Revisions from 1988 Annual (Preliminary), MA28A, Nov. 1989, p. 11.

[3]Includes Glauber's salt.

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

TABLE 7

SODIUM SULFATE YEAREND PRICES

		1990	1991
Sodium sulfate (100% Na_2SO_4):			
East, bulk, carlot, works, freight equalized	per ton	$113.00-$114.00	$113.00-$114.00
Gulf, bulk, carlot, same basis	do.	90.00- 105.00	110.00
West, bulk, carlot, same basis	do.	122.00	127.00
Salt cake (100% Na_2SO_4):			
East, bulk, f.o.b. works	do.	65.00- 62.00	72.00
West, same basis	do.	90.00- —	—

Sources: Chemical Marketing Reporter. Current Prices of Chemicals and Related Materials. V. 238, No. 27, Dec. 31, 1990, p. 31, and V. 240, No. 27, Dec. 30, 1991, p. 31.

TABLE 8
U.S. IMPORTS FOR CONSUMPTION OF SODIUM SULFATE

(Thousand metric tons and thousand dollars)

Year	Disodium sulfate, salt cake[1] [2]		Disodium sulfate, other[3]		Total[4]	
	Quantity	Value[5]	Quantity	Value[5]	Quantity	Value[5]
1987	34	2,189	92	8,173	125	10,363
1988	27	1,930	109	10,034	136	11,962
1989	41	3,350	132	10,641	173	13,990
1990	40	3,277	121	9,879	162	13,155
1991	57	5,139	100	8,668	157	13,807

[1]Beginning in 1989, import data were reclassified under the Harmonized Tariff System. Salt cake is HTS No. 2833111000. In prior years, salt cake was under TSUSA No. 4214200.
[2]Includes Glauber's salt as follows: 1987--666 tons ($38,318); and 1988--604 tons ($16,963). TSUSA No. was 4214600.
[3]Harmonized Tariff System No. 2833115000 in 1989, changed to No. 2833115010 in 1990; TSUSA No. 4214400 for prior years.
[4]Data may not add to totals shown because of independent rounding.
[5]C.i.f. value at U.S. ports.

Source: Bureau of the Census.

TABLE 9
U.S. IMPORTS OF SODIUM SULFATE, BY COUNTRY

Country	Disodium sulfate, salt cake[1]		Disodium sulfate, other[2]		Total	
	Quantity (metric tons)	Value[3] (dollars)	Quantity (metric tons)	Value[3] (dollars)	Quantity (metric tons)	Value3 (dollars)
1990:						
Brazil	122	21,045	—	—	122	21,045
Canada	40,117	3,220,484	103,164	8,584,982	143,281	11,805,466
Finland	28	9,794	—	—	28	9,794
Germany, Federal Republic of	14	1,426	—	—	14	1,426
Ireland	1	5,447	—	—	1	5,447
Japan	40	18,407	—	—	40	18,407
Mexico	—	—	18,179	1,293,881	18,179	1,293,881
Total	40,322	3,276,603	121,343	9,878,863	161,665	13,155,466
1991:						
Brazil	133	20,839	—	—	133	20,839
Canada	56,956	5,062,033	96,025	8,375,281	152,981	13,437,314
Finland	22	4,553	—	—	22	4,553
Germany, Federal Republic of	179	17,939	—	—	179	17,939
Japan	58	33,592	—	—	58	33,592
Mexico	—	—	3,527	292,506	3,527	292,506
Total	57,348	5,138,956	99,552	8,667,787	156,900	13,806,743

[1]Beginning in 1989, import data were reclassified under the Harmonized Tariff System. Salt cake is HTS No. 2833111000. In prior years, salt cake was under TSUSA No. 4214200.
[2]Harmonized Tariff System No. 2833115000 in 1989, changed to No. 2833115010 in 1990. TSUSA No. 4214400 for prior years.
[3]C.i.f. value at U.S. ports.

Source: Bureau of the Census.

TABLE 10
U.S. EXPORTS OF SODIUM SULFATE

(Thousand metric tons and thousand dollars)

Year	Disodium sulfate, salt cake[1]		Disodium sulfate, other[2]		Total[3]	
	Quantity	Value[4]	Quantity	Value[4]	Quantity	Value[4]
1987	96	8,882	15	1,672	111	10,554
1988	62	5,128	15	3,609	77	8,737
1989	60	5,409	2	832	62	6,241
1990	61	6,092	1	612	62	6,704
1991	82	8,316	21	3,179	103	11,495

[1]Prior to 1989, salt cake was Schedule B No. 4214200. In 1989, it was reclassified under the Harmonized Tariff System as HTS No. 2833111000.
[2]Prior to 1989, other sodium sulfate was Schedule B No. 4214500. In 1989, it is isted as HTS No. 2833115000.
[3]Data may not add to totals shown because of independent rounding.
[4]C.i.f. value at U.S. ports.

Source: Bureau of the Census.

TABLE 11
U.S. EXPORTS OF SODIUM SULFATE, BY COUNTRY

Country	Disodium sulfate, salt cake[1]		Disodium sulfate, other[2]		Total[3]	
	Quantity (metric tons)	Value[4] (dollars)	Quantity (metric tons)	Value[4] (dollars)	Quantity (metric tons)	Value[4] (dollars)
1990:						
Australia	32,628	3,468,288	—	—	32,628	3,468,288
Bahrain	—	—	9	19,358	9	19,358
Brazil	—	—	4	15,707	4	15,707
Canada	375	50,141	—	—	375	50,141
China	—	—	17	24,339	17	24,339
Colombia	4,418	246,519	—	—	4,418	246,519
Costa Rica	—	—	18	12,730	18	12,730
Denmark	—	—	5	11,660	5	11,660
Dominican Republic	—	—	138	40,721	138	40,721
France	—	—	4	17,280	4	17,280
Germany, Federal Republic of	—	—	5	12,325	5	12,325
Hong Kong	—	—	47	61,458	47	61,458
Indonesia	—	—	30	24,000	30	24,000
Italy	—	—	9	63,318	9	63,318
Japan	—	—	15	21,025	15	21,025
Korea, Republic of	5,586	633,418	—	—	5,586	633,418
Mexico	334	35,802	249	84,000	583	119,802
Netherlands	—	—	1	3,759	1	3,759
New Zealand	10,585	946,663	—	—	10,585	946,663
Panama	70	12,125	—	—	70	12,125
Portugal	—	—	103	63,280	103	63,280
Singapore	420	43,560	27	33,016	447	76,576
Spain	—	—	1	3,306	1	3,306
Switzerland	—	—	6	4,222	6	4,222
Taiwan	—	—	181	77,734	181	77,734
Thailand	6,205	639,117	—	—	6,205	639,117
United Kingdom	—	—	16	18,661	16	18,661
Venezuela	160	16,496	—	—	160	16,496
Total[3]	60,781	6,092,129	885	611,899	61,666	6,704,028
1991:						
Australia	34,172	3,474,861	—	—	34,172	3,474,861
Belize	19	3,239	—	—	19	3,239
Brazil	—	—	4	12,813	4	12,813
Canada	856	97,264	—	—	856	97,264
Chile	15,262	1,369,796	—	—	15,262	1,369,796
China	—	—	38	151,748	38	151,748
Colombia	4,993	353,474	9,130	614,288	14,123	967,762
Dominican Republic	—	—	420	105,512	420	105,512
Ecuador	—	—	14	13,477	14	13,477
Egypt	54	15,000	—	—	54	15,000
Germany, Federal Republic of	—	—	5	22,844	5	22,844
Hong Kong	—	—	29	24,152	29	24,152
Israel	—	—	2	11,060	2	11,060
Italy	—	—	29	10,211	29	10,211

See footnotes at end of table.

TABLE 11—Continued

U.S. EXPORTS OF SODIUM SULFATE, BY COUNTRY

Country	Disodium sulfate, salt cake[1]		Disodium sulfate, other[2]		Total[3]	
	Quantity (metric tons)	Value[4] (dollars)	Quantity (metric tons)	Value[4] (dollars)	Quantity (metric tons)	Value[4] (dollars)
Jamaica	—	—	13	22,001	13	22,001
Japan	—	—	445	216,868	445	216,868
Korea, Republic of	5,417	650,067	9,374	1,176,924	14,791	1,826,991
Malaysia	—	—	1	3,649	1	3,649
Mexico	223	30,941	726	257,472	949	288,413
Netherlands	—	—	2	8,055	2	8,055
New Zealand	8,160	765,694	460	400,448	8,620	1,166,142
Nigeria	5,071	701,810	—	—	5,071	701,810
Philippines	35	6,781	14	7,897	49	14,678
South Africa, Republic of	—	—	20	29,049	20	29,049
Switzerland	—	—	18	7,924	18	7,924
Taiwan	25	5,000	18	31,115	43	36,115
United Kingdom	—	—	18	8,735	18	8,735
Venezuela	7,862	842,248	83	42,686	7,945	884,934
Total[3]	82,149	8,316,175	20,863	3,178,928	103,012	11,495,103

[1]Prior to 1989, salt cake was Schedule B No. 42114200. In 1989, it was reclassifed under the Harmonized Tariff System as HTS No. 2833111000.
[2]Prior to 1989, other sodium sulfate was Schedule B No. 4214500. In 1989, it is listed as HTS No. 2833115000.
[3]Data may not add to totals shown because of independent rounding.
[4]F.a.s. value at U.S. ports.

Source: Bureau of the Census.

TABLE 12

SODIUM SULFATE: WORLD PRODUCTION, BY COUNTRY[1]

(Metric tons)

Country[2]	1987	1988	1989	1990	1991[e]
Natural:					
Argentina	27,483	15,341	10,281	[e]11,000	10,500
Canada	342,076	330,971	[r]327,000	[r]347,000	340,000
Chile[3]	12,406	15,879	[r]10,245	[r]13,497	13,000
China[e 4]	18,000	27,000	27,000	27,000	28,000
Egypt	42,484	[e]42,500	45,677	[r]41,418	41,000
Iran	[r]264,442	[r]213,521	[r]184,848	[r]176,951	180,000
Mexico[5]	486,245	502,448	603,551	[e]650,000	650,000
Netherlands[e]	22,000	22,000	22,000	22,000	22,000
South Africa, Republic of	241	255	15	[e]20	20
Spain	475,255	[e]450,000	[e]450,000	[r e]430,000	450,000
Turkey	82,628	79,427	[r e]85,000	[r e]85,000	85,000
U.S.S.R.[e 6]	365,000	375,000	365,000	[r]340,000	320,000
United States (sold by producers)	346,140	361,345	339,761	349,256	[7]353,836
Total	[r]2,484,400	[r]2,435,687	[r]2,470,378	[r]2,493,142	2,493,356
Synthetic:					
Austria[e]	109,000	118,000	120,000	120,000	120,000
Belgium[e]	260,000	255,000	255,000	250,000	250,000
Brazil[e]	7,000	9,000	9,000	9,000	9,000
Chile[8]	48,000	47,000	[r]56,245	[r]59,509	60,000
Finland[e]	35,000	35,000	[r]33,000	[r]33,000	33,000
France[e]	115,000	154,000	[r]120,000	120,000	120,000
Germany, Federal Republic of:					
Eastern states	179,000	180,000	175,000	[r]170,000	160,000
Western states	164,000	[r]175,000	[r]172,000	[r]167,000	165,000
Total	343,000	355,000	347,000	337,000	325,000
Greece[e]	7,000	7,000	[e]6,000	[e]6,000	6,000
Hungary[e]	9,000	9,000	9,000	[e]8,000	8,000
Italy[e]	80,000	127,000	130,000	130,000	125,000
Japan	255,313	246,541	256,393	[r]253,131	254,000
Netherlands[e]	15,000	15,000	15,000	15,000	15,000
Pakistan[e]	1,000	1,000	1,000	1,000	1,000
Portugal[e]	55,000	54,000	55,000	55,000	50,000
Spain[e]	165,000	165,000	165,000	160,000	150,000
Sweden[e]	100,000	100,000	100,000	100,000	100,000
Turkey[e]	27,000	27,000	27,000	27,000	30,000
U.S.S.R.[e 6]	260,000	270,000	270,000	[r]250,000	220,000
United Kingdom[e]	90,000	90,000	90,000	90,000	90,000
United States[9]	391,541	381,517	345,555	315,604	[7]342,576
Yugoslavia	37,556	41,479	[r]50,333	[r]37,953	35,000
Total	2,410,410	[r]2,507,537	[r]2,460,526	[r]2,377,197	2,343,576
Grand total	[r]4,894,810	[r]4,943,224	[r]4,930,904	[r]4,870,339	4,836,932

[e]Estimated. [r]Revised.

[1]Table includes data available through May 6, 1992.

[2]In addition to the countries listed, China, Norway, Poland, Romania, and Switzerland are known or are assumed to have produced synthetic sodium sulfate, and other unlisted countries may have produced this commodity, but production figures are not reported, and general information is not adequate for the formulation of reliable estimates of output levels.

[3]Natural mine output, excluding byproduct output from the nitrate industry, which is reported separately under "Synthetic" in this table.

[4]Byproduct sodium sulfate is known to be recovered but reliable data are not available; not included under "Synthetic."

[5]Total output as reported in the Anuario Estadístico de la Industria Química Mexicana.

[6]Conjectural estimates based on 1968 information on natural sodium sulfate and general economic conditions.

[7]Reported figure.

[8]Byproduct of nitrate industry.

[9]Derived approximate figures; data presented are the difference between reported total sodium sulfate production (natural and synthetic not differentiated) and reported natural sodium sulfate sold by producers (reported under "Natural" in this table).

FIGURE 1

PRODUCTION OF SODIUM SULFATE NATURAL VERSUS SYNTHETIC

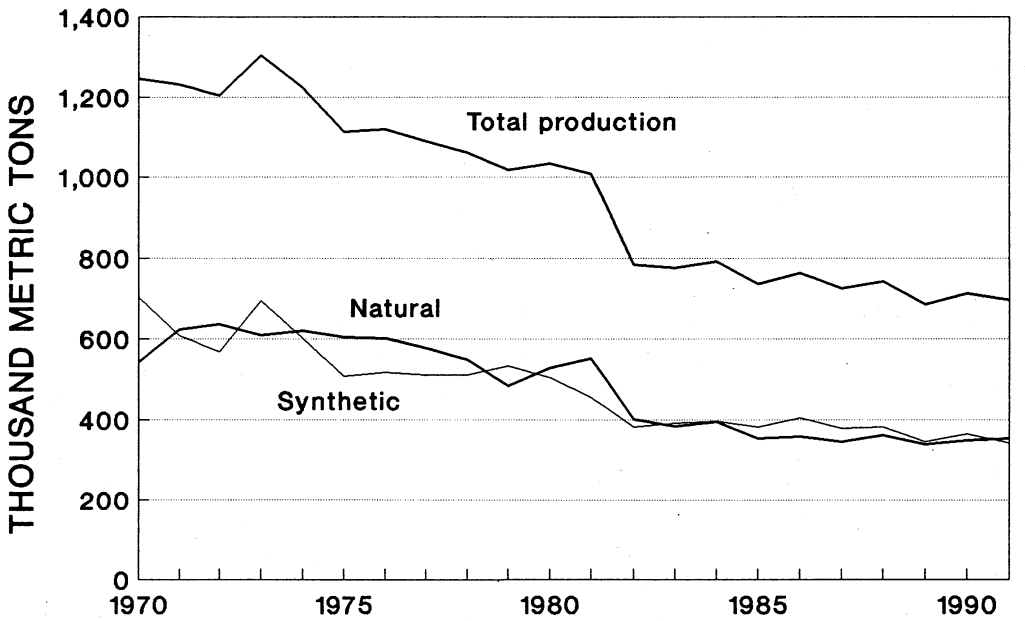

FIGURE 2

SODIUM SULFATE SUPPLY-DEMAND RELATIONSHIPS, 1991

(Thousand metric tons)

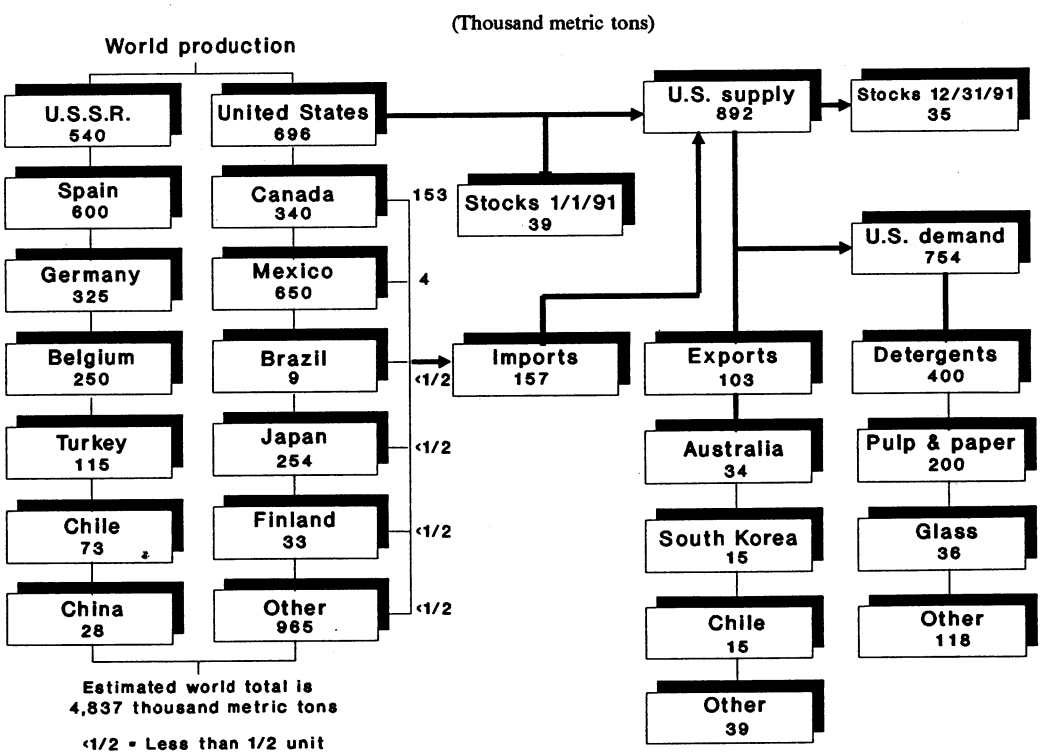

FIGURE 3
SODIUM SULFATE END USES

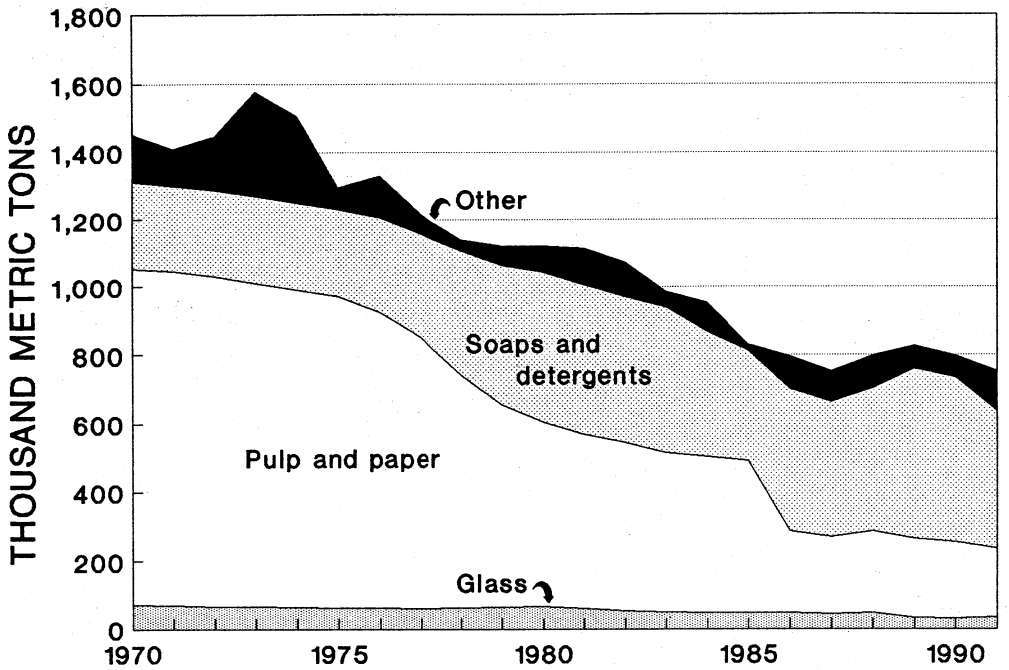

FIGURE 4
IMPORTS AND EXPORTS OF SODIUM SULFATE