BORON

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Boron is produced domestically only in the State of California. Boron products sold on the market are produced from a surface mine, underground mines, in situ, and from brine. The United States and Turkey are the world's largest producers of boron, changing positions from year to year. Boron is priced and sold on the boron oxide basis, which varies by ore and compound and on the absence or presence of sodium and calcium. Boron exports are about one-half of the domestic production.

Legislation and Government Programs

The Department of Energy began disposing of radioactive waste using a vitrification process that used boron and lithium at its Savannah River Site. The site, operated by Westinghouse Savannah River Co., is the home of the world's largest waste vitrification technology center. The 132,490 cubic meters (35 million gallons) of radioactive waste now in storage will be concentrated to drive off the water and then separated from the solid salts by chemical reactions. The results will be 1,890 cubic meters (500,000 gallons) of radioactive waste. The time to vitrify the current amount of waste was estimated at 20 years. The waste is mixed with a premelted molten glass containing boron and lithium that is poured into a canister for cooling and storage. About 1% of the waste mixture is radioactive. The Savannah River site will be used as an interim facility until the year 2020. In the future, the canisters will be moved to a repository 1.6 kilometers (1 mile) deep under ground. The only other vitrification site in operation is in West Valley, NY. The Richland, WA, site plans to begin operations between the year 2000 and 2005. The Idaho Falls, ID, plant is 20 years from being operational (Lafferty, 1996).

Members of International Code Council, a nonprofit organization jointly staffed and funded by the United States' three national model code organizations, expect the new International Building Code (IBC) to be operational by the year 2000. Boron products are used in products that cover fire resistance, insulation, roofing, glass, and other home construction products. The IBC will utilize the three existing codes—the Building Officials and Code Administrators International, Inc., BOCA National Building Code (BNBC); Uniform Building Code (UBC) from the International Conference of Building Officials (ICBO); and the Standard Building Code from Southern Building Code Congress International, Inc. (SBCCI)—as a basis for defining the model. Besides the three existing codes, nine Southern States have separate State codes. The IBC will make it simpler and more cost effective for building professionals to comply with U.S. code requirements and will present a set of uniform codes and standards for builders and suppliers based outside the United States. These firms want to advertise nationally, but want to have their products recognized and usable under a single set of standards. U.S. architects, engineers, builders, subcontractors, and building suppliers are spending more time and money complying with multiple and sometimes conflicting codes. The approach has been to use the best of what is being utilized and apply the code nationally (Engineering News Record, 1996).

Production

Domestic data for boron were developed by the U.S. Geological Survey from a voluntary survey of U.S. operations. The majority of boron production continued to be from Kern County, CA, with the balance from San Bernardino and Inyo Counties, CA. Of the four operations to which a "sold and used" survey request was sent, four responded, representing 100% of the total boron sold or used. *(See table 1.)*

American Borate Co. mined small amounts of colemanite and ulexite/probertite from the Billie Mine. Colemanite was processed at Lathrop Well, NV. Storage and grinding facilities were at Dunn, CA. (*See table 2.*)

Fort Cady Minerals Corp. produced a salable product named CADYCAL 100. The product was 43% boron oxide that screens 81% less than 325 mesh. Because CADYCAL is a chemically precipitated product, it has advantages in consistency of the chemical compositionl; i.e., high boron oxide content, low impurities, and consistent physical size. The design of a larger facility was initiated with Flour-Daniel, Inc., which was awarded the design contract. Production of 30,000 tons per year with expansion to 90,000 tons per year was planned.

North American Chemical Co. (NACC), owned by the Harris Chemical North America, Inc., is headquartered in New York and has operating headquarters in Overland Park, KS. NACC operated the Trona and Westend plants at Searles Lake, in San Bernardino County, to produce refined sodium borate compounds and boric acid from the mineral-rich lake brines. Searles Lake is a dry lake playa with three major subsurface evaporite horizons. NACC owns 3,964 hectares (9,197 acres). NACC implemented technical changes in its production operation that took effect April 1996. A 243-hectare (600 acre) area was selected that contains the highest concentration of borax reserves in the lake, about 8,000 tons per 0.40 hectares (1 acre) or reserves of 4.8 million tons. A series of closed systems will circulate brines in the upper unit salt layer of the lake to increase the borax grade to a theoretical 1.45%. The brine will be processed at the Westend plant and circulated through a heat exchanger back to the upper salt layer. The Trona Railway operated between Trona and Searles Station and connected to the Southern Pacific Railroad. The boron products transported were used in ceramics, high-temperature glassware, and insulation.

NACC announced the completion of the sale and leaseback of its Argus electric- and steam-generating facility in Searles Valley, CA, on July 25. Steam and electricity from the Argus Utilities facility serve NACC's production facilities at its Searles Valley complex. Net proceeds from the sale were $70 million which were used to reduce debt under its existing revolving credit agreement. Under terms of the agreement, NACC will lease back the Argus facility for a term of 15 years, including a 2-year bargain renewal period. The lease provides for three renewal periods of up to 5 years each through the life of the facility.

U.S. Borax, Inc. (Borax) is a wholly owned subsidiary of RTZ-CRA. On December 21, 1995, The RTZ Corp. PLC and CRA Ltd. merged to form The RTZ Corp. PLC, CRA Ltd, and Group Companies (RTZ-CRA). Group companies are separate and independently managed. RTZ-CRA planned an annual investment of $40 million during the next 5 years at its Boron, CA, mine and refinery. The deposit contains reserves up to 113 million tons of sodium borates and an addition 198 million tons of calcium borates. (Review, 1996). There are sufficient reserves to last 40 years at current mining rates. Borax currently extracts bout 18 million tons per year of material, including 2.7 million tons of ore averaging 23% boron oxide content (Mining Journal, 1996). The deposit is a sequence of borax and kernite crystals interbedded with claystone. The world-class sodium borate deposit at Boron was being developed by modern open pit operations. Using a German-made Orenstein & Koppel RH120c, the hydraulic shovel digs from the top down. This reduces the level of loaded bucket hoisting and keeps the ore horizons separate (Borax Pioneer, 1996a). Calcium borate ore is stockpiled.

Tincal ore is dissolved in hot borate solutions. Clear borax solution is cooled to precipitate a decahydrate and pentahydrate borax. After drying, the products are stored bulk or bagged and palletized.

Kernite ore is dissolved in a mixture of sulfuric acid and hot borax liquor. The solution is filtered and pumped to tanks that feed the crystallizes where boric acid is formed. The boric acid crystals are washed and dried. Production is stored in bins for sampling and then transferred to storage silos for shipment. A 25% increase in boric acid capacity was announced by the company to bring capacity to 200,000 tons per year (Glass, 1996a).

During 1995, a new system to dewater and wash pentahydrate borax and boric acid was installed at Boron, CA. The system uses vacuum belt filters and a series of three washes to provide a product with greater consistency and already reduced levels of sulfate, carbonate, chloride, and arsenic. The use of the gentler process reduced crystal damage and reduced the dust fraction from 12% to 5% for boric acid and from 6% to less than 2% for the pentahydrate borax.

Variations in heat caused by the installation of a new dryer resulted in the product being too dry, causing fines, or too moist, both of which contribute to caking. The startup problems were corrected in September, and the improved products are available to customers all over the world. (Borax Pioneer, 1996b).

Boron operates a zero discharge operation. Waste water is impounded and evaporated to recover borate material. More than 360,000 tons of borate has been recovered in the past decade.

The majority of material from Boron was shipped to Borax's storage in Wilmington, CA, part of the Port of Los Angeles. Products made at Wilmington are used in agricultural, industrial, and speciality applications. U.S. mined products are loaded onto bulk carriers for transport to terminals at Rotterdam, the Netherlands, and Valencia, Spain, that provide for the unloading, inspection, packing, and distribution of European orders. At the Borax refining complex at Coudekerque, near Dunkirk, France, pharmaceutical, technical, and special quantity grades of borax and boric acid are manufactured for the European market. Recently, Borax expanded its distribution network by establishing warehouse facilities in Russia and the Ukraine.

During the year, Borax formed a separate speciality chemicals department to focus on borate flame retardants. Demand for the fire retardants is growing 15% per year. Speciality chemicals accounted for about 11% to 12% of Borax's sales. Borax has more than doubled its zinc borate fire-retardants plant capacity in Wilmington during a $3 million expansion. Zinc borate is used with, or in place of, antimony trioxide, serving as a promoter in chlorine- or bromine-based fire-retardant systems. Zinc borate has an advantage over other materials because it forms a glassy char that inhibits combustion and suppresses smoke. It is also less expensive than antimony trioxide. Patented and sold under the trade name Firebrake 415, the new zinc borate can tolerate temperatures up to 415° C. This allows for its use in nylon, which is processed at 300° C. Firebreak 500, another zinc borate, can withstand temperatures well over 1,000° C (Chemical Engineering, 1996).

Consumption

Glass accounts for three major borate applications, as follows: glass fiber insulation, borosilicate glass, and textile glass fiber. The use of borates in glass fiber thermal insulation, primarily used in new construction, was a large area of demand for borates and the principal insulating material used in the construction industry. Composed of very thin fibers spun from molten glass, its purpose is to trap and hold air. Typically between 4% and 5% boron oxide is incorporated in the formulation to aid melting, inhibit devitrification, and improve the aqueous durability of the finished product.

Borates also were used in manufacturing high-tensile-strength glass fiber materials used in a range of products. The process of producing glass fiber uses a borosilicate E-glass formulation that is continuously drawn through platinum alloy bushings into continuous filaments of between 9 and 20 microns in diameter. E-glass, or textile fiberglass, typically contains between 6% and 8% boron oxide. Originally these glasses were used for electrical purposes, and low sodium levels were important. Major applications were reinforcements for plastics, but the low sodium tolerance still applies to the requirements for the production of the reinforced glass. The nonconductive and low dielectric properties of high-strength glass-reinforced materials make them transparent to radar and thus valuable for "stealth" applications. E-glass, a calcium aluminoborosilicate glass that has a balance of mechanical, chemical, and electrical properties, is widely applied in composites because of the moderate cost.

Boron, added in amounts of between 10% and 13% to glass, reduced the viscosity of the melt, assisted with fiber formation during processing, allowed for improved specific optical properties, increased resistance to aqueous or chemical attack, enhanced certain mechanical properties, and reduced the thermal expansion coefficient and thermal shock resistance.

Boron is important to many speciality glasses such as heat-resistant domestic Pyrex glass and optical glass. Boron imparts a low thermal expansion level. The most common forms of boron minerals are borax (tincal), ulexite, colemanite, and kernite. In glass such as Pyrex, sodium borates or boric acid is commonly used. In optical glass, boric acid is commonly used (Industrial Minerals, 1996a).

PPG Industries Inc. is increasing the production of fiberglass chopped strand for reinforcing polyethylene terephalate (PET) polyester to meet growing demand in automotive composite applications. The company is also expanding production of a chopped strand fiberglass reinforcement for nylon resin in auto applications (Glass Industry, 1996b).

Fiberglass insulation represents the largest secondary market for recycled glass containers in the United States. A recent survey reported that more than 425 million kilograms (936 million pounds) of recycled glass was used in the manufacture of fiberglass insulation in 1995. This resulted in a savings of 708,000 cubic meters (25 million cubic feet) of landfill space. Estimated figures for 1996 are calculated at more than 454,000 tons (1 billion pounds). According to officials of North American Insulation Manufacturers Association, the industry average is about 30% recycled glass, but some manufacturing facilities are averaging up to 40%, depending on availability of the recycled glass (Glass Industry, 1997).

Boron compounds continued to find application in the manufacture of biological growth control chemicals for use in water treatments, algicide, fertilizers, herbicides, and insecticides. Boron was applied as a spray and incorporated in herbicides, fertilizers, and irrigation water. Boron is a micronutrient essential to crop growth.

Boron compounds were used as flame retardants where they reduced flammability by melting and preventing oxygen from contact with the burning surface. Although not as effective as other flame retardants, they were less expensive. In cellulose materials such as timber, particle board, paper, wood fiber, and cotton products, sodium borates and boric acid were used. Anhydrous borax was used in the manufacture of flame-retardant fiberboard. In plastics, zinc borate was the most widely used borate compound.

The alloys of the nonmetal boron and neodymium and iron metals produced the strongest magnetic material known. The permanent magnets are used in automotive direct-current motors, computer disk drives, portable power tools, and home appliances.

Boron also was used as a bleaching agent in detergents and cleaning products, such as concentrated washing powders. Perborates carry active oxygen that form hydrogen peroxide in solution. Perborate tetrahydrate was displaced by perborate monohydrate, which was more soluble in cool laundry wash water temperatures.

Prices

The price for boron compounds increased except for high-purity anhydrous boric acid, which decreased more than 27%. Reported prices increased between 3% and 18%.(*See table 3.*) Prices of colemanite imported from Argentina averaged $364 per ton during 1996.

An Industrial Mienrals Prices & Data 1996 was published that included information on Turkish, British, Argentinian, and United States prices of boron minerals and compounds (Industrial Minerals Information Ltd., 1997).

Foreign Trade

The General Agreement on Tariffs & Trade (GATT) that was signed into law in December 1994 and took effect January 1, 1995. GATT lowered chemical tariffs by an average of 30%. Chemicals, including bromine, are the Nation's largest export commodities, as more than 10 cents out of every export dollar is a product of the chemical industry. The agreement's intellectual property provisions include greater patent protection for products developed by U.S. firms. GATT changes patent enforcement from 17 years from the date of issue to 20 years from the date of application. Patents issued on applications filed before June 8, 1995, will be enforceable for either 17 years from the issue date or 20 years from the filing date, whichever is longer.

The majority of material from the Borax facility in Boron was shipped to storage, loading, and shipping facilities at Wilmington, CA. A large part of the output was exported to Western Europe from Wilmington to Botlek, Netherlands. A distribution center and bulk borate terminal was located at Rotterdam, Netherlands; a boric acid plant at Coudekerque, France; warehouses in Valencia, Spain, and Widnes, UK.; and laboratories at Guildford, United Kingdom. *(See tables 4 and 5.)*

World Review

Argentina.—The Republic recently enacted an environmental supplement to its federal mining code, known as law No. 24,585. The enforcement of its terms will fall to mining authorities. Under the Argentine Constitution, legislative power is primarily lodged in the Provinces, with the central government having only those powers delegated to it. All the Provinces have ratified the mining code. Regulated activities covered by the act fall into two broad categories. The initial category includes all operations from prospecting through mining development, extraction, and closure. The second group includes all postextraction treatment, including mining recovery, grinding, milling, smelting, refining, and waste disposal (Trower, 1996).

Borax Argentina S.A. was the country's leading producer of borates. Borax mines tincal at Tincalayu, hydroboracite at Sijes, and ulexite from two dry lake beds, Salar Cauchari and Salar Quisquiro, all in the Salta Province at elevations more than 4,000 meters (14,000 feet). The tincal and ulexite are processed at Quijano, near Salta. Most of the production is shipped to South American customers through Campo Quijano.

Ulex S.A. produces colemanite and hydroboracite in Salta Province. At the Sol de Manana Mine, colemanite and hydroborocite were mined. Ulexite, found in veins, is hand mined for resale to two boric acid producers.

Boron deficiency was a major problem with sunflowers in Argentina, the world's leading exporter of sunflower oil. Farmers in the temperate plain do not need artificial fertilizers because the soil is rich in nitrogen and phosphorus. Boron fertilization applied to the leaves produced an average yield increase of 20%. Economic analysis showed that a 20% increase in sunflower production gives a 35% increase in net income. The use of boron fertilizers on Argentinian sunflowers can increase the return on capital by 56% (Borax Pioneer, 1996c).

Bolivia.—Boron Chemical International and Teck Corp., both Vancouver-based companies, were exploring and evaluating a number of ulexite deposits. One feasibility study was completed on a deposit close to the Chilean border. A 75,000-ton-per-year operation was expected to cost $28 million. There were no immediate plans to begin development (Kendall, 1996).

Canada.—Kobitex Inc. distributes Etibanks' refined boron minerals in North America. Included is granular and powdered boric acid, borax penta and deca hydrate from Bandirma, and Etibor-48 and anhydrous borax from Kirka. The products are shipped from Bandirma and Izmir. Kobitex is presently actively supplying products to cellulose insulation, gypsum board, and large chemical distributors. In 1997, Kobitex plans to add fiberglass manufacturers and agriculture companies to its distribution list (Ovi Gulersen, Kobitex Inc., written commun., 1996).

Chile.—Quimica e Industrial del Borax Ltda. (Quiborax) mined from Salar de Surire, the largest ulexite deposit in the world. The salar is located at a 4,250-meter altitude within the border of the Monumento Natural de Surire, a national park in Chile. The ore is trucked to the El Aguila production facility north of Arica. The products are exported from the ports at Arica, Iquiqui, and Antofogasta. The National Boraxx Corp. (Cleveland, OH) packages and distributes boric acid in the United States for Quiborax.

Compania Minera Salar de Atacama (Minsal), is 100% owned by Sociedad Quimica y Minera de Chile SA (SQM). A large integrated facility is planned to began production of 16,000 tons per year of boric acid in 1998 (Chemical Marketing Reporter, 1996a).

Europe.—Starting January 1, 1996, all sales of U.S. Borax Inc. products in Europe are bought, distributed, and sold through Borax Europe Ltd., previously known as Borax Consolidated Ltd. The major change is in the use of a more convenient business system to record orders, keep track of inventory, and plan for delivery to customers. Named BOSS, for Borax Ordering and Sales System, the system is expected to benefit the customer in reducing errors and monitoring orders (Borax Pioneer, 1996d).

India.—Submarginal borax reserves of 74,200 tons have been estimated in thePuga Valley Districts of Jammu and Kashmir. In Rajasthan, the bitterns from Lake Sambhar are reported to contain about 0.5% borax.

Owens-Corning will produce glass-fiber reinforcement in India through a joint venture with the Mahindra Group. A 66-million-pound-per-year plant will be constructed by 1998 in Taloja, north of Bombay (Modern Plastics, 1996).

Japan.—Sumitomo Special Metals Co. announced a production capacity increase in its neodymium, iron, and boron magnets. Sumitomo will install a sintering furnace and machines for cutting and grinding at its wholly owned firm, Kinki Sumitoku Electonics Co., Hyogo Prefecture. Production will be increased from 130 tons to 250 tons per month. The magnets are used in personal computer voice coil motors and air conditioner motors (Intertech Corp., 1997).

Peru.—The Ministry of Energy and Mines published maximum permissible limits for liquid effluents from mining and mineral-processing operations. This is the first standard promulgated under the 1991 mining law for liquid effluents from mining and metallurgical operations. There is one standard for operations started after May 1993 and a second, less stringent standard for operations in existence before May 1993. Arsenic, one of the items for which there is a maximum permissible emissions limit, is commonly found in borate ores (Engineering and Mining Journal, 1996).

Russia.—Primorsky Industrial Amalagmation, in Dalnegorsk, produces boron minerals from datolite containing between 6% and 12% boron oxide. The company is part of the Russian Agricultural Joint Stock Co., known as ROSAGROCHIM. ROSAGROCHIM coordinates the activities of about 100 companies.

Turkey.—Turkey's boron operations are under the control of the Government corporation, Etibank. Ulexite is mined at Bigadic; colemanite at Bigadic, Emet, and Kestelek; and tincal at Kirka. The Bigadic borate district was reported to be the world's largest colemanite and ulexite deposits. Etibank received ISO 9002 accreditation at the Kirka Works and the Bandirma Borax Works plant, where the company refines tincal and colemanite ores and concentrates, respectively. Pentahydrate borax (Etibor 48) production capacity is to be expanded 20%, or 40,000 tons per year by 1997. Production capacity of boric acid is reported to be 150,000 tons per year at the Bandirma plant (Chemical Marketing Reporter, 1996b).

The Bandirma Borax and Acid Works produces borax decahydrate, borax pentahydrate, sodium perborate, and boric acid. The Kirka Borax Works produces tincal concentrate, borax pentahydrate, and anhydrous borax.

Emet Colemanite Works, located in Emet District of Kutahya Province, had a production capacity of 700,000 tons per year of run-of-mine ores, both open pit and underground mines. Colemanite ores are processed in a 500,000-tons-per-year concentrator and supplied to domestic and international markets. In 1994, 700,000 tons of colemanite ores and 305,250 tons of colemanite concentrates were produced. Most of the colemanite concentrates are exported. The remaining production is used in the boric acid plant in Bandirma. In 1994, 87,184 tons of colemanite concentrates was sent to the Bandirma boric acid plant.

Bigadic Colemanite Works, located in Bigadic District of Balikesir Province, has a production capacity of 500,000 tons of run-of-mine colemanite and ulexite ores from three open pits and two underground mines. The concentrator has a capacity of 400,000 tons per year that is supplied for export. In 1994, 159,600 tons of run-of-mine colemanite ores and 328,150 tons of run-of-mine ulexite ores were processed. A total of 93,900 tons of colemanite concentrates and 198,200 tons of ulexite concentrates were produced. All products at Bigadic are for export.

Kestelek Boron Mine is located in Mustafakemalpa, a District of Bursa Province. The underground mine was closed at the end of 1994 because of high cost and low sales. Production is now from the open pit. Kestelek Boron is now a subsidiary of Bigadic. In 1994, 115,895 tons of run-of-mine colemanite ore, 19,281 tons of lumpy colemanite, and 37,956 tons of colemanite concentrates were produced for export.

The Kirka Borax Works is located near Seyitgazi District of Eskisehir Province. The concentrator has a capacity of 600,000 tons per year of tincal concentrates. A derivatives facility was begun in 1984 for the production of 160,000 tons per year of borax decahydrate and 60,000 tons per year of anhydrous borax. Technical problems regarding the anhydrous production are being studied. An expansion project was under way to increase pentahydrate production capacity to 320,000 tons per year. There is a storage and loading facility 20 kilometers away at Degirmenozu with a railway connection to the port at Bandirma. In 1994, 783,000 tons of run-of-mine ores, 558,000 tons of tincal concentrates, and 154,449 tons of borax pentahydrate were produced.

In 1994, Bandirma Borax and Acid Works, located in Bandirma District of Bahikesir Province, produced 30,090 tons of borax, 9,273 tons of borax pentahydrate, 46,100 tons of boric acid, and 15,067 tons of sodium borate (Etibank, 1994).

In addition to the Government operations, private processing of boron reserves from stockpiles and dumps have occurred for the past decade.

A comprehensive history of the Turkish boron mines and their impact on the boron industry was published in 1996. Included are the story of the Turkish boron mines and boron industry, Turkey’s history, its political system, and its past and present relations with Europe. At the end of the book is a summary of boron applications, geological and mineralogical information, statistics, and other facts and figures useful to those in the boron business (Bühler, 1996).

Current Research and Technology

Ciba Additives acquired the worldwide licenses of 19 patents and patent applications from Mead Corp. in the area of borate photoinitiators. Principal areas of applications include laser imaging, electronic applications, printing plates, resists, and thick sections (Krivyakina, 1996).

A scientist at Harvard University used carbon nanotubes to prepare nanoscale carbide materials using boron carbon in an intermediate processing step. The carbide nanorods might have applications in nanostructured composite materials. Ceramic or metal matrix composites strengthened by embedding rodlike structures that may prove useful in making turbine blades and other aerospace components (Freemantle, 1995).

Scientists in Germany have synthesized a siliconboron carbonitride with high thermal stability, up to 2000° C. The material may be used for the production of ceramic fibers, coatings, and composites that are chemically and mechanically stable at ultrahigh temperatures (Chemical & Engineering News, 1996).

In an effort to build an affordable short-span bridge, Kansas Structural Composites built a traffic-bearing bridge in three sections using fiberglass-reinforced polymer laminate. Fiberglass is one of the chief uses for boron. Recycled polyester resins make up 30% of the bridge weight and were combined with glass fiber to make the core and bottom fiberglass laminate layer (Reisch, 1997).

Outlook

Production of boron minerals and compounds has increased between 1992 and 1996. Production and imports reported in 1 year may be utilized over a period of years. In addition, environmental concerns may change the demand for boron significantly in a short period. The regulation of fire retardants in products has resulted in changes in boron usage as a fire retardant. The 2.6-million-ton-per-year borate products market is growing at about 1.5% per year (Industrial Minerals, 1996b).

Agriculture.—Farming exports are showing increased strength and demand for boron usage in agriculture is expected to increase.

Ceramics and Glass.—Fiberglass, closely related to construction and transportation, was expected to increase. Owens-Corning announced a capacity expansion for the next 3 years in Brazil, the Republic of Korea, Western Europe, and North America. The company projects an annual growth of about 5% in North America and Western Europe, and more than 10% in Asia and the Pacific Rim (Modern Plastics, 1996).

PPG Industries forecasts demand for fiberglass reinforcements will be 4.8% over that of 1995. The thermoset market is growing between 150% to 200% times the gross domestic product. The roofing business, for which paper fiberglass is used, has grown more than 10% between 1992 and 1994, and 1996 was expected to see a 4.2% increase in demand over that of 1995. Demand for textile fiberglass grew about 15% in 1994 and is projected to have a 1.9% increase in demand in 1996. The demand for insulation fiberglass is expected to remain flat because of low interest rates. Fiberglass insulation is used primarily in houses, and during times of low-interest rates, housing starts increase, therefore increasing demand for fiberglass (Glass Industry, 1996b).

Coatings and Plating.—Primarily used as a protective coating for steel products and as a glazing on ceramic tiles, boron use is expected to increase.

Fire Retardants.—Demand for borated flame retardants has grown 15% per year. Zinc borate is often used with, or in place of, antimony trioxide. Zinc borate serves as a synergist with chlorine- or bromine-based fire-retardant systems (Chemical Engineering, 1996).

Fabricated Metal Products.—Boron usage in specialized metal was expected to increase.

Soaps and Detergents.—Usage in soaps and detergents was expected to increase 4% per year during the next 5 years.

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

TABLE 1
SALIENT STATISTICS OF BORON MINERALS AND COMPOUNDS 1/

(Thousand metric tons and thousand dollars)

	1992	1993	1994	1995	1996
United States:					
Sold or used by producers:					
Quantity:					
Gross weight 2/	1,010	1,060	1,110	1,190 r/	1,150
Boron oxide (B2O3) content	554	574	550	728 r/	581
Value	$339,000	$373,000	$443,000	$560,000 r/	$519,000
Exports:					
Boric acid: 3/					
Quantity	80	75	87	75	42
Value	$53,700	$50,500	$53,300	$68,100	$35,300
Sodium borates:					
Quantity	489 4/	481 4/	498 4/	588	381 4/
Value	$159,000 4/	$181,000 4/	$165,000	$227,000	$133,000 4/
Imports for consumption: 4/					
Borax:					
Quantity	16	40	9	9	NA
Value	$5,330	$1,230	$2,700	$936	NA
Boric acid:					
Quantity	6	17	20	16	18
Value	$4,340	$11,900	$12,900	$10,100	$10,800
Colemanite:					
Quantity	30	90	27	45	NA
Value	$16,100	$48,600	$10,800	$8,600	NA
Ulexite:					
Quantity	42	149	120	153	NA
Value	$11,300	$40,700	$24,000	$39,300	NA
Consumption: Boron oxide (B2O3) content	345	321	296	NA	NA
World: Production	2,670	2,690 r/	2,860 r/	2,890 r/	2,980 e/

e/ Estimated. r/ Revised. NA Not available.
1/ Data are rounded to three significant digits; may not add to totals shown.
2/ Minerals and compounds sold or used by producers, including both actual mine production and marketable products.
3/ Includes orthoboric and anhydrous boric acid.
4/ Source: Bureau of the Census.

TABLE 2
BORON MINERALS OF COMMERCIAL IMPORTANCE 1/

Mineral	Chemical composition	B2O3 weight percent
Boracite (stassfurite)	Mg6B14O26Cl2	62.2
Colemanite	Ca2B6O11 • 5H2O	50.8
Hydroboracite	CaMgB6O11 • 6H2O	50.5
Kernite (rasortie)	Na2B4O7 • 4H2O	51.0
Priceite (pandermite)	CaB10O19 • 7H2O	49.8
Probertite (kramerite)	NaCaB3O9 • 5H2O	49.6
Sassolite (natural boric acid)	H3BO3	56.3
Szaibelyite (ascharite)	MgBO2(OH)	41.4
Tincal (natural borax)	Na2B4O7 • 1OH2O	36.5
Tincalconite (mohavite)	Na2B4O7 • 5H2O	47.8
Ulexite (boronatrocalcite)	NaCaB5O9 • 8H2O	43.0

1/ Parentheses include common names.

TABLE 3
YEAREND 1996 PRICES FOR BORON MINERALS AND COMPOUNDS PER METRIC TON 1/

Product	Price, Dec. 31, 1995 (rounded dollars)	Price, Dec. 31, 1996 (rounded dollars)
Borax, technical, anhydrous, 99%, bulk, carload, works 2/	794	818
Borax, technical, anhydrous, 99%, bags, carload, works 2/	843	884
Borax, technical, granular, decahydrate, 99%, bags, carload, works 2/	333	381
Borax, technical, granular, decahydrate, 99.5%, bulk, carload, works 2/	283	315
Borax, technical, granular, pentahydrate, 99.5%, bags, carload, works 2/	374	443
Borax, technical, granular, pentahydrate, 99.5%, bulk, carload, works 2/	324	375
Boric acid, technical, granular, 99.9%, bags, carload, works 2/	830	883
Boric acid, technical, granular, 99.9%, bulk, carload, works 2/	780	819
Boric acid, United States Borax & Chemical Corp., high-purity anhydrous, 99% B2O3, 100-pound-bags, carlots	1,951	1,419
Colemanite, Turkish, 42% B2O3, ground to a minus 70-mesh, f.o.b. railcars, Kings Creek, SC 3/	191	NA
Ulexite, Chilien, 38% B2O3, ground to a minus 6-mesh, f.o.b railcars, Norfolk, VA 3/	257	NA

NA Not available.

1/ U.S. f.o.b. plant or port prices per metric ton of product. Other conditions of final preparation, transportation, quantities, and qualities not stated are subject to negotiation and/or somewhat different price quotations.

2/ Chemical Marketing Reporter. V. 249, No. 1, Jan. 1996, p. 27; V. 250, No. 27, Dec. 1996.

3/ Bureau of the Census.

TABLE 4
U.S. EXPORTS OF BORIC ACID AND REFINED SODIUM BORATE COMPOUNDS, BY COUNTRY 1/

	1995			1996		
	Boric acid 2/		Sodium	Boric acid 2/		Sodium
Country	Quantity (metric tons)	Value (thousands)	borates 3/ (metric tons)	Quantity (metric tons)	Value (thousands)	borates 3/ (metric tons)
Australia	1,490	$754	6710	1,190	$633	5,040
Belgium	1	9	44	--	--	53
Brazil	2,480	982	1,140	2,590	1,080	1,070
Canada	5,150	3,540	35,600	4,970	3,440	38,300
Colombia	200	197	1,910	78	85	596
France	181	92	83	53	34	29
Germany	114	93	5	141	3,470	13
Hong Kong	585	448	5,060	136	135	3,470
India	--	--	694	--	--	63
Indonesia	1,800	991	12,500	371	222	8,100
Israel	105	88	173	43	32	124
Japan	11,400	10,800	27,600	8,830	8,050	22,300
Korea, Republic of	5,590	3,630	25,800	2,300	1,940	14,600
Malaysia	1,380	796	11,000	222	209	6,660
Mexico	6,700	3,250	18,200	4,210	2,620	15,100
Netherlands	16,400	27,200	329,000	6,630	7,690	198,000
New Zealand	504	262	3,010	225	116	1,620
Philippines	561	226	2,580	9	11	1,390
Singapore	197	149	1,460	557	338	983
South Africa	695	366	1,180	293	162	677
Spain	9,850	8,750	65,800	3,560	1,400	35,900
Taiwan	5,990	3,510	11,700	3,530	2,110	8,350
Thailand	1,380	1,020	7,310	801	637	5,650
United Kingdom	77	113	498	146	141	149
Venezuela	241	180	873	330	233	941
Other	1,450	661	18,500	836	535	11,900
Total	74,500	68,100	588,000	42,100	35,300	381,000

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

2/ HTS code No. 2810.00.0000.

3/ HTS code Nos. 2840.19.0000, 2840.30.0000, and 2840.20.0000.

Source: Bureau of the Census.

TABLE 5

U.S. IMPORTS FOR CONSUMPTION OF BORIC ACID, BY COUNTRY 1/

Country	1995 Quantity (metric tons)	1995 Value 2/ (thousands)	1996 Quantity (metric tons)	1996 Value 2/ (thousands)
Belgium	2	$2	--	--
Bolivia	989	411	3,460	$1,730
Canada	3	12	6	5
Chile	7,510	3,520	6,310	3,500
France	12	36	8	35
Georgia	42	27	--	--
Germany	11	13	13	35
Italy	1,240	1,290	1,050	1,130
Japan	180	161	110	204
Netherlands	18	11	--	--
New Zealand	--	--	40	25
Peru	471	249	842	510
Russia	438	425	218	186
South Africa	--	--	20	28
Switzerland	--	--	2	1
Turkey	4,670	3,920	5,830	3,420
United Kingdom	4	5	2	3
Total	15,600	10,100	17,900	10,800

1/ Data are rounded to three significant digits; may not add to totals shown.
2/ U.S. Customs declared values.

Source: Bureau of the Census.

TABLE 6

BORON MINERALS: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Thousand metric tons)

Country	1992	1993	1994	1995	1996 e/
Argentina	125	146	215 r/	245 r/	245
Bolivia (ulexite)	18 r/	12	10	7 r/	7
Chile (ulexite)	203	117	86	90 e/	90
China e/ 3/	127	155	188 r/	140	180
Germany (borax) e/	2	2	2	2	2
Iran (borax) e/ 4/	(5/) 6/	1	1	1	1
Kazakstan e/	100	90	80	80	80
Peru	27	37 r/	30 r/	30 r/ e/	30
Turkey 7/	1,059	1,079	1,140	1,100 e/	1,200
United States 8/	1,010	1,060	1,110	1,190 r/	1,150 6/
Total	2,670	2,690 r/	2,860 r/	2,890 r/	2,980

e/ Estimated. 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 May 20, 1997.
3/ B2O3 equivalent.
4/ Data are for years beginning Mar. 21 of that stated.
5/ Less than 1/2 unit.
6/ Reported figure.
7/ Concentrates from ore.
8/ Minerals and compounds sold or used by producers, including both actual mine production and marketable products.