

2005 Minerals Yearbook

BORON

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Boron, a nonmetal, has atomic number 5 and is in periodic group 13. Elemental boron is a dark brown powder in the amorphous form and a yellowish-brown hard, brittle solid in the monoclinic crystalline form. Elemental boron is marketed in grades from 90% to 99% purity. Borax is a white crystalline substance chemically known as sodium tetraborate decahydrate and found in nature as the mineral tincal. Boric acid is a white, colorless crystalline solid sold in technical national formulary and special quality grades as granules or powder. Boron oxide is a colorless hard, brittle, solid resembling glass that is ground and marketed most often under the name anhydrous boric acid.

Boron ore produced domestically during 2005 totaled 1.15 million metric tons (Mt) valued at \$713 million (table 1). The boron oxide (B₂O₂) content was 612,000 metric tons (t). The most common minerals of commercial importance in the United States were colemanite, kernite, tincal, and ulexite (table 2). Boron compounds and minerals were produced by surface and underground mining and from brine. U.S. consumption of minerals and compounds reported in boron oxide content (table 3) was significantly more than reported for previous years and was withheld while verifying the reported data. Boron products are priced and sold based on the boric oxide content, which varies by ore and compound, and on the absence or presence of sodium and calcium (table 4). Boron compounds exported by producers were boric acid (183,000 t) and sodium borate (308,000 t) (tables 1, 5). Boron imports consisted primarily of borax, boric acid, colemanite, and ulexite (tables 1, 5-6). Turkey and the United States were the world's leading producers of boron minerals (table 7).

Legislation and Government Programs

Searles Valley Minerals, Inc. (SVM) (a subsidiary of Sun Pertners, Ltd., Boca Raton, FL) is one of 15 trade associations and business groups taking part in Climate VISION (Voluntary Innovative Sector Initiatives: Opportunities Now), a presidential public-private partnership established in 2003. The associations' goal was to reduce carbon emission by 4.2% per metric ton of product produced by 2012. The Trona plant has already exceeded that goal. The cost of the project that included insulating equipment and installing energy efficient burners in the driers has rewarded SVM by increased efficiency and energy savings (Saholt, 2005).

In the process of setting standards that will determine if borate material may be used, and if so, the amount, the Consumer Product Safety Commission met to determine a flammability standard for upholstered furniture. The Commission also considered a final rule under the Flammable Fabrics Act for mattress flammability (open flame) (Consumer Product Safety Commission, 2006). Currently, only California has a standard

to make residential mattresses resistant to open flames. Between 1995 and 1999, 440 deaths and 2,230 injuries as well as \$274 million in property damage were a result of residential fires. The rule would create one national flammability standard that could reduce the number of deaths by 80% (Skrzycki, 2005).

Production

More than 200 minerals contain boric oxide, but only a few were of commercial importance (table 2). Four minerals make up almost 90% of the borates used by industry worldwide; they are the sodium borates borax and kernite, calcium borate colemanite, and sodium-calcium borate ulexite. These minerals were extracted primarily in California and Turkey and to a lesser extent in Argentina, Bolivia, Chile, China, and Peru.

Domestic data for boron were derived by the U.S. Geological Survey from a voluntary survey of four 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. All four operations to which a survey request was sent responded, representing 100% of the total boron produced and consumed (tables 1, 3).

American Borate Co. (ABC) mined small amounts of colemanite and ulexite-probertite underground at the Billie Mine in Death Valley, CA. The ore was transported to Lathrop Well, NV, for processing. Storage and grinding facilities were at Dunn, CA. During 2005, reclamation of the mine began as ABC lost its prime customer.

Fort Cady Minerals Corp. used an in situ process near Hector, CA, to produce a product that contained 48% boron oxide. During 2005, the plant was idle, but the product in storage was being marketed. The company had hired consultants to assess the market for boron oxide derivatives and whether additional downstream plants should be built to market boron compounds. An assessment was ongoing during 2005.

SVM continued production of borax and boric acid from brines pumped from Searles Lake.

U.S. Borax, Inc. (a wholly owned subsidiary of London, United Kingdom-based Rio Tinto plc) mined borate ores at Boron, CA, by open pit methods and transported the ores to a storage area by trucks. The property is the world's largest producer of refined borate products (Mattern, 2005). The ore was processed into sodium borate or boric acid products in the refinery complex adjacent to the mine. An onsite plant also produced anhydrous sodium borate and boric oxide. Refinery products were shipped by railcar or truck to North American customers or to the U.S. Borax Wilmington, CA, facility at the Port of Los Angeles for international distribution. In addition to its refinery and shipping terminal in Wilmington, U.S. Borax has its global headquarters in Valencia, CA, and its Owens Lake,

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CA, trona mine supplies raw material to the Boron, CA, refinery. U.S. Borax's Owens Lake operation allowed the company to ensure control of the trona supply used in the borate refining process. Trona provided a cost-effective source of carbonates, which helped reduce scaling in the processing equipment. Multiyear labor agreements that will provide additional operational flexibility and efficiency were negotiated at U.S. Borax's U.S. operations.

Consumption

Agriculture.—Boron is 1 of 16 nutrients essential to all plants. Boron is necessary in controlling flowering, fruit development, germination, plant reproduction, and pollen production. Domestic consumption was estimated at 2% in fertilizer usage. Boron is essential to plant growth and can be applied as a spray and incorporated in fertilizer, herbicides, and irrigation water. Boron fertilizers can quadruple corn yields and increase cotton yields by more than 227 kilograms per acre (500 pounds per acre). Boron deficiencies in crops are found primarily in soils low in organic matter and in acid, sandy soils in humid regions. Boron applied in May and June during early growth can be combined with calcium. For early season apples, boron can be applied post-harvest to provide adequate nutrition when buds begin to develop for blooming the next growing season. In the crop year ending June 30, 2005, 12,900 t (14,200 short tons) of boron micronutrients was applied on crops compared with 9,480 t (10,400 short tons) in crop year 2004. The leading consuming U.S. region in 2004 and 2005 was the Pacific, which used approximately 3,950 t (4,360 short tons) in both years (Terry and Kirby, 2004, p. 37; 2005, p. 37).

Fire Retardants.—Zinc borate was used in plastics as a multifunctional boron-base fire retardant with applications in a variety of plastics and rubber compounds. Depending on the polymer used and fire standards to be met, zinc bromate can replace other fire-retardant additives, such as antimony oxide. Zinc bromate was normally used in conjunction with aluminum trihydrate, magnesium hydroxide, or a silicon polymer. Boric acid is used in cellulose insulation, in cotton mattresses, and in wood as a fire retardant.

Glass.—Glass is a generic term for a fused-silica material with many different compositions. For most scientific glassware, low-expansion borosilicate glass is used, because it is inert to most chemicals and can withstand changes in temperature. The major glass sectors are container, flat, fiber, and specialty. The glass industry remained the leading domestic market for boron production, as in previous years. Boron oxide generally reduces melting temperatures and helps with the fiberizing process by lowering viscosity, controlling thermal expansion, inhibits devitrification, increases durability and chemical resistance, and reduces susceptibility to mechanical and thermal shock. Various brands of borosilicate glass are Corning Inc.'s Pyrex®, Kimbel Glass Co.'s Kimax, and Schott North America Inc.'s Duran®.

Reinforcing fibers are produced by drawing fibers from orifices in a platinum bushing, spraying the fibers with a sizing and winding onto a spool. Fiber glass for reinforced plastics accounted for most production. The fibers are mixed with thermosetting materials such as epoxy, polyester, and vinyl

esters to form composites. In the United States the following companies produce fiberglass: CertainTeed Corp., Owens-Corning Fibreglas Corp., PPG Industries, and Saint Gobain Owens.

Glass Fiber Inc. of Chino, CA, received a permit to operate a fireproof insulation required for all commercial air craft beginning in 2007. The plant will recycle glass to produce the insulation. The company has contacts with European Airbus and American Boeing companies to supply new aircraft and maintenance, repair, and overhaul for replacement blankets (Kitching, 2004§1).

Borosilicate glass, with a loading of high level nuclear waste of up to 30%, reduced the melting temperature without sacrifice in leach ability. Emphasis on cleanup of defense sites including France, Germany, Japan, the United Kingdom, and the United States uses glass technology to immobilize contaminated materials and sites. The glass encased waste is encased in a nickel-base alloy that provides protective barriers against chemical and physical stresses during disposal, interim storage, and transportation.

High boron frits mature rapidly, improve the speed at which smooth, even glaze surfaces develop, and provide good bases for coloring oxides. For the glass surfaces of ceramics and enamels boric oxide acts as a network former and flux.

Soaps and Detergents.—Sodium percarbonate can substitute for sodium perborate in laundry products.

Other.—Boron oxide is incorporated into cellulose materials, borates change the oxidation reactions and promote the formation of 'char' thereby inhibiting combustions. Boric acid is effective in reducing the flammability of cellulose insulation, cotton batting used in mattresses, and wood composites. Borates are a part of the starch adhesive formulation for corrugated paper and paperboard and peptizing agent in the manufacture of casein-base and dextrin-base adhesive.

Boron fiber is a wire of tungsten with elemental boron deposited during a reaction of boron trichloride and hydrogen gas at 800° to 2000° C. Boron fiber is so stiff and strong that it has been used to patch across the fuselage of jet fighter aircraft to hold the wings on. The primary structural member of the B-1 bomber is a single lengthwise beam constructed of boron fiber construction.

Borazine and polyborazylene can be used as precursor's chemicals to boron nitride coatings and composites.

Boric acid has applications in cosmetics, pharmaceuticals, and toiletries. Borates are also added to lubricants, brake fluids, metalworking fluids, water treatment chemicals, and fuel additives. Boron oxide inhibits corrosion.

Transportation

The Trona Railway, connected to the Southern Pacific Railroad between Trona and Searles Stations in California, provided a dedicated line with access to the national rail systems for the borate and soda ash markets.

Almost all U.S. Borax bulk products were shipped in North America by rail. The Boron Mine at Boron is served solely by

¹References that include a section mark (§) are found in the Internet References Cited section.

the Burlington Northern Santa Fe Railroad. In order to connect to another rail line, a transload or transfer point was set up in Cantil, CA, which is served by the Union Pacific Railroad. Trucks of product from Boron are driven to Cantil, about 64 kilometers (km) (40 miles) northwest of Boron, CA, and loaded into dedicated railcars to be shipped to customers.

Cross-country rail shipments are more cost effective in the United States than the use of ocean transportation. Prices for rail haulage depended on a number of factors including the ability of customers to load and unload efficiently, the ability to use whole unit trains, and the ability to supply their own railcars. The recent increase in fuel prices is another factor affecting cost with carriers passing on surcharges to customers.

Ocean transport of U.S. Borax products was from the Port of Wilmington, where the company had a privately owned berth in the harbor. Products destined for Europe were shipped from the bulk terminal in Wilmington to a company-owned facility in the Port of Rotterdam, Netherlands, to company facilities in Spain, and to contracted warehouses. Borax Group also maintains secondary stock points that include Austria, Germany, Norway, the Republic of Korea, Taiwan, and Ukraine. The most centrally located U.S. Borax port location in Europe was Antwerp, Belgium. The industrial minerals market in Europe was characterized by high volumes of imported materials, mostly forwarded through the industrialized areas of Belgium, France, Germany, and the Netherlands for destinations in Central Europe, such as Austria, the Czech Republic, and Slovenia. A decision to import borates was based on the geographic location, the range of service needed, and prices.

U.S. Borax used barges to ship borates from Rotterdam, Netherlands, to customers in Belgium, Eastern Europe, France, Germany, and countries even farther away. Barges were the most efficient and reliable method of transporting goods in Europe because most of the large industrial areas could be reached on waterways that link parts of the North, Baltic, Black, and Mediterranean Seas and the Atlantic Ocean.

Prices

Prices of boron minerals and compounds produced in Chile, Turkey, and the United States are listed in table 4.

World Review

Argentina.—In 2005, Argentina was the leading producer of boron minerals in South America. Borax Argentina S.A. (a subsidiary of Rio Tinto plc) was the country's leading producer of borates and exported to the United States (tables 6-7). Borax Argentina mined borates at four deposits—Tincalayu and Sijes in Salta Province, at more than 4,270 meters (m) (14,000 feet) above sea level, and two dry lake beds, Salars Cauchari and Diabillo in Jujuy Province at 3,370 m. Yacimiento de Boroato El Porvenir at the Salar Cauchari produces ulexite that grades 37% boron oxide. The Tincalayu Mine, originally developed in 1976, was Argentina's largest open pit operation and measured 1.5 km long, 500 m wide, and 100 m deep. Commercial borates mined were colemanite, hydroborocite, kernite, tincal, and ulexite. The clay overburden averages 50 m and typically overlies 30 to 40

m of ore. Tailings from the company's ulexite concentration operation were used as feedstock to supply 8,000 t of boric acid production.

In 1998, Minera Santa Rita S.R.L. bought the boric acid manufacturing plant in Campo Quijano, and doubled the production in 1999. In 2005, boric acid sales were reported at 27,657 kg. The company produced derivative products for specific applications such as granular deca- and penta-hydrate borax, technical grade boric acid power, and various grades and sizes of the natural boron minerals. The products are sold in 25-kilogram and 1-ton bags. The ore was mined from Salar de Pozuelos at Mina San Mateo, Salar de Pastos Grandes at Mina San Cayetona, and Salar de Ratones at Mina Isla. The company reported a reserve of more than 1 Mt of minerals (Minera Santa Rita S.R.L., 2006§).

Other borate producers in the Province of Juyuy included Processadora de Boratos Argentina S.A. (owned by Ferro Corp. and Canadian JEM Resources & Engineering, Inc.), which produced borates from 2-m-thick layers of tincal and ulexite interbedded with clay and lenses of inyoite; Cia Minera Gavenda S.A., which produced borates at the La Inundada Mine at Salar Cauchari from layers of ulexite up to 1-m thick that grade between 11% and 35% B₂O₃; and Triboro S.A., which operated the Irene Mine where ulexite was mined that contained between 11% and 35% B₂O₃. Other producers in Argentina were Coop. de Borateros, Moncholi y Guijarro, Ramiro Matinez, and Viento Blanco S.R.L.

Manufacturas Los Andes S.A. is a newly formed company, that produces boric acid located in the town of Olacapato. The mine and plant was located in the Andes Mountain Range at an elevation of 3,700 m, near the border with Chile. Ulexite from Salar de Diabillo is mined and produced into 99.5% pure boric acid (Gruposaenz, 2006§).

Bolivia.—Quiborax was preparing a claim about the expropriation of its mining concessions in Salar de Uyuni for the World Bank's international center for the settlement of investment disputes. Quiborax's subsidiary Non Metallic Minerals (NMM) extracted ulexite from Salar de Uyuni in southwest Potosi until Bolivia's mining and hydrocarbons ministry rescinded the concessions in June 2004. Quiborax had to wait six months before taking action. NMM exported 76,280 Mt of ulexite to Chile between 2001 and August 2004 (Industrial Minerals, 2005)

India.—A 10.75-crore enriched boric acid plant was expected to be built in Khamman district by 2009. The plant is being promoted by the Department of Atomic Energy (Business Standard, 2006§).

Serbia.—The mineral rights to the Piskanja boron property were awarded to Rio Tinto plc in fall 2005, prompting legal action by Erin Ventures Inc., Kelowna, Canada, based on a prior joint venture contract with Elektroprevreda-Serbia, the Serbian government's wholly owned national power company (Erin Ventures, 2005§). Piskanja is the larger of two boron deposits in the Jarando Basin, an area in which the joint venture, Ras-Borati LTD., had been active. The primary mineralization is colemanite and ulexite. Proven and probable reserves are estimated at 7 Mt with an average grade of 39% boron oxide, according to the Geologic and Mining Institute in Belgrade. The other deposit,

the Pobrdjski Potok property on the north side of the basin, is thought to have resources of only 140,000 t with an average grade of 37% boron oxide (Erin Ventures, Inc., 2001§).

Turkey.—Turkey was the leading producer of boron ore in the world and was expanding plant capacity to produce boron compounds. Turkey has an estimated 29.1% share of the worldwide borate market. Annual boric acid production capacity was 100,000 metric tons per year (t/yr) at Emet, a new plant, 85,000 t/yr at Bandirma, and 35,000 t/yr at Kirka. A 48,000-t/yr borax pentahydrate plant, a 65,000-t/yr borax decahydrate plant, and a 10,000-t/yr anhydrous borax plant were located at Kirka. Other capacities included a 22,000-t/yr sodium perborate tetrahydrate plant and a 9,000-t/yr sodium perborate monohydrate plant at Bandirma. Borate mine capacity was available at Bigadic (180,000 t/yr of colemanite), Emet (660,000 t/yr of colemanite), and Mustafa Kemalpasa (480,000 t/yr of colemanite and ulexite). In addition, 800,000 t/yr of tincal was produced at Kirka.

Current Research and Technology

An osmium diboride compound was prepared by solidstate synthesis procedures to prepare a material that was close in hardness to a diamond. Hard materials are widely used to provide durable and wear-resistant coating for drilling and cutting tools and in other applications (Chemical & Engineering News, 2005).

Millennium Cell Inc.'s HOD systems generate hydrogen from sodium borohydride, which is a derivative of borax. Sodium borohydride fuel solutions are nonflammable, high in energy density, and easily distributed for civilian and military users. The restrictions of battery capacity and the inefficiency of power consumption have become major factors limiting the effective use of mobile electronic equipment. The Air Force Research Laboratory awarded a \$2.6 million contract in spring 2005 to Protonex Technology Corp. and Millennium Cell Inc. to further the development of a lighter, innovative power solution. The contract addresses the need to replace the BA 5590, the lithiumsulfur dioxide battery used for military communications and other needs with the Protonex proton exchange membrane (PEM) fuel cell with the Millennium Cell's Hydrogen on Demand® fuel in an integrated, 30-watt HOD/PEM system (Gerber, 2005).

Magnesium diboride conducts electricity without resistance at temperatures approaching 40 K and can be cooled by liquid hydrogen or liquid neon or by cheap, closed-cycle refrigeration units that can be cooled below 20 K. Wires were prepared by exposing boron filaments to magnesium vapor. Possible applications include superconducting magnets and powerlines (Canfield and Sergey, 2005).

Three boron compounds exist in the titanium-boron system: titanium boride (TiB), titanium diboride (TiB₂), and trititanium tetraboride (Ti₃B₄) at boron concentrations of about 18%, 22%, and 30% by weight. Because TiB forms as long, pure single-crystal whiskers, it is useful for reinforcing titanium. Large

increases in strength can be obtained with a relatively small amount of reinforcement. Its use is also attractive because there is no intermediate phase between titanium and TiB and the formation of TiB requires a lower amount of boron compared to ${\rm TiB}_2$. Possible uses include replacement of high-strength steels, saving 40% of the weight of the structure and providing significant increases in corrosion resistance, oxidation, and wear. Present applications included automobile components and golf club heads (Ravi Chandran, Panda, and Sahay, 2004).

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$\label{table 1} {\sf TABLE~1}$ SALIENT STATISTICS OF BORON MINERALS AND COMPOUNDS 1

(Thousand metric tons and thousand dollars)

	2001	2002	2003	2004	2005
United States:					
Sold or used by producers:					
Quantity:					
Gross weight ²	1,050	1,050	1,150	1,210	1,150
B ₂ O ₃ content	536	543 ^r	605 ^r	637	612
Value	506,000	513,000	591,000	626,000	713,000
Exports: ³					
Boric acid: ⁴					
Quantity	85	84	70	61	183
Value	47,000	44,600	36,400	34,900	96,800
Sodium borates:					
Quantity	221	150	131	135	308
Value	91,700	63,100	55,400	60,200	110,000
Imports for consumption:					
Borax: ³					
Quantity	1	(5)	(5)	(5)	1
Value	642	94	19	62	319
Boric acid: ³					
Quantity	56	49	47	49	52
Value	21,700	18,500	19,000	20,300	22,500
Colemanite:					
Quantity ⁶	35	32	24	21	31
Value	9,790	8,960	6,960	6,070	8,900
Ulexite:					
Quantity ⁶	109	125	80	110	103
Value	21,800	25,000	16,000	21,900	31,000
Consumption, B ₂ O ₃ content	347	359	366 ^r	385	W
World, production	4,730	4,590 ^r	4,730 ^r	5,070 ^r	4,910 '

^eEstimated. ^rRevised. W Witheld to avoid disclosing company proprietary data.

¹Data are rounded to no more than three significant digits.

²Minerals and compounds sold or used by producers, including actual mine production, and marketable products.

³Source: U.S. Census Bureau.

⁴Includes orthoboric and anhydrous boric acid. Harmonized Tariff Schedule of the United States codes 2840.19.0000, 2840.30.0000, and 2840.20.0000.

⁵Less than ½ unit.

⁶Source: Journal of Commerce Port Import/Export Reporting Service.

 ${\it TABLE~2} \\ {\it BORON~MINERALS~OF~COMMERCIAL~IMPORTANCE} \\$

		B_2O_3 ,
	Chemical	weight
Mineral ¹	composition	percentage
Boracite (stassfurite)	$Mg_3B_7O_{13}Cl$	62.2
Colemanite	$Ca_2B_6O_{11}\cdot 5H_2O$	50.8
Datolite	CaBSiO ₄ OH	24.9
Hydroboracite	CaMgB ₆ O ₁₁ ·6H ₂ O	50.5
Kernite (rasortie)	$Na_2B_4O_7 \cdot 4H_2O$	51.0
Priceite (pandermite)	$CaB_{10}O_{19} \cdot 7H_2O$	49.8
Probertite (kramerite)	NaCaB ₃ O ₉ ·5H ₂ O	49.6
Sassolite (natural boric acid)	H_3BO_3	56.3
Szaibelyite (ascharite)	${\rm MgBO_2OH}$	41.4
Tincal (natural borax)	Na ₂ B ₄ O ₇ ·10H ₂ O	36.5
Tincalconite (mohavite)	Na ₂ B ₄ O ₇ ·5H ₂ O	47.8
Ulexite (boronatrocalcite)	NaCaB ₅ O ₉ ·8H ₂ O	43.0
1		

¹Parentheses include common names.

TABLE 3 $\mbox{U.s. CONSUMPTION OF BORON MINERALS AND COMPOUNDS, } \\ \mbox{BY END USE}^{1,2}$

(Metric tons of B₂O₃ content)

End use	2004	2005
Agriculture	9,360	W
Borosilicate glasses	19,800	W
Enamels, frits, glazes	9,930	W
Fire retardants:		
Cellulosic insulation	12,700	W
Other	2,380	W
Insulation-grade glass fibers	178,000	W
Metallurgy	181	W
Miscellaneous uses	45,400	W
Nuclear applications	124	W
Soaps and detergents	18,300	W
Sold to distributors, end use unknown	27,000	W
Textile-grade glass fibers	61,900	W
Total	385,000	W

W Withheld to avoid disclosing company proprietary data.

 $^{^{1}\}mathrm{Data}$ are rounded to no more than three significant digits; may not add to totals shown.

²Includes imports of borax, boric acid, colemanite, and ulexite.

$\label{eq:table 4} \textbf{YEAREND PRICES FOR BORON MINERALS AND COMPOUNDS}^1$

(Dollars per metric ton)

	Price,	Price,
	December 31,	December 31,
Product	2004	2005
Borax, technical, anhydrous, 99%, bulk, carload, works ²	900-930	900-930
Borax, technical, anhydrous, 99%, bags, carload, works ²	846	NA
Borax, technical, granular, decahydrate, 99%, bags, carload, works ²	378	378
Borax, technical, granular, decahydrate, 99.5%, bulk, carload, works ³	374	340-380
Borax, technical, granular, pentahydrate, 99.5%, bags, carload, works ²	426	426
Borax, technical, granular, pentahydrate, 99.5%, bulk, carload, work ²	400-425	400-425
Boric acid, technical, granular, 99.9%, bags, carload, works ²	836	836
Boric acid, technical, granular, 99.9%, bulk, carload, works ²	788	NA
Boric acid, United States Borax & Chemical Corp., high-purity anhydrous, 99% B ₂ O ₃ , 100-pound-bags, carlots ²	1,996	900-935
Colemanite, Turkish, 42% B ₂ O ₃ , ground to a minus 70-mesh, free on board (f.o.b.) railcars, Kings Creek, SC ³	270-290	270-290
Ulexite, Lima, 40% B ₂ O ₃ , ground to a minus 6-mesh, f.o.b railcars, Norfolk, VA	200	250-300

NA Not available.

¹U.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. Values have been rounded to the nearest dollar.

²Source: Chemical Market Reporter, v. 267, no. 1, January 3, 2005, p. 20; pricelist April 17-23, 2006.

³Source: Industrial Minerals, no. 448, January 2005, p. 72; no. 459, December 2005, p. 70.

 ${\it TABLE 5}$ U.S. EXPORTS OF BORIC ACID AND REFINED SODIUM BORATE COMPOUNDS, BY COUNTRY $^{\rm I}$

		2004			2005		
	Boric	Boric acid ²		Boric acid ²		Sodium	
	Quantity	Value	borates ³	Quantity	Value	borates ³	
Country	(metric tons)	(thousands)	(metric tons)	(metric tons)	(thousands)	(metric tons)	
Australia	1,910	\$849	4,530	1,900	\$931	6,680	
Belgium	11	24	144			102	
Brazil	890	525	1,700	2,640	1,420	875	
Canada	5,180	3,580	44,500	5,350	3,850	50,400	
China	9,630	4,510	23,000	20,600	9,700	62,100	
Colombia	34	29	2,650	54	53	4,430	
France	35	27	1	125	111	117	
Germany	978	1,040	8	432	1,070	11	
Hong Kong	6,230	2,740	449	4,350	2,080	317	
India	1	3	100	701	254	9,010	
Indonesia	1,090	587	3,080	586	341	310	
Italy	2	7	2,560	40	53	3,440	
Japan	14,600	9,780	18,000	22,500	21,300	24,300	
Korea, Republic of	7,310	3,620	5,750	19	9,820	14,900	
Malaysia	769	567	1,570	1,370	1,080	20,000	
Mexico	3,030	1,730	7,730	2,870	1,680	11,100	
Netherlands	11	7	3	53,500	20,800	57,900	
New Zealand	445	184	2,560	817	414	2,880	
Philippines	133	81	1,230	111	68	1,130	
Singapore	822	436	1,290	950	541	753	
Taiwan	5,030	2,480	3,800	23,000	11,900	4,100	
Thailand	2,610	1,850	7,000	3,520	1,940	7,240	
United Kingdom	7	35	1	1,600	646	1,500	
Venezuela	75	77	240	72	80	400	
Vietnam	172	84	759	1,170	615	1,440	
Other	64	69	2,290	34,700	6,040	22,300	
Total	61,000	34,900	135,000	183,000	96,800	308,000	

⁻⁻ Zero.

Source: U.S. Census Bureau.

¹Data are rounded to no more than three significant digits; may not add to totals shown.

²Harmonized Tariff Schedule of the United States (HTS) code 2810.00.0000.

 $^{^{3}}$ HTS codes 2840.19.0000, 2840.30.0000, and 2840.20.0000.

 $\label{eq:table 6} \text{U.s. IMPORTS FOR CONSUMPTION OF BORIC ACID, BY COUNTRY}^1$

	200	04	2005		
	Quantity	Value ²	Quantity	Value ²	
Country	(metric tons)	(thousands)	(metric tons)	(thousands)	
Argentina	1,340	\$579	1,630	\$694	
Australia	15	40	1	2	
Bolivia	2,680	985	3,840	1,360	
Chile	12,800	4,670	15,100	6,130	
China	1	2	32	83	
France	488	813	1,270	1,720	
Germany	27	46	22	31	
India	12	22	13	28	
Italy	1,210	1,320	1,290	1,500	
Japan	157	148	109	160	
Korea, Republic of	18	7			
Peru	4,340	1,610	4,610	1,700	
Russia	411	179	67	40	
Turkey	25,800	9,730	23,900	8,970	
United Kingdom	78	115	57	107	
Other	21	22	21	23	
Total	49,400	20,300	51,900	22,500	

⁻⁻ Zero.

Source: U.S. Census Bureau.

¹Data are rounded to no more than three significant digits; may not add to totals shown.

²U.S. customs declared values.

 ${\it TABLE~7} \\ {\it BORON~MINERALS:~WORLD~PRODUCTION,~BY~COUNTRY}^{1,\,2}$

(Thousand metric tons)

Country	2001	2002	2003	2004	2005 ^e
Argentina	632 ^r	516 ^r	512 ^r	821 ^r	820
Bolivia, ulexite	32	40	110	68 ^r	68
Chile, ulexite	328	431	401	594 ^r	590
China ^{e, 3}	150	145	130	135	140
Germany, borax ^e	1	1	1	1	2
Iran, borax ⁴	3	2	3 ^r	3	3
Kazakhstan ^e	30	30	30	30	30
Peru	9	7	9	9 r	9 p
Russia ^{e, 6}	1,000	1,000	1,000	500	400
Turkey ⁷	1,493	1,346 ^r	1,377 ^r	1,697 ^r	1,700
United States ⁸	1,050	1,050	1,150	1,210	1,150 5
Total	4,730	4,590 ^r	4,730 ^r	5,070 ^r	4,910

^eEstimated. ^pPreliminary. ^rRevised.

¹World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

²Table includes data available through May 20, 2006.

³Boron oxide (B₂O₃) equivalent.

⁴Data are for years beginning March 21 of that stated.

⁵Reported figure.

 $^{^6}$ Blended Russian datolite ore that reportedly grades 8.6% B $_2$ O $_3$.

⁷Concentrates from ore.

⁸Minerals and compounds sold or used by producers, including both actual mine production and marketable products.