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BORON

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Boron

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U.S. consumption of minerals and compounds reported in boron oxide continued to increase in 2011; quantities are withheld to avoid disclosing company proprietary data (table 1). Turkey and the United States were the world's leading producers of boron minerals (table 6). World production of boron minerals increased in 2011 to an estimated 4.55 million metric tons (Mt) compared with 4.05 Mt in 2010 (excluding U.S. production). The United States exported 235,000 metric tons (t) of boric acid, a decrease from 264,000 t in 2010. In 2011, 492,000 t of sodium borates was exported, an increase from 423,000 t in 2010 (tables 1, 4). Boron imports consisted primarily of borax, boric acid, colemanite, and ulexite (tables 1, 5).

Elemental boron is a metalloid that had limited commercial applications. The main applications were as a doping agent in the manufacture of semiconductors and as an ignition source in airbags. The global consumption rate of elemental boron was estimated to be 15 metric tons per year (t/yr). Boron compounds, chiefly borates, are commercially important; therefore, boron products are priced and sold based on boric oxide content (B_2O_3), which varies by ore and compound, and on the absence or presence of sodium and calcium (table 2). Borax, one of the most important boron minerals for industrial use, is a white crystalline substance chemically known as sodium tetraborate decahydrate and is found in nature as the mineral tincal. Boric acid, also known as orthoboric acid or boracic acid, is a white, colorless crystalline solid sold in technical, national formulary, and special quality grades as granules or powder. Colemanite (hydrated calcium borate), kernite (hydrated sodium borate), tincal, and ulexite (hydrated sodium calcium borate) were the minerals of most commercial importance in the United States (table 2).

Production

Four minerals make up 90% of the borates used by industry worldwide: the sodium borates tincal and kernite, the calcium borate colemanite, and the sodium-calcium borate ulexite. Borate deposits are associated with volcanic activity and arid climates, and the largest borate deposits are located in the Mojave Desert of the United States, the Alpide belt in southern Asia, and the Andean belt of South America. As a result, most borates were extracted primarily in California and Turkey and to a lesser extent in Argentina, Bolivia, Chile, China, and Peru. Boron compounds and minerals were produced by surface and underground mining and from brine.

Domestic data for boron were derived by the U.S. Geological Survey from a voluntary survey of two U.S. producers—Rio Tinto Group's U.S. Borax Inc. and Searles Valley Minerals, Inc. (SVM). Both companies responded; however, data were withheld to avoid disclosing company proprietary data (table 1).

SVM, acquired by the Indian company Nirma in 2007, produced borax and boric acid from brines containing potassium and sodium borates that were extracted from three salt layers, up to 100 meters (m) deep, in Searles Lake, located near Trona in San Bernardino County, CA. SVM's Trona and Westend plants refined the brines, producing anhydrous, decahydrate, and pentahydrous borax. These brines also supplied other commercial salts in addition to sodium borates and boric acid. The Trona plant has a reported capacity of 27,500 t/yr B_2O_3, and the Westend plant has a reported capacity of 82,300 t/yr B_2O_3.

Rio Tinto Borax (a wholly owned subsidiary of United Kingdom-based Rio Tinto Minerals) mined mainly tincal and kernite at Boron, CA, by open pit methods, and the ore was transported by truck to a storage area. The tincal had an average grade of 25.3% B_2O_3 and the kernite had an average grade of 31.9% B_2O_3. Boric acid and refined sodium borates were produced at an onsite processing plant. Refined borate products were shipped by railcar or truck to North American customers or to the company's Wilmington, CA, facility and exported from the Port of Los Angeles. Specialty borate products were made at the Wilmington plant. According to a U.S. Securities and Exchange Commission report filed by Rio Tinto Borax, the company produced 504,000 t of borates in 2011, a slight increase from the 500,000 t reported in 2010 (Rio Tinto plc, 2012, p. 22). Rio Tinto's production of borates during the third quarter of 2011 was reported at 127,000 t, a decrease of 10% from 141,000 t that was mined during the same quarter of 2010, as a result of scheduled maintenance at its Boron, CA, mine (Watts, 2011).

Consumption

In 2011, U.S. imports for consumption of borax, boric acid, colemanite, and ulexite were 82,000 t, a 19% decrease from 101,000 t imported in 2010. The first reported use of borax was as a flux or bonding agent by Arabian gold- and silversmiths in the eighth century, but current research suggests Babylonians may have used it 4,000 years ago. Today, there are more than 300 end uses for borates, but the majority of the world's supply is sold and distributed for end uses related to agriculture, ceramics, detergents, ferroboron, fire retardants, and glass (Garrett, 1998; Hamilton, 2006).

Agriculture.—Fertilizers represented the third largest application of borates. Boron was the most widely used micronutrient, applied primarily to promote fruit and seed production. Boron fertilizers were mostly sourced from borax, boric acid, and calcium borate owing to their high water solubility; thus, boron fertilizers can be delivered through sprays or irrigation water. Domestic consumption of boron fertilizers was estimated to be approximately 2% of total U.S. fertilizer consumption.

Boron is essential for plant uptake of primary and secondary nutrients, such as calcium, manganese, magnesium, phosphorus, and zinc. It influences the transport of nutrients through plant membranes, which directly correlates into improved fruit development, germination, plant reproduction, and pollen production. Normal plant leaves typically contain 25 to 100 parts per million of boron, with 1 kilogram per hectare of boron (1 pound per acre) in soil being adequate to maintain these levels. U.S. boron deficiencies in crops are found primarily in the Atlantic coastal plains, Great Lakes region, and the coastal Pacific Northwest, where soils tend to be acidic, leached, coarse sandy, or organic in nature. Excessive boron fertilization, on the other hand, can cause crop toxicity, which studies suggested was more often caused by higher boron levels in irrigation water than those in soil (Troeh and Thompson, 2005, p. 489).

Ceramics.—Ceramics comprise the second largest application of borates after glass, accounting for 10% of world consumption. Borates play an important role in ceramic glazes and enamels, increasing chemical, thermal, and wear resistance. Borax and colemanite are used in ceramics primarily as fluxing agents, with borax being used in higher temperature, and colemanite in lower temperature firings. Borates are also used in technical ceramics, an industry with applications in aerospace, ballistics, electronics, and medicine, which experienced strong growth during the past decade. The amount of B_2O_3 used in glazes varies between 8% and 24% and the amount used in enamels is between 17% and 32% by weight.

Boron carbide is a key ingredient in lightweight ceramic armor, the use of which increased United States and European consumption of boron carbide during the past few years. Small arms protective inserts, used by the U.S. military, are boron carbide ceramic plates inserted into Kevlar flak jackets to protect against high-velocity projectiles (Industrial Minerals, 2008b).

Detergents and Soaps.—The use of borates in detergents and soaps represented the fourth largest market, accounting for 4% of world consumption. Borates were incorporated into laundry detergents, soaps, and other cleaning products because they can be used as alkaline buffers, enzyme stabilizers, oxygen-based bleaching agents, and water softeners. Two borates, sodium perborate and perborate tetrahydrate, were used as oxidizing bleaching agents because they contain true peroxygen bonds. Hydrogen peroxide, a very effective bleaching agent, is produced when sodium perborate undergoes hydrolysis while in contact with water. Because hydrogen peroxide cannot be effectively incorporated into detergents, sodium perborate acts as its carrier (Rio Tinto Borax, 2005). Sodium perborate, however, requires hot water to undergo hydrolysis, and concerns have emerged over excessive boron levels in waterways owing to sodium perborate in detergents. Sodium percarbonate has been used as a substitute primarily in Europe because it produces hydrogen peroxide at lower temperatures. This substitution has affected boron consumption.

Ferroboron.—Ferroboron (FeB) is a binary alloy of iron with a boron content between 17.5% and 24% and is the lowest cost boron additive for steel and other ferrous metals. On average, the steel industry consumes more than 50% of the ferroboron produced annually (Eti Holding Inc., 2003, p. 8). Boron steel, containing nearly 0.008% ferroboron, possesses a higher strength and lighter weight than that of average high-strength steel, and is a useful material in the manufacturing of safe and fuel efficient automobiles.

Fire Retardants.—Borates were incorporated into various materials, such as cellulosic insulation, textiles, and timber, to impart flame retardant properties to the materials. Boric acid was incorporated into wood flame-retardants to inhibit the transfer of combustible vapors and reduce the effective heat of combustion, resulting in reduced flame spread. Zinc borate was used in plastics as a multifunctional boron-based fire retardant, with applications in a variety of plastics and rubber compounds.

Glass.—The principle market for borates in 2011 was glass, representing approximately 60% of global borate consumption. Boron is used as an additive in glass to reduce thermal expansion, improve strength, chemical resistance, and durability, and provide resistance against vibration, high temperature, and thermal shock. Boron is also used as a fluxing agent, reducing the viscosity of glass during formation to improve manufacturing. Depending on the application and quality of the glass, borax, boric acid, colemanite, ulexite, and sodium borates are typically used.

Insulation and textile fiberglass represented the largest single use of borates worldwide, at 45% of world consumption. End uses for fiberglass are corrosion-resistant, heat-resistant, and high-strength fabrics; insulation; reinforcement; and sound absorption. The incorporation of borates into fiberglass greatly improves quality, establishing a product that is strong, lightweight, and thermal and chemical resistant (Garrett, 1998).

Borosilicate refers to glass with boric oxide content between 5% and 30%. The boron in borosilicate imparts many valuable properties to the glass, such as increased mechanical strength, low coefficient of thermal expansion, and resistance to chemical attack and thermal shock. Past application of borosilicate ranged from Pyrex® kitchenware to the thermal protection tiles on the National Aeronautics and Space Administration Space Shuttle Orbiters.

Other.—Various boron compounds are used in nuclear powerplants to control neutrons produced during nuclear fission. The isotope boron-10, in particular, possesses a high propensity for absorbing free neutrons, producing lithium and alpha particles after absorbing neutrons. Control rods composed of boron carbide are lowered into a nuclear reactor to control the fission reaction by capturing neutrons. Boric acid is used in the cooling water surrounding nuclear reactors to absorb escaping neutrons (Ceradyne Inc., 2011).

Boron nitride can be found in large quantities in cosmetics owing to its low coefficient of friction and lack of toxicity. It has been shown to be a useful alternative to talcum powder, which studies show may be linked to ovarian cancer (Emsley, 2004, p. 15–17). Boric acid has applications in cosmetics, pharmaceuticals, and toiletries. Borates are also added to brake fluids, fuel additives, lubricants, metalworking fluids, and water treatment chemicals. Boron oxide inhibits corrosion.

Transportation and Distribution

Almost all U.S. borates were shipped in North America by rail. Both U.S. producers had rail fleets dedicated to the exclusive transportation of their products. Small shipments of borates were shipped by rail or truck in specialty bags, usually of 2,100-pound capacity. Prices for rail haulage depended on the ability of customers to load and unload efficiently, the ability to use unit trains and to supply one's own railcars, and fuel prices.

SVM owned the Trona Railway, a 50-kilometer (km) (31-mile) shortline railroad that connects to the Southern Pacific Railroad between Trona and Searles stations in California. The Trona Railway provided a dedicated line with access to the national rail system for the borate, soda ash, and sodium sulfate markets. Nearly 80% of output was transported by rail to domestic consumers and to the ports of Long Beach and San Diego in California for export.

The Boron Mine was served solely by 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, served by the Union Pacific Railroad. Trucks of product from Boron were driven to Cantil, about 64 km (40 miles) northwest of Boron and loaded into dedicated railcars to be shipped to customers.

Rio Tinto Borax used a privately owned berth located in the Port of Los Angeles, CA, for ocean transportation of borate products. Products destined for Europe were shipped from the bulk terminal in Wilmington to a company-owned facility in the Port of Rotterdam, Netherlands, company facilities in Spain, or contracted warehouses. The most centrally located Rio Tinto 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, including Austria, the Czech Republic, and Slovenia. A decision to import borates was based on the geographic location, the range of borate products needed, and prices.

Prices

Yearend prices of boron minerals and compounds produced in the United States are listed in table 3. Prices for borates increased from 2010 to 2011 as a result of a stabilization in marketplace conditions following depressed prices observed in 2008 and 2009. The decrease in price observed from 2008 to 2009 reflected an imbalance between supply and demand created by the economic downturn observed beginning in the fourth quarter of 2008. Table 4 lists the free alongside ship values for U.S exports of boric acid and quantities of boric acid and refined sodium borate compounds exported to various countries.

Foreign Trade

Exports of boron compounds and minerals in 2011 increased by 6% to 727,000 t from 687,000 t in 2010. In 2011, China received the largest amount of sodium borates and boric acid from the United States owing to increased consumption of borates used in the Chinese glass and ceramic industries. Imports of 82,000 t in 2011 represented a 19% decrease from the 101,000 t reported in 2010 (table 1).

World Review

Argentina.—Argentina remained the leading producer of boron minerals in South America in 2011 (table 6). Borate deposits are located primarily in the Puna region, which includes the northwestern tip of Argentina, the southeastern corner of Peru, the southwestern corner of Bolivia, and the northeastern border of Chile. Recent increased demand in Asia and North America for borate use in ceramics and glass led to increased production of Argentine borates, boric acid in particular.

Borax Argentina S.A. (a subsidiary of Rio Tinto Minerals), the country's leading producer of borates, operated the Tincalayu Mine, the largest open pit operation in the country and located at 4,100 m (13,400 feet) above sea level. The deposit consisted primarily of borax, with rare occurrences of ulexite and 15 other borates. Rio Tinto also produced refined borate ores and boric acid at refineries in Campo Quijano, Sijes, and Tincalayu in Salta Province and Porvenir in Jujuy Province (Rio Tinto plc, 2011, p. 80). In 2011, Borax Argentina produced 85,000 t of tincal, 30,000 t of ulexite, 35,000 t of colemanite (Lismore, 2012b).

Minera Santa Rita S.R.L. (MSR) operated mines in Catamarca, Jujuy, and Salta Provinces and operated a processing plant in Campo Quijano, which produced granular deca- and pentahydrate borax, technical-grade boric acid powder, and various grades and sizes of the natural boron minerals. MSR exports 97% of its products to 28 countries through the port of Buenos Aires and by land to Brazil (Santa Rita Mining Co., 2012).

Chile.—In 2011, Chile was the second leading producer of boron minerals in South America (table 6). The 489,000 t of boron minerals produced in 2011 was a slight decrease from that of 2010. The Chilean borate producers were all located on the northeastern border of Chile, which contains one the world's largest deposits of ulexite. The leading producer, Quimica e Industrial del Borax Ltda. (Quiborax), mined 450,000 t/yr of crude ulexite and produced up to 80,000 t/yr of boric acid and 40,000 t/yr of granular ulexite (Tran, 2008).

China.—China possesses more than 100 borate deposits in 14 Provinces. The northeastern Province of Liaoning and the western Province of Qinghai accounted for more than 80% of the resources, mostly in the form of sassolite and tincal. Chinese boron resources are of low quality, averaging about 8.4% B_2O_3, in comparison to the Turkish and United States reserves, which average about 26% to 31% and 25.3% to 31.9% B_2O_3, respectively (Industrial Minerals, 2008a; Baylis, 2010, p. 5).

The Chinese Government was considering closing a loophole that gives a 5% tax rebate on the export of alloys in attempts to curtail misuse of the rebate. Some carbon steel mills added small amounts of boron, nearly 0.0005% by weight, to pass the steel off as an alloy in order to collect the rebate. This practice may have given these mills as much as a 20% pricing advantage on their products (Metal Bulletin, 2011).

Turkey.—Approximately 73% of the world's boron reserves are located in Turkey (Engineering and Mining Journal, 2012). The main borate producing areas of Turkey, all controlled by the state-owned mining company Eti Maden AS, are Bigadic (colemanite and ulexite), Emet (colemanite), Kestelek (colemanite, probertite, and ulexite), and Kirka (tincal). Production of refined borates increased during the past few years owing to continued investment in new refineries and technologies. Eti Maden planned to expand its share in the world boron market from 36% to 39% by 2013, increasing sales to $1 billion by expanding its production facilities and product range. In 2009, Turkey exported 4 Mt of borates valued at $104 million (Today's Zaman, 2009; Uyanik, 2010).

Outlook

Consumption of borates is expected to increase, spurred by strong demand in the Asian and South American agriculture, ceramic, and glass markets. World consumption of borates was projected to reach 2.0 Mt B_2O_3 by 2014, compared with 1.5 Mt B_2O_3 in 2010 (Roskill Information Services Ltd., 2010, p. 167; O'Driscoll, 2011).

The European Union (EU) added borates to a list of banned minerals, which required detergent makers to decrease their use of boron following an EU ruling that determined continuous exposure may be harmful (Lismore, 2012a). Demand for boron-based fertilizers was expected to rise as a result of an increase in demand for food and biofuel crops. Higher crop prices have enabled farmers to invest more capital in advanced farming techniques and higher-grade fertilizers. Consumption of borates by the ceramics industry was expected to shift away from Europe to Asia, which accounted for 60% of world demand in 2011.

A year following the earthquake in Japan, boric acid remained limited. Used extensively to cool the damaged Fukushima reactor cores following the destruction of the powerplant's cooling system, the demand for boric acid supplies remained high (Ollett, 2012). The demand for boric acid is likely to remain high as its use as a coolant in nuclear reactor plants may expand.

Consumption of boron nitride is expected to increase owing to the development of high-volume production techniques coupled with the creation of new technologies. The properties intrinsic to cubic boron nitride, such as hardness (second only to diamond), high thermal conductivity, and oxidation resistance make it an ideal material in a variety of emerging applications. Hexagonal boron nitride was used in additives, ceramics, and intermetallic composites, imparting thermal shock resistance, improved machinability, and reduction of friction.

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TABLE 1
SALIENT STATISTICS OF BORON MINERALS AND COMPOUNDS[1]

(Thousand metric tons and thousand dollars)

	2007	2008	2009	2010	2011
United States:					
Sold or used by producers:					
Quantity:					
Gross weight[2]	W	W	W	W	W
B_2O_3 content	W	W	W	W	W
Value	W	W	W	W	W
Exports:[3]					
Boric acid:[4]					
Quantity	248	303	171	264	235
Value	124,000	165,000	109,000	170,000	166,000
Sodium borates:					
Quantity	446	519	417	423	492
Value	146,000	192,000	176,000	218,000	244,000
Imports for consumption:					
Borax:[3]					
Quantity	1	1	(5)	(5)	(5)
Value	647	566	376	183	174
Boric acid:[3]					
Quantity	67	50	36	50	57
Value	27,500	26,200	26,100	30,100	40,800
Colemanite:					
Quantity[6]	26	30	31	50	20
Value	7,640	8,880	8,630	18,400	19,000
Ulexite:					
Quantity[6]	92	75	28	1	5
Value	27,600	22,600	11,300	238	858
Consumption, B_2O_3 content	W	W	W	W	W
World, production[7]	4,200	4,480	3,710 r	4,050 r	4,550 e

[e]Estimated. [r]Revised. W Withheld to avoid disclosing company proprietary data.

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

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

[3]Source: U.S. Census Bureau.

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

[5]Less than ½ unit.

[6]Source: PIERS.

[7]U.S. production withheld from world production in 2007–11 to avoid disclosing company proprietary data.

TABLE 2
BORON MINERALS OF COMMERCIAL IMPORTANCE

Mineral[1]	Chemical composition	B_2O_3, weight percentage
Boracite (stassfurite)	$Mg_3B_7O_{13}Cl$	62.2
Colemanite	$Ca_2B_6O_{11}\cdot 5H_2O$	50.8
Datolite	$CaBSiO_4OH$	24.9
Hydroboracite	$CaMgB_6O_{11}\cdot 6H_2O$	50.5
Kernite (rasorite)	$Na_2B_4O_7\cdot 4H_2O$	51.0
Priceite (pandermite)	$CaB_{10}O_{19}\cdot 7H_2O$	49.8
Probertite (kramerite)	$NaCaB_3O_9\cdot 5H_2O$	49.6
Sassolite (natural boric acid)	H_3BO_3	56.3
Szaibelyite (ascharite)	$MgBO_2OH$	41.4
Tincal (natural borax)	$Na_2B_4O_7\cdot 10H_2O$	36.5
Tincalconite (mohavite)	$Na_2B_4O_7\cdot 5H_2O$	47.8
Ulexite (boronatrocalcite)	$NaCaB_5O_9\cdot 8H_2O$	43.0

[1]Parentheses indicate common names.

TABLE 3
YEAREND PRICES FOR BORON MINERALS AND COMPOUNDS[1]

(Dollars per metric ton)

Product	Price, December 31, 2009	Price, December 31, 2010	Price, December 31, 2011
Borax, decahydrate, Buenos Aires	520	520	947–979
Boric acid, Chile	800	735	1,390–1,460
Colemanite, Buenos Aires, 40% boron oxide (B_2O_3)	370–420	370–420	690–730
Ulexite, Buenos Aires, 40% B_2O_3	350–380	350–380	666–697
Ulexite, granular, Chile, 40% B_2O_3	400	400	692–734
Ulexite, Lima, 40% B_2O_3	250–300	350–370	687–723

[1]U.S. free on board 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.

Source: Industrial Minerals, no. 507, December 2009, p. 68; no. 519, December 2010, p. 69; no. 531, December 2011, p. 61.

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

	2010			2011		
	Boric acid[2]		Sodium	Boric acid[2]		Sodium
	Quantity	Value[3]	borates[4]	Quantity	Value[3]	borates[4]
Country	(metric tons)	(thousands)	(metric tons)	(metric tons)	(thousands)	(metric tons)
Australia	1,780	$1,120	4,330	1,880	$1,150	5,120
Belgium	3	11	14	31	62	12
Brazil	1,190	1,550	927	923	1,360	80
Canada	2,530	2,290	27,500	2,240	2,550	23,400
China	59,900	35,000	104,000	39,800	25,400	134,000
Colombia	159	210	6,840	219	298	7,270
France	120	81	324	407	207	278
Germany	1,380	1,670	1	706	1,910	1
Hong Kong	--	--	--	400	206	20
India	3,930	2,840	32,300	4,010	2,860	21,400
Indonesia	1,340	935	9,630	904	717	11,000
Italy	93	94	1,080	1	4	604
Japan	46,100	32,500	25,300	35,700	27,900	25,800
Korea, Republic of	49,700	27,700	12,700	50,200	33,300	13,500
Malaysia	3,340	1,940	25,700	6,510	3,870	54,000
Mexico	6,540	5,240	34,700	7,600	6,400	36,300
Netherlands	38,600	24,200	99,200	26,400	16,900	74,700
New Zealand	428	289	2,010	277	195	1,470
Philippines	121	89	1,980	87	92	2,200
Saudi Arabia	1,720	1,310	1,130	4,280	2,950	673
Singapore	1,610	2,880	1,050	1,160	2,230	913
Spain	1,840	1,080	661	--	--	700
Taiwan	31,200	17,800	3,250	43,400	29,100	4,240
Thailand	3,610	2,210	8,600	2,790	1,940	8,740
United Kingdom	--	--	2	5	24	9
Venezuela	253	2,190	240	135	320	46
Vietnam	2,990	1,940	5,060	2,430	1,820	51,100
Other	3,900 r	2,950 r	13,800 r	2,750	2,260	14,900
Total	264,000	170,000	423,000	235,000	166,000	492,000

[r]Revised. -- Zero.
[1]Data are rounded to no more than three significant digits; may not add to totals shown.
[2]Harmonized Tariff Schedule of the United States (HTS) code 2810.00.0000.
[3]Free alongside ship valuation.
[4]HTS codes 2840.19.0000, 2840.20.0000, and 2840.30.0000.

Source: U.S. Census Bureau.

TABLE 5
U.S. IMPORTS FOR CONSUMPTION OF BORIC ACID, BY COUNTRY[1]

	2010		2011	
Country	Quantity (metric tons)	Value[2] (thousands)	Quantity (metric tons)	Value[2] (thousands)
Argentina	1,080	$790	506	$514
Bolivia	4,160	2,330	4,180	2,840
Brazil	--	--	154	100
Chile	7,340	4,380	8,750	7,180
China	100	162	758	1,030
France	505	657	270	277
Germany	103	100	350	210
India	627	607	175	265
Italy	1,570	1,600	1,490	1,880
Japan	173	111	58	38
Peru	2,920	1,850	3,190	2,360
Russia	923	483	1,180	785
Turkey	30,000	17,000	35,500	23,300
United Kingdom	1	2	18	23
Other	27	39	37	69
Total	49,500	30,100	56,600	40,800

-- Zero.

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

[2]U.S. customs declared values.

Source: U.S. Census Bureau.

TABLE 6
BORON MINERALS: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Thousand metric tons)

Country	2007	2008	2009	2010	2011[e]
Argentina	670	786	500	623 [r]	600
Bolivia, ulexite	64	56	86	97	135 [3]
Chile, ulexite	528	583	608	504	489 [3]
China[e, 4]	145	140	93 [r]	100 [r]	100
Iran, borax[e, 5]	2 [3]	1 [3]	1	2	1
Kazakhstan[e]	30	30	30	30	30
Peru	234	350	187	293	293 [p]
Russia[e, 6]	400	400	400	400	400
Turkey[e, 7]	2,128 [3]	2,139 [3]	1,800	2,000	2,500
United States[8]	W	W	W	W	W
Total	4,200	4,480	3,710 [r]	4,050 [r]	4,550

[e]Estimated. [p]Preliminary. [r]Revised. W Withheld to avoid disclosing company proprietary data, not included in total.

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

[2]Table includes data available through June 11, 2012.

[3]Reported figure.

[4]Boron oxide (B_2O_3) equivalent.

[5]Data are for years beginning March 21 of that stated.

[6]Blended Russian datolite ore that reportedly grades 8.6% B_2O_3.

[7]Concentrates from ore.

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