2015 Minerals Yearbook

BORON [ADVANCE RELEASE]

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Boron

Robert D. Crangle, Jr.

Domestic survey data and tables were prepared by Sheema Merchant, statistical assistant, and the world production table was prepared by Lisa D. Miller, international data coordinator.

In 2015, most of the boron products consumed in the United States were manufactured domestically. Two companies produced borates in the United States—U.S. Borax, Inc. in Boron, CA, and Searles Valley Minerals, Inc. in Trona, CA. U.S. consumption of minerals and compounds reported in boric oxide (B_2O_3) content decreased in 2015; however, quantity data were 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 decreased slightly in 2015 to an estimated 9.38 million metric tons (Mt) compared with 9.40 Mt in 2014 (excluding U.S. production). The United States exported an estimated 198,000 metric tons (t) of boric acid in 2015, a decrease of 12% from 225,000 t in 2014.

Elemental boron is a metalloid with limited commercial applications. The main applications were as a doping agent in the manufacture of semiconductors and as an ignition source in airbags. Global consumption of elemental boron was estimated to be 15 metric tons per year (t/yr). Boron compounds, chiefly borates, are commercially important; boron products are priced and sold based on B_2O_3 content, 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.

Production

Although more than 200 boron minerals occur naturally, only 4 account for 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 and from publicly available U.S. Securities and Exchange Commission (SEC) information for two U.S. producers—Searles Valley Minerals (SVM) and Rio Tinto Group's U.S. Borax. Data from both companies were withheld to avoid disclosing company proprietary data (table 1).

SVM (a subsidiary of Nirma Ltd., India) 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.

U.S. Borax (a wholly owned subsidiary of United-Kingdom-based Rio Tinto plc) mined mainly tincal and kernite at Boron, CA, by open pit methods. 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 customers in North America or to the company's Wilmington, CA, facility and exported from the Port of Los Angeles, CA. U.S. Borax supplied more than 30% of the world's refined borates (Rio Tinto plc, 2016, p. 36). According to a report filed by Rio Tinto, the company produced 476,000 t of borates in 2015, a decrease of 6% from the 508,000 t reported in 2014; the production decrease was a result of lower market demand (Rio Tinto plc, 2016, p. 214).

Consumption

The first reported use of borax was as a flux or bonding agent by Arabian goldsmiths and silversmiths in the eighth century, but current research suggests that the Babylonians may have used it 4,000 years ago. In 2015, borates were used in more than 300 end uses, but the 5 leading uses, in decreasing order of quantity, were glass, ceramics, agriculture, detergents, and bleaches (Hamilton, 2006).

Agriculture.—Boron was the most widely used fertilizer 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 water for irrigation.

Boron is essential for plant uptake of primary and secondary nutrients, such as calcium, magnesium, manganese, phosphorus, and zinc. It improves the transport of nutrients through plant membranes, which directly correlates to improved fruit development, germination, plant reproduction, and pollen production. Normal plant leaves typically contain 25 to 100 parts per million boron, with 1 kilogram of boron per hectare (1 pound per acre) in soil being adequate to maintain these levels. In the United States, crops with boron deficiencies are often found in the Atlantic Coastal Plain, Great Lakes region, and the coastal Pacific Northwest, where soils tend to be acidic, coarse sandy, leached, or organic in nature (Albrecht, 1967; U.S. Department of Agriculture, 1998).

***Ceramics.*—**Ceramics were the second-leading application for 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 firings and colemanite in lower temperature firings. Borates also are used in technical ceramics, products with applications in aerospace, ballistics, electronics, and medicine, all of 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 varies between 17% and 32% by weight.

Boron carbide is a key ingredient in lightweight ceramic armor, the use of which increased consumption of boron carbide in the United States and Europe since 2002. 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-ranked 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. Sodium perborate and perborate tetrahydrate were used as oxidizing bleaching agents. 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 (U.S. Borax, Inc., undated). 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 reduced boron consumption for detergent applications.

***Glass.*—**The principal market for borates in 2015 was glass, representing approximately 60% of global borate consumption. Boron is used as an additive in glass to reduce thermal expansion; to improve strength, chemical resistance, and durability; and to provide resistance against vibration, high temperature, and thermal shock. Boron also is 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, sodium borates, and (or) ulexite can be used.

Insulation and textile fiberglass represented the largest single use of borates worldwide, accounting for 45% of world borate consumption. End uses for fiberglass are corrosion-resistant, heat-resistant, and high-strength fabrics; thermal insulation; reinforcement; and sound absorption. The incorporation of borates into fiberglass greatly improves quality by increasing the absorbance of infrared radiation (U.S. Borax, Inc., 2016).

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, lower coefficient of thermal expansion, and greater resistance to chemical attack and thermal shock. Applications of borosilicate range from Pyrex® kitchenware to the thermal protection tiles for spacecraft.

***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, resulting in the production of lithium and alpha particles. 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 is used in many cosmetics owing to its low coefficient of friction and lack of toxicity. 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. Boric oxide inhibits corrosion.

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, a product manufactured through the addition of ferroboron, is stronger and lighter in weight than average high-strength steel, which makes it useful in the manufacture of safe and fuel-efficient automobiles (Ray and others, 1966). Ferroboron is also used in the manufacture of neodymium magnets, rare-earth permanent magnets frequently used in actuators, bearings and couplings, computer drives, and servomotors.

Borates were incorporated into various materials, such as cellulosic insulation, textiles, and timber, to impart flame-retardant properties. 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.

Transportation

Almost all U.S. borates were shipped by rail in North America. Both U.S. producers had rail fleets dedicated to the exclusive transportation of their products. Small quantities of borates were shipped by rail or truck in specialty bags, usually of 950-kilogram 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) short-line 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, CA, and San Diego, CA, for export.

U.S. Borax's 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 onto dedicated railcars for shipment to customers.

U.S. 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, CA, to a company-owned facility in the Port of Rotterdam, Netherlands; company facilities in Spain; or contracted warehouses. The most centrally located port used by Rio Tinto for borax shipments 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 to other destinations in 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

Average unit values for borates, based on publicly available information obtained through SEC filing information, decreased by 8% in 2015 compared with those reported for 2014 (Rio Tinto plc, 2016, p. 36). Other 2015 borate values, as published by Industrial Minerals, ranged in average unit price from $620 per metric ton (ulexite) to $975 per metric ton (borax) (table 3).

Foreign Trade

Boric acid exports for 2015 were 198,000 t, a 12% decrease from the 225,000 t reported in 2014. Exports of sodium borates decreased by 15% in 2015 to 495,000 t from 584,000 t in 2014 (table 4). In 2015, China received the most sodium borates from the United States, totaling 46% of all exports. Canada, China, Japan, Malaysia, and Netherlands were the leading importers of mined borates from the United States in 2015 (table 4). Boron imports consisted primarily of borax, boric acid, colemanite, and ulexite (tables 1, 5). U.S. imports for consumption of boric acid were 39,800 t in 2015 and represented a 30% decrease from the 56,600 t reported in 2014 (table 5).

World Review

Argentina.—Argentina was the second-leading producer of boron minerals in South America in 2015 (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. The principal markets for borates produced in Argentina were Brazil and, to a lesser degree, domestic consumers (Orocobre Ltd., 2016).

Borax Argentina S.A. (a subsidiary of Orocobre Ltd.), the country's leading producer of borates, operated the Tincalayu Mine, the largest open pit operation in the country, which is 4,100 m (13,500 feet) above sea level. The deposit consisted primarily of borax, with rare occurrences of ulexite and 15 other borates (Orocobre Ltd., 2016).

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 natural boron minerals. MSR exported 97% of its mined borates to 30 countries through the Port of Buenos Aires and by land to Brazil (Minera Santa Rita S.R.L., undated).

Chile.—Chile was the leading borate producer in South America with production of 580,000 t of borates, primarily ulexite, in 2015. The largest ulexite deposit in the world, Salar de Suirire, was operated by Quimica e Industrial del Borax Ltda., a Government entity with reserves estimated to be 1.5 Mt. Almost all of the material mined at this location was exported in 2015 (Quiborax SA, 2016).

China.—Because China has low-grade boron resources and demand for boron was expected to increase in China, imports from Chile, Russia, Turkey, and the United States also were expected to increase during the next several years. More than 100 borate deposits occur in 14 Provinces in China. 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. China's boron resources are of low quality, averaging about 8% B_2O_3, in comparison with reserves from Turkey and the United States, which average from 26% to 31% and 25% to 32% B_2O_3, respectively (Industrial Minerals, 2008a; Baylis, 2010, p. 5; National Boron Research Institute, 2012).

Serbia.—A Canadian mining and exploration company, Erin Ventures Inc., initiated proceedings to begin borate mining in Piskanja, a mining region in Serbia approximately 250 km (155 miles) south of Belgrade. The deposit is primarily composed of colemanite and ulexite with estimated reserves of 11.8 Mt at an average B_2O_3 content between 29% and 31%. Mining did not commence in 2015 but was expected to begin soon thereafter (Erin Ventures Inc., 2016).

Turkey.—The first known instances of borate mining in Turkey date to Roman times, with some of the world's most active borate mining continuing to this day. Approximately 73% of the world's boron reserves are in Turkey, with the Kirka deposit at Eskisehir reported to be the largest tincal deposit in the world (Engineering and Mining Journal, 2012; National Boron Research Institute, 2012; Özdemir and others, 2013). 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 since 2008 owing to continued investment in new refineries and technologies. A recent examination of plant species in boron-rich areas of Turkey revealed a number of indicator plants, which may be used for boron prospecting in Turkey or in similar biome areas elsewhere in the world (Özdemir and others, 2013). Eti Maden projects a borate production capacity of 5.5 Mt with an anticipated sales income of $2.5 billion by 2023 (Helvaci, 2015, p. 209).

Outlook

Consumption of borates is expected to increase, spurred by strong demand in agriculture, ceramic, and glass markets in Asia and South America. Continued investment in new refineries and technologies and the continued increase in demand were expected to fuel growth in world production for the foreseeable future. In 2013, the European Union (EU) added borates to the Registration, Evaluation, Authorization, and Restrictions of Chemicals (REACH) Restricted Substances List (RSL), following an EU study that determined continuous exposure may be harmful. The ruling required detergent makers to decrease their use of boron (Lismore, 2012). Consumption of boron-based fertilizers is expected to increase as the demand for food and biofuel crops also increases. 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 is expected to shift away from Europe to Asia, which accounted for the majority of world demand for ceramics in 2015.

Consumption of boron nitride is expected to increase owing to the development of high-volume production techniques coupled with the creation of new technologies requiring boron nitride. 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 is 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)

	2011	2012	2013	2014	2015
United States:					
Sold or used by producers:					
Quantity:					
Gross weight	W	W	W	W	W
B_2O_3 content	W	W	W	W	W
Value	W	W	W	W	W
Exports:					
Boric acid:[2]					
Quantity	235	190	232	225	198
Value	166,000	155,000 r	211,000	178,000	149,000
Sodium borates:					
Quantity	492	457	489	584	495
Value	244,000	259,000 r	287,000	304,000	264,000
Imports for consumption:					
Refined borax:[3]					
Quantity	69	86	127	152	136
Value	28,400	33,300	45,300	52,400	49,200
Boric acid:[2]					
Quantity	56	55	53	57	40
Value	40,800	42,800	36,700	37,600 r	25,800
Colemanite:[4]					
Quantity	--	24	38	45	35
Value[e]	--	8,410	12,400	14,500	11,900
Ulexite:[4]					
Quantity	--	1	--	34	70
Value[e]	--	77	--	2,840	4,620
Consumption, B_2O_3 content	W	W	W	W	W
World, production[5]	8,150 r	5,910 r	6,030 r	9,400 r	9,380 e

[e]Estimated. [r]Revised. W Withheld to avoid disclosing company proprietary data. -- Zero.
[1]Data are rounded to no more than three significant digits.
[2]Source: U.S. Census Bureau, Harmonized Tariff Schedule of the United States code for boric acid, 2810.00.0000.
[3]Source: U.S. Census Bureau, Harmonized Tariff Schedule of the United States codes for refined borax, 2840.11.0000 and 2840.19.0000.
[4]Source: U.S. Census Bureau, Harmonized Tariff Schedule of the United States code for calcium borates, 2528.00.0010.
[5]U.S. production withheld from world production to avoid disclosing company proprietary data.

TABLE 2
BORON MINERALS OF COMMERCIAL IMPORTANCE

Mineral[1]	Chemical composition	B_2O_3,[2] weight percent
Boracite (stassfurtite)	$Mg_3B_7O_{13}Cl$	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.
[2]Boric oxide.

TABLE 3
YEAREND PRICES FOR BORON MINERALS AND COMPOUNDS

(Dollars per metric ton)

	Price		
Product	December 31, 2013	December 31, 2014	December 31, 2015
Borax, decahydrate, Buenos Aires	947–979	940–975	940–975
Boric acid, Chile	600–900	620–900	620–900
Colemanite, Buenos Aires, 40% boric oxide (B_2O_3)	690–730	690–730	690–730
Ulexite, Buenos Aires, 40% B_2O_3	666–697	690–750	690–750
Ulexite, granular, Chile, 40% B_2O_3	692–734	720–820	720–820
Ulexite, Lima, 40% B_2O_3	620–652	620–650	620–650

Source: Industrial Minerals magazine (London) via http://www.indmin.com.

TABLE 4

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

	2014			2015		
	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)
Algeria	--	--	26	--	--	41
Argentina	30	$43	10	1	$3	74
Australia	1,210	1,070	6,100	1,340	1,030	6,390
Bangladesh	444	417	745	835	613	1,330
Brazil	4,630	3,420	1,110	1,520	1,190	1,150
Burma	30	26	207	149	97	326
Canada	2,850	2,930	22,700	3,520	3,490	23,600
Chile	--	--	1,800	--	--	1,870
China	37,300	27,100	238,000	37,700	27,800	226,000
Colombia	401	414	6,280	422	398	5,480
Costa Rica	--	--	1,470	--	--	595
Dominican Republic	--	--	18	--	--	52
Ecuador	60	61	1,160	5	10	888
Egypt	--	--	40	--	--	--
France	55	84	308	262	167	62
Germany	588	378	115	269	129	7
Ghana	19	23	--	7	9	6
Guatemala	--	--	5,630	11	10	4,070
Honduras	--	--	84	80	79	642
India	5,880	5,020	27,500	4,910	3,780	21,500
Indonesia	2,130	1,710	2,640	498	364	1,130
Jamaica	--	--	--	3	14	--
Japan	33,600	28,500	26,400	23,500	193,000	21,900
Kenya	--	--	36	--	--	36
Korea, Republic of	38,900	30,800	12,200	35,200	27,600	12,500
Kuwait	--	--	2,100	--	--	1,950
Lithuania	40	28	1	40	28	--
Malaysia	6,150	4,330	92,500	745	544	62,800
Mexico	7,660	8,140	15,400	10,400	7,020	13,600
Netherlands	33,600	25,800	82,400	37,300	25,500	53,200
New Zealand	552	542	1,530	379	347	1,050
Nicaragua	--	--	509	17	15	763
Nigeria	60	74	20	7	9	32
Oman	--	--	49	--	--	--
Pakistan	1,610	772	931	20	17	1,780
Panama	5	5	35	2	3	57
Peru	379	350	1,080	160	143	1,360
Philippines	40	40	2,410	20	17	1,580
Russia	158	120	1,170	--	--	218
Saudi Arabia	2,530	2,070	901	1,360	989	154
Singapore	798	419	1,010	615	489	697
South Africa	219	208	2,150	298	267	2,420
Spain	--	--	2,630	--	--	3,040
Taiwan	37,200	28,000	2,440	31,900	23,900	2,750
Thailand	2,880	2,390	9,290	2,290	1,850	9,630
Tunisia	1	4	98	--	--	--
United Arab Emirates	161	130	4	19	14	--
United Kingdom	5	38	678	112	93	599
Venezuela	148	448	118	11	15	142
Vietnam	2,900	2,260	9,470	1,740	1,280	7,480
Other	37 r	41 r	111 r	2	8	55
Total	225,000	178,000	584,000	198,000	323,000	495,000

[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; data adjusted by the U.S. Geological Survey.

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

	2014		2015	
Country	Quantity (metric tons)	Value[2] (thousands)	Quantity (metric tons)	Value[2] (thousands)
Argentina	1,840	$1,380	458	$366
Australia	1	4	1	4
Bolivia	3,530	2,090	3,270	1,910
Canada	20	3	533	412
Chile	8,980	5,780	8,480	5,240
China	362	910	192	220
France	48	64	--	--
Germany	45	56	14	19
Hong Kong	137	222	184	253
India	12	28	22	59
Italy	3,090	2,310	3,440	2,390
Japan	55	72	249	221
Korea	44	33	--	--
Mexico	1	9	--	--
Netherlands	38	70	146	136
Peru	728	578	1,160	833
Russia	703	481	300	156
Turkey	37,000	23,500	21,300	13,500
United Kingdom	1	4	1	4
Total	56,600	37,600	39,800	25,800

-- 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	2011	2012	2013	2014	2015[e]
Argentina	649	479	426	450 [r, e]	450
Bolivia, ulexite, natural	135	128	150	152	150
Chile, ulexite, natural	489	444	581	497 [r]	500
China[e, 3]	150	160	160	160	160
Iran, borax[e, 4]	1 [5]	1	1 [5]	1	1
Kazakhstan[e]	300 [r]	300 [r]	348 [r, 5]	507 [r, 5]	500
Peru, borates, crude	--	104	224	240 [r]	240
Russia[e, 6]	75 [r]	75 [r]	76 [r, 5]	81 [r, 5]	80
Turkey, run of mine[7]	6,348	4,220	4,066	7,310 [r]	7,300
United States[8]	W	W	W	W	W
Total	8,150 [r]	5,910 [r]	6,030 [r]	9,400 [r]	9,380

[e]Estimated. [r]Revised. W Withheld to avoid disclosing company proprietary data; not included in total. -- Zero.

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

[2]Includes data available through September 21, 2016.

[3]Boric oxide (B_2O_3) equivalent.

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

[5]Reported figure.

[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.