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2019 Minerals Yearbook

BORON [ADVANCE RELEASE]

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Boron

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In 2019, most boron products consumed in the United States were manufactured domestically. Two companies produced borates in the United States—U.S. Borax, Inc. (a subsidiary of Rio Tinto Group plc) in Boron, CA, and Searles Valley Minerals, Inc. (SVM) (a subsidiary of Nirma Ltd., India) in Trona, CA. U.S. consumption of minerals and compounds reported in boric oxide (B_2O_3) content decreased in 2019; 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 5). The United States exported 332,000 metric tons (t) of boric acid in 2019, an increase of 27% from that in 2018.

Elemental boron is a metalloid with limited commercial applications. Its main applications were as a doping agent in the manufacture of semiconductors and as an ignition source in automobile safety airbags. Boron compounds, chiefly borates, were commercially significant; boron products were priced and sold on the basis of B_2O_3 content, which varied by ore and compound, and on the absence or presence of sodium and calcium (table 2). Borax, one of the most important boron compounds 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 or colorless crystalline solid and was sold in technical, national formulary, and special quality grades as granules or powder.

Production

Although more than 200 boron minerals occur naturally, only 4 accounted 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 along the southern margin of Eurasia, and the Andean belt of South America. As a result, most borates were extracted 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) filings for two U.S. producers—SVM and Rio Tinto's U.S. Borax. Data from both companies were withheld to avoid disclosing company proprietary data (table 1).

SVM 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, 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 were the sources of other commercial salts in addition to sodium borates and boric acid.

In 2019, SVM's Trona and Westend plants were damaged by earthquakes on July 4 and 5, significantly slowing production. As of late 2019, the company was still repairing its plants. It was unknown when the Trona plant would be back at full production (Barnwell, 2019).

U.S. Borax 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 approximately 25% of the world's refined borates. According to an SEC report filed by Rio Tinto, the company produced 520,000 t of borates in 2019, a slight increase from the 512,000 t reported in 2018 (Rio Tinto plc, 2020, p. 53–54).

An Australian company, ioneer Ltd (previously Global Geoscience Ltd.), the sole owner of the Rhyolite Ridge lithium-boron project in Nevada, continued to work toward its goal of beginning boric acid production by mid-2021. Initial production was expected to be 173,000 t of boric acid and 20,200 t of lithium carbonate annually. This project had a planned 30-year mine life with an option to expand the project in the future (ioneer Ltd, 2019, p. 1).

American Pacific Borate and Lithium Ltd. (Perth, Western Australia, Australia) changed its name to American Pacific Borates Ltd. (APB) in 2019 (Cummins, 2019). It was the sole owner of the Fort Cady project, in the Mojave Desert in southern California, which is a large colemanite deposit with high lithium potential. In 2018, two companies based in China, Sinochem and Sinomach, signed strategic cooperation agreements to work with APB on developing borates for Chinese markets. In 2019, both companies confirmed that samples from the Fort Cady project had high-grade boric acid with low calcium levels. APB was considering escalating rampup with more initial boric acid production and production of specialty granular fertilizers, used on fruit, nut, and tobacco crops, to capitalize on the potassium fertilizer market (George, 2019a, b). A definitive feasibility study was completed at the end of 2019. In it, APB stated that it was aiming to start production in 2021 (American Pacific Borates Ltd., 2018, p. 35).

Consumption

The first reported use of borax was as a flux or bonding agent by Arabian goldsmiths and silversmiths in the eighth century, but some research suggests that the Babylonians may have used it more than 2,000 years ago (Wisniak, 2005). In 2019, borates were used in more than 300 end uses; the five leading uses were, in decreasing order of estimated quantity, glass, ceramics, agriculture, detergents, and bleaches (Eti Mine Works, 2020, p. 59–60). Consumption of borates was expected to increase in the future (Rio Tinto plc, 2020, p. 59).

Agriculture.—Boron was an important micronutrient used in fertilizers, primarily to promote fruit and seed production. Boron fertilizers were mostly sourced from borax, boric acid, and calcium borate owing to their water solubility; thus, boron fertilizers could be delivered through sprays or irrigation water. The agriculture industry accounted for approximately 15% of world boron consumption and consumption was expected to increase as the world's population increased (Eti Mine Works, 2020, p. 59).

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; 1 kilogram of boron per hectare (1 pound per acre) in soil is 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 coastal Pacific Northwest, where soils tend to be acidic, coarse sandy, leached, or organic in nature (U.S. Department of Agriculture, 1998; Gupta, 2016, p. 242–268).

Ceramics.—The ceramic industry accounted for an estimated 15% of world boron consumption in 2019 (Eti Mine Works, 2020, p. 60). Borates played an important role in ceramic glazes and enamels, increasing chemical, thermal, and wear resistance. Borax and colemanite were used in ceramics primarily as fluxing agents, with borax being used in higher temperature firings and colemanite in lower temperature firings. Borates also were 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 varied between 8% and 24% and the amount used in enamels varied between 17% and 32%, by weight.

Boron carbide, the third hardest known material after cubic boron nitride and diamond, was a key ingredient in lightweight ceramic armor. Small arms protective inserts, used by the U.S. military, were boron carbide ceramic plates inserted into para-aramid flak jackets to protect against high-velocity projectiles. The ceramics industry also used boron carbide as an abrasive powder to polish, lap, and cut ceramics (Precision Ceramics USA, undated).

Detergents and Soaps.—The use of borates in detergents and soaps accounted for an estimated 3% of world consumption (Eti Mine Works, 2020, p. 60). Borates were incorporated into laundry detergents, soaps, and other cleaning products because they could be used as alkaline buffers, enzyme stabilizers, oxygen-based bleaching agents, and water softeners (U.S. Borax, Inc., 2019a). 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. Sodium perborate, however, requires hot water to undergo hydrolysis, requiring more energy to initiate the reaction than other compounds, and concerns have emerged over excessive boron levels in waterways owing to sodium perborate in detergents. Sodium percarbonate was used as a substitute primarily in Europe because it produces hydrogen peroxide at lower temperatures and does not increase boron content in waterways. This substitution has reduced boron consumption for detergent applications.

Glass.—The principal market for borates in 2019 was glass, representing approximately 48% of global borate consumption (Eti Mine Works, 2020, p. 59). Boron was 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 was used as a fluxing agent, reducing the viscosity of glass during formation to improve manufacturing. Depending on the application and quality of the glass needed, borax, boric acid, colemanite, sodium borates, and (or) ulexite could be used.

End uses for fiberglass were corrosion-resistant, heat-resistant, and high-strength fabrics; thermal insulation; reinforcement; and sound absorption. The incorporation of borates into fiberglass greatly improved quality by increasing the absorbance of infrared radiation (U.S. Borax, Inc., 2019b). Approximately 90% of manufactured textile fiberglass was used to create electronic glass (e-glass), originally used for electronics, but more recently used to fortify thermoset and thermoplastic polymer composite structures.

Borosilicate refers to glass with a boric oxide content of 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 ranged from glass kitchenware to the thermal protection tiles for spacecraft.

Other.—Various boron compounds were 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 were lowered into a nuclear reactor to control the fission reaction by capturing neutrons. Boric acid was used in the cooling water surrounding nuclear reactors to absorb escaping neutrons (Ceradyne, Inc., 2011).

Boron nitride was used in many cosmetics owing to its low coefficient of friction and lack of toxicity. Boric acid had applications in cosmetics, pharmaceuticals, and toiletries. Borates were added to brake fluids, fuel additives, lubricants, metalworking fluids, and water-treatment chemicals. Boric oxide was used as a corrosion inhibitor.

Ferroboron (FeB) is a binary alloy of iron with a boron content between 17.5% and 24% and was the lowest cost boron additive for steel and other ferrous alloys. On average, the steel industry consumed more than 50% of the ferroboron produced annually (Eti Holding Inc., 2003, p. 8). Boron steel, a product manufactured through the addition of ferroboron, was stronger and lighter in weight than average high-strength steel, which made it useful in the manufacture of safe and fuel-efficient automobiles (Ray and others, 1966). Ferroboron was 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 flame retardants for wood 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 respective products. Small quantities of borates were shipped by rail or truck in specialty bags, often referred to as bulk 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.

In 2019, SVM's railway sustained damage from earthquakes on July 4 and 5 and was temporarily shut down. The railway was inspected by Government agencies to ensure safety. The company was given permission to resume using the railway, but at a restricted speed limit of 10 miles per hour. SVM used a tamping machine to fix realignment issues and repair the damage the railway (Barnwell, 2019).

U.S. Borax's Boron Mine was served solely by the BNSF Railway (formerly 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. Truckloads 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 at the Port of Los Angeles, CA, for ocean transport 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, Czechia, and Slovenia. European borate imports were influenced by geographic location, the borate products needed, and prices.

Prices

Average unit values for borates, based on publicly available information obtained through SEC filing information, decreased by 7% when compared with those reported for 2018 (Rio Tinto plc, 2020, p. 54, 252). The average unit value of boric acid exports decreased by 27% to $463 per metric ton from $632 per metric ton in 2018 (tables 1, 3). The average unit value of refined borax exports decreased by 5% to $449 per metric ton from $472 per metric ton in 2018 (tables 1, 3). The average unit value for boric acid imports for consumption increased by 3% to $587 per metric ton from $570 per metric ton in 2018 (tables 1, 4). The average unit value of refined borax imports decreased slightly to $340 per metric ton from $349 per metric ton in 2018 (table 1).

Foreign Trade

Boric acid exports for 2019 were 332,000 t, a 27% increase from 261,000 t in 2018. In 2019, 25% of boric acid exports were sent to Mexico, 19% to China, 15% to the Netherlands, and 12%, each, to the Republic of Korea and Taiwan. The remaining 17% of boric acid exports went to 30 other countries and localities. Refined borax exports decreased slightly to 598,000 t from 610,000 t in 2018. Exports of sodium borates decreased by 26% in 2019 to 12,900 t from 17,400 t in 2018 (table 1, 3).

Boron imports consisted primarily of refined borax, boric acid, colemanite, and ulexite (table 1). U.S. imports for consumption of boric acid were 41,500 t in 2019, which represented a 19% decrease from 51,300 t in 2018 (table 4). In 2019, 63% of total boric acid imports originated from Turkey, followed by Chile (10%), Italy and Russia (7% each), and 13 other countries and localities accounting for the remaining 13%.

World Review

Argentina.—Argentina was estimated to be the third-ranked producer of boron minerals in South America in 2019 (table 5). 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 corner of Chile.

Borax Argentina S.A. (a subsidiary of Orocobre Ltd., Brisbane, Queensland, Australia), the country's leading producer of borates, operated the Tincalayu and Sijes Mines, the largest open pit operations in the country, which were 4,100 m (13,500 feet) and 4,540 m (14,900 feet) above sea level, respectively. The deposit consists primarily of borax, with rare occurrences of ulexite and 15 other borates. Borate production was 42,635 t in 2019 (Orocobre Ltd., 2019, p. 29).

Orocobre continued an expansion study for their Tincalayu operation. The expansion could increase Tincalayu's refined-borate-processing capacity from 30,000 metric tons per year (t/yr) to approximately 120,000 t/yr of borax decahydrate equivalent. The expansion review also included a 40,000-t/yr boric acid plant. This expansion was expected to make the production of refined borates more efficient (Orocobre Ltd., 2019, p. 30).

Minera Santa Rita S.R.L. (MSR) owned and operated mines in Catamarca, Jujuy, and Salta Provinces, which contain tincalconite and ulexite deposits. MSR also operated a processing plant in Campo Quijano, which produced 50,000 t/yr of derivative boron products, with plans to increase production to 75,000 t/yr. MSR primarily extracted borates from its Salar Hombre Muerto open pit mine. This open pit mine was reported to have 2 million metric tons (Mt) of proven reserves and production of approximately 60,000 t/yr (Minera Santa Rita S.R.L., undated).

Chile.—Chile was the leading borate compound producer in South America with boric acid production estimated to be 105,000 t and ulexite production estimated to be 400,000 t in 2019 (table 5). The largest ulexite deposit in the world, Salar de Suirire, was operated by Quiborax SA, a Government entity with reserves estimated to be 1.5 Mt. Almost all the material mined at this location was exported in 2019 (Quiborax SA, 2019a). Quiborax operations had a boric acid production capacity of 36,000 t/yr, in addition to 100,000-t/yr capacity for borate derived agrochemical products (Quiborax SA, 2019b).

China.—China has low-grade boron resources. 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 average about 8% B_2O_3, in comparison with reserves from Turkey and the United States, which average from 26% to 31% B_2O_3 and from 25% to 32% B_2O_3, respectively (Industrial Minerals, 2008; Baylis, 2010, p. 5; Fastmarkets IM, 2011).

Serbia.—Erin Ventures Inc. (Victoria, British Columbia, Canada) continued exploration drilling at its Piskanja Borate Project as it prepared to conduct feasibility studies. Piskanja is a mining region in Serbia approximately 250 km (155 miles) south of Belgrade. The deposit is primarily composed of colemanite and ulexite averaging about 31% B_2O_3 with indicated mineral resources of 7.8 Mt (MINING.com, 2019).

Rio Tinto continued a prefeasibility study in Jadar Valley in 2019. The deposit contains boron and lithium ore. Rio Tinto was planning to conduct assessments to consider the socioeconomic effects on the local communities of constructing a mine and processing facility in conjunction with environmental assessments (Rio Tinto plc, 2020, p. 53, 55).

Turkey.—The first known borate mining in Turkey dates to Roman times, with borate mining continuing to this day. Approximately 73% of the world's boron reserves are in Turkey; the Kirka deposit at Eskisehir is reported to be the largest tincal deposit in the world (Engineering and Mining Journal, 2012; Özdemir and others, 2013; Eti Mine Works, undated). The main borate-producing areas of Turkey, all controlled by the state-owned mining company Eti Maden AS, were Bigadic (colemanite and ulexite), Emet (colemanite), Kestelek (colemanite, probertite, and ulexite), and Kirka (tincal).

Production of refined borates was expected to increase in coming years owing to investment in new refineries and technologies. In 2019, Turkey began producing the first boron fire extinguisher powder. Boron can be used to extinguish a variety of fires including metal fires and those that are at an extremely high temperature. Boron has the added benefit of being noncarcinogenic (Daily Sabah, 2019). In 2018, Eti Maden and China's Dalian Jinma Boron Technology Group Co., Ltd. signed a Memorandum of Understanding to build a boron carbide processing facility in Balikesir. Although this facility would process mostly boron carbide, boron nitride and ferroboron were also expected to be processed (Daily Sabah, 2018). Construction began for the boron carbide processing facility in 2019 and was anticipated to be completed by 2021 (Temizer, 2019).

Outlook

Consumption of borates is expected to increase, spurred by strong demand in agricultural, ceramic, and glass markets in Asia and South America. Continued investment in new refineries and technologies and the continued increase in demand are expected to fuel growth in world production for the foreseeable future. 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 in advanced farming techniques and higher grade fertilizers. The borate market is estimated to reach a compound annual growth rate of 3% worldwide, increasing consumption to over 2.5 Mt of B_2O_3 content by 2023 (Orocobre Ltd., undated).

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TABLE 1
U.S. SALIENT STATISTICS OF BORON MINERALS AND COMPOUNDS[1]

(Thousand metric tons and thousand dollars)

	2015	2016	2017	2018	2019
Sold or used by producers:					
Quantity:					
Gross weight	W	W	W	W	W
Boric oxide (B_2O_3) content	W	W	W	W	W
Value	W	W	W	W	W
Exports:					
Boric acid:[2]					
Quantity	195	238 r	216 r	261 r	332
Value	149,000 r	149,000	139,000 r	165,000	154,000
Refined borax:[3]					
Quantity	527	581	572	610	598
Value	269,000	295,000	284,000	288,000	268,000
Sodium borates:[4]					
Quantity	10	12	15	17	13
Value	26,800	27,100	31,900	35,700	29,800
Imports for consumption:					
Boric acid:[2]					
Quantity	40	46	40	51	41
Value	25,700	27,800	23,000	29,300	24,300
Colemanite:[5]					
Quantity	35	35	58	73	42
Value[e]	11,900	11,400	20,400	26,600	15,700
Refined borax:[3]					
Quantity	136	173	158	133	161
Value	49,200	60,400	55,500	46,500	54,600
Ulexite:[6]					
Quantity	70	43	24	34	38
Value[e]	4,620	4,790	10,900	15,700	10,700
Consumption, B_2O_3 content	W	W	W	W	W

[e]Estimated. [r]Revised. W Withheld to avoid disclosing company proprietary data.
[1]Table includes data available through April 22, 2020. Data are rounded to no more than three significant digits.
[2]Source: U.S. Census Bureau, Harmonized Tariff Schedule of the United States (HTS) code and Schedule B code for boric acid, 2810.00.0000.
[3]Source: U.S. Census Bureau, HTS and Schedule B codes for refined borax, 2840.11.0000 and 2840.19.0000.
[4]Source: U.S. Census Bureau, Schedule B codes for sodium borates, 2840.20.0000 and 2840.30.0000.
[5]Source: U.S. Census Bureau, HTS code for calcium borates, 2528.00.0010.
[6]Source: U.S. Census Bureau, HTS code for natural sodium borates, 2528.00.0005.

TABLE 2
BORON MINERALS OF COMMERCIAL IMPORTANCE

Mineral[1]	Chemical composition	B_2O_3 content[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)	$Ca_4B_{10}O_{19}\cdot 7H_2O$	49.8
Probertite (kramerite)	$NaCaB_5O_9\cdot 5H_2O$	49.6
Sassolite (natural boric acid)	H_3BO_3	56.3
Szaibelyite (ascharite)	$MgBO_2OH$	41.4
Tincal (natural borax)	$Na_2B_4O_5(OH)_4\cdot 8H_2O$	36.5
Tincalconite (mohavite)	$Na_2B_4O_7\cdot 5H_2O$	47.8
Ulexite (boronatrocalcite)	$NaCaB_5O_9\cdot 8H_2O$	43.0

[1]Common names in parentheses.
[2]Boric oxide.

Source: Fleischer, Michael, 1987, Glossary of mineral species (5th ed.): Tucson, AZ, The Mineralogical Record Inc., 227 p.

TABLE 3

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

	2018				2019			
	Boric acid[2]				Boric acid[2]			
Country or locality	Quantity (metric tons)	Value[3] (thousands)	Refined borax[4] (metric tons)	Sodium borates[5] (metric tons)	Quantity (metric tons)	Value[3] (thousands)	Refined borax[4] (metric tons)	Sodium borates[5] (metric tons)
Argentina	--	--	89	297	--	--	231	78
Australia	2,180	$1,500	5,320	147	1,590	$1,080	4,100	145
Bangladesh	645	459	636	336	894	692	1,250	480
Brazil	1,800 r	1,330	11,900	1,580	2,110	1,500	14,400	425
Burma	61	46	829	--	41	28	611	--
Canada	9,400	4,360	29,500	2,720	4,730	3,930	19,000	3,350
Chile	--	--	201	757	--	--	219	590
China	53,000	32,800	279,000	1,140	63,400	37,300	318,000	880
Colombia	621	484	4,450	130	246	220	3,690	87
Costa Rica	307	250	316	112	--	--	79	96
Ecuador	20	17	1,140	12	24	23	788	2
Guatemala	120	81	2,950	384	20	12	438	72
Honduras	40	26	960	120	20	13	500	72
India	2,410	1,390	36,200	1,240	842	508	36,600	1,090
Indonesia	476	306	19,100	8	1,130	669	32,900	--
Japan	24,200	18,500	26,200	1,440	19,600	15,000	23,000	1,740
Korea, Republic of	49,300	31,700	14,300	251	41,000	25,800	11,900	253
Kuwait	--	--	500	16	20	14	1,200	--
Malaysia	9,850	5,630	73,300	36	7,530	4,140	46,600	36
Mexico	7,510 e	5,080	27,400	730	84,300	5,220	23,000	568
Netherlands	34,500	21,900	24,200	2,310	48,900	23,600	24,500	970
New Zealand	458	330	1,530	36	362	260	1,240	--
Nicaragua	141	113	558	52	--	--	764	73
Pakistan	960	721	1,080	113	621	464	1,300	--
Peru	20	16	1,830	48	11	8	1,320	48
Philippines	132	95	1,280	101	--	--	1,310	119
Saudi Arabia	1,640	1,070	79	191	2,410	1,520	279	43
Singapore	966	672	354	222	1,410	774	357	108
South Africa	3,140	527	2,090	56	1,370	998	1,820	113
Spain	6,530	3,030	9,830	1,130	5,500	2,630	2,880	509
Taiwan	43,600 r	27,500	7,040	526	38,600	23,700	4,100	301
Thailand	3,030	2,130	10,800	192	2,310	1,590	8,900	68
United Kingdom	86	130	--	44	18	12	--	240
Vietnam	2,940	1,870	8,400	96	1,690	1,050	9,020	72
Other	560 r	613 r	6,740	832	1,020	852	1,480	323
Total	261,000 r	165,000	610,000	17,400	332,000	154,000	598,000	12,900

[e]Estimated. [r]Revised. -- Zero.

[1]Table includes data available through May 5, 2020. Data are rounded to no more than three significant digits; may not add to totals shown.

[2]United States Schedule B code 2810.00.0000.

[3]Free alongside ship valuation.

[4]Schedule B codes 2840.11.0000 and 2840.19.0000.

[5]Schedule B codes 2840.20.0000 and 2840.30.0000.

Source: U.S. Census Bureau; data adjusted by the U.S. Geological Survey.

TABLE 4
U.S. IMPORTS FOR CONSUMPTION OF BORIC ACID, BY COUNTRY OR LOCALITY[1]

Country or locality	2018 Quantity (metric tons)	2018 Value[2] (thousands)	2019 Quantity (metric tons)	2019 Value[2] (thousands)
Argentina	536	$355	274	$205
Australia	16	11	20	47
Bolivia	2,630	1,270	1,630	657
Canada	170	120	53	66
Chile	8,170	4,560	4,110	2,370
China	307	442	226	330
France	2	5	50	32
Germany	20	44	21	54
Hong Kong	105	175	--	--
India	324	253	135	147
Italy	2,610 r	1,870 r	3,090	2,170
Japan	13	74	206	166
Korea, Republic of	60	26	--	--
Mexico	--	--	12	7
Netherlands	101	70	--	--
Peru	2,040	1,220	2,570	1,520
Russia	903	390	2,940	1,680
Switzerland	1	8	12	27
Taiwan	14	13	--	--
Turkey	33,300	18,400	26,100	14,900
United Kingdom	--	--	1	5
Total	51,300 r	29,300	41,500	24,300

[r]Revised. -- Zero.
[1]Table includes data available through March 27, 2020. 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, Harmonized Tariff Schedule of the United States code for boric acid, 2810.00.0000.

TABLE 5
BORON MINERALS: WORLD PRODUCTION, BY COUNTRY OR LOCALITY[1]

(Thousand metric tons)

Country or locality	2015	2016	2017	2018	2019
Argentina, materials, crude	247	148	130	71 r	71 e
Bolivia:					
Boric acid	18	17	15 r	16 r	5 e
Ulexite, natural	149	183	208 r	216 r	200 e
Chile:					
Boric acid	101	104	112	106 r	105 e
Ulexite, natural	518	559	607	398 r	400 e
China[2]	74 r	49 r	255 r	250 r, e	250 e
Germany, compounds	136	147	141	121 r	120 e
Iran, borax	1 e	1 e	1 e	-- r, e	NA
Peru, borates, crude	579	34	--	101	111
Russia[3]	80	79	75	80 e	80 e
Turkey:					
Concentrate	1,840	1,607	1,640	2,200 r	2,200 e
Crude ore	5,072	4,815	5,801	6,000 r, e	6,000 e
Refined borates[2]	1,839	1,831	2,025	2,432 r	2,400 e
United States[4]	W	W	W	W	W

[e]Estimated. [r]Revised. NA Not available. W Withheld to avoid disclosing company proprietary data. -- Zero.
[1]Table includes data available through April 21, 2020. All data are reported unless otherwise noted. Estimated data are rounded to no more than three significant digits.
[2]Boric oxide (B_2O_3) equivalent.
[3]Blended Russian datolite ore that reportedly grades 8.6% B_2O_3.
[4]Minerals and compounds sold or used by producers, including both actual mine production and marketable products.