# 2018 Minerals Yearbook

## BORON [ADVANCE RELEASE]

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# Boron

Amanda S. Brioche

**Domestic survey data and tables were prepared by Sheema Merchant, statistical assistant.**

In 2018, 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. (SVM) in Trona, CA. U.S. consumption of minerals and compounds reported in boric oxide ($B_2O_3$) content decreased in 2018; 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 260,000 metric tons (t) of boric acid in 2018, a 15% increase from that of 2017.

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, are commercially significant; boron products are priced and sold on the basis of $B_2O_3$ 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 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 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—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 were the sources of other commercial salts in addition to sodium borates and boric acid.

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 (Rio Tinto plc, 2019, p. 46). According to an SEC report filed by Rio Tinto, the company produced 512,000 t of borates in 2018, a slight decrease from the 517,000 t reported in 2017 (Rio Tinto plc, 2019, p. 48).

An Australia-based company, ioneer Ltd (previously Global Geoscience Ltd.), conducted prefeasibility studies for their Rhyolite Ridge lithium-boron project in Nevada throughout 2018. The reported results indicated the project's initial potential to produce between 160,000 and 220,000 t/yr of boric acid (Quinn, 2018). One prefeasibility study predicted that this project will have a 30-year mine life with an option to expand the project in the future (Stutt, 2018). Production was anticipated to potentially start at the Rhyolite Ridge project as soon as 2021.

American Pacific Borate and Lithium Ltd., headquartered in Australia, acquired the Fort Cady project, located in the Mojave Desert in southern California, in 2018 (Mining Journal, 2018). Fort Cady is a large colemanite deposit with a high lithium potential. Two Chinese companies, Sinochem and Sinomach, have signed strategic cooperation agreements to work with American Pacific on developing borates for the Chinese market. A definitive feasibility study was completed at the end of 2018. In it, American Pacific stated that it is aiming for production to start potentially in 2021 (American Pacific Borate and Lithium Ltd., 2018). In 2018, American Pacific also entered into an agreement to completely own the Salt Wells project, a boron-lithium-rich project located in Nevada. The Salt Wells project was in its very early stages.

## 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 over 2,000 years ago. In 2018, borates were used in more than 300 end uses, but the 5 leading uses were, in decreasing order of estimated quantity, glass, ceramics, agriculture, detergents, and bleaches (Eti Mine Works, 2018, p. 46–47). Consumption of borates was expected to increase as standards of living around the world increase over the coming years (Rio Tinto plc, 2019, p. 49).

***Agriculture.***—Boron is 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 high water solubility; thus, boron fertilizers can be delivered through sprays or water for irrigation. The agriculture industry accounted for approximately 16% of world boron consumption, and consumption is expected to increase as the world's population increases (Eti Mine Works, 2018, p. 32–33, 46–47).

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 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 16% of world boron consumption (Eti Mine Works, 2018, p. 46–47). 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, the third hardest known material after cubic boron nitride and diamond, is a key ingredient in lightweight ceramic armor. 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. The ceramics industry also uses 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 2% of world consumption (Eti Mine Works, 2018, p. 46–47). 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 (U.S. Borax, Inc., 2018a). 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 has been 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 2018 was glass, representing approximately 47% of global borate consumption (Eti Mine Works, 2018, p. 46–47). 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.

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., 2018b). Approximately 90% of manufactured textile fiberglass is used to create electronic glass (e-glass), originally used for electronics, now predominately used to fortify thermoset and thermoplastic polymer composite structures.

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 alloys. 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 acquire 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.

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. 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 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, Czechia, 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, slightly decreased when compared with those reported for 2017 (Rio Tinto plc, 2019, p. 44). The average unit value of boric acid exports increased slightly to $634 per ton from $623 per ton in 2017 (tables 1, 3). The average sodium borate export unit value decreased slightly to $505 per ton from last year's value of $514 per ton (tables 1, 3). The average unit value for boric acid imports for consumption decreased to $570 per ton from last year's $579 per ton (tables 1, 4). The average unit value of refined borax imports was $350 per ton in 2018, about the same as the 2017 value (table 1).

**Foreign Trade**

Boric acid exports for 2018 were 260,000 t, a 15% increase from 227,000 t in 2017. Exports of sodium borates increased by 7% in 2018 to 571,000 t from 531,000 t in 2017 (tables 1, 3). Boron imports consisted primarily of borax, boric acid, colemanite, and ulexite (tables 1, 4). U.S. imports for consumption of boric acid were 51,400 t in 2018, which represented a 30% increase from the 39,600 t in 2017. In 2018, 65% of total boric acid imports originated from Turkey, followed by Chile with 16%, Bolivia and Italy, each with 5%, and 16 other countries and localities accounting for the remaining 9% (table 4).

**World Review**

***Argentina.***—Argentina was estimated to be the second-ranked producer of boron minerals in South America in 2018 (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 border of Chile. The principal markets for borates produced in Argentina were throughout South America (Orocobre Ltd., 2018, p. 29–30).

Borax Argentina S.A. (a subsidiary of Orocobre Ltd.), the country's leading producer of borates, operated the Tincalayu and Sijes Mines, the largest open pit operations in the country, which are 4,100 m (13,500 feet) and 4,540 m (14,900 feet) above sea level, respectively. Record-high production was reported at Borax Argentina's boric acid plant and Tincalayu open pit operation (Orocobre Ltd., 2018, p. 5, 30). Tincalayu deposits consisted primarily of borax, with rare occurrences of ulexite and 15 other borates with a reported production of 36,553 t in 2018 (Orocobre Ltd., 2018, p. 29).

Orocobre was reviewing an expansion study for their Tincalayu operation. The expansion could possibly increase Tincalayu's refined-borate-processing capacity from 30,000 metric tons per year (t/yr) to approximately 120,000 t/yr of borax dehydrated equivalent (Orocobre Ltd., 2018, p. 30). The expansion review also includes a boric acid plant with a capacity of 40,000 t/yr. A project to build a gas pipeline to supply the expanded plant was approved in early 2018.

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 the majority of its mined borates to 28 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 compound producer in South America with boric acid production estimated to be

100,000 t and ulexite production estimated to be 600,000 t in 2018 (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 million metric tons (Mt). Almost all the material mined at this location was exported in 2018 (Quiborax SA, 2018a). Quiborax operations have a boric acid production capacity of 36,000 t/yr, in addition to 100,000-t/yr capacity of borate derived agrochemical products (Quiborax SA, 2018b). In May 2018, the 14-year-long dispute between the Bolivian Government and Quiborax came to an end with a ruling in favor of Quiborax. The Bolivian Government must now pay Quiborax $48.6 million for the land seized in 2004 that was used for the company's ulexite mining and revoked mining concessions (Herrera, 2018).

***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% and 25% to 32% $B_2O_3$, respectively (Industrial Minerals, 2008; Baylis, 2010, p. 5; National Boron Research Institute, 2012).

***Serbia.***—Erin Ventures Inc. (Canada) entered into a strategic partnership with a London-based commodity investment company, acquiring funds needed to continue development of the Piskanja Borate Project (Daniels, 2018). Piskanja is 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.

Rio Tinto continued a prefeasibility study in Jadar Valley, in 2018. The deposit contains both boron and lithium ore. Rio Tinto was planning to conduct assessments that will consider the socioeconomic effects of constructing a mine and processing facility on the local communities, in conjunction with environmental assessments (Rio Tinto plc, 2019).

***Turkey.***—The first known instances of borate mining in Turkey date to Roman times, with 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, were Bigadic (colemanite and ulexite), Emet (colemanite), Kestelek (colemanite, probertite, and ulexite), and Kirka (tincal). Eti Maden opened warehouses and logistic centers with a company based in Hong Kong to distribute their products from a location closer to the majority of their customer base (Eti Mine Works, 2018, p. 20).

Production of refined borates was expected to increase over the coming years owing to investment in new refineries and technologies. Eti Maden continued to invest in the production of boron carbide, boron nitride, and ferroboron owing to their importance in many industries, including the electronics, iron, and steel industries (Eti Mine Works, 2018, p. 70). 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 (Daily Sabah, 2018). Although this facility will process mostly boron carbide, boron nitride and ferroboron were also projected to be processed. As a result of boron carbide's numerous uses in the defense industry, it was expected to become a significant export for Turkey.

## 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. 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. 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 2018.

The expectation of increased boron demand prompted several companies to perform boron feasibility studies at new mine prospects in a few countries, including the United States. Two companies, American Pacific Borate and Lithium Ltd. and ioneer Ltd, have boron projects in California and Nevada. American Pacific completed a definitive feasibility study for its Fort Cady project at the end of 2018, which stated that the company is aiming for production to start in 2021. Prefeasibility studies for ioneer's Rhyolite Ridge lithium-boron project in Nevada completed in 2018 reported that the site could produce up to 220,000 t/yr of boric acid and have a mine life of 30 years; the company is also aiming for production to start as soon as 2021.

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

(Thousand metric tons and thousand dollars)

| | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|
| 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 | 226 r | 195 | 237 r | 227 r | 260 |
| Value | 178,000 | 150,000 r | 149,000 r | 141,000 r | 165,000 |
| Refined borax and sodium borates: | | | | | |
| Quantity | 580 r | 495 r | 543 r | 531 r | 571 |
| Value | 304,000 r | 264,000 r | 283,000 r | 273,000 r | 288,000 |
| Imports for consumption: | | | | | |
| Boric acid:[2] | | | | | |
| Quantity | 57 | 40 | 46 | 40 | 51 |
| Value | 37,400 | 25,700 | 27,800 | 23,000 | 29,300 |
| Colemanite:[3] | | | | | |
| Quantity | 45 | 35 | 35 | 58 r | 73 |
| Value[e] | 14,500 | 11,900 | 11,400 | 20,400 | 26,600 |
| Refined borax:[4] | | | | | |
| Quantity | 152 | 136 | 173 | 158 | 133 |
| Value | 52,400 | 49,200 | 60,400 | 55,500 | 46,500 |
| Ulexite:[3] | | | | | |
| Quantity | 34 | 70 | 43 | 24 | 34 |
| Value[e] | 2,840 | 4,620 | 4,790 | 10,900 | 15,700 |
| 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 June 6, 2019. 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 sodium borates, 2528.00.0005 and 2580.00.0010.
[4]Source: U.S. Census Bureau, Harmonized Tariff Schedule of the United States codes for refined borax, 2840.11.0000 and 2840.19.0000.

TABLE 2
BORON MINERALS OF COMMERCIAL IMPORTANCE

| Mineral[1] | Chemical composition | [2]$B_2O_3$ content 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) | $Na_2B_4O_5(OH)_4\cdot 8H2O$ | 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.

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]

| Country or locality | 2017 Boric acid[2] Quantity (metric tons) | 2017 Boric acid[2] Value[3] (thousands) | 2017 Refined borax and sodium borates[4] (metric tons) | 2018 Boric acid[2] Quantity (metric tons) | 2018 Boric acid[2] Value[3] (thousands) | 2018 Refined borax and sodium borates[4] (metric tons) |
|---|---|---|---|---|---|---|
| Argentina | -- | -- | 170 | -- | -- | 386 |
| Australia | 1,910 r | $1,390 r | 4,900 | 2,180 | $1,500 | 4,510 |
| Bangladesh | 774 | 535 | 1,790 | 645 | 459 | 972 |
| Brazil | 2,470 r | 1,880 r | 5,900 | 1,080 | 1,330 | 12,800 |
| Burma | 83 | 63 | 796 | 61 | 46 | 829 |
| Canada | 5,730 r | 5,060 r | 25,400 r | 9,400 | 4,360 | 31,700 |
| Chile | -- | -- | 600 | -- | -- | 818 |
| China | 57,200 r | 27,800 | 248,000 | 53,000 | 32,800 | 256,000 |
| Colombia | 734 | 624 | 4,080 | 621 | 484 | 4,600 |
| Costa Rica | 31 r | 24 r | 706 | 307 | 250 | 428 |
| Ecuador | 21 | 17 | 868 | 20 | 17 | 1,040 |
| El Salvador | 2 | 9 | 19 | 4 | 11 | 164 |
| France | 62 | 127 | 177 | 38 | 147 | 157 |
| Germany | -- | -- | 109 | 1 | 6 | 132 |
| Guatemala | -- | -- | 3,870 | 120 | 81 | 3,330 |
| Honduras | -- | -- | 952 | 40 | 26 | 1,080 |
| India | 2,900 | 1,830 | 28,300 | 2,410 | 1,390 | 36,500 |
| Indonesia | 71 | 56 | 2,280 | 476 | 306 | 18,700 |
| Japan | 21,300 | 15,900 | 23,200 | 24,200 | 18,500 | 21,900 |
| Korea, Republic of | 35,800 r | 23,500 r | 12,500 | 49,300 | 31,700 | 12,800 |
| Kuwait | 20 | 14 | -- | -- | -- | 516 |
| Malaysia | 8,430 | 4,860 | 65,500 | 9,850 | 5,630 | 72,800 |
| Mexico | 8,970 r | 7,740 r | 20,600 r | 7,510 e | 5,080 | 22,400 |
| Netherlands | 20,800 | 12,900 | 34,900 | 34,500 | 21,900 | 21,400 |
| New Zealand | 380 | 310 | 1,190 | 458 | 330 | 1,570 |
| Nicaragua | 20 | 16 | 334 | 141 | 113 | 610 |
| Pakistan | 754 | 577 | 1,140 | 960 | 721 | 1,190 |
| Peru | -- | -- | 1,270 | 20 | 16 | 1,380 |
| Philippines | 111 | 82 | 1,830 | 132 | 95 | 1,370 |
| Saudi Arabia | 1,300 | 831 | 247 | 1,640 | 1,070 | 363 |
| Singapore | 700 | 493 | 680 | 966 | 672 | 577 |
| South Africa | 537 | 415 | 1,860 | 3,140 | 527 | 2,040 |
| Spain | 11,400 | 5,990 | 10,600 | 6,530 | 3,030 | 11,000 |
| Switzerland | 2 | 8 | -- | -- | -- | 1 |
| Taiwan | 38,300 r | 24,800 | 3,120 | 43,500 | 27,500 | 3,160 |
| Thailand | 2,120 | 1,480 | 9,710 | 3,030 | 2,130 | 10,600 |
| United Arab Emirates | 200 | 139 | 23 | 40 | 27 | 21 |
| United Kingdom | 73 r | 61 r | 1,240 | 86 | 130 | 44 |
| Venezuela | -- | -- | -- | 46 | 41 | 59 |
| Vietnam | 2,150 | 1,420 | 10,400 | 2,940 | 1,870 | 8,500 |
| Other | 1,590 | 317 | 2,030 r | 431 | 381 | 1,970 |
| Total | 227,000 r | 141,000 r | 531,000 r | 260,000 | 165,000 | 571,000 |

eEstimated. rRevised. -- Zero.

[1]Table includes data available through June 6, 2019. 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 2840.19.0000, 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 | 2017 Quantity (metric tons) | 2017 Value[2] (thousands) | 2018 Quantity (metric tons) | 2018 Value[2] (thousands) |
|---|---|---|---|---|
| Argentina | 20 | $15 | 536 | $355 |
| Australia | 13 | 70 | 16 | 11 |
| Bolivia | 2,430 | 932 | 2,630 | 1,270 |
| Canada | 431 | 321 | 170 | 120 |
| Chile | 6,340 | 3,480 | 8,170 | 4,560 |
| China | 72 | 117 | 307 | 442 |
| France | 231 | 151 | 2 | 5 |
| Germany | 49 | 29 | 20 | 44 |
| Hong Kong | 920 | 614 | 105 | 175 |
| India | 183 | 153 | 324 | 253 |
| Italy | 2,840 | 2,050 | 2,660 | 1,900 |
| Japan | 25 | 60 | 13 | 74 |
| Korea, Republic of | 1,280 | 546 | 60 | 26 |
| Netherlands | 95 | 61 | 101 | 70 |
| Peru | 2,590 | 1,540 | 2,040 | 1,220 |
| Russia | 1,350 | 607 | 903 | 390 |
| Switzerland | 1 | 2 | 1 | 8 |
| Taiwan | 69 | 74 | 14 | 13 |
| Turkey | 20,700 | 12,100 | 33,300 | 18,400 |
| United Kingdom | 1 | 6 | -- | -- |
| Total | 39,600 | 23,000 | 51,400 | 29,300 |

-- Zero.

[1]Table includes data available through June 6, 2019. 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 5
BORON MINERALS: WORLD PRODUCTION, BY COUNTRY OR LOCALITY[1]

(Thousand metric tons)

| Country or locality | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|
| Argentina, materials, crude | 395 | 247 | 148 | 130 r | 200 e |
| Bolivia: | | | | | |
| Boric acid | 16 | 18 | 17 | 17 e | 17 e |
| Ulexite, natural | 152 | 149 | 183 r | 145 r, e | 150 e |
| Chile: | | | | | |
| Boric acid | 95 | 101 | 104 | 112 | 100 e |
| Ulexite, natural | 497 | 518 | 559 | 607 r | 600 e |
| China[2] | 97 | 90 | 80 | 70 e | 75 e |
| Germany, compounds | 139 | 136 r | 147 r | 141 r | 143 e |
| Iran, borax[e] | 1 | 1 | 1 | 1 | 1 |
| Kazakhstan | 507 | 500 e | 500 e | 500 e | 500 e |
| Peru, borates, crude | 240 | 579 | 34 | -- | 101 |
| Russia[3] | 81 | 80 r, e | 79 r | 75 | 80 e |
| Turkey: | | | | | |
| Concentrate | 1,870 e | 1,840 e | 1,607 | 1,640 r | 1,650 e |
| Crude ore | 7,310 e | 5,072 | 4,815 | 5,801 r | 5,000 e |
| Refined borates | 1,995 | 1,839 | 1,831 | 2,025 | 2,000 e |
| United States[4] | W | W | W | W | W |

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

[1]Table includes data available through April 11, 2019. All data are reported unless otherwise noted. Estimated data are rounded to no more than three significant digits.

[2]Boric oxide 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.