



# 2013 Minerals Yearbook

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## BORON [ADVANCE RELEASE]

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# BORON

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In 2013, 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 increased in 2013; however, quantities 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 increased by 7% in 2013 to an estimated 3.47 million metric tons (Mt) compared with 3.23 Mt in 2012 (excluding U.S. production). The United States exported 232,000 metric tons (t) of boric acid in 2013, an increase of 22% from 190,000 in 2012. In 2013, 514,000 t of sodium borates were exported, an increase of 12% from 457,000 t in 2011 (tables 1, 4). Boron imports consisted primarily of borax, boric acid, colemanite, and ulexite (tables 1, 5).

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. The global rate of 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

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 Alpid 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 and Searles Valley Minerals, Inc. (SVM). Data from both companies were withheld to avoid disclosing company proprietary data (table 1).

SVM (a subsidiary of the Indian company Nirma Ltd.) 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. This deposit is located at Searles Lake near the town of Trona in San Bernardino County, CA. SVM's Trona and Westend plants refined the brines, producing anhydrous, decahydrate, and pentahydrated 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  $B_2O_3$ .

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, 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. U.S. Borax supplied more than 30% of the world's refined borates (Rio Tinto plc, 2014, p. 31). According to a Securities and Exchange Commission report filed by Rio Tinto, the company produced 495,000 t of borates in 2013, an increase of 7% from the 463,000 t reported in 2012 (Rio Tinto plc, 2014, p. 212).

## 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. Today, borates are used in more than 300 end uses, but the 5 leading uses are, in order of greatest consumption, glass, ceramics, agriculture, detergents, and bleaches (Hamilton, 2006).

**Agriculture.**—Fertilizers represented the third-ranked 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.

Boron is essential for plant uptake of primary and secondary nutrients, such as calcium, magnesium, manganese, 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 (1 pound per acre) of boron 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, leached, coarse sandy, or organic in nature (Albrecht, 1967; USDA, 1998).

**Ceramics.**—Ceramics constituted 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 and colemanite in lower temperature firings. Borates also are 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 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 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-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. Two borates, 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 affected boron consumption.

**Glass.**—The principal market for borates in 2013 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 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, sodium borates, and ulexite can be 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 by increasing the absorbance of infrared radiation (U.S. Borax, Inc., 2014).

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. 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, 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 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. Boron 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, possesses a higher strength and lighter 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, a rare-earth permanent magnet 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 (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, CA, and San Diego, CA, 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 onto dedicated railcars to be shipped 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 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 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 export data, increased by 11% in 2013 compared with those reported for 2012.

## Foreign Trade

Exports of boron minerals and compounds increased by 15% in 2013 to 746,000 t from 647,000 t in 2012. In 2013, China received the largest combined amount of sodium borates and boric acid from the United States owing to increased consumption of borates by the glass and ceramic industries in China. Canada, China, Korea, Malaysia, and the Netherlands received the largest quantities of mined borates from the United States in 2013. U.S. imports for consumption of borax, boric acid, colemanite, and ulexite were 73,000 t in 2013 and represented a 25% decrease from the 97,000 t reported in 2012 (table 1).

## World Review

**Europe.**—In Europe, more stringent building standards with respect to heat conservation were being enacted. Consequently, increased consumption of borates for fiberglass insulation may be expected (International Energy Agency, 2008).

**Argentina.**—Argentina was the second-leading producer of boron minerals in South America in 2013 (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., 2014).

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 (13,400 feet) above sea level. The deposit consisted primarily of borax, with rare occurrences of ulexite and 15 other borates (Orocobre Ltd., 2014).

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 (Mineral Santa Rita S.R.L., undated).

**Chile.**—Chile was the leading borate producer in South America with 581,000 t of borates, primarily ulexite, in 2013. The largest ulexite deposit in the world, Salar de Suirire, was operated by Quimica e Industrial del Borax Ltda., created as a Government-owned entity in 1986, with reserves estimated at 1.5 Mt. Almost all the material mined at this location was exported in 2013 (Quiborax SA, undated).

**China.**—Because China has low-grade boron resources and demand for boron is expected to increase, 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<sub>2</sub>O<sub>3</sub>, in comparison with reserves in Turkey and the United States, which average about 26% to 31% and 25% to 32% B<sub>2</sub>O<sub>3</sub>, respectively (Industrial Minerals, 2008a; Baylis, 2010, p. 5).

**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<sub>2</sub>O<sub>3</sub> content between 29% and 31%. Mining did not commence in 2013 but was expected to begin in the near future (Erin Ventures, 2014).

**Turkey.**—Approximately 73% of the world's boron reserves are in Turkey, with the Kirka deposit at Eskisehir reported to be the largest boron deposit in the world (Özdemir and others 2013; 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. 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).

## 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 are expected to fuel growth in world production during the next several years. The European Union (EU) added borates to the Registration, Evaluation, Authorization, and Restrictions of Chemicals (REACH) Restricted Substances List (RSL), a list of restricted materials, following an EU study that determined continuous exposure may be harmful. The ruling will require detergent makers to decrease their use of boron (Lismore, 2012). Demand for boron-based fertilizers is expected to increase as the 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 is expected to shift away from Europe to Asia, which accounted for 60% of world demand for ceramics in 2013.

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.

## References Cited

- Albrecht, W.M., 1967, Soil reaction (pH) and balanced plant nutrition: Columbia, MO, University of Missouri, December. (Accessed February 24, 2015, at <http://www.soilandhealth.org/01aglibrary/010143albpap/ph.balanced%20nutrition/ph.bal.nut.htm>.)
- Baylis, Robert, 2010, The Chinese boron market and the role of western suppliers: Industrial Minerals International Congress, 20th, Miami, FL, March 21–24, presentation, 31 p.
- Ceradyne Inc., 2011, Boron products: Costa Mesa, CA, Ceradyne Inc. (Accessed October 22, 2014, at <http://www.ceradyneboron.com/about/boron-products.aspx>.)
- Engineering and Mining Journal, 2012, Industrial minerals—The boron country: Engineering and Mining Journal, v. 213, no. 1, January, p. 61.
- Erin Ventures Inc., 2014, Properties—Piskanja: Victoria, British Columbia, Canada, Erin Ventures Inc. (Accessed October 22, 2014, at [http://www.erinventures.com/properties/serbia\\_piskanja.php](http://www.erinventures.com/properties/serbia_piskanja.php).)
- Eti Holding Inc., 2003, Pre-feasibility report summaries of boron carbide, boron nitride, ferroboration, frit and glaze, textile glass fibre, zinc borate: Ankara, Turkey, Eti Holding Inc., 23 p.
- Hamilton, Samuel, 2006, Boron: Mining Engineering, v. 58, no. 6, June, p. 21–22.
- Industrial Minerals, 2008a, Serving China's ceramics: Industrial Minerals, no. 488, May, p. 35.
- Industrial Minerals, 2008b, Technical ceramics take off: Industrial Minerals, no. 495, December, p. 66.
- International Energy Agency, 2008, Energy efficiency requirements in building codes, energy efficiency policies for new buildings: Paris, France, International Energy Agency. (Accessed April 13, 2015, at <https://www.iea.org/efficiency/CD-EnergyEfficiencyPolicy2009/2-Buildings/2-Building%20Codes%20for%20COP%202009.pdf>.)
- Lismore, Siobhan, 2012, Borates used in detergents added to REACH list: Industrial Minerals, February 13. (Accessed October 22, 2014, at <http://www.indmin.com/>.)
- Minera Santa Rita S.R.L., [undated], Our products: Campo Quijano, Argentina, Minera Santa Rita S.R.L. (Accessed October 22, 2014, at <http://www.santaritasrl.com/>.)
- Orocobre Ltd., 2014, Markets for borates and boron: Milton, Queensland, Australia, Orocobre Ltd. (Accessed October 22, 2014, at [http://www.orocobre.com/Projects\\_Borax.htm](http://www.orocobre.com/Projects_Borax.htm).)
- Özdemir, Zeynep, Zorlu, Semiha, Akyıldız, Mustafa, and Eryılmaz, F.Y., 2013, Determination of indicator plants for boron in the Kirka (Eskisehir, Turkey) boron deposit area: International Journal of Geosciences, v. 5, no. 1, p. 77–84.
- Quiborax SA, [undated], Our mine: Santiago, Chile, Quiborax SA. (Accessed January 22, 2015, at <http://www.quiborax.com/>.)
- Ray, H.N., Ghosh, M.S., Biswas, K., and Ray, Sunil, 1966, Note on determination of boron in steel and ferro-boron: Analytical and bioanalytical chemistry, v. 217, no. 3, p. 189–191.
- Rio Tinto plc, 2014, Form 20-F—Annual report for the fiscal year ended December 31, 2013: Washington, DC, Securities and Exchange Commission, March 15. (Accessed October 22, 2014, at [http://www.riotinto.com/documents/RT\\_Annual\\_report\\_2013.pdf](http://www.riotinto.com/documents/RT_Annual_report_2013.pdf).)
- U.S. Borax, Inc., 2014, Insulation: Boron, CA, U.S. Borax, Inc. (Accessed October 22, 2014, at <http://www.borax.com/market/insulation.aspx>.)
- U.S. Borax, Inc., [undated], Borates in detergency: Boron, CA, U.S. Borax, Inc., 4 p. (Accessed October 22, 2014, at [http://www.borax.com/docs/euf\\_pdfs/euf-borates-boratesindetergency](http://www.borax.com/docs/euf_pdfs/euf-borates-boratesindetergency).)
- U.S. Department of Agriculture, 1998, Dominant soil orders: U.S. Department of Agriculture. (Accessed February 24, 2015, at [http://www.nrcs.usda.gov/Internet/FSE\\_MEDIA/stelprdb1237749.pdf](http://www.nrcs.usda.gov/Internet/FSE_MEDIA/stelprdb1237749.pdf).)

## GENERAL SOURCES OF INFORMATION

### U.S. Geological Survey Publications

- Boron. Ch. in Mineral Commodity Summaries, annual.
- Evaporites and Brines. Ch. in United States Mineral Resources, Professional Paper 820, 1973.
- Historical Statistics for Mineral and Material Commodities in the United States. Data Series 140.

### Other

- Boron. Ch. in Mineral Facts and Problems, U.S. Bureau of Mines, Bulletin 675, 1985.
- European Borates Association.
- Industrial Minerals Association—North America.

TABLE 1  
SALIENT STATISTICS OF BORON MINERALS AND COMPOUNDS<sup>1</sup>

(Thousand metric tons and thousand dollars)

	2009	2010	2011	2012	2013
United States:					
Sold or used by producers:					
Quantity:					
Gross weight	W	W	W	W	W
B <sub>2</sub> O <sub>3</sub> content	W	W	W	W	W
Value	W	W	W	W	W
Exports: <sup>2</sup>					
Boric acid: <sup>3</sup>					
Quantity	171	264	235	190	232
Value	109,000	170,000	166,000	155,000	211,000
Sodium borates:					
Quantity	417	423	492	457 <sup>r</sup>	514
Value	176,000	218,000	244,000	260,000 <sup>r</sup>	287,000
Imports for consumption:					
Borax: <sup>2</sup>					
Quantity	(4)	(4)	2	2	2
Value	376	183	959	844	778
Boric acid: <sup>2</sup>					
Quantity	36	50	57	55	53
Value	26,100	30,100	40,800	42,800 <sup>r</sup>	36,700
Colemanite: <sup>5</sup>					
Quantity	31	50	20	28	5
Value	8,630	18,400	19,000	23,200	2,970
Ulexite: <sup>5</sup>					
Quantity	28	1	5	12	13
Value	11,300	238	858	2,940	3,080
Consumption, B <sub>2</sub> O <sub>3</sub> content	W	W	W	W	W
World, production <sup>6</sup>	3,600 <sup>r</sup>	4,120 <sup>r</sup>	3,780 <sup>r</sup>	3,230 <sup>r,c</sup>	3,470 <sup>c</sup>

<sup>c</sup>Estimated. <sup>r</sup>Revised. W Withheld to avoid disclosing company proprietary data.

<sup>1</sup>Data are rounded to no more than three significant digits.

<sup>2</sup>Source: U.S. Census Bureau.

<sup>3</sup>Includes orthoboric and anhydrous boric acid. Harmonized Tariff Schedule of the United States codes 2840.19.0000, 2840.20.0000, and 2840.30.0000.

<sup>4</sup>Less than ½ unit.

<sup>5</sup>Source: PIERS.

<sup>6</sup>U.S. production withheld from world production to avoid disclosing company proprietary data.

TABLE 2  
BORON MINERALS OF COMMERCIAL IMPORTANCE

Mineral <sup>1</sup>	Chemical composition	B <sub>2</sub> O <sub>3</sub> , <sup>2</sup> weight percent
Boracite (stassfurite)	Mg <sub>3</sub> B <sub>7</sub> O <sub>13</sub> Cl	62.2
Colemanite	Ca <sub>2</sub> B <sub>6</sub> O <sub>11</sub> ·5H <sub>2</sub> O	50.8
Datolite	CaBSi <sub>4</sub> O <sub>4</sub> OH	24.9
Hydroboracite	CaMgB <sub>6</sub> O <sub>11</sub> ·6H <sub>2</sub> O	50.5
Kernite (rasorite)	Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> ·4H <sub>2</sub> O	51.0
Priceite (pandermite)	CaB <sub>10</sub> O <sub>19</sub> ·7H <sub>2</sub> O	49.8
Probertite (kramerite)	NaCaB <sub>3</sub> O <sub>9</sub> ·5H <sub>2</sub> O	49.6
Sassolite (natural boric acid)	H <sub>3</sub> BO <sub>3</sub>	56.3
Szaibelyite (ascharite)	MgBO <sub>2</sub> OH	41.4
Tincal (natural borax)	Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> ·10H <sub>2</sub> O	36.5
Tincalconite (mohavite)	Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> ·5H <sub>2</sub> O	47.8
Ulexite (boronatrocalcite)	NaCaB <sub>5</sub> O <sub>9</sub> ·8H <sub>2</sub> O	43.0

<sup>1</sup>Parentheses indicate common names.

<sup>2</sup>Boric oxide.

TABLE 3  
YEAREND PRICES FOR BORON MINERALS AND COMPOUNDS

(Dollars per metric ton)

Product	Price, December 31, 2011	Price, December 31, 2012	Price, December 31, 2013
Borax, decahydrate, Buenos Aires	947–979	910–940	947–979
Boric acid, Chile	1,390–1,460	1,250–1,309	600–900
Colemanite, Buenos Aires, 40% boron oxide (B <sub>2</sub> O <sub>3</sub> )	690–730	690–730	690–730
Ulexite, Buenos Aires, 40% B <sub>2</sub> O <sub>3</sub>	666–697	666–697	666–697
Ulexite, granular, Chile, 40% B <sub>2</sub> O <sub>3</sub>	692–734	692–734	692–734
Ulexite, Lima, 40% B <sub>2</sub> O <sub>3</sub>	687–723	630–652	620–652

Source: Industrial Minerals, no. 531, December 2011, p. 61; no. 543, December 2012, p. 76; no. 555, December 2013, p. 52–53.

TABLE 4  
U.S. EXPORTS OF BORIC ACID AND REFINED SODIUM BORATE COMPOUNDS, BY COUNTRY<sup>1</sup>

Country	2012			2013		
	Boric acid <sup>2</sup>		Sodium	Boric acid <sup>2</sup>		Sodium
	Quantity (metric tons)	Value <sup>3</sup> (thousands)	borates <sup>4</sup> (metric tons)	Quantity (metric tons)	Value <sup>3</sup> (thousands)	borates <sup>4</sup> (metric tons)
Algeria	1	\$3	42	--	--	--
Argentina	1	4	112	1	\$3	71
Australia	1,490	1,180	6,400	1,700	1,630	6,740
Bangladesh	801	567	541	886	817	1,370
Brazil	1,340	1,680	324	4,250	3,630	749
Bulgaria	44	40	--	--	--	--
Canada	2,930 <sup>r</sup>	3,680 <sup>r</sup>	18,700 <sup>r</sup>	2,880	2,980	18,600
Chile	--	--	1,920	--	--	1,300
China	19,300	14,100	152,000	31,100	25,700	190,000
Colombia	693	716	7,760	671	646	6,460
Costa Rica	10	13	1,000	1	6	503
Dominican Republic	1	7	65	1	4	30
Ecuador	158	189	1,600	198	203	1,470
Egypt	20	14	55	--	--	41
El Salvador	2	7	--	7	10	104
France	216	370	401	111	186	93
Germany	1,750	1,250	5	589	697	16
Ghana	15	10	6	12	15	--
Guatemala	20	23	2,910	--	--	4,520
Honduras	20	24	1,710	39	48	5
India	4,660	3,360	26,000	4,750	4,290	32,800
Indonesia	890	679	7,810	2,140	1,860	481
Israel	24	34	--	--	--	--
Italy	230	225	2,190	320	205	1,400
Jamaica	2	13	--	105	77	6
Japan	27,200	22,500	25,100	38,300	37,300	23,900
Jordan	20	14	--	--	--	--
Korea, Republic of	40,700	34,300	14,300	46,700	43,300	13,700
Kuwait	20	14	1,900	58	65	2,390
Malaysia	3,490	2,710	62,800	3,530	2,830	62,700
Mexico	9,030 <sup>r</sup>	8,460 <sup>r</sup>	26,100 <sup>r</sup>	7,530	7,660	14,900
Netherlands	31,300	23,900	62,200	34,700	31,600	93,200
New Zealand	475	323	1,380	497	594	1,170
Nicaragua	--	--	122	--	--	61
Nigeria	28	19	12	38	48	40
Oman	--	--	114	--	--	97
Pakistan	669	470	1,250	897	809	1,010
Panama	5	6	34	2	3	36
Peru	353	349	1,130	256	292	995
Philippines	77	62	2,300	72	69	2,230
Russia	--	--	958	516	467	2,020
Saudi Arabia	823	580	372	1,930	1,660	836
Singapore	1,790	2,880	708	437	525	650
South Africa	357	249	2,040	178	213	2,580
Spain	--	--	1,000	--	--	851
Taiwan	33,600	25,600	4,070	39,800	33,500	4,360
Thailand	2,510	1,950	8,590	2,840	2,500	7,990
United Arab Emirates	120	83	--	138	123	--
United Kingdom	32	16	26	32	65	154
Venezuela	380	783	257	1,620	1,960	314

See footnotes at end of table.



TABLE 4—Continued  
U.S. EXPORTS OF BORIC ACID AND REFINED SODIUM BORATE COMPOUNDS, BY COUNTRY<sup>1</sup>

Country	2012			2013		
	Boric acid <sup>2</sup>		Sodium borates <sup>4</sup>	Boric acid <sup>2</sup>		Sodium borates <sup>4</sup>
	Quantity (metric tons)	Value <sup>3</sup> (thousands)		Quantity (metric tons)	Value <sup>3</sup> (thousands)	
Vietnam	2,100	1,500	7,410	2,600	2,260	10,600
Other	-- <sup>r</sup>	-- <sup>r</sup>	390 <sup>r</sup>	26	91	464
Total	190,000	155,000	457,000 <sup>r</sup>	232,000	211,000	514,000

<sup>r</sup>Revised. -- Zero.

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

<sup>2</sup>Harmonized Tariff Schedule of the United States (HTS) code 2810.00.0000.

<sup>3</sup>Free alongside ship valuation.

<sup>4</sup>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<sup>1</sup>

Country	2012		2013	
	Quantity (metric tons)	Value <sup>2</sup> (thousands)	Quantity (metric tons)	Value <sup>2</sup> (thousands)
Argentina	2,320	\$2,330	2,240	\$1,900
Australia	1	3	2	24
Bolivia	4,470	3,180	3,620	2,340
Canada	13	24	19	19
Chile	7,070 <sup>r</sup>	5,550 <sup>r</sup>	7,020	4,920
China	1,260 <sup>r</sup>	1,540 <sup>r</sup>	402	784
France	378	386	1080	917
Germany	114	102	53	98
Hong Kong	18	29	126	210
India	77	90	30	48
Ireland	3	11	1	9
Italy	2,540	2,240	2,840	2,140
Japan	98	90	80	92
Mexico	--	--	6	5
Netherlands	26	23	31	17
Peru	891	938	1,090	910
Russia	480	399	622	540
Turkey	34,900	25,900	33,500	21,700
United Kingdom	--	--	16	16
Total	54,600 <sup>r</sup>	42,800 <sup>r</sup>	52,800	36,700

<sup>r</sup>Revised. -- Zero.

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

<sup>2</sup>U.S. customs declared values.

Source: U.S. Census Bureau.

TABLE 6  
BORON MINERALS: WORLD PRODUCTION, BY COUNTRY<sup>1,2</sup>

(Thousand metric tons)

Country	2009	2010	2011	2012 <sup>e</sup>	2013 <sup>e</sup>
Argentina	506 <sup>r</sup>	623	649	479 <sup>r,3</sup>	500
Bolivia, ulexite	86	97	135	128 <sup>r</sup>	150 <sup>3</sup>
Chile, ulexite	608	504	489	444 <sup>3</sup>	581
China <sup>e,4</sup>	145	150	150	160	160
Iran, borax <sup>5</sup>	(6)	1 <sup>e</sup>	1	1	1
Kazakhstan <sup>e</sup>	30	30	30	30	30
Peru	187	293	-- <sup>r</sup>	104 <sup>3</sup>	224
Russia <sup>e,7</sup>	300 <sup>r</sup>	200 <sup>r</sup>	200 <sup>r</sup>	250 <sup>r</sup>	250
Turkey <sup>e,8</sup>	1,740 <sup>r</sup>	2,220 <sup>r</sup>	2,130 <sup>r,3</sup>	1,632 <sup>r</sup>	1,572
United States <sup>9</sup>	W	W	W	W	W
Total	3,600 <sup>r</sup>	4,120 <sup>r</sup>	3,780 <sup>r</sup>	3,230 <sup>r</sup>	3,470

<sup>e</sup>Estimated. <sup>r</sup>Revised. W Withheld to avoid disclosing company proprietary data; not included in "Total." -- Zero.

<sup>1</sup>Totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

<sup>2</sup>Includes data available through July 16, 2014.

<sup>3</sup>Reported figure.

<sup>4</sup>Boron oxide (B<sub>2</sub>O<sub>3</sub>) equivalent.

<sup>5</sup>Data are for years beginning March 21 of that stated.

<sup>6</sup>Less than ½ unit

<sup>7</sup>Blended Russian datolite ore that reportedly grades 8.6% B<sub>2</sub>O<sub>3</sub>.

<sup>8</sup>Concentrates from ore.

<sup>9</sup>Minerals and compounds sold or used by producers, including both actual mine production and marketable products.