# Indian Minerals Yearbook 2013

## (Part- III : Mineral Reviews)

## 52nd Edition

# BORON MINERALS

### (FINAL RELEASE)

**GOVERNMENT OF INDIA**
**MINISTRY OF MINES**
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**July, 2015**

# 6 Boron Minerals

Boron minerals occur mostly as borates which are deposited from volcanic gases or hot springs near volcanic activities. The deposits, predominantly of borax and sassolite are formed as a result of drying up of shallow saline and alkaline tertiary lakes called 'Playa'. The principal boron minerals are borax, hydrated sodium borate ($Na_2O.2B_2O_3.10H_2O$), kernite (rasorite), hydrated sodium borate ($Na_2O.2B_2O_3.4H_2O$), colemanite, hydrated calcium borate ($Ca_2B_6O_{11}.5H_2O$), and ulexite, hydrated sodium calcium borate ($NaCaB_5O_9.8H_2O$). Besides the above four boron minerals of commercial importance, two minerals; viz, sassolite ($H_3BO_3$), the natural boric acid and boracite ($Mg_3B_7O_{13}Cl$) are less important.

Borax is not produced in India presently. However, it was obtained since early times from the Lakes in Jammu & Kashmir in India and Tibet. The domestic requirements of boron minerals are met solely through imports of crude borate which is refined in the country for producing borax and boric acid.

## RESOURCES

Economically workable deposits of borax have not been established in the country so far. The only deposit of little economic significance is reported from Puga Valley in Leh district, Jammu & Kashmir. As per the UNFC system, total resources of borax as on 1.4.2010, are estimated at 74,204 tonnes in Jammu & Kashmir. All resources are of reconnaissance category, viz, UNFC Code 334. Occurrences are also reported from Surendranagar district, Gujarat and Nagaur district, Rajasthan. The bittern obtained from Sambar Lake in Jaipur district, Rajasthan, also contains about 0.5% borax.

## USES

Glass and porcelain industries are the major consumers of borax and boric acid. It is an essential component of heat-resisting boro-silicate glass, glass fibres and industrial & optical glass. In glass, enamels and ceramics, it controls thermal expansion, improves durability, assists melting processes and adds to inorganic colours and decorations.

Borax is used in medicine (boric powder), leather processing, adhesive, corrosion inhibition, ferrous wire manufacture, flame-proofing and timber preservation.

Borax is used as a flux in brazing, welding, soldering and in the manufacture of artificial gems like, cubic boron nitride, (commercially called 'Borazon') which equals diamond in hardness and boron carbide, titanium boride and tungsten boride which are next to diamond in hardness.

Its easy solubility and property to soften hard water find applications in soaps, cleaners & detergents and for water treatment. Because of its mild alkalinity and germicidal nature, it is used in manufacturing toothpastes and mouth washes. Borax is used as an antiseptic and emulsifying agent in cosmetics industry. As a decolourising agent, it is used in vanaspati industry. In textile industry, borax is used as a decolourising agent as well as for maintaining the alkalinity of solutions used for producing rayons. It prevents mould formation in citrus fruits. In agriculture, borax is used as an essential plant nutrient.

Boron compounds are used for fertilizers, algicides, herbicides and insecticides. Borax and boric acid are used in fire-retardant treatment and as food grain preservative, respectively.

Borate ester is used as dehydrating agent, special solvent and catalyst in chemical industry. In nuclear reactor, boron acts as neutron absorber. "Boron neutron capture therapy", a form of radiochemotherapy, is becoming increasingly important for treatment of certain forms of cancers and boron neutron capture synovectomy for treatment of arthritis.

Borates are consumed mainly in glass fibre for insulations and textile-grade fibre. They are also used as anti-knock agents in gasoline. Diborane (gas), pentaborane (liquid) and decaborane (solid) are potential jet and rocket engine fuels. Boron hydride also has potential value as rocket fuel. The high energy fuel value imparted by the addition of boron compounds has given considerable strategic significance to borates. Another use of borates is the invention of oxgano-sodium borate (liquibor) for use in hydraulic brake fluids.

### Substitutes

Substitutes in applications such as soaps, detergents, enamels and insulations are available. In detergents, boron compounds can be replaced with chlorine and enzymes. Lithium compounds can be used to make enamels and glass products. Insulation substitutes include cellulose, foams and mineral wools. Substitution of borosilicate glass by plastic materials may reduce the use of boron.

### Technical Possibilities

A proprietary process called 'Hydrogen on Demand' has been developed using water and sodium borohydride. Hydrogen from the system can be used in fuel cells or internal combustion engines. A longer-life battery based on boron has also been designed. Synthetic diamond containing about 3% boron which is normally a semiconductor becomes superconductor at 4°K. Boron-doped diamond thus has numerous possible applications as it can carry electricity without resistance.

Improvements made in evaporating brine solutions are widening the choice of source. Production of boric acid through solution mining of colemanite is a possibility.

### Environmental Concern

Natural borates are not very toxic to animals but can be toxic to plants even though low levels of boron are essential for plant life. Boron-hydrogen compounds known as boranes which do not occur in nature are highly toxic and have posed problems in some industrial applications. Environmental concerns have hastened substitution in soaps and detergents. In Europe, borates continue to be listed under hazardous substances and the risk evaluated for their safety under conditions of normal handling and use related to classification and labelling already exists. The US Food and Nutrition Board announced that the essentiality data on boron was adequate to establish a daily tolerable Upper Intake Level (UL) for an adult at 20 mg boron.

## INDUSTRY

In borax manufacturing process, crude sodium borate is dissolved in water, charged, oxidised, crystallised and centrifuged. Centrifuged material is then dried to get borax decahydrate.

Crude calcium borate lumps are crushed and wet-ground with mother liquor to make slurry. This slurry is decomposed with sulphuric acid to give calcium sulphate and boric acid. Boric acid is separated by filtration, purified, cooled and centrifuged to produce boric acid granules which are powdered as per demand.

Borax Morarji Ltd, Ambernath, Thane district, Maharashtra, engaged in refining of imported crude borates to produce borax and boric acid has installed capacities of 25,000 tpy borax and 8,000 tpy boric acid. National Peroxide Limited, Vadavali, Thane district, Maharashtra, produces sodium perborate which is used as a bleaching agent. The installed capacity of that plant is 1,500 tonnes per year. Indo Borax and Chemical Limited operates borax and boric acid plants at Pithampur, Madhya Pradesh.

Ferro-boron is a boron ferro-alloy containing 0.2% to 24% boron used primarily to introduce small quantities of boron into speciality steels. Domestic production of ferro-boron was 92 tonnes and 42 tonnes, in 2011-12 and 2012-13, respectively.

## CONSUMPTION

The consumption of borax in the organised sector was at 22,800 tonnes in 2012-13. Chemical and glass industries were the major consumers accounting for about 93% borax consumption (Table-1).

**Table – 1 : Consumption* of Borax, 2010-11 to 2012-13 (By Industries)**

(In tonnes)

| Industry | 2010-11 | 2011-12(R) | 2012-13(P) |
|---|---|---|---|
| **All Industries** | **23700** | **23700** | **22800** |
| Ceramic | 800(5) | 800(5) | 800(5) |
| Chemicals | 19900(5) | 19900(5) | 19900(5) |
| Glass | 2200(21) | 2200(21) | 1300(21) |
| Graphite products | 100(7) | 100(7) | 100(7) |
| Others (abrasive, cosmetic, paint, paper, pharmaceutical, refractory, textile and vanaspati) | 700(15) | 700(15) | 700(15) |

*Figures rounded off.*
*Figures in parentheses denote the number of units in organised sector reporting* consumption.*
*(* Includes actual reported consumption and/or estimates made wherever required).*

# WORLD REVIEW

The estimated world reserves of boron minerals are about 210 million tonnes in terms of boric oxide. Countries with sizeable resources are Argentina, Chile, China, Peru, Russia, Turkey, and USA. The world reserves of boron minerals are given in Table-2.

Turkey, USA, Argentina, Chile, and Russia are the major producers of boron minerals. China and Peru also have substantial ore production. These countries contributed about 5 million tonnes to world production.

Turkey possesses the largest and best quality of boron reserves and produces the highest amount of boron compounds in the world. A major portion of the world boron demand is met by production from Turkey. All of the known boron deposits of the country are in Western Anatolia, in the Eskiþehir-Kýrka, Kütahya-Emet, Bursa-Kestelek and Balýkesir- Bigadiç regions. In Turkey, Government-owned Eti Maden operated processing plants at Bandirma and Kirka. Turkey was the world's largest producer of boron ore in 2013. Carrying out production of natural and chemical boron compounds, Eti Mining has become the leader of the global boron sector with a wide product range. Eti Mining's production went to 1.78 million tonnes of chemical boron compounds during 2013.

Serbia is considered under-explored despite its wide spectrum of mineral deposits. Canada based Ultra Lithium, in conjunction with Beijing Zairun Mining Investment Co. Ltd (BZMI), has announced drilling at its lithium and boron properties in Koceljeva, Serbia, located approximately 60km southwest of Belgrade, covering an area of around 66km$^{2.}$

The world production of borates from 2010 to 2012 is given in Table-3.

**Table – 2 : World Reserves of Boron (By Principal Countries)**

(In '000 tonnes of boric oxide)

| Country | Reserves |
|---|---|
| **World: Total (rounded)** | **210000** |
| Argentina | 2000 |
| Bolivia | NA |
| Chile | 35000 |
| China | 32000 |
| Peru | 4000 |
| Russia | 40000 |
| Turkey | 60000 |
| USA | 40000 |

***Source***: *Mineral Commodity Summaries, 2014.*

**Table – 3 : World Production of Borates (By Principal Countries)**

(In '000 tonnes)

| Country | 2010 | 2011 | 2012 |
|---|---|---|---|
| Argentina | 623 | 649 | 600$^{e}$ |
| Chile | 504 | 491 | 450 |
| China$^{(e)}$ | 200 | 200 | 200 |
| Peru | 293 | - | 104 |
| Russia$^{(e)}$ | 400 | 400 | 400 |
| Turkey | 1910 | 2272 | 2700$^{e}$ |
| USA$^{(e)}$ | 1200 | 1250 | 1300 |

***Source:*** *World Mineral Production, 2008-2012.*

# FOREIGN TRADE

## Exports

Exports of borax (total) increased considerably to 2,488 tonnes in 2012-13 from 1,765 tonnes in the previous year. Exports in 2012-13 comprised natural borate 813 tonnes, sodium borate 1165 tonnes and other borates 510 tonnes. Exports were mainly to USA and Malaysia. Exports of boric acid decreased to 1,465 tonnes in 2012-13 from 1,751 tonnes in the previous year. Exports were mainly to Nigeria (18%). Since 2011-12, there was no report of exports of boron (Tables- 4 to 8).

## Imports

Imports of borax (total) decreased slightly to 95,047 tonnes in 2012-13 from 96,994 tonnes in the previous year. Imports in 2012-13 comprised natural borate 26,656 tonnes, sodium borate 63,880 tonnes and other borates 4,511 tonnes. Borax was mainly imported from Turkey (56%), USA (26%), Spain and China (3% each), Argentina and Chile (2% each). Imports of boric acid increased considerably to 12,841 tonnes in 2012-13 from 7,918 tonnes in the previous year. Boric acid was imported mainly from USA (42%) and Turkey (34%). In 2012-13, import of boron was negligible similar to that of during 2011-12 (Tables- 9 to 14).

**Table – 4 : Exports of Borax : Total (By Countries)**

| Country | 2011-12 | | 2012-13 | |
|---|---|---|---|---|
| | Qty (t) | Value (₹ '000) | Qty (t) | Value (₹ '000) |
| **All Countries** | **1765** | **85280** | **2488** | **122645** |
| USA | 217 | 15119 | 503 | 38459 |
| Malaysia | 325 | 10699 | 396 | 15036 |
| Bangladesh | 65 | 6591 | 174 | 12378 |
| Sri Lanka | 73 | 13336 | 26 | 7259 |
| Saudi Arabia | 63 | 2676 | 159 | 6293 |
| UK | ++ | 45 | 34 | 4941 |
| UAE | 50 | 1481 | 92 | 4633 |
| Nepal | 254 | 2225 | 144 | 4544 |
| Australia | ++ | 32 | 35 | 4261 |
| China | 125 | 10335 | 41 | 4212 |
| Other countries | 593 | 22741 | 884 | 20629 |

**Table – 5 : Exports of Natural Borate (By Countries)**

| Country | 2011-12 | | 2012-13 | |
|---|---|---|---|---|
| | Qty (t) | Value (₹ '000) | Qty (t) | Value (₹ '000) |
| **All Countries** | **682** | **7194** | **813** | **12930** |
| Nepal | 240 | 1645 | 78 | 3185 |
| Kenya | 150 | 1766 | 325 | 2575 |
| Oman | - | - | 72 | 2169 |
| UAE | 2 | 134 | 43 | 1760 |
| Tanzania | ++ | 27 | 99 | 1107 |
| Brazil | - | - | ++ | 474 |
| Nigeria | 61 | 1223 | 27 | 368 |
| Sri Lanka | 56 | 593 | 4 | 217 |
| Mauritius | - | - | 80 | 194 |
| Saudi Arabia | 1 | 84 | 22 | 173 |
| Other countries | 172 | 1722 | 63 | 708 |

**Table – 6 : Exports of Sodium Borate (By Countries)**

| Country | 2011-12 | | 2012-13 | |
|---|---|---|---|---|
| | Qty (t) | Value (₹ '000) | Qty (t) | Value (₹ '000) |
| **All Countries** | **570** | **30197** | **1165** | **59913** |
| USA | 174 | 12390 | 358 | 24705 |
| Malaysia | 325 | 10699 | 396 | 15036 |
| Saudi Arabia | 2 | 444 | 101 | 4540 |
| Bangladesh | 22 | 1349 | 38 | 3561 |
| Myanmar | - | - | 72 | 2786 |
| France | 20 | 3039 | 12 | 2022 |
| UAE | ++ | 47 | 39 | 1770 |
| Ghana | ++ | 3 | 49 | 1686 |
| Nepal | 4 | 186 | 66 | 1335 |
| Oman | - | - | 10 | 1117 |
| Other countries | 23 | 2040 | 24 | 1355 |

**Table – 7 : Exports of Borax : Other Borates (By Countries)**

| Country | 2011-12 | | 2012-13 | |
|---|---|---|---|---|
| | Qty (t) | Value (₹ '000) | Qty (t) | Value (₹ '000) |
| **All Countries** | **513** | **47889** | **510** | **49802** |
| USA | 23 | 2563 | 145 | 13738 |
| Bangladesh | 43 | 5242 | 136 | 8817 |
| Sri Lanka | 16 | 12682 | 21 | 7010 |
| UK | ++ | 24 | 34 | 4891 |
| Australia | - | - | 28 | 4157 |
| China | 125 | 10335 | 40 | 4091 |
| Saudi Arabia | 60 | 2148 | 36 | 1580 |
| Belgium | 1 | 964 | 12 | 1280 |
| UAE | 48 | 1301 | 10 | 1103 |
| Kenya | - | - | 20 | 810 |
| Other countries | 197 | 12630 | 28 | 2325 |

**Table – 8 : Exports of Boric Acid (By Countries)**

| Country | 2011-12 | | 2012-13 | |
|---|---|---|---|---|
| | Qty (t) | Value (₹ '000) | Qty (t) | Value (₹ '000) |
| **All Countries** | **1751** | **83449** | **1465** | **71485** |
| Nigeria | 377 | 13642 | 268 | 17391 |
| Japan | 338 | 24762 | 183 | 17091 |
| Malaysia | 11 | 462 | 56 | 3530 |
| Australia | 38 | 4197 | 26 | 3421 |
| UK | 40 | 4757 | 24 | 3260 |
| Sri Lanka | 4 | 421 | 37 | 2721 |
| Indonesia | - | - | 48 | 2522 |
| Nepal | 54 | 2015 | 43 | 2479 |
| Tanzania | 28 | 764 | 135 | 2277 |
| Jordan | 3 | 202 | 141 | 2124 |
| Other countries | 858 | 32227 | 504 | 14669 |

**Table – 9 : Imports of Borax : Total (By Countries)**

| Country | 2011-12 | | 2012-13 | |
|---|---|---|---|---|
| | Qty (t) | Value (₹ '000) | Qty (t) | Value (₹ '000) |
| **All Countries** | **96994** | **2621167** | **95047** | **2980036** |
| Turkey | 52073 | 1208087 | 53523 | 1471474 |
| USA | 18699 | 631095 | 24601 | 922345 |
| China | 5587 | 216378 | 2529 | 148884 |
| Spain | 2913 | 85012 | 3312 | 112486 |
| Argentina | 4448 | 111565 | 1864 | 50474 |
| Germany | 628 | 32089 | 1055 | 35682 |
| Malaysia | 502 | 27371 | 651 | 31700 |
| Chile | 1793 | 24096 | 1854 | 24862 |
| Austria | 433 | 22784 | 433 | 24259 |
| Bolivia | 2965 | 35869 | 1186 | 23180 |
| Other countries | 6953 | 226821 | 4039 | 134690 |

**Table – 10 : Imports of Natural Borate (By Countries)**

| Country | 2011-12 | | 2012-13 | |
|---|---|---|---|---|
| | Qty (t) | Value (₹ '000) | Qty (t) | Value (₹ '000) |
| **All Countries** | **32546** | **658862** | **26656** | **638221** |
| Turkey | 16998 | 337978 | 15924 | 384853 |
| Spain | 1806 | 48311 | 2116 | 62605 |
| Argentina | 4448 | 111565 | 1864 | 50474 |
| Chile | 1793 | 24096 | 1854 | 24862 |
| Bolivia | 2965 | 35869 | 1186 | 23180 |
| China | 1267 | 34249 | 810 | 19619 |
| Germany | 401 | 11315 | 572 | 16633 |
| Sri Lanka | - | - | 600 | 13758 |
| Yugoslavia | 101 | 2006 | 480 | 10870 |
| Serbia | | | | |
| Unspecified | 94 | 1788 | 380 | 8715 |
| Other countries | 2673 | 51685 | 870 | 22652 |

**Table – 11 : Imports of Sodium Borate (By Countries)**

| Country | 2011-12 | | 2012-13 | |
|---|---|---|---|---|
| | Qty (t) | Value (₹ '000) | Qty (t) | Value (₹ '000) |
| **All Countries** | **59706** | **1642191** | **63880** | **2017625** |
| Turkey | 33151 | 825811 | 35932 | 1030490 |
| USA | 18342 | 556110 | 23620 | 805460 |
| Spain | 1107 | 36696 | 1196 | 49882 |
| China | 3098 | 96396 | 647 | 37382 |
| Malaysia | 372 | 18808 | 522 | 22723 |
| Germany | 169 | 5584 | 459 | 14248 |
| UAE | 379 | 10524 | 151 | 6369 |
| Japan | 452 | 10985 | 154 | 5947 |
| Kuwait | - | - | 168 | 4785 |
| Netherlands | - | - | 72 | 4171 |
| Other countries | 2636 | 81277 | 959 | 36168 |

**Table – 12 : Imports of Borax : Other Borates (By Countries)**

| Country | 2011-12 | | 2012-13 | |
|---|---|---|---|---|
| | Qty (t) | Value (₹ '000) | Qty (t) | Value (₹ '000) |
| **All Countries** | **4742** | **320114** | **4511** | **324190** |
| USA | 357 | 74973 | 789 | 111994 |
| China | 1222 | 85733 | 1072 | 91884 |
| Turkey | 1924 | 44298 | 1667 | 56131 |
| Austria | 433 | 22784 | 433 | 24259 |
| Slovenia | - | - | 161 | 9406 |
| Malaysia | 130 | 8563 | 129 | 8978 |
| UK | ++ | 100 | 21 | 5173 |
| Germany | 58 | 15190 | 24 | 4801 |
| Peru | 5 | 578 | 107 | 3222 |
| UAE | - | - | 20 | 1917 |
| Other countries | 613 | 67895 | 88 | 6425 |

**Table – 13 : Imports of Boric Acid**
**(By Countries)**

| Country | 2011-12 | | 2012-13 | |
|---|---|---|---|---|
| | Qty (t) | Value (₹'000) | Qty (t) | Value (₹'000) |
| **All Countries** | **7918** | **349536** | **12841** | **650562** |
| USA | 2662 | 121454 | 5450 | 286134 |
| Turkey | 3929 | 166883 | 4358 | 213383 |
| Argentina | - | - | 1075 | 49774 |
| Peru | 156 | 5560 | 931 | 44774 |
| China | 234 | 12202 | 398 | 19320 |
| Germany | 35 | 1687 | 168 | 8613 |
| Malaysia | - | - | 160 | 8430 |
| Japan | 59 | 2128 | 85 | 8384 |
| Indonesia | - | - | 105 | 5248 |
| Chile | - | - | 60 | 3083 |
| Other countries | 843 | 39622 | 51 | 3419 |

**Table – 14 : Imports of Boron**
**(By Countries)**

| Country | 2011-12 | | 2012-13 | |
|---|---|---|---|---|
| | Qty (t) | Value (₹'000) | Qty (t) | Value (₹'000) |
| **All Countries** | **++** | **335** | **++** | **765** |
| China | - | - | ++ | 502 |
| USA | ++ | 176 | ++ | 199 |
| Germany | ++ | 24 | ++ | 22 |
| Japan | ++ | 17 | ++ | 21 |
| UK | ++ | 118 | ++ | 21 |

## FUTURE OUTLOOK

Increased usage of ceramic tiles will keep consumption of boron minerals in end uses like the enamels, frits and glazes. Demand as a fertilizer will remain high, whereas, usage in soaps and detergents will be low because of environmental concerns. Some cars have been replacing metal parts with reinforced fibreglass plastic parts of reduced weight to increase the efficiency of gasoline consumption. This may enhance the demand for borax in the production of fibre glass.