

BORON MINERALS



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**BORON MINERALS**

**(FINAL RELEASE)**

**GOVERNMENT OF INDIA  
MINISTRY OF MINES  
INDIAN BUREAU OF MINES**

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## 6 Boron Minerals

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**B**oron 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 ( $\text{Na}_2\text{O}\cdot 2\text{B}_2\text{O}_3\cdot 10\text{H}_2\text{O}$ ), kernite (rasorite), hydrated sodium borate ( $\text{Na}_2\text{O}\cdot 2\text{B}_2\text{O}_3\cdot 4\text{H}_2\text{O}$ ), colemanite, hydrated calcium borate ( $\text{Ca}_2\text{B}_6\text{O}_{11}\cdot 5\text{H}_2\text{O}$ ), and ulexite, hydrated sodium calcium borate ( $\text{NaCaB}_5\text{O}_9\cdot 8\text{H}_2\text{O}$ ). Besides the above four boron minerals of commercial importance, two minerals, viz, sassolite ( $\text{H}_3\text{BO}_3$ ), the natural boric acid and boracite ( $\text{Mg}_3\text{B}_7\text{O}_{13}\text{Cl}$ ) are less important.

Borax is, presently, not produced in India. However, it was obtained since ancient times from the Lakes in Jammu & Kashmir in India. 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 viable 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 borosilicate 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 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 and has installed capacities of 25,000 tpy borax and 8,000 tpy boric acid. National Peroxide Limited, Vadavali, Kalyan, Thane district, Maharashtra, produces sodium perborate which is used as a bleaching agent. 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 21 tonnes and 42 tonnes, in 2013-14 and 2014-15, respectively.

## CONSUMPTION

The consumption of borax in the organised sector increased marginally from 22,900 tonnes in 2013-14 to 23,100 tonnes in 2014-15. Chemical and glass industries were the major consumers accounting for about 93% borax consumption (Table-1).

**Table – 1 : Consumption\* of Borax, 2012-13 to 2014-15 (By Industries)**

| Industry   | (In tonnes)  |              |              |
|--|--------------|--------------|--------------|
|  | 2012-13(R)   | 2013-14(P)   | 2014-15(E)   |
| <b>All Industries</b>  | <b>22800</b> | <b>22900</b> | <b>23100</b> |
| Ceramic  | 800(5)       | 800(5)       | 800(5)       |
| Chemical   | 19900(5)     | 19900(5)     | 19900(5)     |
| Glass  | 1300(21)     | 1400(21)     | 1600(2)      |
| 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.*

*\* Paucity of data, hence consumption may not be completed.*

## WORLD REVIEW

The estimated world reserves of boron minerals are about 380 million tonnes in terms of boric oxide. Countries with sizeable resources are Chile, China, Peru, Russia, Turkey and USA. The world reserves of boron in terms of boric oxide are given in Table-2.

## Argentina

Argentina was the second-leading producer of boron minerals in South America in 2014. Borate deposits are located primarily in the Puna region, which includes the northwestern tip of Argentina, the southeastern corner of Peru, the southeastern 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.

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

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 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.

## Chile

Chile was the leading borate producer in South America with 580,000 tonnes of borates, primarily ulexite, in 2014. The largest ulexite deposit in the world, Salar de Suirire, was operated by Quimica e Industrial del Borax Ltd, a Govt. entity with reserves estimated at 1.5 million tonnes. Almost all the material mined at this location was exported in 2014.

## China

China has low-grade boron resources and demand for boron is expected to increase, imports from Chile, Russia, Turkey and the United States expected to raise 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>.

## 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 south of Belgrade. The deposit is primarily composed of colemanite and ulexite with estimated reserves of 11.8 million tonnes at an average B<sub>2</sub>O<sub>3</sub> content between 29% and 31%. Mining did not commence in 2014 but was expected to begin in the near future.

## Turkey

Approximately 61% of the world's boron reserves are in Turkey with average B<sub>2</sub>O<sub>3</sub> content from 26 to 31 percent. The Kirka deposit at Eskisehir reported to be the largest boron deposit in the world. 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.

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

(In '000 tonnes of boric oxide)

| Country             | Reserves      |
|---------------------|---------------|
| <b>World: Total</b> | <b>381000</b> |
| Argentina           | NA            |
| Bolivia             | NA            |
| Chile               | 35000         |
| China               | 32000         |
| Kazakhstan          | NA            |
| Peru                | 4000          |
| Russia              | 40000         |
| Turkey              | 230000        |
| USA                 | 40000         |

*Source: Mineral Commodity Summaries, 2016.*

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

(In '000 tonnes)

| Country                | 2012             | 2013             | 2014              |
|------------------------|------------------|------------------|-------------------|
| <b>World: Total</b>    | <b>5105</b>      | <b>5283</b>      | <b>5436</b>       |
| Argentina <sup>e</sup> | 660              | 670              | 740               |
| Bolivia                | 143              | 157              | 152               |
| Chile                  | 450              | 582              | 592               |
| China <sup>e</sup>     | 200 <sup>e</sup> | 320 <sup>e</sup> | 330               |
| Peru                   | 104              | 224              | 240               |
| Russia <sup>e</sup>    | 400              | 250              | 300               |
| Turkey                 | 1815             | 1748             | 1750 <sup>e</sup> |
| USA <sup>e</sup>       | 1300             | 1300             | 1300              |
| Other countries        | 33               | 32               | 32                |

*Source: World Mineral Production, 2010-2014.*

**FOREIGN TRADE****Exports**

Exports of borax (total) increased considerably to 2,655 tonnes in 2014-15 from 1,623 tonnes in the previous year. Exports in 2014-15 comprised natural borate 102 tonnes, sodium borate 2,114 tonnes and other borates 439 tonnes. Exports of Borax (total) were mainly to Malaysia, Iran, USA, Nepal, Bangladesh and UAE. Exports of boric acid increased to 1,282 tonnes in 2014-15 from 785 tonnes in the previous year. Exports were mainly to Nigeria, Iran and Thailand (Tables- 4 to 8).

**Imports**

Imports of borax (total) increased significantly to 1,46,301 tonnes in 2014-15 from 1,12,775 tonnes in the previous year. Imports in 2014-15 comprised natural borate 67,430 tonnes, sodium borate 75,332 tonnes and other borates 3,539 tonnes. Borax (total) was mainly imported from Turkey, USA, Bolivia, Spain, Chile and China. Imports of boric acid also increased to 17,305 tonnes in 2014-15 from 12,525 tonnes in the previous year. Boric acid was imported mainly from Turkey, USA and Peru. In 2014-15, import of boron was negligible and was similar to that of the previous year (Tables- 9 to 14).

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

| Country              | 2013-14     |               | 2014-15 (P) |               |
|----------------------|-------------|---------------|-------------|---------------|
|                      | Qty (t)     | Value (₹'000) | Qty (t)     | Value (₹'000) |
| <b>All Countries</b> | <b>1623</b> | <b>125006</b> | <b>2655</b> | <b>164699</b> |
| Malaysia             | 380         | 16195         | 985         | 41762         |
| Iran                 | 119         | 5993          | 691         | 31730         |
| USA                  | 162         | 27018         | 149         | 25059         |
| Sri Lanka            | 18          | 16637         | 22          | 16691         |
| Bangladesh           | 110         | 13942         | 106         | 13526         |
| Nepal                | 145         | 6007          | 196         | 4861          |
| UAE                  | 40          | 2289          | 122         | 4644          |
| UK                   | 52          | 7621          | 31          | 4629          |
| Saudi Arabia         | 40          | 1763          | 100         | 4248          |
| France               | 20          | 3482          | 20          | 3579          |
| Other countries      | 537         | 24059         | 233         | 13970         |

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

| Country              | 2013-14    |               | 2014-15 (P) |               |
|----------------------|------------|---------------|-------------|---------------|
|                      | Qty (t)    | Value (₹'000) | Qty (t)     | Value (₹'000) |
| <b>All Countries</b> | <b>310</b> | <b>6076</b>   | <b>102</b>  | <b>1026</b>   |
| Nepal                | 34         | 1314          | 101         | 837           |
| Uganda               | 3          | 117           | 1           | 119           |
| Baharain             | ++         | 63            | ++          | 68            |
| South Africa         | -          | -             | ++          | 1             |
| Jordan               | -          | -             | ++          | 1             |
| Mozambique           | -          | -             | -           | -             |
| UAE                  | -          | -             | -           | -             |
| Other countries      | 273        | 4582          | -           | -             |

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

| Country              | 2013-14    |               | 2014-15 (P) |               |
|----------------------|------------|---------------|-------------|---------------|
|                      | Qty (t)    | Value (₹'000) | Qty (t)     | Value (₹'000) |
| <b>All Countries</b> | <b>805</b> | <b>41232</b>  | <b>2114</b> | <b>95148</b>  |
| Malaysia             | 380        | 16195         | 984         | 41627         |
| Iran                 | 96         | 4351          | 685         | 30946         |
| UAE                  | 25         | 939           | 122         | 4622          |
| Saudi Arabia         | 40         | 1744          | 100         | 4248          |
| Nepal                | 108        | 4501          | 93          | 3834          |
| France               | -          | -             | 20          | 3571          |
| Myanmar              | 48         | 1920          | 48          | 2052          |
| Thailand             | -          | -             | 40          | 1966          |
| Oman                 | -          | -             | 5           | 769           |
| USA                  | 4          | 3500          | 5           | 679           |
| Other countries      | 104        | 8082          | 12          | 834           |

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

| Country              | 2013-14    |               | 2014-15 (P) |               |
|----------------------|------------|---------------|-------------|---------------|
|                      | Qty (t)    | Value (₹'000) | Qty (t)     | Value (₹'000) |
| <b>All Countries</b> | <b>508</b> | <b>77699</b>  | <b>439</b>  | <b>68525</b>  |
| USA                  | 158        | 23519         | 144         | 24380         |
| Sri Lanka            | 16         | 16501         | 22          | 16691         |
| Bangladesh           | 74         | 10415         | 105         | 13478         |
| UK                   | 52         | 7618          | 31          | 4629          |
| Australia            | 44         | 7044          | 18          | 2930          |
| Thailand             | 48         | 1543          | 48          | 1474          |
| Kenya                | 1          | 119           | 20          | 908           |
| Myanmar              | 35         | 1424          | 20          | 810           |
| Iran                 | 23         | 1642          | 6           | 783           |
| Syria                | 1          | 99            | 12          | 555           |
| Other countries      | 56         | 7775          | 13          | 1887          |

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

| Country              | 2013-14    |               | 2014-15 (P) |               |
|----------------------|------------|---------------|-------------|---------------|
|                      | Qty (t)    | Value (₹'000) | Qty (t)     | Value (₹'000) |
| <b>All Countries</b> | <b>785</b> | <b>63000</b>  | <b>1282</b> | <b>91951</b>  |
| Nigeria              | 258        | 18683         | 400         | 31347         |
| Iran                 | -          | -             | 210         | 12186         |
| Thailand             | ++         | 47            | 105         | 4811          |
| Kenya                | 28         | 2640          | 54          | 4242          |
| Jordan               | 33         | 2906          | 43          | 3595          |
| USA                  | 30         | 3856          | 25          | 3323          |
| Indonesia            | -          | -             | 63          | 3318          |
| Cameroon             | 27         | 3347          | 34          | 3164          |
| Nepal                | 85         | 3050          | 30          | 3135          |
| Sudan                | 7          | 798           | 18          | 2532          |
| Other countries      | 317        | 27673         | 300         | 20298         |

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

| Country              | 2013-14       |                | 2014-15 (P)   |                |
|----------------------|---------------|----------------|---------------|----------------|
|                      | Qty (t)       | Value (₹'000)  | Qty (t)       | Value (₹'000)  |
| <b>All Countries</b> | <b>112775</b> | <b>3551233</b> | <b>146301</b> | <b>4474017</b> |
| Turkey               | 70167         | 1899533        | 93523         | 2593957        |
| USA                  | 30517         | 1150912        | 31282         | 1182207        |
| Spain                | 5106          | 195355         | 7845          | 287943         |
| Bolivia              | 736           | 17432          | 8459          | 126150         |
| China                | 1136          | 94639          | 1180          | 103310         |
| Austria              | 639           | 42912          | 805           | 54607          |
| Chile                | 1755          | 27037          | 1566          | 24317          |
| Argentina            | 790           | 25167          | 596           | 22829          |
| Netherlands          | 114           | 12618          | 136           | 13846          |
| Russia               | 2             | 9728           | 3             | 10428          |
| Other countries      | 1813          | 75900          | 906           | 54423          |

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

| Country               | 2013-14      |                | 2014-15 (P)  |                |
|-----------------------|--------------|----------------|--------------|----------------|
|                       | Qty (t)      | Value (₹'000)  | Qty (t)      | Value (₹'000)  |
| <b>All Countries</b>  | <b>44856</b> | <b>1057753</b> | <b>67430</b> | <b>1590619</b> |
| Turkey                | 37103        | 842429         | 51006        | 1229669        |
| Spain                 | 3427         | 117942         | 5612         | 184275         |
| Bolivia               | 736          | 17432          | 8459         | 126150         |
| Chile                 | 1755         | 27037          | 1566         | 24317          |
| Argentina             | 790          | 25167          | 570          | 20723          |
| Serbia and Montenegro | 601          | 15484          | 99           | 2380           |
| China                 | -            | -              | ++           | 45             |
| Japan                 | -            | -              | ++           | 43             |
| USA                   | -            | -              | ++           | 15             |
| Unspecified           | -            | -              | 118          | 3002           |
| Other countries       | 444          | 12262          | -            | -              |

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

| Country              | 2013-14      |                | 2014-15 (P)  |                |
|----------------------|--------------|----------------|--------------|----------------|
|                      | Qty (t)      | Value (₹'000)  | Qty (t)      | Value (₹'000)  |
| <b>All Countries</b> | <b>63425</b> | <b>2204918</b> | <b>75332</b> | <b>2586805</b> |
| Turkey               | 31539        | 1011019        | 42167        | 1348634        |
| USA                  | 29595        | 1083765        | 30205        | 1092012        |
| Spain                | 1679         | 77259          | 2233         | 103416         |
| Netherlands          | 114          | 12553          | 136          | 13835          |
| China                | 167          | 8039           | 131          | 9223           |
| Peru                 | 107          | 3448           | 216          | 6556           |
| Malaysia             | 172          | 4212           | 160          | 4768           |
| Argentina            | -            | -              | 26           | 2106           |
| Italy                | 2            | 697            | 13           | 1815           |
| Germany              | 1            | 1354           | 1            | 1538           |
| Other countries      | 49           | 2572           | 44           | 2902           |

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

| Country              | 2013-14     |               | 2014-15 (P) |               |
|----------------------|-------------|---------------|-------------|---------------|
|                      | Qty (t)     | Value (₹'000) | Qty (t)     | Value (₹'000) |
| <b>All Countries</b> | <b>4494</b> | <b>288562</b> | <b>3539</b> | <b>296593</b> |
| China                | 969         | 86600         | 1049        | 94042         |
| USA                  | 922         | 67147         | 1077        | 90181         |
| Austria              | 639         | 42912         | 805         | 54607         |
| Turkey               | 1525        | 46084         | 350         | 15655         |
| Russia               | 2           | 9728          | 3           | 10428         |
| Slovenia             | 66          | 3608          | 115         | 8727          |
| UK                   | 14          | 8871          | 8           | 6761          |
| Malaysia             | 80          | 5688          | 90          | 5536          |
| Germany              | 24          | 3276          | 4           | 3345          |
| Peru                 | 220         | 7731          | 10          | 1669          |
| Other countries      | 33          | 6917          | 28          | 5642          |

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

| Country              | 2013-14      |               | 2014-15 (P)  |               |
|----------------------|--------------|---------------|--------------|---------------|
|                      | Qty (t)      | Value (₹'000) | Qty (t)      | Value (₹'000) |
| <b>All Countries</b> | <b>12525</b> | <b>648740</b> | <b>17305</b> | <b>859435</b> |
| USA                  | 3936         | 218975        | 6699         | 351444        |
| Turkey               | 6591         | 330139        | 6669         | 324736        |
| Peru                 | 938          | 46775         | 2914         | 133798        |
| Argentina            | 600          | 30752         | 742          | 34234         |
| Russia               | 436          | 20376         | 140          | 6505          |
| Singapore            | ++           | 2             | 118          | 6137          |
| China                | 21           | 1279          | 21           | 1955          |
| Germany              | 1            | 230           | 2            | 620           |
| Spain                | -            | -             | ++           | 6             |
| Other countries      | 2            | 212           | -            | -             |

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

| Country              | 2013-14    |                  | 2014-15 (P) |                  |
|----------------------|------------|------------------|-------------|------------------|
|                      | Qty<br>(t) | Value<br>(₹'000) | Qty<br>(t)  | Value<br>(₹'000) |
| <b>All Countries</b> | <b>++</b>  | <b>3801</b>      | <b>1</b>    | <b>2863</b>      |
| USA                  | ++         | 2003             | ++          | 1422             |
| China                | ++         | 1419             | ++          | 455              |
| Belgium              | ++         | 98               | ++          | 439              |
| Italy                | -          | -                | 1           | 237              |
| UK                   | ++         | 198              | ++          | 192              |
| Japan                | ++         | 80               | ++          | 81               |
| Germany              | ++         | 3                | ++          | 37               |

### FUTURE 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 during the next several years. In 2013, the European Union (EU) added borates to the Registration, Evaluation, Authorisation and Restrictions of Chemicals (REACH) Restricted Substances List (RSL), following an EU study that determined continuous exposure may be harmful. The ruling required detergent makers to decrease their use of boron. Consumption of boron-based fertilizers is expected to increase as the demand for food and biofuel crops also increases. Higher crop prices have enabled farmers to invest more capital in advanced farming techniques and higher grade fertilizers. Consumption of borates by the Ceramics Industry is expected to shift away from Europe to Asia, which accounted for the majority of world demand for ceramics in 2014.