

19 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 ($\text{Na}_2\text{O} \cdot 2\text{B}_2\text{O}_3 \cdot 10\text{H}_2\text{O}$), 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 (H_3BO_3), the natural boric acid and boracite ($\text{Mg}_3\text{B}_7\text{O}_{13}\text{Cl}$) are less important.

Borax is not produced in India presently. However, it was obtained since early times from the Salt 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 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 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.

As a fluxing agent, it is used in brazing, welding and soldering.

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. In cosmetics, borax is used as an antiseptic and emulsifying agent. 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.

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Borates are consumed mainly in glass fibre for insulations and textile-grade fibre. Borates 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

Substitutions for boron minerals in several applications except glass products are in vogue. 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

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

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.

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) 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 17,000 tpy borax and 6,000 tpy boric acid. National Peroxide Limited at Vadavali, Thane district, Maharashtra, produces sodium perborate which is used as a bleaching agent. The installed capacity of that plant is 1,200 tonnes per year. Indo Borax and Chemical Limited operates borax and boric acid plants at Pithampur, Madhya Pradesh. However, plant capacity is not available.

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 83 tonnes and 90 tonnes, in 2008-09 and 2009-10, respectively.

CONSUMPTION

The reported consumption of borax in the organised sector remained static at 23,900 tonnes in 2008-09 and 2009-10. Chemical and glass industries were the major consumers accounting for about 95% borax consumption (Table-1).

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Table – 1 : Reported Consumption of Borax, 2007-08 to 2009-10 (By Industries)

(In tonnes)			
Industry	2007-08	2008-09(R)	2009-10(P)
All Industries	23900	23900	23900
Ceramic	800 (6)	800 (6)	800 (6)
Chemicals®	19900 (5)	19900 (5)	19900 (5)
Glass	2500 (25)	2500 (25)	2500 (25)
Graphite products	100 (23)	200 (23)	200 (23)
Others (abrasive, paint, paper, pharmaceutical, refractory, textile and vanaspati)	500 (16)	500 (16)	500 (16)

Figures rounded off. Data collected on non-statutory basis. Figures in parentheses denote the number of units in organised sector reporting* consumption. (* Includes actual reported consumption and/or estimates made wherever required). @ Includes consumption of ulexite and colemanite.

WORLD REVIEW

The estimated world reserves of boron minerals are about 170 million tonnes in terms of boric oxide. Countries with sizeable resources are Argentina, Turkey, Russia, USA, China and Peru. The world reserves of boron minerals are given in Table-2.

Turkey, USA, Chile, Argentina, and Russia are the major producers of boron minerals. China also has substantial ore production. These countries contributed about 4.8 million tonnes to world production.

In Turkey, Government-owned Eti Maden operated processing plants at Bandirma and Kirka. A large tincal deposit at Kirka is the only commercial sodium borate deposit known in Turkey. Turkey was the world's largest producer of boron ore in 2009. Comibol of Bolivia is planning to develop the Salar de Uyuni salt flats for future borate production. A pilot plant is to be established for boric acid plant of 20,000 tpy capacity. Borax Argentina SA (a subsidiary of Rio Tinto plc) is Argentina's leading producer and exporter to USA. Borax Argentina mined at three deposits, Tincalayu mine being the largest open-pit operation which despatches about 100,000 tpy ore.

In Chile, Quimica del Borax (Quiborax), Rio Grande, produces about 450,000 tpy ulexite. Quiborax also has an 80,000 tpy boric acid plant and 40,000 tpy capacity granular ulexite plant. In China, deposits of borates in Hunan, Jilin, Qinghai and Liaoning provinces are operated. Eighty percent production is reported from Qinghai Province.

The world production of borates from 2007 to 2009 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)	170000
Argentina	2000
Bolivia	NA
Chile	NA
China	25000
Iran	1000
Khzakhstan	NA
Peru	4000
Russia	40000
Turkey	60000
USA	40000

Source: Mineral Commodity Summaries, 2010.

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

(In '000 tonnes)			
Country	2007	2008	2009
Argentina	670	790	500
Chile	535	591	613
China ^(e)	290	280	290
Peru	234	350	187
Russia ^(e)	400	400	410
Turkey	1997 ^(e)	2193	1682
USA ^(e)	1150	1150	1150

Source: World Mineral Production, 2005-2009.

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FOREIGN TRADE

Exports

Exports of borax (total) increased to 1,654 tonnes in 2009-10 from 1,545 tonnes in the previous year. Exports in 2009-10 comprised natural borate 942 tonnes, sodium borate 584 tonnes and other borates 128 tonnes. Exports were mainly to Kenya (22%), Bangladesh (18%) and USA (16%). Exports of boric acid increased to 804 tonnes in 2009-10 from 581 tonnes in the previous year. Exports were mainly to USA (79%). In 2009-10, exports of boron decreased to 356 tonnes from 383 tonnes in the previous year. Exports were mainly to Chinese Taipei /Taiwan (84%) (Tables 4 to 9).

Imports

Imports of borax (total) decreased to 78,003 tonnes in 2009-10 from 98,533 tonnes in the previous year. Imports in 2009-10 comprised natural borate 30,690 tonnes, sodium borate 42,314 tonnes and other borates 4,999 tonnes. Borax was mainly imported from Turkey (48%), USA (23%), Argentina (11%) and Bolivia (7%). Imports of boric acid decreased to 7,786 tonnes in 2009-10 from 10,108 tonnes in the previous year. Boric acid was imported mainly from Turkey (66%) and USA (25%). In 2009-10, import of boron was one tonne and negligible in the previous year (Tables 10 to 15).

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

Country	2008-09		2009-10	
	Qty (t)	Value (Rs.'000)	Qty (t)	Value (Rs.'000)
All Countries	1545	40414	1654	41690
USA	223	7518	266	12191
Australia	120	6905	109	5292
Bangladesh	390	4735	298	4132
Kenya	19	668	370	3281
Malaysia	2	114	125	3180
Saudi Arabia	62	2239	60	1768
Nepal	227	1135	94	1302
U K	32	1910	16	955
U A E	61	2283	18	384
China	40	3073	-	-
Other countries	369	9834	298	9205

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

Country	2008-09		2009-10	
	Qty (t)	Value (Rs.'000)	Qty (t)	Value (Rs.'000)
All Countries	902	9674	942	9342
Kenya	8	482	370	3278
Nigeria	10	120	69	1962
Nepal	209	743	86	779
Jordan	-	-	28	679
Bangladesh	340	1506	261	672
UAE	41	1420	18	344
Bahrain	27	431	12	245
Djibouti	20	447	2	128
U S A	96	2579	1	18
Sri Lanka	32	1076	1	8
Other countries	119	870	94	1229

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

Country	2008-09		2009-10	
	Qty (t)	Value (Rs.'000)	Qty (t)	Value (Rs.'000)
All Countries	464	21909	584	21039
USA	66	3774	229	8373
Australia	120	6905	96	4057
Malaysia	-	-	125	3180
Saudi Arabia	61	2145	60	1767
New Zealand	20	1028	18	987
UK	32	1910	16	955
Argentina	9	798	10	681
Nepal	17	344	7	369
Bangladesh	14	843	-	-
Myanmar	80	2169	-	-
Other countries	45	1993	23	670

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

Country	2008-09		2009-10	
	Qty (t)	Value (Rs.'000)	Qty (t)	Value (Rs.'000)
All Countries	179	8831	128	11309
USA	61	1165	36	3800
Bangladesh	36	2386	37	3460
Australia	-	-	13	1235
Belgium	-	-	20	1199
Oman	4	234	10	515
Bosnia-Hrzgovin	-	-	4	420
Chile	-	-	2	215
U A E	10	447	++	38
China	40	3073	-	-
France	19	796	-	-
Other countries	9	730	6	427

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

Country	2008-09		2009-10	
	Qty (t)	Value (Rs.'000)	Qty (t)	Value (Rs.'000)
All Countries	581	29567	804	18451
USA	238	11101	632	10703
Saudi Arabia	21	942	33	1402
Uganda	10	238	28	1287
Kenya	67	2640	35	929
Nigeria	12	952	7	552
Sri Lanka	11	912	5	428
Congo, People's Rep. of	47	1491	++	3
Yemen Republic	26	2476	++	2
Japan	60	3968	-	-
Sudan	16	1341	-	-
Other countries	73	3506	64	3145

**Table – 9 : Exports of Boron
(By Countries)**

Country	2008-09		2009-10	
	Qty (t)	Value (Rs.'000)	Qty (t)	Value (Rs.'000)
All Countries	383	44812	356	84795
Chinese Taipei/ Taiwan	314	25900	298	68828
Korea, Rep. of	-	-	40	11674
USA	4	1121	11	2460
Israel	-	-	7	1833
Nepal	4	654	-	-
Netherlands	61	17136	-	-
Other countries	++	1	-	-

**Table – 10 : Imports of Borax
(By Countries)**

Country	2008-09		2009-10	
	Qty (t)	Value (Rs.'000)	Qty (t)	Value (Rs.'000)
All Countries	98533	1994633	78003	1873097
Turkey	35041	727891	37281	828425
USA	23056	539942	18061	519971
Argentina	10444	255636	8730	214637
Spain	3881	97113	3227	92426
Bolivia	20582	233024	5599	62433
China	712	53043	996	5524
Chile	3455	35539	2034	19242
Russia	-	-	4	15673
Germany	148	10568	128	14162
Slovenia	329	15829	192	10067
Other countries	885	26048	1751	40537

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

Country	2008-09		2009-10	
	Qty (t)	Value (Rs.'000)	Qty (t)	Value (Rs.'000)
All Countries	44617	719253	30690	571010
Argentina	10344	252517	8705	213912
Turkey	7147	127763	11066	208896
Bolivia	20582	233024	5599	62433
Spain	2447	59703	1610	40996
Chile	3455	35539	2034	19242
Yugoslavia	-	-	624	11038
Saudi Arabia	-	-	567	5720
USA	351	7582	283	5059
Algeria	-	-	59	1618
Unspecified	284	2739	-	-
Other countries	7	386	143	2096

**Table – 12 : Imports of Sodium Borate
(By Countries)**

Country	2008-09		2009-10	
	Qty (t)	Value (Rs.'000)	Qty (t)	Value (Rs.'000)
All Countries	46214	1020727	42314	1070370
Turkey	24596	527401	23608	554961
USA	19519	435126	16863	457408
Spain	1434	37410	1617	51430
UK	179	4573	174	5403
Argentina	100	3119	25	725
Japan	18	614	25	355
Germany	27	3465	2	82
China	61	1698	++	6
Belgium	8	1781	-	-
Unspecified	217	3225	-	-
Other countries	55	2315	-	-

**Table – 13 : Imports of Borax : Other Borates
(By Countries)**

Country	2008-09		2009-10	
	Qty (t)	Value (Rs.'000)	Qty (t)	Value (Rs.'000)
All Countries	7702	254653	4999	231717
Turkey	3298	72727	2607	64568
USA	3186	97234	915	57504
China	651	51345	900	54275
Russia	-	-	4	15673
Germany	121	7103	125	14044
Slovenia	329	15829	192	10067
Austria	20	752	105	5492
Netherlands	8	1246	16	2395
Australia	44	2412	1	472
Finland	36	5313	-	-
Other countries	9	692	134	7227

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**Table – 14 : Imports of Boric Acid
(By Countries)**

Country	2008-09		2009-10	
	Qty (t)	Value (Rs.'000)	Qty (t)	Value (Rs.'000)
All Countries	10108	309126	7786	282304
Turkey	6502	185035	5100	178860
USA	1757	51237	1965	71743
Peru	192	8803	365	18682
Argentina	193	8888	199	7049
Korea, Rep. of	–	–	40	1678
Netherlands	–	–	42	1499
U K	–	–	39	1388
China	21	729	11	596
Chile	1242	45975	–	–
Malaysia	200	8340	–	–
Other countries	1	119	25	809

**Table – 15 : Imports of Boron
(By Countries)**

Country	2008-09		2009-10	
	Qty (t)	Value (Rs.'000)	Qty (t)	Value (Rs.'000)
All Countries	++	3517	1	2252
USA	++	3353	++	1524
China	–	–	++	572
Germany	++	65	1	155
Belgium	++	98	–	–
Other countries	++	1	++	1

FUTURE OUTLOOK

Increased usage of ceramic tiles will keep consumption of boron minerals in the enamels, frits and glazes end-use high. 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 will enhance the demand of borax for the production of fibre glass.