

BORON MINERALS



Indian Minerals Yearbook 2021 (Part- III : Mineral Reviews)

60th Edition

BORON MINERALS

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

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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, 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.

RESERVES/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 NMI data, based on UNFC system, the total reserves/resources of borax as on 1.4.2020, has been 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 Jaipur district, Rajasthan (Table-1).

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 is equal to 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. Its mild alkalinity and germicidal nature, enable its use 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

Table – 1 : Reserves/Resources of Borax as on 1.4.2020 (P)
(By Grades/States)

(In tonnes)

Grade/State	Reserves		Remaining Resources				Total Resources (A+B)
	Total (A)	Pre-feasibility STD221	Measured STD331	Indicated STD332	Inferred STD333	Reconnaissance STD334	
All India : Total	-	-	-	-	-	74204	74204
By Grades							
Unclassified	-	-	-	-	-	74204	74204
By States							
Jammu & Kashmir	-	-	-	-	-	74204	74204

4-3
Figures rounded off.

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.

Boron is an essential plant nutrient and boron compounds, such as, borax and boric acid are used as fertilizers in agriculture, although they are only required in small amounts, with excess being toxic.

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.

Sodium percarbonate can replace borates in detergents and requires lower temperatures to undergo hydrolysis, which is an environmental consideration. Some enamels can use other glass-producing substances, such as, phosphates. In soaps, sodium and potassium salts of fatty acids can act as cleaning and emulsifying agents.

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 CONCERNS

Natural borates are not very toxic to animals but can be toxic to plants 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, is engaged in refining of imported crude borates to produce borax and boric acid. The annual production capacity for all grades of borax and boric acid are 24,000 MT at Dahej, GIDC in the State of Gujarat. Apart from two other producers, National Peroxide Limited (NPL) located at Kalyan district, Maharashtra, is the largest producer of Hydrogen Peroxide in the country.

During the year, the Company completed the expansion of its plant situated at Kalyan which resulted in an increase in the plant rated capacity from 95,000 MT per annum to 1,50,000 MT per annum based on 50% (w/w) Hydrogen Peroxide levels.

NPL is a pioneer in Hydrogen Peroxide Industry in India and has been at the forefront in development of technology, brand image and market share in the country. Indo Borax and Chemical Limited operates borax and boric acid plants at Pithampur, Madhya Pradesh.

Ferroboration is a boron ferroalloy containing 0.2% to 24% boron used primarily to introduce small quantities of boron into speciality steels.

WORLD REVIEW

The world reserves of boron in terms of boric oxide are furnished in Table-2.

Turkey was the leading producer of borates followed by USA, Kazakhstan, Chile, China and Bolivia (Table-3).

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

(In '000 tonnes of boric oxide)

Country	Reserves
World: Total⁽¹⁾	xx
Argentina, crude ore	NA
Bolivia, ulexite	NA
Chile, ulexite	35000
China, boric oxide equivalent	24000
Germany, compounds	NA
Peru, crude borates	4000
Russia, datolite ore	40000
Turkey, refined borates	120000
USA	40000

Source: USGS, Mineral Commodity Summaries, 2022.
1 World totals could not be calculated because production and reserves are not reported in a consistent manner by all countries.

xx: Not applicable

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

(In metric tonnes)

Country	2018	2019	2020
Turkey	3970486	8555690	2819111
USA ^(a)	1300000	1300000	1300000
Kazakhstan	500000	500000	500000
Chile	398411	352255	288103
China ^(b)	75000	250000	250000
Bolivia	232268	214500*	258143
Peru	100552	111108	43645
Argentina	71212	181818	134604
Russia*	80000	80000	80000
Iran ^(c)	1200	2519	2500

Source: BGS, World Mineral Production, 2016-20,
a: Soblor used by producers, b: B₂O₃ equivalent.
*: Estimate, a: Sold or used by producers, b: B₂O₃ equivalent,
c: Years ended 20 March following that stated.

To provide a generalised view of the development in various countries, the contrywise description sourced from latest available publication of Minerals Yearbook 'USGS' 2018 has been furnished as below.

Turkey

The first known instances of borate mining in Turkey date to Roman times, with borate mining continuing to this day. Approximately 73% of the world's boron reserves are in Turkey, with the Kirka deposit at Eskisehir reported to be the largest tincal deposit in the world. The main borate producing areas of Turkey, all controlled by the state-owned mining company Eti Maden AS, were Bigadic (colemanite and ulexite), Emet (colemanite), Kestelek (colemanite, probertite, and ulexite), and Kirka (tincal). Eti Maden opened warehouses and logistic centers with a company based in Hong Kong to distribute their products from a location closer to the majority of their customer base. Production of refined borates was expected to increase over the coming years owing to investment in new refineries and technologies. Eti Maden continued to invest in the production of boron carbide, boron nitride, and ferroboration owing to their importance in many industries, including the electronics, iron, and steel industries. In 2018, Eti Maden and China's Dalian Jinma Boron Technology Group Co., Ltd. signed a Memorandum of Understanding to build a boron carbide processing facility in Balikesir. Although this facility will process mostly boron carbide, boron nitride and ferroboration were also projected to be processed. As a result of boron carbide's numerous uses in the defense industry, it was expected to become a significant export for Turkey.

Argentina

Argentina was estimated to be the second-ranked producer of boron minerals in South America in 2018. Borate deposits are located primarily in the Puna region, which includes the northwestern tip of Argentina, the southeastern corner of Peru, the southwestern corner of Bolivia, and the northeastern border of Chile. The principal markets for borates produced in Argentina were throughout South America Borax Argentina S.A. (a subsidiary of Orocobre Ltd.), the country's leading producer of borates, operated the Tincalayu and Sijes Mines, the largest open pit operations in the country, which are 4,100 m (13,500 feet) and 4,540 m (14,900 feet) above sea level, respectively. Record-high production was reported at Borax Argentina's boric acid plant and Tincalayu open pit operation. Tincalayu deposits consisted primarily of borax, with rare occurrences of ulexite and 15 other borates with a reported production of 36,553 tonnes in 2018. Orocobre was reviewing an expansion study for their Tincalayu operation. The expansion could possibly increase Tincalayu's refined-borate-processing capacity from 30,000 metric tonnes per year (tonnes/year) to approximately

120,000 tonnes/year of borax dehydrated equivalent. The expansion review also includes a boric acid plant with a capacity of 40,000 tonnes/year. A project to build a gas pipeline to supply the expanded plant was approved in early 2018. Minera Santa Rita S.R.L.(MSR) operated mines in Catamarca, Jujuy, and Salta Provinces and operated a processing plant in Campo Quijano, which produced granular deca- and pentahydrate borax, technical-grade boric acid powder, and various grades and sizes of natural boron minerals. MSR exported the majority of its mined borates to 28 countries through the Port of Buenos Aires and by land to Brazil.

Chile

Chile was the leading borate compound producer in South America with boric acid production estimated to be 100,000 tonnes and ulexite production estimated to be 600,000 tonnes in 2018. The largest ulexite deposit in the world, Salar de Suirire, was operated by Quiborax SA, a Government entity with reserves estimated to be 1.5 million metric tonnes (Mt). Almost all the material mined at this location was exported in 2018. Quiborax operations have a boric acid production capacity of 36,000 tonnes/year, in addition to 100,000 tonnes/year capacity of borate derived agrochemical products. In May 2018, the 14-year-long dispute between the Bolivian Government and Quiborax came to an end with a ruling in favor of Quiborax. The Bolivian Government must now pay Quiborax \$48.6 million for the land seized in 2004 that was used for the company's ulexite mining and revoked mining concessions.

China

China has low-grade boron resources. More than 100 borate deposits occur in 14 Provinces in China. The northeastern Province of Liaoning and the western Province of Qinghai accounted for more than 80% of the resources, mostly in the form of sassolite and tincal. China's boron resources average about 8% B₂O₃ in comparison with reserves from Turkey and the United States, which average from 26% to 31% and 25% to 32% B₂O₃, respectively.

Serbia

Erin Ventures Inc. (Canada) entered into a strategic partnership with a London-based commodity investment company, acquiring funds needed to continue development of the Piskanja Borate Project. Piskanja is a mining region in Serbia approximately 250 km (155 miles) south of Belgrade. The deposit is primarily composed of colemanite and ulexite with estimated reserves of 11.8

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

FOREIGN TRADE

Exports

Exports of borax (total) increased considerably by 1% to 2,996 tonnes in 2020-21 from 2,977 tonnes in the previous year. Exports of natural borate in 2020-21 decreased substantially to 55 tonnes from 214 tonnes in the previous year. In 2020-21, exports of sodium borate were at 741 tonnes and other borates at 2,200 tonnes. Exports of Borax (total) were mainly to USA (46%), Italy (10%), Syria & Nepal (6% each), Poland (5%) and UAE (3%). Exports of boric acid increased by 28% to 1,952 tonnes in 2020-21 from 1,520 tonnes in the previous year. Exports of boric acid were mainly to Iran (40%), Nigeria (17%), Nepal (7%) and Uganda (5%) (Tables-4 to 9).

Imports

Unlike exports, imports of borax (total) increased slightly by 10% to 1,94,448 tonnes in 2020-21 from 1,76,421 tonnes in the previous year. Imports of natural borate also decreased slightly by 2% to 83,207 tonnes as compared to 84,699 tonnes in the previous year. In 2020-21, imports of sodium borate were at 1,01,477 tonnes and other borates 9,764 tonnes. Borax (total) was mainly imported from Turkey (57%), USA (21%), Spain (15%) and Bolivia (8%). Imports of boric acid decreased to 6,897 tonnes in 2020-21 from 4,826 tonnes in the previous year. Boric acid was imported mainly from Turkey (81%), Singapore (15%), and Peru (2%). Import of boron was negligible in both current and the previous year (Tables-10 to 15).

**Table – 4 : Exports of Boron
(By Countries)**

Country	2019-20 (R)		2020-21 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	++	91	5	525
Nepal	-	-	5	198
Sudan	-	-	++	131
USA	++	29	++	117
UK	++	25	++	51
France	-	-	++	20
Spain	-	-	++	8
Bangladesh	++	25	-	-
Portugal	++	12	-	-

Figures rounded off

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**Table – 5 : Exports of Borax
(By Countries)**

Country	2019-20 (R)		2020-21 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	2977	359860	2996	414601
USA	940	175743	1391	263087
Italy	315	41462	304	36116
Poland	240	30818	140	17212
Bangladesh	155	18372	74	15598
Syria	156	6813	188	9846
South Africa	37	6189	73	9796
Oman	45	9774	64	9387
Nepal	274	11733	187	9063
UAE	77	4365	81	7070
Australia	64	10862	44	5355
Other countries	674	43729	450	32071

Figures rounded off

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

Country	2019-20 (R)		2020-21 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	214	6806	55	5633
Oman	-	-	27	2417
Saudi Arabia	++	1	14	2073
Kuwait	4	272	12	753
UAE	-	-	2	360
Zambia	-	-	++	18
Nigeria	-	-	++	12
Argentina	210	6526	-	-
USA	++	5	-	-
Egypt	++	1	-	-
Kenya	++	1	-	-

Figures rounded off

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**Table – 7 : Exports of Sodium Borate
(By Countries)**

Country	2019-20 (R)		2020-21 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	773	54235	741	56265
USA	25	17354	25	21815
Nepal	251	9872	151	6519
Syria	-	-	96	5637
Myanmar	88	3669	88	4016
Tanzania	2	83	92	3707
Malaysia	++	16	75	3509
Saudi Arabia	++	17	44	1936
UAE	48	1688	49	1806
South Africa	-	-	40	1666
Australia	24	1182	24	1310
Other countries	335	20354	57	4344

Figures rounded off

**Table – 9 : Exports of Boric Acid
(By Countries)**

Country	2019-20 (R)		2020-21 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	1520	121969	1952	160749
Iran	168	8577	777	43689
Nigeria	218	17901	326	27384
Nepal	129	9909	137	10942
USA	67	11857	50	9815
Uganda	48	4033	95	9335
Cote D'Ivoire	27	2222	40	3757
Congo D.Rep.	47	4225	36	3533
Guinea	11	916	28	3265
Kenya	88	6980	26	3054
Rwanda	14	1265	27	2996
Other countries	703	54084	410	42979

Figures rounded off

**Table – 8 : Exports of Borax: Other Borates
(By Countries)**

Country	2019-20 (R)		2020-21 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	1990	298819	2200	352703
USA	915	158384	1366	241272
Italy	315	41462	304	36116
Poland	240	30818	140	17212
Bangladesh	94	16517	74	15449
South Africa	37	6189	33	8130
Oman	45	9771	37	6904
UAE	29	2677	30	4904
Syria	156	6813	92	4209
Australia	40	9680	20	4045
France	-	-	21	3484
Other countries	119	16508	83	10978

Figures rounded off

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

Country	2019-20 (R)		2020-21 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	176421	5644322	194448	6337254
Turkey	112539	3295226	111804	3426889
USA	37463	1336546	41604	1520214
Spain	8522	308061	10461	417300
Malaysia	920	30176	7467	252633
Bolivia	9434	143418	15020	235104
China	1519	170647	1348	158480
Argentina	2045	62675	3628	105296
Singapore	1663	59882	1898	71848
UK	681	132379	220	45089
Austria	424	34950	262	23733
Other countries	1211	70362	736	80668

Figures rounded off

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

Country	2019-20 (R)		2020-21 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	84699	2157324	83207	2113660
Turkey	65016	1672500	54464	1379528
Spain	8328	295846	10443	411949
Bolivia	9434	143418	15020	235104
Argentina	1160	29936	3280	87005
Japan	-	-	++	74
Chile	684	10171	-	-
USA	36	3330	-	-
Oman	13	1420	-	-
Peru	28	692	-	-
China	++	7	-	-
Other countries	++	4	-	-

Figures rounded off

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

Country	2019-20 (R)		2020-21 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	81531	2776165	101477	3557620
Turkey	42985	1427884	52927	1823516
USA	35851	1236246	39794	1412759
Malaysia	920	30176	7392	249124
Singapore	216	6784	719	25498
Netherlands	108	12369	119	15073
China	56	4305	100	8445
Argentina	780	23678	216	6727
Peru	56	4073	84	6442
Germany	4	6300	2	4132
UK	355	13003	100	3242
Other countries	200	11347	24	2662

Figures rounded off

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

Country	2019-20 (R)		2020-21 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	10191	710833	9764	665974
Turkey	4538	194842	4413	223845
China	1463	166335	1248	150035
USA	1576	96970	1810	107455
Singapore	1447	53098	1179	46350
UK	326	119376	120	41847
Austria	424	34950	262	23733
Peru	140	10142	196	15110
Argentina	105	9061	132	11564
Slovenia	114	6463	109	9186
Slovakia	-	-	114	7429
Other countries	58	19596	181	29420

Figures rounded off

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

Country	2019-20 (R)		2020-21 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	4826	210517	6897	313194
Turkey	2344	101845	5581	251826
Singapore	1281	55425	1028	45874
Peru	421	17668	150	6814
USA	513	21678	98	4924
China	50	3363	40	2909
Germany	5	877	++	788
Japan	1	111	++	50
France	-	-	++	4
Malaysia	-	-	++	3
UK	++	12	++	2
Other countries	211	9538	-	-

Figures rounded off

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

Country	2019-20 (R)		2020-21 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	++	2193	++	1899
Hong Kong	-	-	++	850
China	-	-	++	591
Germany	++	337	++	158
Belgium	++	162	++	131
USA	++	1061	++	124
UK	++	131	++	45
Canada	++	502	-	-

Figures rounded off

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 for the foreseeable future. In 2013, the European Union (EU) added borates to the Registration, Evaluation, Authorisation and Restrictions of Chemicals (REACH) Restricted Substances List, following an EU study that determined continuous exposure to humans may be harmful. The ruling required detergent makers to decrease their use of boron (Lismore, 2012). Consumption of boron-based fertilizers is

expected to increase as the demand for food and biofuel crops is on the rise. Higher crop prices have enabled farmers to invest in advanced farming techniques and higher grade fertilizers.

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 for a variety of emerging applications. Hexagonal boron nitride is used in producing ceramics, creating intermetallic composites, imparting thermal shock resistance, improving machinability and reducing friction.