

BORON

By a Special Contributor

Boron does not occur naturally as a free element but in oxygenated compounds or borates, most commonly as sodium borate in minerals such as kernite and tincal (natural borax), or as calcium borate, eg colemanite. Deposits are sedimentary and generally associated with evaporites or geothermal springs. The deposits range in age from Permian to Recent, with the more important ones formed during the Miocene and Upper Pliocene.

Some of the largest deposits of sodium borate are located in the Mojave Desert of California whilst colemanite is an important component of the Emet deposits in Turkey. In Russia, the magnesium borate mineral, szaibelyite, is exploited and the calcium borosilicate mineral datolite, which is mined at Dalnegorsk and refined to produce boric acid and synthetic calcium carbonate. In the US, tincal and kernite ores and brines are the principal sources of refined borate chemical compounds, the most common products being borax pentahydrate and anhydrous borax. Colemanite is commonly sold as a calcined powder or as a concentrate. Boric acid, a white crystalline solid, is sold in a variety of grades as granules or powder.

Boron compounds are used in a wide variety of products and manufacturing processes, and there are currently over 300 industrial and specialty applications, including: fluxes; agriculture; fire retardants; corrosion inhibition; lubricants; glass forming; detergents; ceramics; neutron absorption; and wood treatment.

In 2002, demand improved in the Asia Pacific region and in North America where sales were aided by strong construction activity. In the previous year, a combination of depressed economic conditions in the US, the Brazilian energy crisis, and product substitution in the perborate sector resulted in a 4% fall in global B_2O_3 demand. There was continued substitution of perborates in 2002 but this was partially offset by a tighter market for boric acid (H_3BO_3).

Consumption and uses

Fibre-glass manufacture is the largest single end use of borates. This application alone consumes nearly one third of the global B_2O_3 production. Sodium borates are a critical ingredient in insulation fibre-glass formulations as they promote glass forming at reduced temperatures and enhance the insulation properties of the final product. North America is the largest regional market for insulation fibre glass.

Borates also play an important role in the production of continuous strand and textile fibre glass. Boric oxide reduces the liquidus temperature of the glass to prevent devitrification during fibre forming. It also lowers the surface tension of the molten glass to allow for smooth fiberisation at the bushing. Borate demand by textile fibre-glass manufacturers was reduced significantly during

2001 due to high product inventories resulting from the economic downturn. Modest recovery in the continuous strand fibre-glass sector was expected in the second half of 2002.

Perborate, as an oxygen-carrier in detergent bleaching systems, is another important end use for borates, particularly in Europe. This market has faced stiff competition in recent years due to substitution by sodium percarbonate, and declined by 10-15% in 2001 to approximately 120,000 t of B₂O₃. Borates are also widely used in washing liquids and household cleaning products.

Borates are used in the manufacture of frits and glazes to increase the strength, scratch resistance, and chemical resistance of ceramic wares such as wall and floor tiles, tableware and porcelain as well as enameled appliances. These applications account for about 15% of borate sales.

Borosilicate glass applications consumed about 10% of global B₂O₃ production. The addition of borate to glass formulations increases thermal resistance and mechanical strength, and enhances aqueous and chemical durability. Growth in the borosilicate glass sector has generally been flat to negative in recent years due to product substitution by tempered glass and plastics.

In agriculture, boron is considered an essential micronutrient for crops, accounting for about 8% of global B₂O₃ consumption. Cotton, oil palm, coffee and sugar beet are examples of crops that are boron susceptible.

New applications

During the year, Rio Tinto's subsidiaries, Rio Tinto Borax and the Luzenac Group, continued with their development of autocausticising technology for use in the kraft paper process. Borates react with part of the sodium carbonate in the recovery boiler to form a borate compound which converts to sodium hydroxide when hydrated. The process requires little capital investment and reduces lime and energy requirements whilst retaining the viscosity, brightness and strength of the paper produced. Talc is used as a coating pigment and a filler in the paper.

In the longer term, an intriguing potential new application for borates reported by Rio Tinto Borax is the use of sodium boro-hydride as an important component in hydrogen-based fuel cells. Although currently prohibitively expensive relative to fossil fuels, hydrogen-based fuel cells could eventually prove to be an environmentally-friendly alternative for powering motor vehicles.

Production

The US is the largest borate-producing country, accounting for more than 45% of global production, and about 50% of domestic production of boron compounds is exported. The estimated value of boric oxide contained in minerals and compounds last year is estimated by the the United States Geological Survey (USGS) at US\$468 million.

Turkey contributes about 30-35% of world production and is the largest ore producer. The South American countries - Argentina, Bolivia, Chile and Peru combined - account for slightly less than 10%, with the remainder coming from China and Russia. The USGS reports world ore production last year at 4.8 Mt (2001:4.6 Mt), with the US contributing 1.2 Mt, Turkey 1.5 Mt, Russia 1.0 Mt, Argentina 500,000 t, Chile 330,000 t and China 150,000 t. The USGS estimates that Turkey has the largest reserves, with 60 Mt, and a reserve base of 150 Mt, followed by Russia (40 Mt and 100 Mt), the US (40 Mt and 80 Mt) and China (25 Mt and 47 Mt).

World supply is dominated by two companies, Rio Tinto Borax and Eti Holdings. Between them, they supply around 75% of the borates used in the world.

Rio Tinto Borax, a wholly owned subsidiary of Rio Tinto plc, produces a wide range of refined industrial and speciality borate products from its mines at Boron, in the Mojave Desert, California, and from brine solution operations in Salta Province, Argentina. Output of B₂O₃ in 2002 totalled 529,000 t, 6% lower than the 564,000 t produced in 2001. The Boron operations contributed 514,000 t (549,000 t) and in Argentina, the Tincalayu, Sijes, Porvenir and Maggie operations contributed 15,000 t, unchanged from the previous year. In August 2002, Rio Tinto Borax announced that it was going ahead with the construction of a US\$2.6 million boric acid plant in Argentina, adjacent to its Campo Quijano refinery, with completion scheduled for early 2003. By 2005, Borax is planning to increase its boric acid capacity by 90,000 t/y.

Borax contributed US\$92 million to Rio Tinto's earnings in 2002, 10% lower than in 2001. Sales were slightly higher and the cost reduction programme continued but this was more than offset by reduced pension credits and a higher effective tax rate. In the first half of 2003, net earnings were down slightly and sales showed only a marginal improvement, but production was 8% higher.

The other main US producers are IMC Chemicals (IMCC), a subsidiary of IMC Global Inc., and American Borate Co. ABC supplies borate minerals from its underground mine in Death Valley, California, and processes ore in Nevada for overseas export. IMCC produces soda ash and industrial borates from brines at Searles Lake, California, and efforts continued through the year for the assets to be divested.

Eti Holdings is a Turkish State Economic Enterprise (SEE), producing borate minerals and refined products from its four mines in western Turkey. Approximately 90% of production is exported although the company is making efforts to add value to its products and is committed to a substantial investment programme. A third production line at its Kirka sodium borate pentahydrate plant was commissioned in 2001, raising capacity from 320,000 t to 480,000 t/y, and at Emet it is building a new boric acid plant that is scheduled to produce at the rate of 100,000 t/y beginning in 2003. During 2002, it was planned to increase capacity at the Bandirma plant from 45,000 t to 60,000 t/y. Eti Holdings is also constructing a 240,000 t/y capacity acid plant near Bandirma that will use pyrite to

supply sulphuric acid for the boric acid plants at Emet and Bandirma. Construction has been awarded to an SNC-Lavalin/Dogan consortium.

In Eti Holdings' 2000 Annual Report, the chairman outlined plans to increase borate refining capacity from 500,000 t to 1.2 Mt/y in line with its policy to produce and market value-added products rather than boron minerals and concentrates for export. In December 2000, Eti Holdings was placed in the 'scope of privatisation' in response to calls from the IMF for Turkey to hasten privatisation of state-owned industry. However, removal of the borate mines from state control met strong resistance, and the company was returned to its SEE status.

In South America, borates occur mainly as 'salar' type deposits high in the Andean Altiplano where they are exploited by a number of smaller operators, producing a variety of mineral products and refined borates. In Argentina, apart from Rio Tinto Borax, which produces refined sodium borates and fused products, the other operators include Ulex SA, producing graded mineral products, and Procesadora de Boratos Argentinos, producing calcined mineral concentrates. In addition, there are two small boric acid producers and several independent minerals operations.

In Bolivia, borates occur in salars in the south west of the country. The main producer, Tierra Ltda, based at Apacheta, halted boric acid production in 2000.

Chilean borate production is from two main producers, Quiborax, with operations based on ulexite (sodium calcium borate) extracted from the Salar de Surire in northern Chile, and SQM which produces granulated ulexite to complement its range of agricultural products, and boric acid.

Peru's sole borate producer, Inkabor, is a subsidiary of Gruppo Colorobbia of Italy. It mines ulexite at Laguna Salinas in southern Peru, and processes the ore at Arequipa and Lima to produce boric acid and other refined and mineral products.

Chinese borate production is based mainly in Liaoning and Jilin Provinces in northeast China, with minor production in Xizang (Tibet). In northeast China, the magnesium borate, szaibelyite, is mined and refined in numerous small state-owned or privatised plants. The principal product is borax decahydrate, sold mainly in the domestic market. Total Chinese production is estimated to represent about 7% of global production.

In Russia, the main borate producer is the Bor operation at Dalnegorsk in the Russian Far East, where the borosilicate mineral, datolite is mined and refined to produce boric acid and synthetic calcium borate. Around three years ago, the operation was returned to the administration of the regional government, after the Energomash-Bor joint venture had been declared illegal. Production, which had come to a standstill for two months, quickly returned to normal. Refurbishments are expected to double boric acid capacity to 240,000 t/y and increase output of other borate products from 100,000 t to 140,000 t/y. The most serious obstacle preventing borate products from Dalnegorsk reaching world markets is transportation.

Outlook

At the present time, the market seems poised for a slow recovery during the second half of 2002 and first half of 2003, though recent increases in energy costs could dampen expectations. Global boric acid supply is projected to tighten considerably over the next year. The overall borate market is considered to be relatively mature with a long-term global average growth rate of about 1% per year.