BERYLLIUM

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Beryllium is a very light, strong metal with a high melting point of 1,280°C, good resistance to acids and a high thermal conductivity. These properties make beryllium very useful in a number of applications as a metal, as part of an alloy or as a ceramic. However, the high processing costs associated with beryllium restrict its use to areas where there are no practical alternatives or where performance is critical.

The majority of world beryllium ore production, around 80% in 2003, took place in the US, as shown in Table 1. Most of the remaining output came from China and Brazil. Mining of beryllium minerals may also have taken place in Madagascar, Portugal and Zambia but no official production statistics are available. Beryllium ore production in Russia and Kazakhstan stopped during the 1990s. Beryllium mining was recorded in Argentina, Namibia and Zimbabwe prior to 1996.

A possible new source of beryllium is the Etykinskoye rare metals deposit in Russia where a mine has been under construction since 2000. The first stage of an associated processing plant was completed in 2000 and can handle 750,000 t/y of ore. The plant currently produces tantalum-niobium concentrate but future plans are for the output of 20,000 t/y of lithium and 30,000 t/y of beryllium in concentrates.

Brush Wellman is the sole US beryllium ore producer and mines bertrandite in Utah. In China, the Ningxia non-ferrous metals smeltery has been reported as mining beryllium ores. In Brazil, Esmeralda de Conquista, part of the Mineração Badin Group, has reportedly stockpiled its production of beryl since the early 1990s but may have restarted exports in 2001. Piteiras Mineração of Minas Gerais produces beryllium concentrate based on industrial beryl and gems, which is further processed to produce emerald and industrial beryl.

Production by main companies

Brush Wellman of the US is the only known fully-integrated beryllium company in the world. In May 2000, Brush Wellman became a wholly-owned subsidiary of Brush Engineered Materials (part of its Metal Systems Division, which is further divided into Alloy Products, Technical Materials and Beryllium Products). The Microelectronics Division includes Brush Ceramics Products, which produces beryllium ceramics.

The amount of bertrandite ore processed by Brush Wellman fell from 113,000 t in 1998 to 41,000 t in 2003. Production of beryllium by the company is shown in Table 2. The company reports that the recovery rate of beryllium from the bertrandite is around 87%.

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Bertrandite is used to produce beryllium hydroxide concentrate at Brush Wellman's Delta plant in Utah. The concentrate is then used to produce beryllium metal and alloys at Elmore in Ohio ceramic grade powder at Lorain in Ohio and strip and wire products at Reading in Pennsylvania. Ceramic powder from Lorain is also supplied to the company's plants in Tucson in Arizona and Newburyport in Massachusetts. The Electrofusion Products plant at Fremont California is a fully-integrated producer of beryllium windows.

In 2003, reported sales by the Metal Systems Division were US$239.4 million, compared with US$378.2 million in 2000. Alloy Products accounted for 67.8% of sales, Technical Materials 17.5% and Beryllium Products 14.7%. By 2003, revenues from the Beryllium Products business had risen for four consecutive years, largely following growing demand from the defence sector. Sales of beryllium ceramics were unchanged in 2003 compared with 2002.

In the US, NGK Metals, Starmet and Advanced Industries International produce beryllium products using raw materials supplied by Brush Wellman. Starmet, formerly known as Nuclear Metals Incorporated, jointly developed beryllium-aluminium (BeAl) alloys with Lockheed. Starmet later developed a family of BeAl alloys under the trade name Beralcast®. In October 2000, Advanced Industries International purchased the National Beryllia Division of General Ceramics, which was the second-largest US producer of beryllium oxide ceramics.

NGK Metals Corp, part of NGK Insulators of Japan, is one of the largest producers of beryllium-copper (Be-Cu) alloy castings, strip, rod bar and plate products in the world from its plants in France, Japan and the US. By 2000, the company expected to be capable of producing 600 t/mth of Be-Cu products following a series of investments. In October 2000, the company commissioned a mill-hardening furnace at its Chita plant in Handa City, Aichi Prefecture in Japan, which increased capacity to 400 t/mth. The Chita plant melts and casts Be-Cu into billets. In 1998, NGK Metals spent US$12 million on its Sweetwater plant in the US, mainly on the installation of the first Be-Cu alloy continuous caster in the world, which raised production capacity to around 100 t/mth. In France, NGK has been reported to be adding a new pickling line and to be considering the addition of a new mill-hardening kiln to its Coueron plant. The capacity of the plant was estimated to rise to 100 t/mth following the investment.

The Ulba metallurgical plant in Kazakhstan was the largest beryllium product manufacturer in the former USSR. The plant mainly used beryllium concentrate from mines in Russia but stopped imports in the mid-1990s, partly because it had accumulated considerable stocks of material. This eventually led to the end of Russian beryllium concentrate production during 1997. Ulba reportedly holds sufficient stocks of beryllium concentrate to support production for decades. In 2000, the plant restarted production of beryllium metal, followed in 2001 by technical grade beryllium hydroxide and Be-Cu.

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According to the National Statistical Agency of Kazakhstan, Ulba produced 737 t of beryllium products in 2001, an increase of 71% on 2000 output.

In 2000, Ulba began a US$13 million five-year investment programme in its beryllium business that will include the following:

- Be-Cu master alloy (BCMA) capacity to be increased by 3,000 t/y using carbothermic reaction technology;
- Development of digestion and refining production methods for beryllium hydroxide to international standards;
- Introduction of new techniques to convert beryllium concentrates using existing capacity of up to 200 t/y; and
- Be-Cu product range to be extended and capacity raised by up to 1,000 t/y.

In September 2002, Ulba and the Moscow Precious Metals Processing Plant (MZOTsM) established BerylliUM Ltd, a 50:50 joint venture. The joint venture was set up to increase sales of Be-Cu products in Russia. UMP supplies billets to MZOTsM for the production of Be-Cu and beryllium bronze products. In January 2003, the joint venture started sales of Be-Cu products in Russia and Belarus. This was followed in June 2003 by the signing of an agreement with Tropag Oscar H. Ritter Nachf GmbH of Germany for the sale of Be-Cu rolled products in Europe. Finally, in August, BerylliUM started sales of Be-Cu rod and wire and also rods, cast cylinder billet and plates made of Cu-Co-Be alloy. From March 2004, the company planned to start selling Be-Al master alloy in ingot form produced by UMP.

In China, Ningxia Non-ferrous Metals Smeltery (NNMS) and its subsidiary Ningxia Tantalum Orient produce Be-Cu strip, rods, wire and beryllium sheet and strip. NNMS is also reported to be the only domestic producer of beryllium raw materials. Shuikoushan Nonferrous Metal Company (SNMC) reportedly operates the only beryllium smelter in Asia. SNMC also produces beryllium bronze cast alloy, beryllium oxide, beryllium beads and Be-Cu master alloy. In 2002, SNMC was reported to have significantly expanded its beryllium production capacity. The combined capacity of these companies has been estimated at 500 t/y gross weight of beryl or about 20 t/y of beryllium, mainly in the form of beryllium copper alloys.

Applications

Alloys are the most common form of beryllium product, accounting for an estimated 75% of US consumption. In the US, ceramics (15%) incorporating beryllium oxide, also known as beryllia, are the next most important form of beryllium followed by metal (10%).

Beryllium-copper is the most commonly used type of beryllium alloy. Beryllium-copper alloys are divided into two types: high strength, typically containing between 1.6% and 2% beryllium, and high conductivity, containing around 0.3% beryllium. High-strength alloys are used in telecommunications

applications and high- conductivity alloys in automotive markets. Beryllium copper is also used in drilling equipment, aircraft landing gear and other heavy industrial machinery.

Beryllium-aluminium alloys are becoming increasingly important in terms of beryllium consumption because of their high beryllium content, up to 65% by weight. Applications include aerospace, hard disc drives and brakes.

Beryllium oxide ceramics have excellent electrical insulation properties and a high thermal conductivity. These characteristics, together with a high melting point of 2,570°C and resistance to chemical attack, mean that beryllium oxide ceramics are used in a wide variety of applications in electronics. These include heat sinks for electronic and microelectronic applications. The telecommunication and computer industries use beryllium oxide ceramics in substrates, where performance and the need for high levels of reliability and heat dissipation outweigh the cost.

Beryllium metal is used in military aircraft, spacecraft, inertial guidance systems, high performance brakes and space optical systems because of its strength, low weight and stability over a wide range of temperatures. Other uses for beryllium metal include in reflectors for research nuclear reactors and x-ray windows.

Trade

US trade in beryllium, either exporting beryllium products or importing raw or scrap materials for processing, is a major component of the world total. The US Government imposes import tariffs of 3.7% on beryllium oxide or hydroxide, 5.5% on wrought beryllium and 8.5% on beryllium waste and scrap on imports from countries with normal trade relations. All other forms of beryllium can be imported free of tariff.

The majority of reported world beryllium trade is in the form of waste, scrap, powder, wrought and unwrought material. The most commonly traded type of beryllium material is almost certainly beryllium-copper alloy but data are not generally available.

In 2000, Brush Wellman and Ulba signed an agreement under which the later would supply Brush Wellman with Be-Cu master alloys. This agreement was amended in 2001 and 2003 and the purchase commitments reduced. The 2003 amendment added beryllium vacuum cast billet and extended the agreement to 2012. Ulba has also concluded supply agreements with Chinese organisations and in February 2003 exported an unknown amount of beryllium products to China. The company was also reported to be planning to arrange “extremely large deliveries” of beryllium to China in the future and sees the Chinese market as “very important”.

In 2001, 185 t of crude beryllium products were exported from Brazil, the first such exports since 1995. The majority, 89%, was exported to the US, almost

certainly to Brush Wellman for use as feedstock. The material shipped was probably beryl from Esmeralda de Conquista. In 2002, a further 36 t of crude beryllium products were exported from Brazil.

The only known significant reported trade in beryllium oxide is between US and Chinese companies, and consumers in Japan.

Stocks

The US Government has long held quantities of beryllium in the National Defense Stockpile Center (NDSC) in order to guarantee supplies to the defence industry in times of conflict. These and stocks of other strategic metals and minerals have been progressively reduced over the past decade.

In Fiscal Year 2003, the NDSC sold around 43 t of vacuum-cast beryllium from the national stockpile to Ulba. For Fiscal Year 2004, the NDSC has announced maximum disposal limits of 3,630 t of beryl ore (around 145 t Be content), 1,090 t of Be-Cu master alloy (about 44 t Be content) and 36 t of beryllium metal.

Market trends

World consumption of beryllium is forecast to rise slowly by perhaps 2% annually in the short to medium term. Production and stockpiles are sufficient to meet current and short/medium term demand. This is likely to discourage the development of new sources of beryllium raw materials, with the possible exception of the Etykinskoye deposit in Russia.

In 2003, defence applications accounted for two-thirds of the sales from the Beryllium Products part of the Alloy Products division of Brush Wellman. Sales of beryllium alloy strip rose in 2003 but those of bulk products declined. The rise in sales of strip products resulted from higher demand for products, with higher beryllium contents. Sales of these products rose by 22%, compared with 2002. Sales of thin-diameter rod and wire products also rose in 2003.

Demand for beryllium, especially in the form of alloys, fell in 2001 and 2002 following a fall in consumption by the telecommunications and computer industries. This fall continued in the first three quarters of 2003 but sales started to recover in the fourth quarter. Beryllium product manufacturers became increasingly reliant on these markets in the late 1990s and suffered accordingly when demand fell.

Miniaturisation of electronic products requires the use of strong materials, such as Be-Cu alloys, able to cope with higher operating temperatures. Rising electronic contents of automobiles and the use of higher voltages could lead to higher demand for Be-Cu alloys. The use of Be-Al alloys in aerospace applications is growing, especially in defence projects, but from a low base. Demand for beryllium oxide ceramics for use as substrates was static in 2003 but could grow as ever more powerful computer chips generate larger amounts of heat that must be rapidly dissipated. Beryllium metal consumption

did rise in 2003 but remains concentrated in defence applications, such as refits of the F-16 and the new F22.

Table 1 World Production of Beryllium Ores by Country (t gross weight)[1]

	2001	2002	2003
Brazil	12	12	12
China[e]	500	500	500
Madagascar[e]	1	1	1
Portugal[e]	5	5	5
Russia[e]	-	-	-
US	2,480	1,970	2,000
Zambia[e]	7	7	7
World total	3,005	2,495	2,525

e=estimated

Table 2 Brush Wellman: Estimated production of beryllium (t Be content)[1]

	2001	2002	2003
Bertrandite ore processed (t)	48,000	40,000	41,000
Beryllium grade (%)	0.219	0.232	0.232
Estimated beryllium recovered (100%)	105.12	92.80	95.12
Estimated beryllium recovered (87%)	91.45	80.74	82.75

Source: Brush Wellman and Roskill Information Services Ltd