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BERYLLIUM [ADVANCE RELEASE]

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BERYLLIUM

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U.S. mine shipments of beryllium ore in 2007 decreased slightly from those of the previous year, while ore consumption for the production of beryllium hydroxide increased (table 1). The Defense National Stockpile Center (DNSC) of the U.S. Department of Defense offered and sold selected beryllium materials from the National Defense Stockpile (NDS). On the basis of estimated contained beryllium, total U.S. imports of beryllium materials were higher and total U.S. exports were lower than those of 2006.

Beryllium is gray in color and one of the lightest metals. Its other physical and mechanical properties—outstanding stiffness-to-weight and strength-to-weight ratios, one of the highest melting points of all light metals, high specific heat, excellent thermal conductivity, outstanding dimensional stability over a wide range of temperatures, reflectivity, the lowest neutron absorption cross section of any metal and a high neutron-scattering cross section, and transparency to x rays—make it useful for many applications. Beryllium is used primarily as beryllium-copper alloys, beryllium oxide ceramics, and beryllium metal in a wide variety of products in aerospace, automotive, computer, defense, electronics, heavy machinery, home appliance, industrial component, instrumentation and control system, medical, nuclear, oil and gas drilling, plastic molding, telecommunications, undersea and marine, and other applications.

Only two beryllium minerals are of commercial importance for the production of beryllium. Bertrandite, which contains less than 1% beryllium, is the principal beryllium mineral mined in the United States. Beryl, which contains about 4% beryllium, is the principal mineral mined in the rest of the world. Aquamarine, bixbite, emerald, goshenite, heliodor, and morganite are gem forms of the mineral beryl. More information on gem-quality beryl and chrysoberyl can be found in the Gemstones chapter of the U.S. Geological Survey (USGS) Minerals Yearbook, volume I, Metals and Minerals.

Legislation and Government Programs

Defense Production Act.—In late 2005, the Department of Defense awarded a $9 million contract under its Defense Production Act Title III Program to Brush Wellman Inc. [a subsidiary of leading beryllium producer Brush Engineered Materials Inc. (BEM)] for the engineering and design of a new facility to produce primary beryllium, the feed material used to make beryllium metal products. During 2007, Brush Wellman continued its engineering and design work for the facility, which it planned to build at its Elmore, OH, site. This design phase of the project was anticipated to be completed by mid-2008, and would determine the total cost of the facility. Construction and startup of the new facility were expected to take an additional 2 to 3 years and would require additional title III approval (Brush Engineered Materials Inc., 2008a, p. 37).

National Defense Stockpile.—The United States maintained a stockpile of strategic materials for use during a national emergency. As of December 31, 2007, the NDS goal for hot-pressed beryllium metal powder was 45 metric tons (t) (table 2). A goal of 155 t of hot-pressed beryllium metal powder, however, had been proposed in the 2003 National Defense Stockpile Requirements Report to the Congress. The Annual Materials Plan for fiscal year 2007, which represented the maximum quantities of beryllium materials that could be sold from October 1, 2006, through September 30, 2007, was unchanged from that of fiscal year 2006 (table 2). The DNSC shipped 16 t of beryl ore (1 t of beryllium content) and 27 t of beryllium metal in 2007. NDS calendar yearend inventories of beryllium materials are listed in table 2 (U.S. Department of Defense, 2008, p. 5, 56, 59).

During the calendar year 2007, the DNSC issued a Basic Ordering Agreement solicitation for participants interested in purchasing hot-pressed beryllium metal powder. The DNSC also announced the future sale of beryllium-copper master alloy (BCMA) under a Strategic Supply Alliance. Sales under each program were to begin in early 2008 (Defense National Stockpile Center, 2007a, b).

Production

Domestic production and consumption statistics for beryllium-containing ores, as listed in tables 1 and 4, were based on data collected by the USGS by means of two voluntary surveys of U.S. operations. A small number of unidentified producers may have shipped negligible quantities of byproduct beryl, but these have not been included. In 2007, domestic mine shipments were slightly less than those of 2006.

The United States is one of only three countries known to process beryllium ores and concentrates into beryllium products. Brush Resources Inc. (a subsidiary of BEM) converted bertrandite from open pit mines in the Topaz-Spor Mountain region of Juab County, UT, along with imported beryl and beryl from the NDS, into beryllium hydroxide at its operations near Delta, UT. Some of the beryllium hydroxide was shipped to Elmore, where Brush Wellman Inc. converted it into BCMA, metal, or oxide, and some was sold to NGK Insulators, Ltd. of Japan.

Brush Resources continued development of a new pit at its Utah mine site. Production was to begin in early 2008 (Brush Engineered Materials Inc., 2008a, p. 5).

Environment

Because of the toxic nature of beryllium, various international, national, and State guidelines and regulations have been established regarding beryllium content in air, water, and other media. Industry must maintain careful control over the quantity of beryllium dust, fumes, and mists in the workplace. Control of potential health hazards adds to the final cost of beryllium products (Petkof, 1985, p. 80; Rossman, Preuss, and Powers, 1991, p. 277–281; Kramer, 1998, p. 107–108; Smith, Ingerman, and Amata, 2002, p. 11–15, 193–200).

Consumption

U.S. apparent consumption of all beryllium materials, as calculated from mine shipments, net trade, and changes in Government and industry stocks, was estimated to be about 100 t of contained beryllium in 2007, which was down 56% from the 226 t calculated for 2006. The decrease in apparent consumption was the result of a large drop in shipments of beryl from the NDS, coupled with a decrease in net imports of beryllium materials.

Since the closure of Brush Wellman's primary beryllium production facility in Elmore in 2000, the company has met its beryllium metal requirements by purchasing materials from the NDS and foreign producers. BEM's Beryllium and Beryllium Composites unit manufactured products of beryllium metal and two families of metal matrix composites, one made from aluminum and beryllium and the other made from beryllium and beryllium oxide. The products, in the form of foil, rods, sheets, tubes, and a variety of customized shapes, were produced at plants in Elmore and in Fremont, CA. Sales of beryllium products for defense applications, primarily aerospace and missile systems; for medical applications, including x-ray windows; and for applications using near net shape technologies increased compared with those of 2006. During 2007, the unit shipped some additional beryllium metal products for the National Aeronautics and Space Administration (NASA) James Webb Space Telescope (JWST), and the Joint European Torus (JET) in Culham, United Kingdom. The JET was the world's largest experimental nuclear fusion reactor. Both the JWST and JET projects were substantially complete at yearend 2007 (Brush Engineered Materials Inc., 2008a, p. 32).

BEM's Beryllium and Beryllium Composites unit also included Brush Ceramic Products Inc., which produced beryllium oxide ceramic products for aerospace, automotive electronics, defense, medical, semiconductor, telecommunications, and wireless applications at its plant in Tucson, AZ. Sales of ceramic products declined in 2007 compared with those of 2006 (Brush Engineered Materials Inc., 2008a, p. 32).

BEM's Specialty Engineered Alloys unit produced copper- and nickel-based alloy products, the majority of which contained beryllium. Alloy strip products (which were used as connectors, contacts, shielding, switches, and relays) and alloy bulk products (including bar, plate, rod, tube, and customized forms) were produced at plants in Elmore and in Shoemakersville, PA. In 2007, the total shipment volume of alloy strip products was 11% lower than that of 2006—the result of a softening in the computer and telecommunications market. Shipments of higher beryllium-containing and lower beryllium-containing strip products decreased compared with those of 2006; shipments of thin diameter rod and wire products increased compared with those of 2006. The total shipment volume of bulk alloy products increased 3% compared with that of 2006. Industry sectors to which sales of alloy products increased included aerospace and industrial components. Demand from the automotive sector remained relatively flat in 2007 (Brush Engineered Materials Inc., 2008a, p. 30, 31).

BEM had agreements with the DNSC to purchase beryl ore, BCMA, and beryllium metal from the NDS that expired in 2007. BEM purchased beryllium metal valued at $4.9 million in 2007. The purchased material was used as raw material input for BEM's operations (Brush Engineered Materials Inc., 2008a, p. 71).

BEM also had a long-term supply arrangement with JSC Ulba Metallurgical Plant (UMP), which was part of Kazakhstan's National Atomic Company Kazatomprom, and its marketing representative RWE NUKEM, Inc., Danbury, CT, to purchase BCMA and beryllium vacuum-cast billet through 2012. In 2007, BEM purchased beryllium-containing materials valued at $6.4 million (Brush Engineered Materials Inc., 2008a, p. 71).

Other domestic producers of beryllium alloy products included Applied Materials Science, Inc., Concord, MA; Freedom Alloys Inc., Royersford, PA; NGK Metals Corp. (a subsidiary of NGK Insulators, Ltd.), Sweetwater, TN; and Olin Corp.'s Brass Division, East Alton, IL. American Beryllia Inc. produced beryllium oxide ceramic products at its plant in Haskell, NJ.

Recycling

Beryllium was recycled primarily from new scrap generated during the manufacture of beryllium-containing components. Detailed data on the quantities of recycled beryllium are not available but may represent as much as 10% of U.S. apparent consumption (Cunningham, 2004).

Foreign Trade

U.S. foreign trade in beryllium materials, as reported by the U.S. Census Bureau, is summarized in table 3. On a gross weight basis, beryllium exports decreased by 25% compared with those of 2006. Japan was the major recipient of these materials. On a gross weight basis, beryllium imports decreased by 14%. The decrease was the result of decreased imports of BCMA, beryllium-copper alloy products, and beryllium metal products; imports of beryllium ores, and oxides and hydroxides increased in 2007 relative to those of 2006. Japan and Kazakhstan remained the leading suppliers of beryllium materials to the United States.

Net import reliance as a percentage of apparent consumption is used to measure the adequacy of current domestic beryllium production to meet U.S. demand. Net import reliance was defined as imports minus exports plus adjustments for Government and industry stock changes. Releases from stocks,

including shipments from the NDS, were counted as part of import reliance regardless of whether the materials were imported or produced in the United States. In 2007, net import reliance as a percentage of apparent consumption indicated that the United States was a net exporter of beryllium.

World Review

Beryl is frequently stockpiled for later processing. China is thought to be a significant producer, but does not report its beryl production. As a result, world production and the U.S. share of world production have a high degree of uncertainty. In 2007, estimated world beryllium mine production remained essentially the same as that of 2006 (table 4). The United States accounted for 85% of estimated world production.

China.—Shuikoushan Non-Ferrous Co., Ltd. processed beryllium ores and produced beryllium products in various forms at its 6th Smelting Plant in Songbai Town, Changning City, Hunan Province. The plant had estimated production capacity of 150 metric tons per year (t/yr) of beryllium oxide and 1,500 t/yr of BCMA (McNeil, 2006).

Fuyun Hengsheng Beryllium Industry Co., Ltd.'s refinery (a joint venture established by Xinjiang Nonferrous Metals Industry Group, Xinjiang Henghe Investment Co., Ltd., and Xinjiang Nonferrous Metals Industry Group Nonferrous Metals Co.) was designed to produce 100 t/yr of beryllium oxide and 800 t/yr of BCMA. The refinery is located in Fuyun County, in northwest Xinjiang Uygur Autonomous Region (China Non-Ferrous Metal Import & Export Xinjiang Corp., undated).

In 2007, Fuyun Hengsheng Beryllium Industry Co., Ltd. discovered a beryllium oxide deposit in Fuyun County estimated to be about 3 million metric tons of beryllium oxide. It was thought that this deposit represented more than 70% of total Chinese beryllium oxide resources. The company planned to produce 200,000 t of beryllium oxide from this deposit by yearend 2007 (Antaike China Metal Market, 2007; Interfax China Ltd., 2007b).

UMP and Ningbo Shengtai Electronic Metal Material Co. Ltd. signed a joint-venture agreement for the production of copper-beryllium mill products. The joint-venture company, Yingtan Ulba Shine Metal Materials Company Limited, was formed to increase UMP's presence in the Chinese hi-tech market. UMP was to supply the raw materials, which would be processed at Ningbo's plant in the Cixi Economic Development Zone of Ningbo, Zhejiang Province (Interfax Central Asia General Newswire, 2006; Interfax China Ltd., 2007a).

Ulba-China Co., Ltd. (a subsidiary of UMP formed in 2004 to increase sales of beryllium products in China and southeast Asia) announced it would become the exclusive seller of Ulba's aluminum-beryllium master alloys in southeast Asia beginning January 2008. The previous exclusive sales agreement with Metalink International Co., Ltd. (China) expired at yearend 2006 (Metal-Pages, 2007b).

Kazakhstan.—UMP supplied about 33% of beryllium products to the world market in 2006, compared with 3% in 1999. UMP's production reportedly was from stockpiled beryllium concentrate imported mainly from Russia. The stockpile, which was built up during the Soviet era, was forecast to be sufficient to support production for about 30 years. UMP announced that prices for its beryllium metal and beryllium products would increase by approximately 30% from existing prices owing to inflation and operational costs (Metal Bulletin, 2003; McNeil, 2006; Metal Bulletin Monthly, 2007; Ulba Metallurgical Plant JSC, 2007).

In 2007, it was reported that BerylliUM, a joint-venture company formed by UMP and Moscow OTSM Plant, was formed in 2002 to develop markets for beryllium products in Russia and other world markets. Kazatomprom also planned to start a joint-venture beryllium operation with Ukraine (Interfax Ltd., 2007; Metal-Pages, 2007a).

Outlook

The United States is expected to remain self-sufficient with respect to most of its beryllium requirements. At yearend 2007, BEM reported proven bertrandite reserves in Juab County of 5.92 million dry metric tons (6.53 million dry short tons) with an average grade of 0.266% beryllium. This represented about 15,800 t of contained beryllium, which would be sufficient for more than 100 years of operation based on average production levels in recent years. BEM owned approximately 95% of its proven mineral reserves and leased the remainder (Brush Engineered Materials Inc., 2008a, p. 40–41).

During the first quarter of 2008, BEM shipped lower volumes of beryllium-copper strip products than it did during the first quarter of 2007. The decrease was mainly the result of reduced demand from cellular telephone manufacturers. BEM reported that the appliance and automotive electronics strip alloy markets remained strong, however. BEM also shipped higher volumes of beryllium bulk products during the first quarter of 2008 than it did during the first quarter of 2007. The increase was the result of strong demand from the aerospace, heavy equipment, oil and gas, and undersea telecommunications markets. During the first quarter of 2008, BEM's sales of beryllium metal and metal-matrix composite products for defense applications, industrial x-ray window applications, and beryllium ceramics were lower than those during the first quarter of 2007 (Brush Engineered Materials Inc., 2008b, p. 14–15).

World consumption of beryllium was forecast to increase by about 2% per year during the short to medium term. Production and stockpiles were expected to be sufficient to meet demand (McNeil, 2006).

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TABLE 1
SALIENT BERYLLIUM MINERAL STATISTICS

(Metric tons of beryllium content)

	2003	2004	2005	2006	2007
United States, beryllium-containing ores:					
Mine shipments[1]	85	90	110	155	150
Imports for consumption, beryl[2]	9	--	--	--	1
Consumption, reported[3]	140	130	160	180	190
Stocks, December 31:					
Industry[1]	45	40	35	50	100
U.S. Government, beryl:[2, 4]	261	209	165	9	8
World, production[e, 2]	107	111	137	179	179

[e]Estimated. -- Zero.
[1]Data are rounded to the nearest 5 metric tons.
[2]Based on a beryllium content of 4%.
[3]Data are rounded to the nearest 10 metric tons.
[4]Defense National Stockpile Center. Data for 2003–06 include beryl committed for sale pending shipment and uncommitted beryl. Datum for 2007 is uncommitted beryl only.

TABLE 2

U.S. GOVERNMENT NATIONAL DEFENSE STOCKPILE BERYLLIUM STATISTICS IN 2007[1]

(Metric tons of beryllium content)

Material	Stockpile goal[2]	Disposal authority[3]	Annual Materials Plan[4]	Uncommited Inventory, December 31
Beryl ore	--	8	145	8
Beryllium-copper master alloy	--	3	44	3
Beryllium metal:				
Hot-pressed powder	45	110	--	156 [5]
Vacuum-cast	--	40	36	40
Total	45	150	36	196
Grand total	45	161	225	207

-- Zero.

[1]Data were converted from gross weights reported in short tons; may not add to totals shown.

[2]Goal effective as of December 28, 2001.

[3]Total quantity of material that can be disposed.

[4]Maximum quantity of material that can be disposed during 12-month period ending September 30, 2006.

[5]Held for goal.

Source: Defense National Stockpile Center.

TABLE 3

U.S. FOREIGN TRADE OF BERYLLIUM MATERIALS, BY TYPE[1]

Type and material	2006 Gross weight (kilograms)	2006 Value (thousands)	2007 Gross weight (kilograms)	2007 Value (thousands)	Destinations or sources, 2007[2]
Exports:					
Beryllium, unwrought[3]	93,500	$4,770	74,500	$4,380	Japan, 85%; Belgium, 11%; other, 4%.
Beryllium waste and scrap	177	14	271	47	Hong Kong, 82%; Japan, 18%.
Beryllium, other[4]	41,100	16,700	25,900	14,100	Canada, 58%; United Kingdom, 20%; France, 5%; Germany, 5%; Singapore, 3%; Japan, 2%; other, 7%.
Total	135,000	21,500	101,000	18,500	Japan, 63%; Canada, 15%; Belgium, 8%; United Kingdom, 5%; France, 1%; Germany, 1%; Italy, 1%; Netherlands, 1%; Philippines, 1%; Singapore, 1%; Switzerland, 1%; other, 2%.
Imports:					
Beryllium ores and concentrates	--	--	12,600	13	South Africa, 100%.
Beryllium oxide and hydroxide	32,100	296	77,500	764	Ireland, 67%; United Kingdom, 33%.
Beryllium, unwrought[3]	18,800	3,450	15,000	2,680	Kazakhstan, 100%.
Beryllium waste and scrap	2,620	9	1,630	6	Mexico, 100%.
Beryllium, other[4]	2,240	163	1,210	222	Kazakhstan, 61%; Russia, 35%; United Kingdom, 3%; Switzerland, 1%; Germany[5].
Beryllium-copper master alloy	658,000	7,420	651,000	8,250	Kazakhstan, 83%; Japan, 16%; other, 1%.
Beryllium-copper plates, sheets, and strip	668,000	7,640	428,000	5,410	Japan, 97%; Germany, 3%; other[5].
Total	1,380,000	19,000	1,190,000	17,300	Kazakhstan, 47%; Japan, 44%; Ireland, 4%; United Kingdom, 2%; Germany, 1%; South Africa, 1%; other, 1%.

-- Zero.

[1]Data are rounded to no more than three significant digits; may not add to totals shown.

[2]Data may not add to 100% because of independent rounding.

[3]Includes powders.

[4]Includes articles not elsewhere specified.

[5]Less than ½ unit.

TABLE 4

BERYL: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons of gross weight)

Country[3]	2003	2004	2005	2006	2007
Brazil	(4)	(4)	(4)	(4)	(4)
China[e]	500	500	500	500	500
Madagascar[e, 5]	1	1	1	1	1
Mozambique	78	45	146	150	155
Portugal[e]	5	5	5	5	5
United States, mine shipments[6]	2,100	2,210	2,780	3,830	3,810
Total	2,680	2,760	3,440	4,480	4,470

[e]Estimated.

[1]World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2]Table includes data available through June 16, 2008. Unless otherwise noted, figures represent beryl ore for the production of beryllium and exclude gem-quality beryl.

[3]In addition to the countries listed, Uganda produced beryl ore. Kazakhstan, Nigeria, and Russia may also have produced beryl ore, but information is inadequate to make reliable estimates of production. Other nations that produced gemstone beryl may also have produced some industrial beryl.

[4]Less than ½ unit.

[5]Includes ornamental and industrial products.

[6]Includes bertrandite ore, calculated as equivalent to beryl containing 11% beryllium oxide.