



2005 Minerals Yearbook

BERYLLIUM

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The United States was the world's leading beryllium ore producer in 2005. U.S. mine shipments of beryllium ore increased from those of 2004; ore consumption for the production of beryllium hydroxide also 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 2004.

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, 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, andmorganite 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.—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 beryllium metal. Brush Wellman's beryllium metal production facility in Elmore, OH, had been closed in 2000 as a result of various factors, including equipment obsolescence and the availability of beryllium metal from the NDS. The engineering and design of the new facility was expected to be completed before the end of 2007 and would determine whether the facility

would be built in Elmore or near Brush Wellman's beryllium hydroxide plant in Delta, UT. Construction and startup of the new facility was expected to take 2 to 3 years; funding would require additional title III approval (Brush Wellman Inc., 2005).

National Defense Stockpile.—The United States maintained a stockpile of strategic materials for use during a national emergency. As of December 31, 2005, 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 (AMP) for fiscal year 2005, which represented the maximum quantities of beryllium materials that could be sold from October 1, 2004, through September 30, 2005, was unchanged from that of fiscal year 2004 (table 2). The DNSC sold 241 t of beryl ore (10 t of beryllium content) valued at \$22,300 in February and 27 t of beryllium metal valued at \$4.65 million in September. As of September 30, beryllium inventory sold but not shipped from the NDS included 858 t of beryl ore (34 t of beryllium content), 707 t of beryllium-copper master alloy (BCMA) (28 t of beryllium content), and 28 t of beryllium metal. NDS calendar yearend inventories of beryllium materials are listed in table 2 (U.S. Department of Defense, 2006, p. 5, 10-11, 52, 55-56).

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 2005, domestic mine shipments were greater than those of 2004.

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) extracted bertrandite from open pit mines in the Topaz-Spor Mountain region of Juab County, UT, and converted the bertrandite, along with imported beryl and beryl from the NDS, into beryllium hydroxide at its operations near Delta. 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.

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; Agency for Toxic Substances and Disease Registry, 2002§¹).

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 84 t of contained beryllium in 2005, which was 22% higher than the 69 t calculated for 2004. The increased demand in 2005 was met by increases in domestic mine shipments and imports of contained beryllium.

BEM's Beryllium Products 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 rods, sheets, tubes, and a variety of customized shapes, were produced at plants in Elmore and in Fremont, CA. Sales by this unit were 8% higher than those of 2004. The unit completed delivery of the beryllium blanks for the 6.5-meter diameter optical mirror for the National Aeronautics and Space Administration (NASA) James Webb space telescope. During the past 2 years, BEM supplied 19 mirror blanks, each weighing about 550 pounds, 3 smaller mirrors, and structural parts for the telescope. Sales of beryllium products for other defense and Government applications were strong in the early part of 2005 but weakened during the second half of the year, sales to the medical market were less than those of 2004, and sales to the electronics market have been approximately the same for the past 3 years. In 2005, Beryllium Products began to use a newly developed hot isostatic press consolidation process to make near-net-shape aluminum-beryllium metal matrix composite blanks. The blanks were to be machined into parts for a new optical sensing system for the U.S. Army's Apache combat helicopters (Northrop Grumman Corp., 2005; Brush Engineered Materials Inc., 2006a, p. 4, 7, 18; Brush Wellman Inc., undated §).

BEM's Alloy Products unit produced copper- and nickel-base alloy products, the majority of which contained beryllium. Alloy strip products (which were used as connectors, contacts, switches, relays and shielding) and alloy bulk products (including bar, plate, rod, tube, and customized forms) were produced at plants in Elmore and in Shoemakersville, PA. Alloy Product's sales were 3% higher than those of 2004 as a result of increased demand for bulk products. The volume of bulk product shipments increased by 9% owing to increases in demand from the aerospace, appliance, and heavy equipment markets. Some of the increase was from sales of non-beryllium-containing alloys, particularly to the heavy equipment market (Brush Engineered Materials Inc., 2006a, p. 17-18).

Brush Ceramic Products Inc. (a subsidiary of BEM) produced beryllium oxide ceramic products for aerospace, automotive electronics, defense, medical, semiconductor,

telecommunications, and wireless applications at its plant in Tucson, AZ. During the year, Brush Ceramics increased its manufacturing capacity by 25%. Sales of beryllium oxide ceramic products declined by 17% compared with those of 2004 as a result of changes in demand from the telecommunications and computer market and reduced orders from consumers that were drawing down high inventories (Brush Engineered Materials Inc., 2006a, p. 20; Brush Ceramic Products Inc., 2005; undated §).

BEM had agreements with the DNSC to purchase beryl ore, BCMA, and beryllium metal from the NDS. In 2005, BEM purchased beryllium materials valued at approximately \$7.5 million to be used as raw material input for its operations. The agreements were scheduled to expire in 2007 (Brush Engineered Materials Inc., 2006a, p. 47).

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 2005, BEM purchased beryllium-containing materials valued at \$7.8 million (Brush Engineered Materials Inc., 2006a, p. 47).

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 7% compared with those of 2004. Japan was the major recipient of these materials. On a gross weight basis, beryllium imports decreased by 19% in spite of significant increases in imports of beryllium oxide and unwrought beryllium, including powders. Japan and Kazakhstan were the leading suppliers of beryllium materials to the United States. On the basis of estimated contained beryllium, U.S. imports increased by 9% in 2005 compared with those of 2004.

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 they were imported or produced in the United States. In 2005, net import reliance as a

¹References that include a section mark (§) are found in the Internet References Cited section.

percentage of apparent consumption indicated that the United States was a net exporter of beryllium.

World Industry Structure

In 2005, estimated world beryllium mine production increased by 24% compared with that of 2004 (table 4). The United States accounted for more than 80% of estimated world production.

World Review

China.—Shuikoushan Non-Ferrous Metals 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 an estimated production capacity of 20 metric tons per year (t/yr) of contained beryllium (McNeil, 2005).

In October, a second Chinese beryllium refinery began production in Fuyun County in northwest Xinjiang Uygur Autonomous Region. It was built by Fuyun Hengsheng Beryllium Industry Co., Ltd. (a joint venture established by Xinjiang Nonferrous Metals Industry Group, Xinjiang Henghe Investment Co., Ltd., and Xinjiang Nonferrous Metals Industry Group Nonferrous Metals Co.) and was designed to produce 100 t/yr of industrial beryllium oxide and 800 t/yr of BCMA. Fuyun County reportedly holds more than 70% of China's beryllium ore reserves, including the Keketuohai No. 3 Mine (Metals Place, 2005§; China Non-Ferrous Metal Import & Export Xinjiang Corp., undated §).

Kazakhstan.—UMP reported that its 2005 beryllium production was eight times that of 1999. A 5-year investment program at UMP was scheduled for completion in 2005. The beryllium program had several components. One part of the program was to use carbothermic reaction technology to increase the production capacity for BCMA by 3,000 t/yr. A second part was to extend the beryllium-copper product range and increase the capacity to produce these products by up to 1,000 t/yr. Other parts of the program focused on introducing new techniques for converting beryllium concentrates using the existing 200-t/yr plant capacity and developing digestion and refining production methods to produce beryllium hydroxide to international standards. 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 (Metal Bulletin, 2003; McNeil, 2005; Ulba Metallurgical Plant JSC, 2006§).

Outlook

The United States is expected to remain self-sufficient with respect to most of its beryllium requirements. At yearend 2005, BEM reported proven bertrandite reserves in Juab County of about 5.99 million dry metric tons (6.60 million dry short tons) with an average grade of 0.268% beryllium. This represented about 16,000 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., 2006a, p. 25).

BEM forecast that its sales of beryllium products for aerospace and defense applications could increase during the latter part of 2006. Commercial demand for beryllium products will depend on the performance of the many diverse industries that use them. Industry sectors that use beryllium products include, but are not limited to, aerospace, automotive, computer, defense, electronics, heavy machinery, home appliance, industrial component, instrumentation and control system, medical, nuclear, oil and gas drilling, plastic molding, and telecommunications. BEM stated that demand from such end-use sectors as automotive electronics, industrial components, and telecommunications and computer was strong during the first quarter of 2006 (Brush Engineered Materials Inc., 2006b, p. 15, 21).

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, 2005).

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TABLE 1
SALIENT BERYLLIUM MINERAL STATISTICS

(Metric tons of beryllium content)

	2001	2002	2003	2004	2005
United States, beryllium-containing ores:					
Mine shipments ¹	100	80	85	90	110
Imports for consumption, beryl ²	19	11	9	--	--
Consumption, reported ³	170	120	140	130	160
Stocks, December 31:					
Industry ¹	100	90	45	40	35
U.S. Government, beryl: ^{2,4}					
Committed	33 ^r	34	34	60	34
Uncommitted	281	227	227	149	130
Total	315	261	261	209	165
World, production ^{6,2}	120	101 ^r	108	111 ^r	138

⁶Estimated. ^rRevised. -- Zero.

¹Data are rounded to the nearest 5 metric tons.

²Based on a beryllium content of 4%.

³Data are rounded to the nearest 10 metric tons.

⁴Defense National Stockpile Center. Data were converted from gross weights reported in short tons; may not add to totals shown.

TABLE 2
U.S. GOVERNMENT NATIONAL DEFENSE STOCKPILE BERYLLIUM STATISTICS IN 2005¹

(Metric tons of beryllium content)

Material	Stockpile goal ²	Disposal authority ³	Annual Materials Plan ⁴	Inventory, December 31		Total
				Committed ⁵	Uncommitted	
Beryl ore	--	130	145 ⁶	34	130	165
Beryllium-copper master alloy	--	--	44 ⁶	3	--	3
Beryllium metal:						
Hot-pressed powder	45	110	NA	NA	156 ⁷	NA
Vacuum-cast	--	41	NA	NA	41	NA
Total	45	151	36	28	196	225
Grand total	45	281	225	66	327	393

NA Not available. -- Zero.

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

²Goal effective as of December 28, 2001.

³Total quantity of material that can be disposed.

⁴Maximum quantity of material that can be disposed during 12-month period ending September 30, 2005.

⁵Material that has been sold but not yet shipped.

⁶Actual quantity will be limited to remaining inventory.

⁷Held for goal.

Source: Defense National Stockpile Center.

TABLE 3
U.S. FOREIGN TRADE OF BERYLLIUM MATERIALS, BY TYPE¹

Type and material	2004		2005		Destinations and sources, 2005 ²
	Gross weight (kilograms)	Value (thousands)	Gross weight (kilograms)	Value (thousands)	
Exports:					
Beryllium, unwrought ³	153,000	\$7,320	151,000	\$8,810	Japan, 98%; United Kingdom, 1%; other, 1%.
Beryllium waste and scrap	1,510	51	240	8	Taiwan, 90%; Philippines, 10%.
Beryllium, other ⁴	62,500	12,200	50,300	9,760	Canada, 28%; France, 14%; Japan, 12%; Singapore, 11%; Switzerland, 10%; Germany, 8%; Netherlands, 6%; United Kingdom, 4%; Brazil, 2%; other, 5%.
Total	217,000	19,600	201,000	18,600	Japan, 77%; Canada, 7%; France, 3%; Singapore, 3%; Switzerland, 2%; other, 7%.
Imports:					
Beryllium oxide and hydroxide	31,000	351	75,100	466	United Kingdom, 74%; Belgium, 22%; China, 3%; other, 1%.
Beryllium, unwrought ³	6,270	882	25,600	4,960	Kazakhstan, 100%.
Beryllium waste and scrap	17,200	51	5,820	977	Netherlands, 61%; France, 23%; Germany, 15%.
Beryllium, other ⁴	29,700	2,140	16,500	1,930	Kazakhstan, 50%; Japan, 49%; other, 1%.
Beryllium-copper master alloy	511,000	5,630	457,000	3,980	Kazakhstan, 89%; Japan, 7%; China, 3%; other, 1%.
Beryllium-copper plates, sheets, and strip	685,000	5,170	463,000	3,950	Japan, 96%; Germany, 4%.
Total	1,280,000	14,200	1,040,000	16,300	Japan, 47%; Kazakhstan, 42%; United Kingdom, 5%; China, 2%; Germany, 2%; other, 2%.

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

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

³Includes powders.

⁴Includes articles not elsewhere specified.

Source: U.S. Census Bureau.

TABLE 4
 BERYL: ESTIMATED WORLD PRODUCTION, BY COUNTRY^{1,2}

(Metric tons, gross weight)

Country ³	2001	2002	2003	2004	2005
Brazil	--	(4) ^r	(4) ^r	(4) ^r	(4)
China	500	500	500	500	500
Madagascar ⁵	1 ⁶	1	1	1	1
Mozambique	1 ⁶	54 ⁶	78 ⁶	45 ^{r,6}	146 ⁶
Portugal	5	5	5	5	5
United States, mine shipments ⁷	2,480	1,970	2,100	2,210	2,780
Zambia	7	7	7	7	7
Total	2,990	2,540	2,690 ^r	2,770 ^r	3,440

^rRevised. -- Zero.

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

²Table includes data available through June 11, 2006.

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

⁴Less than ½ unit.

⁵Includes ornamental and industrial products.

⁶Reported figure.

⁷Includes bertrandite ore, calculated as equivalent to beryl containing 11% beryllium oxide.