USGS
science for a changing world

2006 Minerals Yearbook

BERYLLIUM

U.S. Department of the Interior
U.S. Geological Survey

October 2007

BERYLLIUM

By Kim B. Shedd

Domestic survey data and tables were prepared by Alan D. Ray, statistical assistant, and the world production table was prepared by Linder Roberts, international data coordinator.

U.S. mine shipments of beryllium ore in 2006 increased from those of the previous year; 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 and excluding beryllium-copper alloy products, total U.S. imports and total U.S. exports of beryllium materials in 2006 were lower than those of the previous year.

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 2006, Brush Wellman developed a business plan and began engineering and design work for the facility, which it decided to build at its Elmore, OH, site. This phase of the project was expected to be completed by the end of 2007. 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 Wellman Inc., 2006; Brush Engineered Materials Inc., 2007a, p. 27).

National Defense Stockpile.—The United States maintained a stockpile of strategic materials for use during a national emergency. As of December 31, 2006, 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 2006, which represented the maximum quantities of beryllium materials that could be sold from October 1, 2005, through September 30, 2006, was unchanged from that of fiscal year 2005 (table 2). The DNSC sold 1,400 t of beryl ore (56 t of beryllium content) valued at $130,000 in January, 2,040 t of beryl ore (81 t of beryllium content) valued at $177,000 in March, and 27 t of beryllium metal valued at $4.94 million in September. As of September 30, all of the beryl ore remaining in the stockpile had been committed for sale, and the beryllium inventory sold but not shipped from the NDS included 2,670 t of beryl ore (107 t of beryllium content) and 53 t of beryllium metal. NDS calendar yearend inventories of beryllium materials are listed in table 2 (U.S. Department of Defense, 2007, p. 4-5, 9, 11, 54, 57).

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 2006, domestic mine shipments were greater than those of 2005.

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 beryllium-copper master alloy (BCMA), metal, or oxide, and some was sold to NGK Insulators, Ltd. of Japan.

Brush Resources planned to develop a new pit at its Utah mine site. Production was to begin in early 2008 (Brush Engineered Materials Inc., 2007a, p. 33).

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 226 t of contained beryllium in 2006, which was more than two and one-half times the 84 t calculated for 2005. The increase in apparent consumption was the result of higher shipments of beryl from the NDS and bertrandite from domestic mines, coupled with a decrease in net exports 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 acoustic components in the electronics market increased compared with those of 2005. During 2006, the unit shipped some additional beryllium metal products for the National Aeronautics and Space Administration (NASA) James Webb space telescope and began to deliver 4.4 t of beryllium metal to the Joint European Torus (JET) in Culham, United Kingdom. The JET was the world's largest experimental nuclear fusion reactor. The beryllium metal was to be used for inner wall plasma-facing components that will line the inside of the reactor, and was part of a recommissioning project to prepare the reactor for future fusion reaction testing (Brush Engineered Materials Inc., 2007a, p. 13, 23, 27).

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.

BEM's Specialty Engineered Alloys unit produced copper- and nickel-base 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 2006, the total shipment volume of alloy strip products was 6% higher than that of 2005. Shipments of higher beryllium-containing strip products and thin diameter rod and wire products increased compared with those of 2005; shipments of lower beryllium-containing alloy strip products decreased compared with those of 2005. The total shipment volume of bulk alloy products increased 16% compared with that of 2005. Shipments of beryllium-containing bulk alloy products and nonberyllium-containing bulk alloy products each increased compared with those of 2005. Industry sectors to which sales of alloy products increased included aerospace, automotive electronic, industrial components, and telecommunications and computer (Brush Engineered Materials Inc., 2007a, p. 22).

BEM had agreements with the DNSC to purchase beryl ore, BCMA, and beryllium metal from the NDS. In 2006, BEM purchased beryllium materials valued at approximately $0.7 million to be used as raw material input for its operations. The agreements were scheduled to expire in 2007 (Brush Engineered Materials Inc., 2007a, p. 52).

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 2006, BEM purchased beryllium-containing materials valued at $9.1 million (Brush Engineered Materials Inc., 2007a, p. 52).

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 33% compared with those of 2005. Japan was the major recipient of these materials. On a gross weight basis, beryllium imports increased by 33%. The increase was the result of increased imports of BCMA and beryllium-copper alloy products; imports of all other beryllium materials decreased in 2006 relative to those of 2005. 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 2006, net import

reliance as a percentage of apparent consumption was 31%. The shift from being a net exporter of beryllium to a net importer was primarily the result of an increase in beryl shipments from the NDS.

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 2006, estimated world beryllium mine production increased by 30% compared with that of 2005 (table 4). The United States accounted for 85% of estimated world production.

China.—Two companies processed beryllium ores. Shuikoushan Non-Ferrous Co., Ltd. produced beryllium products in various forms at its 6th Smelting Plant in Songbai Town, Changning City, Hunan Province. 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.) produced beryllium oxide and BCMA at its refinery in Fuyun County in northwest Xinjiang Uygur Autonomous Region (China Non-Ferrous Metal Import & Export Xinjiang Corp., undated; Shuikoushan Non-Ferrous Co., Ltd., undated).

UMP and Ningbo Shengtai Electronic Metal Material Co. Ltd. formed a joint venture for the production of copper-beryllium mill products. 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).

Kazakhstan.—UMP reportedly sold 1,643 t of beryllium products, of which 1,604 t was exported, compared with 1,185 t in 2005, of which 1,171 t was exported. 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, 2006; Interfax Ltd., 2007).

A delegation of Russian manufacturers of radioelectronic devices and components visited UMP to discuss the status of the Russian market for beryllium oxide ceramic parts. Various potential future cooperative projects were discussed (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 2006, BEM reported proven bertrandite reserves in Juab County of about 5.94 million dry metric tons (6.55 million dry short tons) with an average grade of 0.267% beryllium. This represented about 15,900 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., 2007a, p. 29).

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. During the first quarter of 2007, BEM shipped lower volumes of alloy products than it did during the first quarter of 2006. The decrease was partly the result of a reduced demand from the automotive electronics market and from the Southeast Asian telecommunications and computer market, where an inventory correction by cell phone manufacturers resulted in reduced demand for beryllium-copper strip products. BEM reported that the aerospace, automotive electronics, and oil and gas markets were showing signs of strengthening, however. During the first quarter of 2007, BEM supplied beryllium blanks to the JET nuclear fusion reactor project, and its sales of beryllium metal and metal-matrix composite products for acoustic speakers; defense applications, including tactical optics such as forward-looking infrared systems, airborne electronics, and space systems; and medical and industrial x-ray applications were higher than those during the first quarter of 2006. Sales of beryllium ceramic materials for laser applications in medical and other markets also increased relative to those during the first quarter of 2006 (Brush Engineered Materials Inc., 2007b, p. 9, 13-14, 19).

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).

References Cited

Brush Engineered Materials Inc., 2007a, Annual report—2006: Cleveland, OH, Brush Engineered Materials Inc., 62 p.

Brush Engineered Materials Inc., 2007b, Form 10-Q for the quarter ended March 31, 2007: Securities and Exchange Commission, April 20, 24 p.

Brush Wellman Inc., 2006, Brush Wellman Inc. selects Elmore, Ohio as site for proposed primary beryllium facility: Cleveland, OH, Brush Wellman Inc. news release, September 18, 2 p.

China Non-Ferrous Metal Import & Export Xinjiang Corp., [undated], Copper & nickel mining: China Non-Ferrous Metal Import & Export Xinjiang Corp. (Accessed January 6, 2006, at http://www.cnieccxj.com/F/03/CustomColumn/top.asp?fatherid=002003&menuid=002003007.)

Cunningham, L.D., 2004, Beryllium recycling in the United States in 2000, *in* Flow studies for recycling metal commodities in the United States: U.S. Geological Survey Circular 1196-P, p. P1–P10. (Accessed July 27, 2006, at http://pubs.usgs.gov/circ/c1196p/c1196p.pdf.)

Interfax Central Asia General Newswire, 2006, Ulba Metals Plant, Ningbo Shine to form beryllium JV: Interfax Central Asia General Newswire, August 14. (Accessed January 19, 2007, at http://www.accessmylibrary.com/coms2/summary_0286-16374094_ITM.)

Interfax Ltd., 2007, Kazatomprom's Ulba plant edges up uranium exports 6% in 2006: Mining & Metals Weekly, v. 16, issue 8 (773), February 16-22, p. 21.

Kramer, D.A., 1998, Beryllium, *in* Metals and minerals: U.S. Geological Survey Minerals Yearbook 1996, v. I, p. 107-112.

McNeil, David, 2006, Beryllium—2005/6: Mining Journal Online. (Accessed May 24, 2007, via http://www.mining-journal.com/home.aspx.)

Metal Bulletin, 2003, Ulba seeks to fulfil its potential: Metal Bulletin, no. 8784, June 23, p. 8.

Petkof, Benjamin, 1985, Beryllium, *in* Mineral facts and problems: U.S. Bureau of Mines Bulletin 675, p. 75-82.

Rossman, M.D., Preuss, O.P., and Powers, M.B., 1991, Beryllium—Biomedical and environmental aspects: Baltimore, MD, Williams & Wilkins, 319 p.

Shuikoushan Non-Ferrous Co., Ltd., [undated], The 6th smelting plant of Shuikoushan Non-Ferrous Co., Ltd.: Shuikoushan Non-Ferrous Co., Ltd. (Accessed July 9, 2007, at http://www.sks-be.com/en/Introduction.htm.)
Smith, Cassandra, Ingerman, Lisa, and Amata, Richard, 2002, Toxicological profile for beryllium: Agency for Toxic Substances and Disease Registry, 247 p. (Accessed May 24, 2007, at http://www.atsdr.cdc.gov/toxprofiles/tp4.pdf.)
Ulba Metallurgical Plant JSC, 2006, Negotiations conducted: Ulba Metallurgical Plant JSC, September 8. (Accessed October 27, 2006, at http://www.ulba.kz/eng/newsa.htm?nom=32.)
U.S. Department of Defense, 2007, Strategic and critical materials operations report to the Congress—Operations under the Strategic and Critical Materials Stock Piling Act during the period October 2005 through September 2006: Washington, DC, U.S. Department of Defense, 66 p.

GENERAL SOURCES OF INFORMATION

U.S. Geological Survey Publications

Beryllium. Ch. in Metal Prices in the United States Through 1998, 1999.
Beryllium. Ch. in Mineral Commodity Summaries, annual.
Beryllium. Ch. in United States Mineral Resources, Professional Paper 820, 1973.
Historical Statistics for Mineral and Material Commodities in the United States, Data Series 140.
Recycling—Metals. Ch. in Minerals Yearbook, annual.

Other

Beryllium. Ch. in Mineral Facts and Problems, U.S. Bureau of Mines Bulletin 675, 1985.
Company reports and media releases.
Defense National Stockpile Center reports and news releases.
Federal Register, daily.
Metal Bulletin, daily, weekly, and monthly.
Mineral Resource of the Month—Beryllium. Geotimes, June 2006.
Mining & Metals Report. Interfax International Ltd., weekly.
Mining Journal Ltd:
Mining Annual Review.
Mining Journal, weekly.
Platts Metals Week, weekly.
Roskill Information Services Ltd.
Ryan's Notes, weekly.
Strategic and Critical Materials Report to the Congress. U.S. Department of Defense.
U.S. International Trade Commission interactive tariff and trade DATAWEB.

TABLE 1
SALIENT BERYLLIUM MINERAL STATISTICS

(Metric tons of beryllium content)

	2002	2003	2004	2005	2006
United States, beryllium-containing ores:					
Mine shipments[1]	80	85	90	110	155
Imports for consumption, beryl[2]	11	9	--	--	--
Consumption, reported[3]	120	140	130	160	180
Stocks, December 31:					
Industry[1]	90	45	40	35	50
U.S. Government, beryl[2, 4]	261	261	209	165	9
World, production[e, 2]	101	107 [r]	111	137 [r]	179

[e]Estimated. [r]Revised. -- 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. Includes beryl committed for sale pending shipment and uncommitted beryl.

TABLE 2
U.S. GOVERNMENT NATIONAL DEFENSE STOCKPILE BERYLLIUM STATISTICS IN 2006[1]

(Metric tons of beryllium content)

Material	Stockpile goal[2]	Disposal authority[3]	Annual Materials Plan[4]	Inventory, December 31		
				Committed[5]	Uncommitted	Total
Beryl ore	--	--	145 [6]	9	--	9
Beryllium-copper master alloy	--	3	44 [6]	--	3	3
Beryllium metal:						
Hot-pressed powder	45	110	--	NA	156 [7]	NA
Vacuum-cast	--	14	36	NA	14	NA
Total	45	123	36	53	169	222
Grand total	45	126	225	62	172	234

NA Not available. -- 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]Material that has been sold but not yet shipped.

[6]Actual quantity will be limited to remaining inventory.

[7]Held for goal.

Source: Defense National Stockpile Center.

TABLE 3
U.S. FOREIGN TRADE OF BERYLLIUM MATERIALS, BY TYPE[1]

Type and material	2005		2006		Destinations or sources, 2006[2]
	Gross weight (kilograms)	Value (thousands)	Gross weight (kilograms)	Value (thousands)	
Exports:					
Beryllium, unwrought[3]	151,000	$8,810	93,500	$4,770	Japan, 93%; Philippines, 3%; United Kingdom, 2%; other, 1%.
Beryllium waste and scrap	240	8	177	14	Republic of Korea, 100%.
Beryllium, other[4]	50,300	9,760	41,100	16,700	Canada, 41%; United Kingdom, 15%; Norway, 13%; Germany, 7%; Japan, 7%; Netherlands, 6%; France, 6%; Switzerland, 2%; other, 4%.
Total	201,000	18,600	135,000	21,500	Japan, 67%; Canada, 13%; United Kingdom, 6%; Norway, 4%; Germany, 3%; Philippines, 2%; Netherlands, 2%; France, 2%; other, 2%.
Imports:					
Beryllium oxide and hydroxide	75,100	466	32,100	296	Germany, 100%; Kazakhstan[5].
Beryllium, unwrought[3]	25,600	4,960	18,800	3,450	Kazakhstan, 100%.
Beryllium waste and scrap	5,820	977	2,620	9	Mexico, 100%.
Beryllium, other[4]	16,500	1,930	2,240	163	United Kingdom, 63%; France, 28%; China, 7%; Mexico, 2%; other[5].
Beryllium-copper master alloy	457,000	3,980	658,000	7,420	Kazakhstan, 97%; Canada, 2%; Germany 1%; other[5].
Beryllium-copper plates, sheets, and strip	463,000	3,950	668,000	7,640	Japan, 99%; Germany, 1%; other[5].
Total	1,040,000	16,300	1,380,000	19,000	Japan, 48%; Kazakhstan, 48%; Germany, 3%; Canada, 1%; other, 1%.

[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.

Source: U.S. Census Bureau.

TABLE 4
BERYL: ESTIMATED WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons of gross weight)

Country[3]	2002	2003	2004	2005	2006
Brazil	(4) [5]	(4) [5]	(4) [5]	(4) [5]	(4)
China	500	500	500	500	500
Madagascar[6]	1	1	1	1	1
Mozambique	54 [5]	78 [5]	45 [5]	146 [5]	150
Portugal	5	5	5	5	5
United States, mine shipments[7]	1,970	2,100	2,210	2,780	3,830
Zambia[8]	-- [r]	-- [r]	-- [r]	-- [r]	--
Total	2,530 [r]	2,680 [r]	2,760 [r]	3,440	4,480

[r]Revised. -- Zero.

[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 11, 2007. 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 estimate production. Other nations that produced gemstone beryl may also have produced some industrial beryl.

[4]Less than ½ unit.

[5]Reported figure.

[6]Includes ornamental and industrial products.

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

[8]Production statistics formerly listed for Zambia are assumed to represent gem-quality beryl.