



# 2008 Minerals Yearbook

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## BERYLLIUM

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# BERYLLIUM

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U.S. mine shipments of beryllium ore in 2008 increased 16% from those of the previous year, while ore consumption for the production of beryllium hydroxide increased 16% (table 1). The Defense National Stockpile Center (DNSC) of the U.S. Department of Defense (DOD) 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 lower and total U.S. exports were higher than those of 2007.

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 2008, estimated world beryllium mine production increased by 14% compared with that of 2007 (table 4). The United States accounted for about 90% of estimated world production.

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 (ignition components), computer (computer chip heat sinks), defense, electronics (highly conductive and strong wire), heavy machinery, home appliance (microwave guides), industrial component (bearings and bushings), 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

**Strategic Materials Protection Board.**—Following a meeting in December, the U.S. Department of Defense Strategic Materials Protection Board (comprised of representatives from the Office of the Secretary of Defense; the Under Secretary of

Defense for Acquisition, Technology, and Logistics; the Under Secretary of Defense for Intelligence; and the Secretaries of the Army, Navy, and Air Force) ruled that high-purity beryllium was both a strategic and a critical material, and required the DOD to maintain a long-term domestic supply (U.S. Department of Defense, 2008, p. 9; Metal-Pages Ltd., 2009).

**Defense Production Act.**—DOD, under its Defense Production Act Title III Program with Brush Wellman Inc. [a subsidiary of leading beryllium producer Brush Engineered Materials Inc. (BEM)], entered phase 2 of its Technology Investment Agreement for the construction and startup of a \$90.4 million primary beryllium facility in Elmore, OH. The objective of the partnership between DOD and Brush Wellman was to ensure a long-term domestic supply of primary beryllium, the feed material used to make beryllium metal products. DOD was to fund 80% of the project, with the remaining 20% to be funded by Brush Wellman. Brush Wellman broke ground for the new facility in July. Construction was expected to be completed by mid-2010 (Brush Engineered Materials Inc., 2008; Smith Horn, 2008).

**National Defense Stockpile.**—The United States maintained a stockpile of strategic materials for use during a national emergency. As of December 31, 2008, the NDS goal for hot-pressed beryllium metal powder was 45 metric tons (t) (table 2). However, a goal of 155 t of hot-pressed beryllium metal powder had been proposed in the 2003 National Defense Stockpile Requirements Report to the Congress. The Annual Materials Plan for fiscal year 2008, which represented the maximum quantities of beryllium materials that could be sold from October 1, 2007, through September 30, 2008, was as follows: 3,000 t of beryl ore (109 t of beryllium content), actual quantity limited to remaining sales authority or inventory; 300 t of beryllium-copper master alloy (BCMA) (11 t of beryllium content), actual quantity limited to remaining sales authority or inventory; and 36 t of beryllium metal (table 2). In 2008, the DNSC sold beryllium vacuum-cast ingot under a Basic Ordering Agreement and BCMA under a Strategic Supply Alliance. The DNSC shipped 210 t of beryl ore (8 t of beryllium content), 78 t of BCMA (3 t of beryllium content), and 36 t of beryllium metal in 2008. The DNSC reported in April that its entire inventory of BCMA has been exhausted (Defense National Stockpile Center, 2008). NDS calendar yearend inventories of beryllium materials are listed in table 2 (U.S. Department of Defense, 2009, p. 5).

## 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 2008, domestic mine shipments were greater than those of 2007.

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 converted it into BCMA, metal, or oxide, and some was sold to NGK Insulators, Ltd. of Japan. Brush Resources completed development of a new bertrandite pit at its Utah mine site and ore extraction began in the first quarter of 2008 (Brush Engineered Materials Inc., 2009, p. 5).

In May, IBC Advanced Alloys Corp. (formerly International Beryllium Corp.), headquartered in Vancouver, British Columbia, Canada, acquired Rare Earths Limited (REL), a Colorado-based beryllium exploration company. The acquisition included the rights to REL's 371 beryllium mineral claims near the Topaz-Spor Mountain region of Juab County, UT, as well as its reference library detailing beryllium mines, deposits, and occurrences worldwide (International Beryllium Corp., 2008c, d). In June, IBC acquired the Boomer Mine located in Park County, CO. The Boomer Mine was historically the second largest beryllium-producing mine in the United States from 1948 until 1963; mining operations were discontinued there in the early 1970s. Also in June, IBC completed the staking of 517 beryllium mineral claims in the Lake George district of Colorado, an area that included the Boomer Mine (International Beryllium Corp., 2008a, b).

In 2008, IBC announced that it would fund a 2-year, \$500,000 research project by Purdue University's Department of Nuclear Engineering to investigate the possibility of producing a longer lasting, more efficient, and safer nuclear fuel pellet by the addition of beryllium oxide to the uranium oxide pellet. Currently produced uranium oxide fuels, while stable and safe, are not efficient at conducting heat, which limits the power generated and causes fuel pellets to crack and degrade prematurely, necessitating replacement before the fuel has been entirely used. The addition of beryllium oxide may help cool the fuel pellet, allowing it to operate at a lower temperature and be used for a longer time, resulting in a more efficient burning of the fuel. A lower temperature would also allow for safer, more flexible reactor operation. If successful, the beryllium oxide-enhanced nuclear fuel pellet could increase demand for beryllium substantially (Mandel, 2008; Venere and Sequin, 2008).

## 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 218 t of contained beryllium in 2008, which was an increase of 118% from the 100 t calculated for 2007. The increase in apparent consumption was the result of shipments of BCMA and beryllium metal from the NDS, and the increased production and consumption of bertrandite by Brush Wellman.

Since the closure of Brush Wellman's primary beryllium production facility in Elmore, OH, 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 acoustic applications; and for applications using near net shape technologies increased compared with those of 2007. Sales of beryllium products for medical and industrial x-ray applications decreased slightly compared with those of 2007. Sales of beryllium products for the National Aeronautics and Space Administration James Webb Space Telescope and the Joint European Torus experimental nuclear fusion reactor in Culham, United Kingdom, ended with the completion of the projects in 2007 (Brush Engineered Materials Inc., 2009, p. 31, 32).

BEM's Beryllium and Beryllium Composites unit 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 increased in 2008 compared with those of 2007 (Brush Engineered Materials Inc., 2009, 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 2008, the total shipment volume of alloy strip products was 13% lower than that of 2007—the result of softening in the automotive market, continued softening in the computer and telecommunications market that began in 2007, and overall weakened demand in the fourth quarter of 2008 brought on by the global financial situation and related economic downturn. Shipments of higher beryllium-containing and lower beryllium-containing strip products decreased compared with those of 2007; shipments of thin-diameter rod and wire products increased compared with those of 2007. The total shipment volume of bulk alloy products increased 6% compared with that of 2007. Sales of strip products in the appliance market increased from those of 2007 (Brush Engineered Materials Inc., 2009, p. 30).

BEM 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. The parties were unable to reach an agreement on a new price and terminated the agreement on December 31, 2008. In 2008, BEM purchased beryllium-containing materials valued at \$8.9 million from NUKEM. Future purchases by BEM may be made from NUKEM through BEM's normal purchasing practices (Brush Engineered Materials Inc., 2009, p. 73).

In May, IBC acquired Freedom Alloys Inc. (Royersford, PA), a beryllium alloy manufacturer. Freedom was a primary producer-supplier of beryllium-copper casting and master alloy ingot products in North American and worldwide markets. In October, IBC acquired Nonferrous Products Inc. (Franklin, IN), a specialty alloy processing company and manufacturer of forged copper, beryllium-copper, and bronze alloys (International Beryllium Corp., 2009, p. 4).

Other domestic producers of beryllium alloy products included Applied Materials Science, Inc., Concord, MA; 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 increased by 12% compared with those of 2007. Japan was the major recipient of these materials. On a gross weight basis, total beryllium imports increased slightly from 2007; however beryllium ores and beryllium oxides and hydroxides decreased. Imports of BCMA, beryllium-copper alloy products, unwrought beryllium, beryllium waste and scrap, and other beryllium increased in 2008 relative to those of 2007. 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 2008, net import reliance as a percentage of apparent consumption was 20%. The shift from being a net exporter of beryllium to a net importer was primarily the result of a drawdown in industry stock and an increase in beryllium shipments from the NDS.

## World Review

**China.**—Yingtian Ulba Shine Metal Materials Company Limited (a joint venture between UMP and Ningbo Shengtai Electronic Metal Material Co. Ltd.) was formed in 2007 to increase UMP's presence in the Chinese high-tech market. UMP was to supply the raw materials, which would be processed into copper-beryllium mill products at Ningbo's plant in the Cixi Economic Development Zone of Ningbo, Zhejiang Province (Interfax Central Asia General Newswire, 2006; Interfax China Ltd., 2007). In 2008, Yingtian Ulba Shine began construction of a plant for the production of flat-rolled products from high-strength, conductive beryllium-copper alloys. Plant capacity was indicated at 2,000 metric tons per year for all products (Kazatomprom JSC, undated; 2009).

**Kazakhstan.**—UMP supplied about one-third of beryllium products to the world market in 2008, compared with 3% in 1999. UMP reportedly produced 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; Mining Reporter, 2009). As part of Japan's efforts to reduce its dependence on Middle East crude oil, Toshiba Corp. made an agreement with Kazatomprom in 2008 to secure supplies of rare metals and reactor components for Toshiba's nuclear power business. The agreement expanded on an existing deal under which Kazatomprom supplied uranium for Toshiba-built nuclear plants. In 2007, Kazatomprom had purchased 10% of Toshiba's nuclear subsidiary, U.S.-based Westinghouse to gain access to advanced nuclear power technology (Soble and Gorst, 2008).

**Russia.**—It was announced that Russian Technologies State Corp. might partner with East Siberian Metals Corp. to develop the Yermakovskoye beryllium deposit in the Siberian republic of Buryatia. Yermakovskoye was considered to be the largest beryllium deposit in Russia (Metal-Pages Ltd., 2008).

## Outlook

The United States is expected to remain self-sufficient with respect to most of its beryllium requirements. At yearend 2008, BEM reported proven bertrandite reserves in Juab County of 5.85 million dry metric tons (6.45 million dry short tons) with an average grade of 0.266% beryllium. This represented about 15,600 t of contained beryllium. BEM owned approximately 95% of its proven mineral reserves and leased the remainder (Brush Engineered Materials Inc., 2009, p. 41–42).

It was expected that the 2009 United States shipments of beryllium-copper strip products and beryllium bulk products would decrease from those of 2008 owing to the global economic downturn. Reduced demand for strip products was anticipated from the automotive electronics and telecommunications and computer markets. Reduced demand for bulk products was expected from the aerospace and oil and gas markets.

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TABLE 1  
SALIENT BERYLLIUM MINERAL STATISTICS

(Metric tons of beryllium content)

	2004	2005	2006	2007	2008
United States, beryllium-containing ores:					
Mine shipments <sup>1</sup>	90	110	155	150	175
Imports for consumption, beryl <sup>2</sup>	--	--	--	1	--
Consumption, reported <sup>3</sup>	130	160	180	190	220
Stocks, December 31:					
Industry <sup>1</sup>	40	35	50	100	60
U.S. Government, beryl <sup>2,4</sup>	209	165	9	8	(5)
World, production <sup>5,2</sup>	111	138 <sup>r</sup>	174 <sup>r</sup>	174 <sup>r</sup>	198

<sup>c</sup>Estimated. <sup>r</sup>Revised. -- Zero.

<sup>1</sup>Data are rounded to the nearest 5 metric tons.

<sup>2</sup>Based on a beryllium content of 4%.

<sup>3</sup>Data are rounded to the nearest 10 metric tons.

<sup>4</sup>Defense National Stockpile Center. Data for 2004–06 include beryl committed for sale pending shipment and uncommitted beryl. Data for 2007–08 are uncommitted beryl only.

<sup>5</sup>Less than ½ unit.

TABLE 2  
U.S. GOVERNMENT NATIONAL DEFENSE STOCKPILE BERYLLIUM STATISTICS IN 2008<sup>1</sup>

(Metric tons of beryllium content)

Material	Stockpile goal <sup>2</sup>	Disposal authority <sup>3</sup>	Annual Materials Plan <sup>4</sup>	Uncommitted inventory, December 31
Beryl ore	--	(5)	109 <sup>6</sup>	(5)
Beryllium-copper master alloy	--	--	11 <sup>6</sup>	--
Beryllium metal:				
Hot-pressed powder	45	89	--	134 <sup>7</sup>
Vacuum-cast	--	25	36	25
Total	45	114	36	160
Grand total	45	114	156	160

-- Zero.

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

<sup>2</sup>Goal effective as of December 28, 2001.

<sup>3</sup>Total quantity of material that can be disposed.

<sup>4</sup>Maximum quantity of material that can be disposed during 12-month period ending September 30, 2008.

<sup>5</sup>Less than ½ unit.

<sup>6</sup>Actual quantity will be limited to remaining inventory.

<sup>7</sup>Held for goal.

Source: Defense National Stockpile Center.

TABLE 3  
U.S. FOREIGN TRADE OF BERYLLIUM MATERIALS, BY TYPE<sup>1</sup>

Type and material	2007		2008		Principal destinations or sources, 2008
	Gross weight (kilograms)	Value (thousands)	Gross weight (kilograms)	Value (thousands)	
<b>Exports:</b>					
Beryllium, unwrought <sup>2</sup>	74,500	\$4,380	69,500	\$4,100	Japan, 92%; Finland, 4%; Switzerland, 2%.
Beryllium waste and scrap	271	47	16,400	1,140	Netherlands, 93%; Austria, 5%.
Beryllium, other <sup>3</sup>	25,900	14,100	26,700	11,300	Canada, 73%; France, 7%; Germany, 4%; Japan, 4%; United Kingdom, 3%; Venezuela, 2%.
<b>Total</b>	<b>101,000</b>	<b>18,500</b>	<b>113,000</b>	<b>16,500</b>	Japan, 57%; Canada, 17%; Netherlands, 14%; Finland, 3%; France, 2%; Switzerland, 2%.
<b>Imports:</b>					
Beryllium ores and concentrates	12,600	13	--	--	
Beryllium oxide and hydroxide	77,500	764	1	2	Liechtenstein, 100%.
Beryllium, unwrought <sup>2</sup>	15,000	2,680	33,200	2,440	Kenya, 68%; Kazakhstan, 29%; Canada, 3%.
Beryllium waste and scrap	1,630	6	4,730	790	Kazakhstan, 88%; Mexico, 10%.
Beryllium, other <sup>3</sup>	1,210	222	5,840	996	Kazakhstan, 45%; Japan, 23%; Germany, 18%; United Kingdom, 12%.
Beryllium-copper master alloy	651,000	8,250	663,000	9,270	Kazakhstan, 89%; Japan, 9%; Germany 2%.
Beryllium-copper plates, sheets, and strip	428,000	5,410	485,000	7,000	Japan, 98%.
<b>Total</b>	<b>1,190,000</b>	<b>17,300</b>	<b>1,190,000</b>	<b>20,500</b>	Kazakhstan, 51%; Japan, 45%; Kenya, 2%.

-- Zero.

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

<sup>2</sup>Includes powders.

<sup>3</sup>Includes articles not elsewhere specified.

Source: U.S. Census Bureau.

TABLE 4  
 BERYL: WORLD PRODUCTION, BY COUNTRY<sup>1,2</sup>

(Metric tons of gross weight)

Country <sup>3</sup>	2004	2005	2006	2007	2008
Brazil	(4)	-- <sup>r</sup>	-- <sup>r</sup>	-- <sup>r</sup>	--
China <sup>e</sup>	500	500	500	500	500
Madagascar <sup>e,5</sup>	12 <sup>r,6</sup>	12 <sup>r</sup>	12 <sup>r</sup>	12 <sup>r</sup>	12 <sup>6</sup>
Mozambique	45	146	16 <sup>r</sup>	30 <sup>r</sup>	30 <sup>e</sup>
Portugal <sup>e</sup>	5	5	5	5	5
United States, mine shipments <sup>7</sup>	2,210	2,780	3,830	3,810	4,410
Total	2,780 <sup>r</sup>	3,450 <sup>r</sup>	4,360 <sup>r</sup>	4,360 <sup>r</sup>	4,960

<sup>e</sup>Estimated. <sup>r</sup>Revised. -- Zero.

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

<sup>2</sup>Table includes data available through June 13, 2009. Unless otherwise noted, figures represent beryl ore for the production of beryllium and exclude gem-quality beryl.

<sup>3</sup>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 ore may also have produced some industrial beryl ore.

<sup>4</sup>Less than ½ unit.

<sup>5</sup>Includes ornamental and industrial products.

<sup>6</sup>Reported figure.

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

