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2009 Minerals Yearbook

BERYLLIUM

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Beryllium

By Brian W. Jaskula

Domestic survey data and tables were prepared by Joseph M. Krisanda, statistical assistant, and the world production table was prepared by Lisa D. Miller, international data coordinator.

U.S. mine shipments of beryllium ore in 2009 decreased 31% from those of 2008, and ore consumption for the production of beryllium hydroxide decreased 32% (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 and exports of beryllium materials were lower than those of 2008.

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 2009, estimated world beryllium mine production decreased by 27% compared with that of 2008 (table 4). The United States accounted for about 84% 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, 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

Strategic Materials Protection Board.—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 Air Force, Army, and Navy) ruled that high-purity beryllium was both a strategic and a critical material, that domestic beryllium production capabilities had abated, and required the DOD to continue to take special actions to maintain a long-term domestic supply (Metal-Pages, 2009; U.S. Department of Defense, 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 $90.3 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. Brush Wellman was to fund approximately $23.2 million of the project, with the remaining balance to be funded by DOD. Construction was expected to be completed by mid-2010 (Smith Horn, 2008; Brush Engineered Materials Inc., 2010a, p. 39).

National Defense Stockpile.—The United States maintained a stockpile of strategic materials for use during a national emergency. As of December 31, 2009, 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 2009, which represented the maximum quantities of beryllium materials that could be sold from October 1, 2008, through September 30, 2009, was as follows: 1,000 t of beryl ore (36 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). The DNSC shipped 19 t of beryllium metal in 2009. NDS calendar yearend inventories of beryllium materials are listed in table 2 (U.S. Department of Defense, 2010, p. 6).

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 2009, domestic mine shipments were less than those of 2008.

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.

As part of its effort to become a vertically integrated supplier of beryllium products, IBC Advanced Alloys Corp. (Vancouver, British Columbia, Canada) focused on three distinct business areas in 2009: beryllium exploration, downstream manufacturing of beryllium products, and beryllium research. In 2008, to support its beryllium exploration effort, IBC acquired Rare Earths Ltd. (REL), a Colorado-based beryllium exploration company. Also in 2008, IBC acquired the Boomer Mine, located in Park County, CO, and 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, c).

In 2009, IBC, in partnership with Purdue University and Texas A&M University, continued research into a new type of beryllium oxide (BeO) enhanced nuclear fuel. IBC was funding 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 BeO 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 BeO 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 BeO-enhanced nuclear fuel pellet could increase demand for beryllium substantially (Mandel, 2008; Venere and Sequin, 2008; IBC Advanced Alloys Corp., 2009b).

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 167 t of contained beryllium in 2009, which was a decrease of 23% from the 218 t calculated for 2008. The decrease in apparent consumption was the result of reduced shipments of beryl ore, BCMA, and beryllium metal from the NDS, and the reduced 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 BeO. 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, and for medical and industrial x-ray applications decreased 26% compared with those of 2008, primarily owing to delayed funding for orders from the defense market in the second half of 2009. Development work on high-end beryllium speaker domes continued throughout 2009, with market growth expected in 2010 (Brush Engineered Materials Inc., 2010a, p. 32).

BEM's Beryllium and Beryllium Composites unit included Brush Ceramic Products Inc., which produced BeO ceramic products for aerospace, defense, electronics, medical, semiconductor, telecommunications, and wireless applications at its plant in Tucson, AZ. Sales of ceramic products decreased 42% in 2009 compared with those of 2008 as the worldwide economic downturn affected BEM's key ceramic customer (Brush Engineered Materials Inc., 2010a, 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 2009, the total shipment volume of alloy strip products was 32% lower than that of 2008—the result of continued softening in the automotive electronics market, the computer and telecommunications market, and excess inventories in the supply chain brought on by the global financial situation and related economic downturn. The total shipment volume of bulk alloy products decreased 45% compared with that of 2008—the result of reduced demand from the aerospace, oil and gas markets, and excess inventories within the supply chain (Brush Engineered Materials Inc., 2010a, p. 30, 31).

BEM's long-term supply arrangement with JSC Ulba Metallurgical Plant (UMP), which was part of Kazakhstan's National Atomic Company Kazatomprom JSC, and its marketing representative RWE NUKEM, Inc. (Danbury, CT) to purchase BCMA and beryllium vacuum-cast billet was terminated on December 31, 2008. In 2009, any purchases by BEM from RWE NUKEM used BEM's normal purchasing practices (Brush Engineered Materials Inc., 2010a, p. 76).

BEM announced that its Electrofusion Products group would provide four beryllium beam pipes for the Large Hadron Collider (LHC), a particle accelerator located near Geneva, Switzerland. The LHC planned to recreate the conditions just after the Big Bang event that theoretically led to the formation of the universe, using the beryllium beam pipes to ensure high energy collisions of subatomic particles. The beryllium in the beam pipes is essentially transparent to the subatomic particles owing to its low atomic number and low density, allowing the particle detectors to be free of significant interference. The beryllium in the beam pipes allows the pipes to remain dimensionally stable with the ultra high vacuum inside. Other advantages of using beryllium in the beam pipes include thermal stability at temperatures approaching absolute zero and lack of magnetism which allows multipole magnets to steer and focus the particle beam without interference. Beryllium's low atomic number also keeps the pipes from becoming radioactive from the radiation bombarding them (Brush Engineered Materials Inc., 2009).

In 2009, as part of IBC's effort to develop downstream beryllium manufacturing capabilities, the company entered into a letter of intent to acquire Beralcast Corp., a privately held specialty alloy manufacturing business based in Nashua, NH, which owned proprietary and patented technology for a castable beryllium aluminum alloy currently used in a variety of aerospace and advanced technology applications. IBC also acquired Specialloy Copper Alloys, LLC (New Madrid, MO), an established specialty alloy manufacturer. Specialloy had significant unused manufacturing capacity, which will be upgraded by IBC for beryllium-copper casting products. In 2008, IBC acquired Freedom Alloys Inc. (Royersford, PA), a primary producer-supplier of beryllium-copper casting and master alloy ingot products and Nonferrous Products Inc. (Franklin, IN), a specialty alloy processing company and manufacturer of forged copper, beryllium-copper, and bronze alloys (Dutton, 2009; IBC Advanced Alloys Corp., 2009a; International Beryllium Corp., 2009, p. 4).

In November, IBC signed a letter of intent with Kazatomprom agreeing to three specific initiatives. The first was to negotiate a 3-year agreement whereby Kazatomprom's UMP would supply beryllium and beryllium alloy to IBC on preagreed terms. The second was to explore mutually beneficial strategic partnerships. The third was to assess the feasibility of a Kazakhstan-based high-volume BeO production facility to support IBC's beryllium-enhanced nuclear fuel initiative (IBC Advanced Alloys Corp., 2009c).

In December, IBC signed a research proposal with a Washington, DC-based clean-energy consulting company to develop the commercial application of beryllium and BeO in the wind energy and turbine market. IBC and its research partner will assess the feasibility of an advanced plasma-based method of applying a BeO coating to beryllium, beryllium copper, and aluminum bronze. A BeO coating on bearings would increase the wear resistance in wind turbines and therefore increase reliability and reduce the costs of operation (IBC Advanced Alloys Corp., 2009d).

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 the basis of estimated contained beryllium, beryllium exports decreased by 80% compared with those of 2008. Canada and Japan were the major recipients of these materials. On the basis of estimated contained beryllium, total beryllium imports decreased by 69% compared with those of 2008; however, beryllium ores and beryllium waste and scrap increased. 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. For 2009, net import reliance as a percentage of apparent consumption was estimated to be about 28% compared with about 20% in 2008. The increase was primarily the result of a decrease in U.S. beryllium mine shipments and continued drawdown in industry stock.

World Review

China.—Yingtan Ulba Shine Metal Materials Co. Ltd. (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 2009, Yingtan Ulba Shine completed construction of a plant and began production of flat-rolled products from high-strength, conductive beryllium-copper alloys. Plant capacity was reported to be about 2,000 metric tons per year (gross weight) for all products, and capacity utilization was expected to be 100% by yearend (Interfax Russia & CIS Metals and Mining Weekly, 2009; Kazakhstan International Business Magazine, 2009).

Kazakhstan.—Kazatomprom reported beryllium sales revenues to be 41% lower than those of 2008. UMP supplied about one-third of beryllium products to the world market in 2009, 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 in 2003 to be sufficient to support production for about 30 years (Metal Bulletin, 2003; McNeil, 2006; Kazatomprom JSC, 2010, p. 31, 32). Kazatomprom signed a letter of intent with

Toshiba Corp. in 2009 to establish a joint venture for the research, exploration, production, and sales of rare metals, including beryllium. Previously, as part of Japan's efforts to reduce its dependence on crude oil from the Middle East, Toshiba 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 (Soble and Gorst, 2008; Reuters, 2009).

Russia.—In 2009, it was announced that East Siberian Metals Corp. and UMP (Kazakhstan) signed a cooperative agreement to develop the Yermakovskoye beryllium deposit in the Siberian Republic of Buryatiya. Russian Technologies State Corp. was also interested in partnering on the project. Yermakovskoye was considered to be the largest beryllium deposit in Russia (Metal-Pages, 2008; Metropol Investment Financial Co. Ltd., 2009).

Outlook

The United States is expected to remain self-sufficient with respect to most of its beryllium requirements. At yearend 2009, BEM reported proven bertrandite reserves in Juab County of 5.83 million dry metric tons (6.43 million dry short tons) with an average grade of 0.266% beryllium. This represented about 15,500 t of contained beryllium. BEM owned approximately 95% of its proven mineral reserves and leased the remainder (Brush Engineered Materials Inc., 2010a, p. 42–43).

It was expected that the 2010 U.S. shipments of beryllium-copper strip products and beryllium bulk products would increase considerably from those of 2009 owing to improved market conditions. Increased demand for strip products was anticipated from the automotive electronics, and telecommunications and computer markets, with the telecommunications and computer markets' consumer electronics segment expected to increase substantially in 2010. Increased demand for bulk products was expected from the aerospace and oil and gas markets. Increased demand for beryllium-based metals and metal matrix composites was anticipated from defense and commercial applications, including medical and analytical x-ray product applications (Brush Engineered Materials Inc., 2010b).

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TABLE 1
SALIENT BERYLLIUM MINERAL STATISTICS

(Metric tons of beryllium content)

	2005	2006	2007	2008	2009
United States, beryllium-containing ores:					
Mine shipments[1]	110	155	150	175	120
Imports for consumption, beryl[2]	--	--	1	--	1
Consumption, reported[3]	160	180	190	220	150
Stocks, December 31:					
Industry1	35	50	100	60	30
U.S. Government, beryl[2, 4]	165	9	8	(5)	(5)
World, production[e, 2]	138	174	174	197	144

[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 2005–06 include beryl committed for sale pending shipment and uncommitted beryl. Data for 2007–09 are uncommitted beryl only.
[5]Less than ½ unit.

TABLE 2

U.S. GOVERNMENT NATIONAL DEFENSE STOCKPILE BERYLLIUM STATISTICS IN 2009[1]

(Metric tons of beryllium content)

Material	Stockpile goal[2]	Disposal authority[3]	Annual Materials Plan[4]	Uncommitted inventory, December 31
Beryl ore	--	(5)	36 [6]	(5)
Beryllium-copper master alloy	--	--	11 [6]	--
Beryllium metal:				
Hot-pressed powder	45	87	--	132 [7]
Vacuum-cast	--	8	36	8
Total	45	95	36	141
Grand total	45	95	83	141

-- 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, 2009.

[5]Less than ½ unit.

[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	2008 Gross weight (kilograms)	2008 Content[2] (kilograms)	2008 Value (thousands)	2009 Gross weight (kilograms)	2009 Content[2] (kilograms)	2009 Value (thousands)	Principal destinations or sources, 2009[3]
Exports:							
Beryllium, unwrought[4]	69,500	69,500	$4,100	5,840	5,840	$231	Japan, 69%; Switzerland, 18%; Germany, 4%; Republic of Korea, 4%; South Africa, 4%.
Beryllium waste and scrap	16,400	16,400	1,140	--	--	--	
Beryllium, other[5]	26,700	26,700	11,300	17,000	17,000	11,500	Canada, 55%; France, 15%; United Kingdom, 8%; Germany, 6%; Japan, 6%; Singapore, 2%.
Total	113,000	113,000	16,500	22,900	22,900	11,700	Canada, 41%; Japan, 22%; France, 11%; Germany, 6%; United Kingdom, 6%; Switzerland, 5%; Republic of Korea, 2%; Singapore, 2%.
Imports:							
Beryllium ores and concentrates	--	--	--	18,000	720	7	Uganda, 100%.
Beryllium oxide and hydroxide	1	(6)	2	--	--	--	
Beryllium, unwrought[4]	33,200	33,200	2,440	2	2	3	Kazakhstan, 100%.
Beryllium waste and scrap	4,730	4,730	790	6,700	6,700	161	Germany, 98%; France, 2%.
Beryllium, other[5]	5,840	5,840	996	5,660	5,660	833	Kazakhstan, 52%; Japan, 28%; Republic of Korea, 12%; Canada, 7%.
Beryllium-copper master alloy	663,000	26,500	9,270	205,000	8,220	2,800	Kazakhstan, 55%; Japan, 40%; Germany 4%.
Beryllium-copper plates, sheets, and strip	485,000	7,270	7,000	165,000	2,480	1,920	Japan, 99%.
Total	1,192,000	77,600	20,500	401,000	23,800	5,720	Japan, 31%; Kazakhstan, 31%; Germany, 29%; Republic of Korea, 3%; Uganda, 3%; Canada, 2%.

XX Not applicable. -- Zero.

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

[2] Estimated from gross weights.

[3] Principal destinations or sources percentages based on estimated beryllium content.

[4] Includes powders.

[5] Includes articles not elsewhere specified.

[6] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 4

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

(Metric tons, gross weight)

Country[3]	2005	2006	2007	2008	2009[e]
China[e]	500	500	500	500	500
Madagascar[e, 4]	12	12	12	12	12
Mozambique	146	16	31 [r]	8 [r]	45
Portugal[e]	5	5	5	5	5
United States, mine shipments[5]	2,780	3,830	3,810	4,410	3,030
Total	3,450	4,360	4,360	4,940 [r]	3,590

[e]Estimated. [r]Revised.

[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 10, 2010. Unless otherwise noted, figures represent beryl ore for the production of beryllium and exclude gem-quality beryl.

[3]Argentina, Kazakhstan, Nigeria, Russia, and Uganda may 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.

[4]Includes ornamental and industrial products.

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