



2010 Minerals Yearbook

BERYLLIUM

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U.S. mine shipments of beryllium ore in 2010 increased by 50% from those of 2009, and ore consumption for the production of beryllium hydroxide increased by 33% (table 1). Defense Logistics Agency, DLA Strategic Materials 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 higher than those of 2009.

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 2010, estimated world beryllium mine production increased by 41% compared with that of 2009 (table 4). The United States accounted for about 88% 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.

High-purity beryllium was ruled both a strategic and a critical material by the U.S. Department of Defense Strategic Materials Protection Board. The Board found that domestic beryllium production capabilities had abated and required the DOD to continue to take special actions to maintain a long-term domestic supply (U.S. Department of Defense, Office of the Secretary, 2009).

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.—DOD, under its Defense Production Act Title III Program with Materion Corp. (formerly known as Brush Engineered Materials Inc.), continued with 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 Materion was to ensure a long-term domestic supply of primary beryllium, the feed material used to make beryllium metal products. Materion was to provide assets, research and development, and technology valued at approximately \$23.2 million to the project, with the remaining balance to be funded by DOD. Construction was expected to be completed by early 2011. Plant capacity was reported to be 73 metric tons per year (t/yr) of high-purity beryllium metal, and approximately two-thirds of the facility's output was to be allocated for defense and government-related end uses, with the remaining output going to the private sector (Smith Horn, 2008; Metal Bulletin, 2010; Materion Corp., 2011a, p. 9).

National Defense Stockpile.—The United States maintained a stockpile of strategic materials for use during a national emergency. As of December 31, 2010, the NDS goal for hot-pressed beryllium metal powder was 45 metric tons (t) (table 2). The Annual Materials Plan for fiscal year 2010, which represented the maximum quantities of beryllium materials that could be sold from October 1, 2009, through September 30, 2010, was as follows: 1 t of beryl ore (approximately 36 kilograms of beryllium content), actual quantity limited to remaining sales authority or inventory; and 54 t of beryllium metal (table 2). The DNSC shipped 29 t of beryllium metal in 2010. NDS calendar yearend inventories of beryllium materials are listed in table 2 (U.S. Department of Defense, 2011, 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 2010, domestic mine shipments were greater than those of 2009.

The United States is one of only three countries known to process beryllium ores and concentrates into beryllium products. Materion converted bertrandite from open pit mines in the

Topaz-Spor Mountain region of Juab County, UT, along with imported beryl, into beryllium hydroxide at its operations near Delta, UT. Some of the beryllium hydroxide was shipped to Elmore, where Materion converted it into beryllium-copper master alloy (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) continued to focus on three distinct business areas in 2010—beryllium exploration, downstream manufacturing of beryllium products, and beryllium research. In September, Fugro Airborne Surveys Corp. (Leidschendam, Netherlands) completed an airborne geophysical survey of IBC's prospective beryllium properties in Juab County, UT, which are adjacent to Materion's beryllium mine at Spor Mountain. The results were expected to delineate the most likely areas of beryllium mineralization that, with subsequent ground investigation, would provide exploratory drill hole targets to begin quantifying IBC's beryllium resources (Metal-Pages, 2010; IBC Advanced Alloys Corp., 2011, p. 9).

In June, IBC entered into a 6-month arrangement with Hydrogen Link, a materials research company focused on hydrogen storage and fuel cell technologies, in a combined effort to research and implement the use of lithium beryllium hydrides and other metal hydrides for the storage of hydrogen. By yearend, IBC was reviewing the possibility of commercializing beryllium-based hydrogen storage technology with potential industry partners (IBC Advanced Alloys Corp., 2011, p. 7).

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 funded 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 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., 2011, p. 6).

In September, junior mineral exploration company BE Resources Inc. (Toronto, Ontario, Canada) commenced drilling at its Warm Springs Beryllium Project in New Mexico. Five exploration boreholes were to be drilled in an effort to define the beryllium resource of the company's mining claims within New Mexico's Sierra and Socorro Counties. By yearend, assay results were reported for two of the five boreholes, with the remaining assays to be reported in 2011 (BE Resources Inc., 2010a, b).

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 of the quantity of beryllium dust, fumes, and mists in the workplace. Control of potential health hazards adds to the final cost of beryllium products (Rossman, Preuss, and Powers, 1991, p. 277–281; 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 456 t of contained beryllium in 2010, which was an increase of 164% from the 173 t calculated for 2009. The increase in apparent consumption was the result of increased shipments of beryllium metal from the NDS, increased imports of all beryllium materials and products, and increased shipments of bertrandite by Materion.

Since the closure of Materion'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. Materion'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. Beryllium product sales increased by 32% compared with those of 2009. Key growth sectors were defense and science applications, primarily aerospace and missile systems; industrial component and commercial aerospace applications; and medical and industrial x-ray applications. Sales of high-end beryllium speaker domes increased modestly in 2010 compared with those of 2009 (Materion Corp., 2011a, p. 32–33).

Materion's Beryllium and Beryllium Composites unit produced BeO ceramic products for aerospace, defense, electronics, medical, semiconductor, telecommunications, and wireless applications at its plant in Tucson, AZ. Sales of ceramic products increased by more than 50% in 2010 compared with those of 2009 owing largely to increased shipments for applications within the telecommunications infrastructure market (Materion Corp., 2011a, p. 33).

Materion's Performance Alloys unit produced copper- and nickel-based alloy products, the majority of which contained beryllium. Alloy strip products (which were used as connectors, contacts, relays, shielding, and switches) and alloy bulk products (including bar, plate, rod, tube, and customized forms) were produced at plants in Elmore and in Shoemakersville, PA. In 2010, the total shipment volume of alloy strip products was 56% greater than that of 2009, owing to increased consumption

from the appliance, automotive electronics, and consumer electronics markets. The total shipment volume of bulk alloy products increased by 70% compared with that of 2009—largely owing to increased consumption from the commercial aerospace and industrial components markets, and the oil and gas sector of the energy market (Materion Corp., 2011a, p. 30–31).

Materion had a 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 through 2011. In 2010, Materion purchased beryllium-containing materials valued at \$2.7 million (Materion Corp., 2011a, p. 77).

In 2010, as part of IBC's effort to develop downstream beryllium manufacturing capabilities, the company acquired 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 previously acquired Specialloy Copper Alloys, LLC (New Madrid, MO), an established specialty alloy manufacturer. Specialloy had significant unused manufacturing capacity, which was expected to be upgraded by IBC for beryllium-copper casting products. IBC also owned 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 (IBC Advanced Alloys Corp., 2010, p. 2–7).

In March, IBC signed long-term beryllium supply agreements with Kazatomprom's UMP agreeing to three specific initiatives. UMP and IBC committed to multiple-year supply commitments for beryllium metal and BCMA, to explore mutually beneficial strategic partnerships, and 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., 2010, p. 2).

IBC teamed with Sentech, Inc., a Washington, DC-based clean-energy consulting company, to commercialize applications of beryllium and BeO in the wind energy and turbine market. IBC and Sentech were to 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., 2011, p. 7).

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 increased by 69% compared with those of 2009. Canada and the United Kingdom were the major recipients of these materials. On the basis of estimated contained beryllium, total beryllium imports were more than 10 times higher than those of 2009. Russia was, by far, the leading supplier of beryllium metal to the United States, while China, Japan, and Kazakhstan were significant suppliers of other beryllium materials.

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 2010, net import reliance as a percentage of apparent consumption was estimated to be about 61% compared with about 31% in 2009. The increase was primarily the result of the large increase in beryllium metal imports from Russia.

World Review

China.—Yingtian Ulba Shine Metal Materials Co. Ltd. (a joint venture between UMP and Ningbo Shengtai Electronic Metal Materials Co. Ltd.) operated a plant that produced flat-rolled products from high-strength, conductive beryllium-copper alloys. Plant capacity was reported to be about 2,000 t/yr (gross weight) for all products (Interfax Russia & CIS Metals and Mining Weekly, 2009; Kazakhstan International Business Magazine, 2009).

Kazakhstan.—Kazatomprom reported production of 1,817 t of beryllium materials (including alloys and ceramics), an increase of 155% from the 712 t produced in 2009. The company's beryllium sales revenues were 80% greater than those of 2009. UMP supplied about 24% of beryllium products to the world market in 2010, compared with 3% in 1999. UMP reportedly produced from stockpiled beryllium concentrate imported mainly from Russia. The concentrate stockpile, which was built up before the breakup of the Soviet Union, was forecast in 2003 to be sufficient to support production for about 30 years (Metal Bulletin, 2003; McNeil, 2006; Kazatomprom JSC, 2011, p. 37, 107).

Kazatomprom signed an agreement with Toshiba Corp. (Tokyo, Japan) in 2010 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; Kazatomprom JSC, 2011, p. 32).

Russia.—East Siberian Metals Corp. (a subsidiary of Metropol Group) and UMP completed the predesign phase for resuming ore mining at the Yermakovskoye beryllium deposit in the Siberian Republic of Buryatiya and the technical design of the processing plant. The new plant would produce beryllium hydroxide, which was expected to be delivered to China, Japan, and Kazakhstan for processing into beryllium metal and beryllium alloys. Yermakovskoye was considered to be the largest beryllium deposit in Russia. Construction of the processing plant was expected to begin in 2013 (Metropol Investment Financial Co. Ltd., 2009; MBC Corp., 2010).

Outlook

The United States is expected to remain self-sufficient with respect to most of its beryllium requirements. At yearend 2010, Materion reported proven bertrandite reserves in Juab County, UT, of 5.81 million dry metric tons with an average grade of 0.266% beryllium. This represented about 15,500 t of contained beryllium. Materion owned approximately 95% of its proven mineral reserves and leased the remainder (Materion Corp., 2011a, p. 42–43).

It was expected that the 2011 U.S. shipments of beryllium-copper strip products and beryllium bulk products would increase from those of 2010 owing to increased demand from the aerospace, automotive electronics, industrial components, oil and gas, and telecommunications infrastructure markets. Increased demand for beryllium-based metals and metal matrix composites was anticipated from commercial applications, including nonmedical and industrial x-ray products, and semiconductor processing equipment (Materion Corp., 2011b).

Research and consulting firm Global Industry Analysts, Inc. predicted the worldwide beryllium market would increase to 465 t of contained beryllium by 2015 owing to increased security concerns, which will likely increase the consumption of beryllium in defense applications. The advent of new alloys of beryllium with aluminum was also expected to contribute to the increase in beryllium consumption (Global Industry Analysts, Inc., 2011).

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TABLE 1
 SALIENT BERYLLIUM MINERAL STATISTICS

(Metric tons, beryllium content)

	2006	2007	2008	2009	2010
United States, beryllium-containing ores:					
Mine shipments ¹	155	150	175	120	180
Imports for consumption, beryl ²	--	1	--	1	5
Consumption, reported ³	180	190	220	150	200
Stocks, December 31:					
Industry ¹	50	100	60	30	15
U.S. Government, beryl ^{2,4}	9	8	(5)	(5)	(5)
World, production ^{6,2}	174	174	197	144	203

⁶Estimated. -- 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 Logistics Agency, DLA Strategic Materials (formerly Defense National Stockpile Center). Data for 2006 include beryl committed for sale pending shipment and uncommitted beryl. Data for 2007–10 are uncommitted beryl only.

⁵Less than ½ unit.

TABLE 2
U.S. GOVERNMENT NATIONAL DEFENSE STOCKPILE BERYLLIUM
STATISTICS IN 2010¹

(Metric tons, beryllium content)

Material	Stockpile goal ²	Disposal authority ³	Annual Materials Plan ⁴	Uncommitted inventory, December 31
Beryl ore	--	(5)	(5) ⁶	(5)
Beryllium metal:				
Hot-pressed powder	45	52	--	97 ⁷
Vacuum-cast	--	14	54	14
Total	45	66	54	112
Grand total	45	66	54	112

-- 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, 2010.

⁵Less than ½ unit.

⁶Actual quantity will be limited to remaining inventory.

⁷Held for goal.

Source: Defense Logistics Agency, DLA Strategic Materials (formerly Defense National Stockpile Center).

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

Type and material	2009			2010			Principal destinations or sources, 2010 ³
	Gross weight (kilograms)	Content ² (kilograms)	Value (thousands)	Gross weight (kilograms)	Content ² (kilograms)	Value (thousands)	
Exports:							
Beryllium, unwrought ⁴	5,840	5,840	\$231	5,020	5,020	\$215	China, 31%; Switzerland, 17%; Mexico, 16%; Thailand, 10 %.
Beryllium waste and scrap	--	--	--	527	527	48	Brazil, 36%; France, 24%; Malaysia, 17%; United Kingdom, 17%.
Beryllium, other ⁵	17,000	17,000	11,500	33,100	33,100	24,100	Canada, 51%; United Kingdom, 25%.
Total	22,900	22,900	11,700	38,700	38,700	24,300	Canada, 43%; United Kingdom, 23%.
Imports for consumption:							
Beryllium ores and concentrates	18,000	720	7	113,000	4,530	68	Mozambique, 40%; Uganda, 37%; Mexico, 16%.
Beryllium oxide and hydroxide	--	--	--	83,300	30,000	548	China, 72%; France, 25%.
Beryllium, unwrought ⁴	2	2	3	22,500	22,500	1,320	Russia, 89%.
Beryllium waste and scrap	6,700	6,700	161	9,240	9,240	319	Germany, 57%; Canada, 38%.
Beryllium, other ⁵	5,660	5,660	833	184,000	184,000	5,150	Russia, 93%.
Beryllium-copper master alloy	205,000	8,220	2,800	323,000	12,900	6,500	Japan, 55%; Kazakhstan, 37%.
Beryllium-copper plates, sheets, and strip	165,000	2,480	1,920	508,000	7,610	6,720	Japan, 100%.
Total	401,000	23,800	5,720	1,240,000	271,000	20,600	Japan, 56%; Russia, 15%; Kazakhstan, 10%.

-- Zero.

¹Data are rounded to no more than three significant digits; may not add to totals shown.²Estimated from gross weights.³Principal destinations or sources percentages based on beryllium content data.⁴Includes powders.⁵Includes articles not elsewhere specified.

Source: U.S. Census Bureau.

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

(Metric tons, gross weight)

Country ³	2006	2007	2008	2009	2010 ^e
China ^c	500	500	500	500	550
Madagascar ^{c, 4}	12	12	12	12	12
Mozambique	16	31	8	45	45
Portugal ^c	5	5	5	5	5
United States, mine shipments ⁵	3,830	3,810	4,410	3,030	4,460
Total	4,360	4,360	4,940	3,590	5,080

^eEstimated.

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 August 11, 2011. Unless otherwise noted, figures represent beryl ore for the production of beryllium and exclude gem-quality beryl.

³In 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.

⁴Includes ornamental and industrial products.

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