



2011 Minerals Yearbook

BERYLLIUM

BERYLLIUM

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U.S. mine shipments of beryllium ore in 2011 increased by 31% from those of 2010, and ore consumption for the production of beryllium hydroxide increased by 25% (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 lower than those of 2010.

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 2011, estimated world beryllium mine production increased by 28% compared with that of 2010 (table 4). The United States accounted for about 91% 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 such as bearings and bushings, computer chip heat sinks, contacts and connectors, disc brakes, highly conductive and strong wire, mirrors, protective housings, switches and relays, and x-ray windows. Industries that use beryllium products include aerospace, automotive, computer, defense, electronics, marine, medical, nuclear, and telecommunications industries.

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., 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 completed in early 2011, while startup of the facility continued throughout the year. 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 (Metal Bulletin, 2010; Materion Corp., 2012a, p. 4).

National Defense Stockpile.—The United States maintained a stockpile of strategic materials for use during a national emergency. As of December 31, 2011, the NDS goal for hot-pressed beryllium metal powder was 45 metric tons (t) (table 2). The Annual Materials Plan for fiscal year 2011, which represented the maximum quantities of beryllium materials that could be sold from October 1, 2010, through September 30, 2011, was 47 t of beryllium metal. The DLA shipped 22 t of beryllium metal in 2011. NDS calendar yearend inventories of beryllium materials are listed in table 2 (U.S. Department of Defense, 2012, 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 2011, domestic mine shipments were greater than those of 2010.

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 2011—beryllium exploration, downstream manufacturing of beryllium products, and beryllium research. In November, IBC completed the first phase of a drilling program at its prospective beryllium property in Juab County, UT, which is adjacent to Materion's beryllium mine at Spor Mountain. The first phase of the program was designed to test the presence and concentration of fluorite bertrandite to begin quantifying IBC's beryllium resources. Laboratory results were expected in early 2012 (IBC Advanced Alloys Corp., 2012, p. 10–11).

IBC manufactured downstream beryllium products at plants located in Franklin, IN, New Madrid, MO, Royersford, PA, and Wilmington, MA. In June, IBC signed a memorandum of understanding with JSC Ulba Metallurgical Plant (UMP), which was part of Kazakhstan's National Atomic Company Kazatomprom JSC, to renew and extend multiyear supply agreements for the delivery of beryllium metal and beryllium master alloys from UMP. IBC previously signed long-term beryllium supply agreements with UMP agreeing to multiple-year supply commitments for beryllium metal and BCMA, to explore mutually beneficial strategic partnerships between the two companies, and to assess the feasibility of a Kazakhstan-based high-volume beryllium oxide (BeO) production facility to support IBC's beryllium-enhanced nuclear fuel initiative (IBC Advanced Alloys Corp., 2012, p. 3–5).

In April, IBC renewed its collaborative research agreements with Purdue University and Texas A&M University to continue investigating a new type of BeO-enhanced nuclear fuel. IBC previously 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. In 2011, IBC also entered into a memorandum of understanding with Global Nuclear Fuel Americas, LLC (GNF-A) (a joint venture between General Electric Co., Hitachi Ltd., and Toshiba Corp.) to apply BeO-enhanced nuclear fuel pellet technology to boiling water reactor fuel at GNF-A's fuel fabrication plant in Wilmington, MA (Mandel, 2008; Venere and Sequin, 2008; IBC Advanced Alloys Corp., 2012, p. 6–7).

In October, junior mineral exploration company BE Resources Inc. (Toronto, Ontario, Canada) placed its Warm Springs Beryllium Project in New Mexico on care-and-maintenance status. Assays from 13 exploration boreholes revealed grades of beryllium oxide well below the cutoff grades determined from the company's beryllium oxide benchmarking project (BE Resources Inc., 2011).

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 333 t of contained beryllium in 2011, which was a decrease of 27% from the 456 t calculated for 2010. The decrease in apparent consumption was the result of decreased imports of beryllium metal from Russia.

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 in this unit decreased slightly compared with those of 2010. Defense and science applications, which account for approximately one-half of the Beryllium and Beryllium Composites unit sales, decreased by 8% compared with those of 2010 owing to government funding delays. Sales increased, however, for industrial component and commercial aerospace applications owing to an increase in the production of x-ray window assemblies. Sales for energy applications increased slightly in 2011 compared with those of 2010 (Materion Corp., 2012a, p. 35–36).

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 decreased slightly in 2011, after increasing more than 50% in 2010 owing largely to increased shipments for applications within the telecommunications infrastructure market (Materion Corp., 2012a, p. 36).

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 2011, the total shipment volume of alloy strip products decreased 7% compared with that of 2010, owing mainly to decreased consumption from the consumer electronics market, and to a lesser extent, the appliance market. The total shipment

volume of bulk alloy products increased by 6% compared with that of 2010—largely owing to increased consumption from the oil and gas sector of the energy market and the telecommunications infrastructure market (Materion Corp., 2012a, p. 33–34).

Materion had a long-term supply arrangement with UMP, and its marketing representative RWE NUKEM, Inc. (Danbury, CT) to purchase BCMA through 2012. In 2011, Materion purchased beryllium-containing materials valued at \$8.8 million (Materion Corp., 2012a, p. 85).

In June, as part of IBC's effort to increase downstream beryllium manufacturing capabilities, the company opened its Wilmington, MA, manufacturing facility which was optimized to produce Beralcast, a castable beryllium aluminum alloy used in a variety of aerospace and advanced technology applications. In 2010, IBC acquired Beralcast Corp., a privately held specialty alloy manufacturing business based in Nashua, NH, which owned proprietary and patented technology for Beralcast alloys. 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., 2012, p. 2–4).

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 planned 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 was expected to 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 from new scrap generated during the manufacture of beryllium-containing components, as well as old scrap collected from end users. Detailed data on the quantities of recycled beryllium are not available but may represent as much as 20% to 25% of U.S. apparent consumption. Beryllium products manufactured from recycled sources by Materion require only 20% of the energy as that of beryllium products manufactured from virgin sources. Materion, therefore, established a comprehensive recycling program for its beryllium products and indicated a 40% recovery rate of beryllium new and old scrap (Stephen Freeman, President, International Business Development, Materion Corp., oral commun., August 2, 2012).

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 45% compared with those of 2010. Canada, Germany, and the United Kingdom were the major recipients of these materials. On the basis of estimated contained beryllium, total beryllium imports decreased by 66% compared with those of 2010. Beryllium imports in 2010, however, were atypically large owing to several substantial shipments of beryllium metal imported from Russia. Although imported from Russia, the beryllium metal was most likely sourced from Kazakhstan, as Russia is not known to produce beryllium metal and beryllium purchase contracts were established in 2010 between companies in the United States and Kazakhstan. In 2011, the leading suppliers of beryllium materials to the United States were Japan and Kazakhstan.

Net import reliance as a percentage of apparent consumption is one measure of the adequacy of current domestic beryllium production to meet U.S. demand. Net import reliance is defined as imports minus exports plus adjustments for Government and industry stock changes. Included among those changes are releases from stocks, including shipments from the NDS, regardless of whether the materials were imported or produced in the United States. For 2011, net import reliance as a percentage of apparent consumption was estimated to be about 29% compared with about 61% in 2010. The decrease was primarily the result of an increase in U.S. beryllium production and a decrease in beryllium imports.

World Review

Kazakhstan.—Kazatomprom reported production of 2,233 t of beryllium materials (including alloys and ceramics), an increase of 23% from the 1,817 t produced in 2010. The company's beryllium sales revenues were 47% greater than those of 2010. UMP supplied about 26% of the world's beryllium products in 2011, 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, 2012a, p. 10; 2012b, p. 29).

In June, UMP increased the prices of its beryllium products by 5% to 8%. In August, UMP announced it would increase the prices of its beryllium products an additional 7% to 12% in January 2012 (JSC Ulba Metallurgical Plant, 2011a, b).

Kazatomprom established a joint venture with Toshiba Corp. (Tokyo, Japan) in 2011 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. That agreement expanded on an existing deal under which Kazatomprom supplied uranium for Toshiba-built nuclear plants (Soble and Gorst, 2008; Kazatomprom JSC, 2011).

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. Financing of the project was to be shared by Metropol and the Russian state-owned corporation Rusnano. Yermakovskoye was considered to be the largest beryllium deposit in Russia. Project design work was expected to be completed by 2012, construction of the complex was to commence in 2013, and the plant was expected to reach its projected annual capacity by 2017 (MBC Corp., 2010; 2011).

Outlook

The United States is expected to remain self-sufficient with respect to most of its beryllium requirements. At yearend 2011, Materion reported proven bertrandite reserves in Juab County, UT, of 5.75 million dry metric tons with an average grade of 0.265% beryllium. This represented about 15,200 t of contained beryllium. Materion owned approximately 95% of its proven mineral reserves and leased the remainder (Materion Corp., 2012a, p. 48).

It was expected that the 2012 U.S. shipments of beryllium-copper strip products and beryllium bulk products would decrease from those of 2011 owing to decreased demand from the consumer electronics and telecommunications infrastructure markets. Demand from the commercial aerospace, heavy equipment, and oil and gas markets was expected to remain similar to that of 2011. Decreased demand for beryllium-based metals and metal matrix composites was anticipated from commercial and defense applications, the latter owing to reduced government spending levels (Materion Corp., 2012b).

Research and consulting firm Global Industry Analysts, Inc. predicted the worldwide beryllium market would increase to 506 t of contained beryllium by 2017 owing to sustained consumption from the computer and telecommunications infrastructure markets and the increasing automotive electronics market. Rapid beryllium consumption from developing markets in Asia and Latin America was also expected (Global Industry Analysts, Inc., 2012).

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TABLE 1
 SALIENT BERYLLIUM MINERAL STATISTICS

(Metric tons of beryllium content)

	2007	2008	2009	2010	2011
United States, beryllium-containing ores:					
Mine shipments ¹	150	175	120	180	235
Imports for consumption, beryl ²	1	--	1	5	6
Consumption, reported ³	190	220	150	200	250
Stocks, December 31:					
Industry ¹	100	60	30	15	10
U.S. Government, beryl ^{2, 4}	8	(5)	(5)	(5)	(5)
World, production ^{5, 2}	174	197	144	204 ^r	261

⁶Estimated. ^rRevised. -- Zero.

¹Data are rounded to the nearest 5 metric tons.

²Based on a beryllium content of 4%.

³Data are rounded to the nearest 10 metric tons.

⁴Defense Logistics Agency, DLA Strategic Materials. Data for 2007–11 are uncommitted beryl.

⁵Less than ½ unit.

TABLE 2
 U.S. GOVERNMENT NATIONAL DEFENSE STOCKPILE BERYLLIUM
 STATISTICS IN 2011¹

(Metric tons of beryllium content)

Material	Stockpile goal ²	Disposal authority ³	Annual Materials Plan ⁴	Uncommitted inventory, December 31
Beryl ore	--	(5)	--	(5)
Beryllium metal:				
Hot-pressed powder	45	38	--	83 ⁶
Vacuum-cast	--	6	47	6
Total	45	44	47	89
Grand total	45	44	47	89

-- 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, 2011.

⁵Less than ½ unit.

⁶Held for goal.

Source: Defense Logistics Agency, DLA Strategic Materials.

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

Type and material	2010		2011		Principal destinations or sources, 2011 ³		
	Gross weight (kilograms)	Content ² (kilograms)	Value (thousands)	Gross weight (kilograms)		Content ² (kilograms)	Value (thousands)
Exports:							
Beryllium, unwrought ⁴	5,020	5,020	\$215	2,880	2,880	\$116	Germany, 22%; Japan, 19%; Hong Kong, 14%; Switzerland, 14%.
Beryllium waste and scrap	527	527	48	2,200	2,200	184	United Kingdom, 71%; Germany, 24%.
Beryllium, other ⁵	33,100	33,100	24,100	16,100	16,100	14,600	Canada, 64%; Germany, 8%; Japan, 6%; Singapore, 5%.
Total	38,700	38,700	24,300	21,200	21,200	14,900	Canada, 49%; Germany, 12%; United Kingdom, 10%; Japan, 7%.
Imports for consumption:							
Beryllium ores and concentrates	113,000	4,530	68	142,000	5,680	180	Nigeria, 72%; South Africa, 14%; Uganda, 14%.
Beryllium oxide and hydroxide	83,300	30,000	548	531	191	9	Japan, 47%; Czech Republic, 35%; China, 18%.
Beryllium, unwrought ⁴	22,500	22,500	1,320	--	--	--	--
Beryllium waste and scrap	9,240	9,240	319	13,200	13,200	245	Singapore, 45%; Germany, 31%; Canada, 24%.
Beryllium, other ⁵	184,000	184,000	5,150	33,600	33,600	4,490	Kazakhstan, 95%.
Beryllium-copper master alloy	323,000	12,900	6,500	792,000	31,700	14,200	Kazakhstan, 77%; India, 10%; Japan, 9%.
Beryllium-copper plates, sheets, and strip	508,000	7,610	6,720	511,000	7,660	7,010	Japan, 100%.
Total	1,240,000	271,000	20,600	1,490,000	92,000	26,100	Kazakhstan, 43%; Japan, 39%; Nigeria, 7%.

-- Zero.

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

²Estimated from gross weights.

³Principal destination or source 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 of gross weight)

Country ³	2007	2008	2009	2010	2011 ^c
China ^c	500	500	500	550	550
Madagascar ^{c,4}	12	12	12	12	12
Mozambique	31	8	45	57 ^r	45
Portugal ^c	5	5	5	5	5
United States, mine shipments ⁵	3,810	4,410	3,030	4,460	5,920
Total	4,360	4,940	3,590	5,090 ^r	6,530

^cEstimated. ^rRevised.

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 July 16, 2012. 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.