



2013 Minerals Yearbook

BERYLLIUM [ADVANCE RELEASE]

BERYLLIUM

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On the basis of estimated beryllium content, U.S. mine shipments of beryllium ore in 2013 increased by 4% to 235 metric tons (t) from those of 2012, and ore consumption for the production of beryllium hydroxide increased by 14% (table 1). From 2003 to 2013, U.S. mine shipments of beryllium ore increased at an average rate of 11% per year, whereas reported ore consumption increased at an average rate of about 6% per year. On the basis of estimated beryllium content, total reported U.S. imports and total exports of beryllium materials in 2013 were significantly less than those of 2012 (table 3).

Beryl, a principal mineral of beryllium, recovered outside of the United States is commonly stockpiled for later processing, and sales or exports may not accurately reflect current recovery. 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 2013, estimated world beryllium ore production increased by 7% compared with that of 2012 (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 physical and mechanical properties—outstanding stiffness-to-weight and strength-to-weight ratios, high melting point relative to all light metals, high specific heat, excellent thermal conductivity, outstanding dimensional stability over a wide range of temperatures, high reflectivity, lowest neutron absorption cross section of any metal and high neutron-scattering cross section, and transparency to x rays—make it useful for many applications. Beryllium is used primarily in beryllium-copper alloys, beryllium oxide ceramics, and as 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, energy, marine, medical, nuclear, and telecommunications.

Only two beryllium minerals are of commercial importance for the production of beryllium. Bertrandite, which contains about 15% beryllium, is the principal beryllium mineral mined in the United States. Bertrandite ore mined in the United States contains about 4% bertrandite, or less than 1% beryllium. Beryl, which contains about 5% beryllium, is the principal mineral mined in the rest of the world from ores grading about 4% beryllium. 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.

Because of the toxic nature of beryllium, various international, national, and State guidelines and regulations have

been established to determine and monitor allowable beryllium content in air, water, and other media. Industry regulations require control of the quantity of beryllium dust, fumes, and mists in the workplace and effluent discharges.

Legislation and Government Programs

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

Defense Production Act.—To ensure current and future availability of high-quality domestic beryllium to meet critical defense needs, the DOD, under the Defense Production Act, Title III, invested in a public-private partnership with Materion Corp. (Mayfield Heights, OH) to build a primary beryllium facility in Elmore, OH. The facility was designed to produce high-purity beryllium metal from beryllium hydroxide sourced from Materion's Delta, UT, operation. Approximately two-thirds of the facility's output was to be allocated for defense and Government-related end uses; the remaining output was to go to the private sector. Plant production capacity was designed to be 73 metric tons per year (t/yr) of beryllium metal. The facility, which began commercial operation in 2012, continued production in 2013 but did not produce at planned capacity on a consistent basis, although output levels improved by yearend (Materion Corp., 2014a, p. 32).

National Defense Stockpile.—The Defense Logistics Agency Strategic Materials, DOD, offered and sold selected beryllium materials from the National Defense Stockpile (NDS). As of December 31, 2013, the NDS goal for beryllium metal was 47 t. The Annual Materials Plan for fiscal year 2013, which represented the maximum quantities of beryllium materials that could be sold from October 1, 2012, through September 30, 2013, increased by 13% from that of fiscal year 2012. In calendar year 2013, the NDS sold approximately 9 t of beryllium metal. The NDS also upgraded a small amount of beryllium hot pressed metal powder into hot isostatic pressing structured metal powder to meet product specification for many modern DOD applications. NDS calendar yearend inventories of beryllium materials are listed in table 2 (U.S. Department of Defense, 2014, p. 2, 4, 5, 7)

Production

Domestic production and consumption statistics for beryllium-containing ores (tables 1 and 4) were based on data collected by the USGS from two voluntary surveys of U.S.

operations. In 2013, 100% of the canvassed respondents replied to the survey. A small number of unidentified producers may have shipped negligible quantities of byproduct beryl, but these have not been included. In 2013, domestic mine shipments were approximately 235 t of contained beryllium, 4% greater than those of 2012.

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, 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. Ninety to ninety-five percent of Materion's beryllium hydroxide was produced from bertrandite, while the remainder was produced from imported beryl. Very high-purity beryllium is made exclusively from beryl, as beryl typically has fewer impurities than bertrandite (Stephen Freeman, President, International Business Development, Materion Corp., oral commun., January 10, 2013).

Based on the expectation that worldwide stockpiles of beryllium concentrate would decrease in the next 2 to 3 years, Materion increased its capacity to produce beryllium hydroxide by opening a new bertrandite pit in the Topaz-Spor Mountain region of Utah in 2013. The company began extracting bertrandite ore from the pit during the second half of 2013 and planned to incrementally increase beryllium hydroxide production at its Delta, UT, operation (Materion Corp., 2013b; 2014a, p. 37).

Consumption

U.S. reported consumption of bertrandite ore and beryl for the production of beryllium hydroxide increased to approximately 250 t of contained beryllium in 2013, a 14% increase from that of 2012 (table 1). U.S. apparent consumption of all beryllium materials in 2013, as calculated from mine shipments, net trade, and changes in Government and industry stocks, was estimated to be about 261 t of contained beryllium, slightly lower than that of 2012.

Since the closure of its previous primary beryllium production facility in Elmore in 2000, Materion has sourced its beryllium metal from the NDS and foreign producers. In 2013, Materion's new primary beryllium facility provided a limited amount of beryllium metal. Materion's Beryllium and Composites unit manufactured beryllium metal products and two families of metal-matrix composites—one made from aluminum and beryllium, and the other made from beryllium and beryllium oxide (BeO or beryllia). 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 slightly compared with those of 2012. Defense and science applications, which accounted for more than 50% of the Beryllium and Composites unit sales, increased by 8% compared with those of 2012, primarily owing to reinstated Government funding that was eliminated or delayed in 2012. Sales for nuclear medicine and other science applications also increased in 2013. Sales of products for industrial component

and commercial aerospace applications decreased by 5%, primarily owing to weaker demand for industrial x-ray applications (Materion Corp., 2014a, p. 31–32).

Materion's Beryllium and Composites unit produced beryllia ceramic products for aerospace, defense, electronics, medical, semiconductor, telecommunications, and wireless applications at its plant in Tucson, AZ. Sales of products for medical applications decreased by 19% compared with those of 2012 owing to lower shipments of x-ray windows and beryllia ceramics for medical laser applications. Beryllia ceramic sales for applications within the telecommunications infrastructure market increased in 2013 (Materion Corp., 2014a, p. 32).

Materion's Performance Alloys unit produced copper- and nickel-base alloy products, most 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 2013, industrial component and commercial aerospace applications accounted for 31% of the Performance Alloys unit sales and consumer electronics applications accounted for 20%. The remaining applications were estimated as indicated—automotive electronics applications, 15%; energy applications, 12%; telecommunications infrastructure applications, 12%; appliance applications, 8%; and defense and medical applications, 2%. The total shipments of alloy strip products increased slightly compared with those of 2012, owing mainly to increased demand from the automotive electronics and consumer electronics markets. Total shipments of bulk alloy products decreased slightly compared with those of 2012, owing to relatively unchanged demand from the industrial component and commercial aerospace market, slightly offset by increased demand from the oil and gas sector of the energy market. The industrial component and commercial aerospace market was reported to be the leading growth market for the Performance Alloys unit (Materion Corp., 2014a, p. 29–30; Stephen Freeman, President, International Business Development, Materion Corp., oral commun., January 10, 2013).

In December, Materion reported that it would increase the prices on its premium-grade copper-beryllium alloy strip, rod, bar, tube, and wire products by 2% to 5% to offset inflationary pressures caused by increased energy, raw materials, and manufacturing costs (Materion Corp., 2013a). Materion had a long-term supply arrangement with JSC Ulba Metallurgical Plant (UMP), part of Kazakhstan's National Atomic Company Kazatomprom JSC, to purchase a total of 352 t of BCMA from 2010 through 2013. In 2013, Materion purchased beryllium-containing materials valued at \$1.8 million, a decrease of 65% from \$5.2 million in purchases from 2012, and completed its contract with UMP (Materion Corp., 2014a, p. 74).

IBC Advanced Alloys Corp. (Vancouver, British Columbia, Canada) manufactured beryllium-aluminum, beryllium-copper, and beryllium-nickel alloys at plants located in Franklin, IN, New Madrid, MO, Royersford, PA, and Wilmington, MA. UMP had multiyear agreements to supply IBC with beryllium metal and BCMA. They agreed 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. In December, IBC was in the final stages of a materials and production qualification process with Lockheed Martin's F-35 Lightning II Electro-Optical Targeting System team to demonstrate the technical and commercial viability of the company's proprietary Beralcast beryllium-aluminum alloy (IBC Advanced Alloys Corp., 2014, p. 1-4)

Other domestic producers of beryllium alloy products included NGK Metals Corp. (a subsidiary of NGK Insulators, Ltd.) in Sweetwater, TN, and GBC Metals, LLC (doing business as Olin Brass) in 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 from 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. consumption. Beryllium products manufactured by Materion from recycled metal require only 20% of the energy as that of beryllium products manufactured from primary material. 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, total beryllium imports decreased by 43% compared with those of 2012, most likely owing to the combination of increased beryllium ore production and a 15% increase in the inventory at Materion's Utah mine and mill in 2013 following the opening of the new pit, completion of Materion's contract to purchase and import BCMA from UMP in Kazakhstan, and Materion's purchase of beryllium metal from the NDS (Materion Corp., 2014a, p. 37, 74). The leading suppliers of beryllium materials to the United States were Japan and Kazakhstan.

On the basis of estimated contained beryllium, beryllium exports decreased by 36% compared with those of 2012. The decrease in exports was most likely the result of unusually high exports in 2012 (159% year-on-year increase from 2011). Canada was the major recipient of these materials. The U.S. Census Bureau, however, only reports exported beryllium metal and not exported BCMA and beryllium oxide and hydroxide. BCMA typically constitutes about 85% of domestic beryllium exports, whereas beryllium metal typically constitutes less than 15% of exports (Stephen Freeman, President, International Business Development, Materion Corp., oral commun., January 10, 2013).

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 stock changes are acquisitions or shipments from the NDS, regardless of whether the materials were imported or produced in the United States. For 2013, net import reliance as a percentage of apparent consumption was estimated to be about 10%, a decrease from about 15% in 2012. Net import reliance as a percentage of apparent consumption has decreased steadily since its peak of 61% in 2010 owing to a combination of increased United States bertrandite production, decreased beryllium imports, and decreased Government stockpile shipments.

World Review

China.—In 2013, China produced an estimated 65 t of contained beryllium (based on 2012 data—the last year with supplied information). Approximately 20 t of the contained beryllium was sourced from domestic ore and 45 t was obtained from foreign sources. China imported most of its contained beryllium from Kazakhstan's UMP, and was thought to be UMP's largest customer (Stephen Freeman, President, International Business Development, Materion Corp., oral commun., January 10, 2013).

Kazakhstan.—UMP produced 99 t of contained beryllium in 2013, a 7% decrease from the 107 t produced in 2012. The decrease may have been partly due to the completion of Materion's contract with UMP in 2013. Production was reported from stockpiled beryllium concentrate imported mainly from Russia, which had accumulated prior to the breakup of the Soviet Union. In 2012, Kazatomprom was awarded a contract to supply neutron-reflecting beryllium blocks for a proton accelerator research complex by Japan's Atomic Energy Agency. The blocks were installed by Kazatomprom in 2013 (Kazatomprom JSC, 2014, p. 33).

Russia.—MBC Corp. (a subsidiary of Metropol Investment Group), Russia's state-owned corporation Rusnano Corp., and technology specialists from a number of research institutions, including Tomsk Polytechnic University and the Moscow Institute of Physics and Technology, continued work on resuming mining and construction of the processing plant at the Yermakovskoye bertrandite deposit in the Siberian Republic of Buryatiya. The new plant would produce beryllium hydroxide, which was expected to be exported to UMP in Kazakhstan, as well as China and Japan, for processing into beryllium metal and beryllium alloys. Financing of the project was to be shared by Metropol and Rusnano. Yermakovskoye was thought to be the largest identified beryllium deposit in Russia. Metropol projected an annual mining and processing capacity of 25,000 t/yr of ore and a beryllium hydroxide production capacity of 130 t/yr. The first pilot production of beryllium was expected by yearend 2014, and the plant was expected to begin commercial production by 2020 (MBC Corp., 2009, 2011; Rusnano Corp., 2012; Russian Radio, 2014).

Outlook

The United States is expected to remain self-sufficient with respect to most of its beryllium requirements. At yearend 2013, Materion reported proven bertrandite reserves in

Juab County, UT, of 5.60 million dry metric tons having an average grade of 0.263% beryllium and containing about 14,700 t of contained beryllium. Materion owned approximately 95% of its proven mineral reserves and leased the remainder from the State (Materion Corp., 2014a, p. 43).

The 2014 sales of beryllium-copper strip products and beryllium bulk products are expected to increase slightly from those of 2013 owing to increased demand from the consumer electronics and energy markets. Sales to the automotive electronics market are expected to decrease, however, and the commercial aerospace, industrial components, and telecommunications infrastructure markets are expected to remain relatively unchanged. Sales of beryllium metal and metal matrix composites are expected to increase approximately 20% in 2014 owing to increased demand from the science and medical markets, primarily for x-ray window applications and medical research (Materion Corp., 2014b).

Merchant Research & Consulting, Ltd. predicted that worldwide beryllium production could possibly exceed 500 t of contained beryllium by the end of 2017 owing to rising global demand from the automotive electronics, computer, and telecommunications infrastructure markets (Merchant Research & Consulting, Ltd., 2014).

Materion forecast worldwide beryllium consumption to increase between 3% and 6% per year and anticipated BCMA consumption to be higher, at approximately 10% per year. The company, consequently, began to expand its BCMA production capacity. The physical size of many beryllium containing components, however, has decreased over time owing to improvements in technology. Therefore, despite the continued growth of beryllium applications, growth in beryllium consumption may lag behind the growth in application demand (Stephen Freeman, President, International Business Development, Materion Corp., oral commun., January 10, 2013).

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TABLE 1
SALIENT BERYLLIUM MINERAL STATISTICS

(Metric tons of beryllium content)

	2009	2010	2011	2012	2013
United States, beryllium-containing ores:					
Mine shipments ¹	120	180	235	225	235
Imports for consumption, beryl ²	1	5	6	12	8
Consumption, reported ³	150	200	250	220	250
Stocks, December 31:					
Industry ¹	30	15	10	15	20
U.S. Government, beryl ^{2,4}	(5)	(5)	(5)	(5)	(5)
World, production ^{5,2}	144	204	262	246	263

⁵Estimated.

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 Strategic Materials. Data are uncommitted beryl.

⁵Less than ½ unit.

TABLE 2
U.S. GOVERNMENT NATIONAL DEFENSE STOCKPILE BERYLLIUM
STATISTICS IN 2013¹

(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	(6)	(6)	(6)	73 ⁷
Structured powder	--	--	--	1
Vacuum-cast	(6)	(6)	(6)	6
Total	47	33	53	80
Grand total	47	33	53	80

-- Zero.

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

²2013 Biennial Report on Stockpile Requirements. Goal is for beryllium metal, excluding beryllium structured powder.

³Total quantity of material that can be disposed.

⁴Maximum quantity of material that can be disposed during 12-month period ending September 30, 2013.

⁵Less than ½ unit.

⁶Stockpile goal, disposal authority, and Annual Materials Plan for beryllium metal included under "Total."

⁷Held for goal.

Source: Defense Logistics Agency Strategic Materials.

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

Type and material	2012				2013				Principal destinations or sources, 2013 ³
	Gross weight (kilograms)	Content ² (kilograms)	Value (thousands)	Gross weight (kilograms)	Content ² (kilograms)	Value (thousands)			
Exports:									
Beryllium, unwrought ⁴	23,300	23,300	\$1,030	10,000	10,000	\$453	China, 24%; Russia, 23%; Germany, 18%; Mexico, 11%; Singapore, 10%.		
Beryllium waste and scrap	9,990	9,990	1,520	3,750	3,750	501	Hong Kong, 86%; Taiwan, 11%.		
Beryllium, other ⁵	21,600	21,600	20,300	21,400	21,400	18,100	Canada, 64%; United Kingdom, 5%; France, 5%; Japan, 5%.		
Total	55,000	55,000	22,800	35,200	35,200	19,100	Canada, 39%; Hong Kong, 9%; Russia, 9%; China, 7%; Germany, 7%.		
Imports for consumption:									
Beryllium ores and concentrates	301,000	12,000	584	204,000	8,140	430	Brazil, 55%; Nigeria, 45%.		
Beryllium oxide and hydroxide	49,600	17,900	549	19,600	7,070	91	Korea, 68%; China, 25%; Japan, 6%.		
Beryllium, unwrought ⁴	2,660	2,660	539	5,930	5,930	1,470	Kazakhstan, 100%.		
Beryllium waste and scrap	11,200	11,200	343	1	1	2	United Kingdom, 100%.		
Beryllium, other ⁵	28,100	28,100	2,640	15,100	15,100	1,850	Kazakhstan, 73%; United Kingdom, 21%.		
Beryllium-copper master alloy	485,000	19,400	8,740	340,000	13,600	6,230	Kazakhstan, 92%; Germany, 4%.		
Beryllium-copper plates, sheets, and strip	558,000	8,370	9,570	484,000	7,270	8,940	Japan, 98%.		
Total	1,440,000	99,700	23,000	1,070,000	57,000	19,000	Japan, 45%; Kazakhstan, 31%; Brazil, 11%; Nigeria, 9%.		

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	2009	2010	2011	2012	2013 ^e
China ^e	500	550	550	500	500
Madagascar ^{e,4}	12	12	12	16	75
Mozambique	45	57	58	58 ⁵	58 ⁵
Portugal ^e	5	5	5	5	5
United States, mine shipments ⁶	3,030	4,460	5,920	5,570	5,910 ⁷
Total	3,590	5,090	6,540	6,150	6,550

^eEstimated.

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

²Includes data available through August 15, 2014. Unless otherwise noted, figures represent beryl ore for the production of beryllium and exclude gem-quality beryl.

³In addition to the countries listed, Brazil, Kazakhstan, Nigeria, Russia, and Uganda 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.

⁵Mozambique reported significantly higher beryl ore production in 2012 and 2013. Due to the uncertainty of the data, however, estimates will be used until the accuracy of the reported data has been confirmed.

⁶Includes bertrandite ore, calculated as equivalent to beryl containing 11% beryllium oxide.

⁷Reported figure.