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2014 Minerals Yearbook

BERYLLIUM [ADVANCE RELEASE]

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Beryllium

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On the basis of estimated beryllium content, U.S. mine shipments of beryllium ore in 2014 increased by 15% to 270 metric tons (t) from 235 t in 2013, and consumption of ore for the production of beryllium hydroxide increased by 12% (table 1). From 2004 to 2014, U.S. mine shipments of beryllium ore increased at an average rate of 12% per year, whereas reported ore consumption increased at an average rate of about 8% per year (fig. 1). On the basis of estimated beryllium content, total reported U.S. imports of beryllium materials increased in 2014 from those of 2013, and total reported U.S. exports of beryllium materials decreased from those of 2013 (table 3).

In 2014, estimated world beryllium ore production increased by 15% compared with that of 2013 (table 4). The United States accounted for more than 90% of estimated world production. China is thought to be a significant producer but does not report its beryl production. Beryl, a principal mineral of beryllium mined outside of the United States, is commonly stockpiled for later processing, and sales or exports may not accurately reflect current recovery. As a result, world production and the U.S. share of world production have a high degree of uncertainty.

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 other 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 high-strength 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. Commercial beryl contains approximately 12% beryllium oxide, 19% aluminum oxide, 67% silicon dioxide, and other oxides. 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

In 2009, high-purity beryllium was designated a strategic and critical material by the U.S. Department of Defense (DOD) Strategic Materials Protection Board. The Board determined 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).

Defense Production Act.—To ensure current and future availability of high-quality domestic beryllium to meet critical defense needs, in 2008, the DOD, under the Defense Production Act Title III Program, 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. Production, which was below planned capacity in 2012 and 2013, increased by 18% in 2014 from that of 2013 (Materion Corp., 2015a, p. 27).

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, 2014, the NDS goal for beryllium metal was 47 t. The Annual Materials Plan for fiscal year 2014, which represented the maximum quantities of beryllium metal that could be sold from October 1, 2013, through September 30, 2014, was 16 t, a decrease of 70% from 53 t in fiscal year 2013. In calendar year 2014, the NDS sold approximately 1 t of beryllium metal. The NDS also upgraded 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, 2015, p. 4–6).

Production

Domestic production and consumption statistics for beryllium-containing ores (tables 1, 4) were based on data collected by the USGS from two voluntary surveys of U.S. operations. In 2014, 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 2014, the only domestic beryllium mine shipped approximately 270 t of contained beryllium, 15% greater than that of 2013.

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, and 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). Since the closure of its previous primary beryllium production facility in Elmore in 2000 and prior to startup of its new Elmore facility, Materion had sourced all of its beryllium metal from the NDS and foreign producers.

Based on the expectation that worldwide stockpiles of beryllium concentrate would decrease in the next 2 to 3 years, Materion opened a new bertrandite pit in the Topaz-Spor Mountain region of Utah in 2013. The company also increased its capacity to produce beryllium hydroxide and planned to incrementally increase production at its Delta, UT, operation. In 2014, the capacity utilization rate of the Delta plant was 73%, an increase of 13% from that of 2013 (Materion Corp., 2014a, p. 37; 2015a, p. 10, 38).

Consumption

In 2014, U.S. reported consumption of bertrandite ore and beryl for the production of beryllium hydroxide was approximately 280 t of contained beryllium, a 12% increase from that of 2013. U.S. apparent consumption of all beryllium materials in 2014, as calculated from mine shipments, net trade, and changes in Government and industry stocks, was estimated to be about 318 t of contained beryllium, an increase of 21% from that of 2013. Beryllium mine shipments and net imports increased in 2014.

In the fourth quarter of 2014, Materion combined its two beryllium production units—Beryllium and Composites and Performance Alloys—plus its nonberyllium Technical Materials unit, into a single new business segment named Performance Alloys and Composites. As a consequence, detailed beryllium consumption information on the two individual beryllium production units in 2014 was only available for the first three quarters of the year. The 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. During the first three quarters of 2014, Beryllium and Composites product sales increased by 18% compared with the first three quarters of 2013, driven by higher sales to the science and medical markets, primarily for x-ray windows and medical research. By yearend 2014, value-added sales to the medical market increased by 77% from that of 2013 owing to higher sales for nuclear medicine applications and the growth of oncology and imaging in emerging markets. Defense end market sales, however, decreased by 22% compared with those of 2013, owing to Government project delays and spending cuts (Materion Corp., 2014c, p. 21; Materion Corp., 2015a, p. 2–3, 27).

Materion's Beryllium and Composites unit also produced beryllia ceramic products for aerospace, defense, electronics, medical, semiconductor, telecommunications, and wireless applications at its plant in Tucson, AZ. Beryllia ceramic sales for applications within the telecommunications infrastructure market increased by 50% in the first half of 2014 owing to increased demand for ceramic products (Materion Corp., 2014b, p. 22).

Materion's Performance Alloys unit produced copper- and nickel-base 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. During the first three quarters of 2014, Performance Alloys product sales increased about 3% compared with the first three quarters of 2013, whereas total shipment volumes remained relatively flat. Industrial component and commercial aerospace applications accounted for an estimated 31% of the Performance Alloys unit sales during the first three quarters of 2014, and consumer electronics applications accounted for 20%. The remaining applications were estimated as indicated—automotive electronics applications, 17%; energy applications, 12%; telecommunications infrastructure applications, 11%; appliance applications, 7%; and defense and medical applications, 2%. By yearend 2014, value-added sales to the energy end market increased 12% owing to higher sales to the oil and gas sector. The industrial component and commercial aerospace market was reported to be the leading growth market for the Performance Alloys unit (Materion Corp., 2014c, p. 20; Materion Corp., 2015a, p. 27; Stephen Freeman, President, International Business Development, Materion Corp., oral commun., January 10, 2013).

Eight application areas composed Materion's new Performance Alloys and Composites business segment. Based on value-added sales revenues at yearend 2014, consumer electronics accounted for 18%; industrial components, 18%; other, 18%; automotive electronics, 15%; energy, 12%; telecommunications infrastructure, 8%; defense, 6%, and medical, 5%. (Materion Corp., 2015c, p. 10).

Materion had an arrangement to purchase a total of 352 t of BCMA from 2010 through 2013 from JSC Ulba Metallurgical Plant (UMP), part of Kazakhstan's National Atomic Company Kazatomprom JSC. The contract was replaced with short-term supply agreements in 2014 (Materion Corp., 2015a, p. 70).

IBC Advanced Alloys Corp. (Vancouver, British Columbia, Canada) manufactured beryllium-aluminum and beryllium-copper alloys and its proprietary Beralcast® alloys, less costly castable beryllium-aluminum products, at plants located in Franklin, IN, New Madrid, MO, Royersford, PA, and Wilmington, MA. IBC had multiyear agreements to purchase beryllium metal and BCMA from UMP. In 2014, IBC entered into a contract with Lockheed Martin to provide critical cast components for Lockheed Martin's F–35 Lightning II Electro-Optical Targeting System. The first component to be delivered was to be an azimuth gimbal housing manufactured using IBC's Beralcast® beryllium-aluminum casting alloy (IBC Advanced Alloys Corp., 2015, p. 1–5).

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 have represented as much as 20% to 25% of U.S. consumption. Beryllium products manufactured by Materion from recycled metal require only 20% of the full-cycle (mine through manufacture) 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 for new and old beryllium 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 beryllium content, total beryllium imports increased by 20% compared with those of 2013, most likely owing to reduced shipments of beryllium metal from the NDS and increased availability of unwrought beryllium metal from Kazakhstan and the United Kingdom. The leading suppliers of beryllium materials to the United States were, by beryllium content, Kazakhstan, Japan, and the United Kingdom.

On the basis of estimated contained beryllium, beryllium exports decreased by 25% compared with those of 2013, mostly from a 78% decrease in exports of unwrought beryllium metal. Canada was the major recipient of these materials. The U.S. Census Bureau, however, only identifies exported beryllium metal; exported BCMA and beryllium oxide and hydroxide are not identified. BCMA typically accounts for about 85% of domestic beryllium exports, whereas beryllium metal typically accounts for 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 2014, net import reliance as a percentage of apparent consumption was 15%, an increase from 10% in 2013. Although it increased moderately in 2014, net import reliance as a percentage of apparent consumption has decreased since its peak of 61% in 2010 owing to a combination of increased U.S. bertrandite production, decreased beryllium imports, and decreased Government stockpile shipments.

World Review

China.—In 2012, the last year for which information was available, China produced an estimated 65 t of beryllium contained in beryllium-copper alloys, beryllium oxide ceramics, and beryllium metal. In 2014, China was believed to have produced a similar amount of contained beryllium. 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 leading customer (Stephen Freeman, President, International Business Development, Materion Corp., oral commun., January 10, 2013).

Kazakhstan.—UMP anticipated producing 95 t of contained beryllium in 2014, a 4% decrease from the 99 t produced in 2013 (based on 2013 data—the last available information). Production was reportedly from stockpiled beryllium concentrate imported mainly from Russia, which had accumulated prior to the breakup of the Soviet Union (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 a processing plant at the Ermakovskoe 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 to China and Japan for processing into beryllium metal and beryllium alloys. Financing of the project was to be shared by Metropol and Rusnano. Ermakovskoe 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 (MBC Corp., 2009, 2011; Rusnano Corp., 2012).

Outlook

The United States is expected to remain self-sufficient with respect to most of its beryllium requirements. At yearend 2014, Materion reported proven bertrandite reserves in Juab County, UT, of 5.60 million dry metric tons having an average grade of 0.262% beryllium and containing about 14,600 t of contained beryllium. Materion owned approximately 90% of its proven mineral reserves and leased the remainder from the State (Materion Corp., 2015a, p. 38).

The 2015 sales from Materion's beryllium-rich Performance Alloys and Composites segment are expected to increase slightly from those of 2014. In the first quarter of 2015, sales to the industrial components market increased by about 6% from that in the first quarter of 2014. First quarter sales to the oil and gas sector of the energy market in 2015, however, were lower than previous quarters and are expected to remain low in 2015 (Materion Corp., 2015b, p. 15, 19).

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 (Aster, 2014).

Materion forecast worldwide beryllium consumption to increase between 3% and 6% per year and anticipated BCMA consumption growth to be higher, at approximately 10% per year. Consequently, the company began to expand its BCMA production capacity. The physical size of many beryllium-containing components, however, has decreased over time owing to improved 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).

In an effort to augment the beryllium metal imported by Russia, Russia's Industry and Trade Ministry financed research on beryllium metal production. In January 2015, Tomsk Polytechnic University and the Siberian Chemical Plant jointly produced Russia's first 100-gram sample of beryllium metal. Scientists expected to initially source raw materials from Russia's Federal State Reserve Agency, and eventually source raw materials from the Yermakovskoye bertrandite deposit in Buryatiya. Commercial production of beryllium metal is expected to begin in 2020 (Dragomanovich, 2015).

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TABLE 1
SALIENT BERYLLIUM MINERAL STATISTICS

(Metric tons of beryllium content)

	2010	2011	2012	2013	2014
United States, beryllium-containing ores:					
Mine shipments[1]	180	235	225	235	270
Imports for consumption, beryl[2]	5	6	12	8	9
Consumption, reported[3]	200	250	220	250	280
Stocks, December 31:					
Industry[1]	15	10	15	20	15
U.S. Government, beryl[2, 4]	(5)	(5)	(5)	(5)	(5)
World, production[e, 2]	204	262	246	262 [r]	300

[e]Estimated. [r]Revised.
[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]Data from Defense Logistics Agency Strategic Materials.
[5]Less than ½ unit.

TABLE 2
U.S. GOVERNMENT NATIONAL DEFENSE STOCKPILE
BERYLLIUM STATISTICS IN 2014[1]

(Metric tons of beryllium content)

Material	Stockpile goal[2]	Annual Materials Plan[3]	Inventory, December 31
Beryl ore	--	--	(4)
Beryllium metal:			
Hot-pressed powder	(5)	(5)	71 [6]
Structured powder	--	--	2
Vacuum-cast	(5)	(5)	6
Total	47	16	79
Grand total	47	16	79

-- Zero.
[1]Data were converted from gross weights reported in short tons; may not add to totals shown.
[2]2013 Biennial Report on Stockpile Requirements. Goal is for beryllium metal, excluding beryllium structured powder.
[3]Maximum quantity of material that can be disposed during 12-month period ending September 30, 2014.
[4]Less than ½ unit.
[5]Stockpile goal, disposal authority, and Annual Materials Plan for beryllium metal included under "Total."
[6]Held for goal.

Source: Defense Logistics Agency Strategic Materials.

TABLE 3
U.S. FOREIGN TRADE OF BERYLLIUM MATERIALS, BY TYPE[1]

Type and material	2013 Gross weight (kilograms)	2013 Content[2] (kilograms)	2013 Value (thousands)	2014 Gross weight (kilograms)	2014 Content[2] (kilograms)	2014 Value (thousands)	Principal destinations or sources, 2014[3]
Exports:							
Beryllium, unwrought[4]	10,000	10,000	$453	2,200	2,200	$95	Germany, 39%; Switzerland, 29%; Korea, 13%; Italy, 6%; Czech Republic, 5%.
Beryllium waste and scrap	3,750	3,750	501	401	401	64	Korea, 100%.
Beryllium, other[5]	21,400	21,400	18,100	23,800	23,800	20,800	Canada, 56%; Belgium, 6%; Colombia, 4%; Switzerland, 4%.
Total	35,200	35,200	19,100	26,400	26,400	21,000	Canada, 51%; Belgium, 6%; Germany, 6%; Switzerland, 6%.
Imports for consumption:							
Beryllium ores and concentrates	204,000	8,140	430	217,000	8,670	563	Brazil, 73%; Nigeria, 18%; Zambia, 8%.
Beryllium oxide and hydroxide	19,600	7,070	91	19,800	7,120	122	Korea, 57%; China, 38%; Canada, 5%.
Beryllium, unwrought[4]	5,930	5,930	1,470	22,700	22,700	5,730	Kazakhstan, 68%; United Kingdom, 32%.
Beryllium waste and scrap	1	1	2	2,060	2,060	9	Canada, 65%; Mexico, 22%; New Zealand, 13%.
Beryllium, other[5]	15,100	15,100	1,850	13,700	13,700	1,160	Kazakhstan, 89%; Canada, 6%; Ukraine, 4%.
Beryllium-copper master alloy	340,000	13,600	6,230	159,000	6,360	3,010	Kazakhstan, 80%; Germany, 18%.
Beryllium-copper plates, sheets, and strip	484,000	7,270	8,940	520,000	7,810	8,200	Japan, 98%.
Total	1,070,000	57,000	19,000	954,000	68,500	18,800	Japan, 54%; Brazil, 17%; Kazakhstan, 16%; Germany, 4%; Nigeria, 4%.

[1]Data are rounded to no more than three significant digits; may not add to totals shown.
[2]Estimated from gross weights.
[3]Principal destination or source percentages based on beryllium gross weight data.
[4]Includes powders.
[5]Includes 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]	2010	2011	2012	2013	2014[e]
China[e]	550	550	500	500	500
Madagascar[e, 4]	12	12	16	75	50
Mozambique	57	58	58 [5]	58 [5]	58
United States, mine shipments[6]	4,460	5,920	5,570	5,910	6,900 [7]
Total	5,080 [r]	6,540	6,140 [r]	6,540 [r]	7,500

[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]Includes data available through May 4, 2015. Unless otherwise noted, figures represent beryl ore for the production of beryllium and exclude gem-quality beryl.

[3]In addition to the countries listed, Brazil, Kazakhstan, Nigeria, Portugal, 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.

[4]Beryl in quartz concentrates.

[5]Mozambique 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.

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

[7]Reported figure.

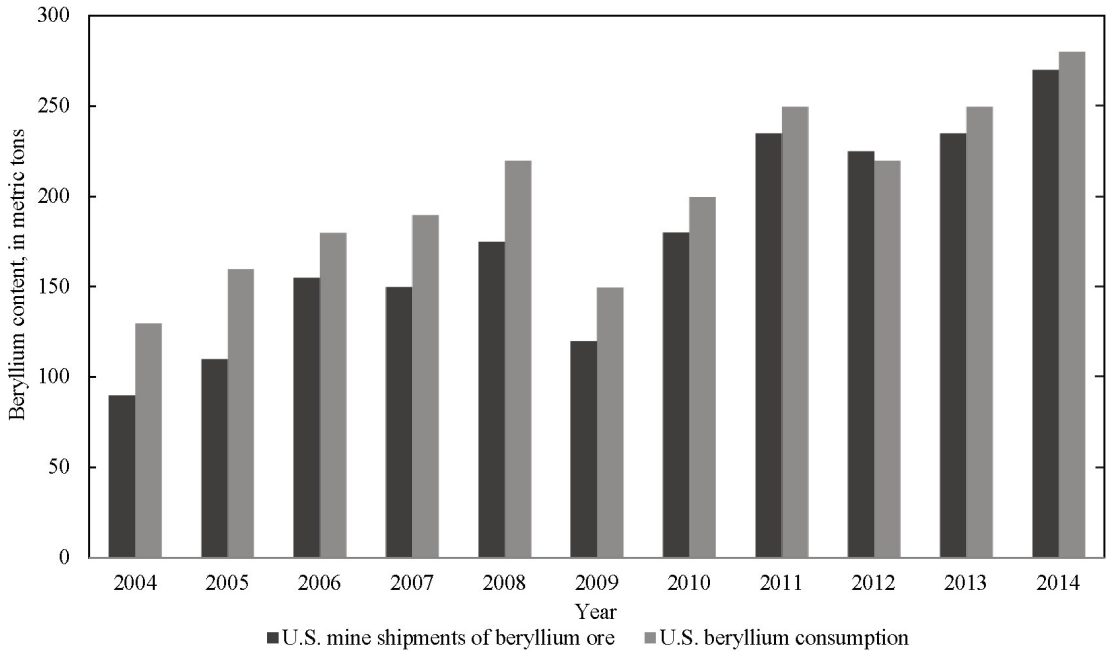

Figure 1. U.S. mine shipments of beryllium ore (Be content) and consumption of beryllium for 2004 through 2014. Source: U.S. Geological Survey.