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2020 Minerals Yearbook

BERYLLIUM [ADVANCE RELEASE]

U.S. Department of the Interior
U.S. Geological Survey

March 2025

U.S. Geological Survey, Reston, Virginia: 2025

Beryllium

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On the basis of estimated beryllium content, U.S. mine shipments of beryllium ore in 2020 increased to 165 metric tons (t) from 160 t in 2019, and reported consumption of ore for the production of beryllium hydroxide increased by 6% to 170 t (table 1). U.S. shipments and consumption of beryllium ore were each 39% lower in 2020 than the peak quantities in 2014 (fig. 1), most likely owing to a decrease in beryllium consumption in oil and gas exploration (Materion Corp., 2016, p. 2, 24). On the basis of estimated beryllium content, imports of beryllium materials decreased slightly in 2020 from those in 2019, and exports of beryllium metal decreased by 32% (table 3).

In 2020, estimated world beryllium ore production (gross weight) increased by 6% compared with that in 2019 (table 4). The United States was the leading producer of mined beryllium, accounting for 66% of estimated world gross weight production. China was the second-ranked producer and accounted for 28%. 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 production. As a result, world production numbers 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 capacity, 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 was 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 used beryllium products included aerospace, automotive, computer, defense, electronics, energy, marine, medical, nuclear, and telecommunications.

In recent years, the leading use for beryllium, which accounted for about 75% of total world consumption, was in copper-base alloys containing from 0.2% to 2.0% beryllium. Beryllium enhances the strength, stiffness, and hardness of copper alloys while retaining relatively good ductility, machinability, and electrical and thermal conductivity. Beryllium-copper alloys were predominantly formed into strip products used as electrical connectors, contacts, relays, shielding, and switches, and as bulk products in the form of bars, plates, rods, and tubes. Oil and gas exploration equipment relied on beryllium alloy bearings, couplings, and instrument housings to drill under corrosive and high-stress and high-temperature conditions without sparking. The second leading use of beryllium, which consumed about 20% of total world production, was as 99.5%-pure (or greater) beryllium metal and beryllium-base alloys containing greater than 60% beryllium (primarily alloyed with aluminum). Beryllium metal and alloys typically were used to produce components for high-technology equipment where low weight, low thermal distortion, and good machinability were critical factors. Beryllium oxide ceramics, which accounted for the remaining 5% of beryllium consumption, were used where electrical insulation and heat extraction were essential, such as automotive electrical systems and heat sinks for radar and radio-frequency equipment (Trueman and Sabey, 2014, p. 101–103).

Only two beryllium minerals are of commercial importance for the production of beryllium. Bertrandite, which can contain as much as 15% beryllium, was the principal beryllium mineral mined in the United States. Bertrandite ore mined in the United States contained about 0.25% beryllium by weight. Beryl, which can contain up to 5% beryllium, was the principal beryllium mineral mined in the rest of the world from ores typically grading 4% beryllium or less. Commercial beryl contains approximately 12% beryllium oxide, 19% aluminum oxide, 67% silicon dioxide, and 2% other oxides (Petkof, 1985, p. 76). Artisanal mining of the gemstone varieties of beryl, most notably aquamarine and emerald, was a primary source of byproduct beryl for beryllium extraction. 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.

Government Actions and Legislation

Because beryllium is toxic, 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.

Defense Production Act.—To ensure current and future availability of high-quality domestic beryllium to meet critical defense needs, in 2008, the U.S. Department of Defense (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. The plant, with a design capacity of 73 metric tons per year (t/yr) of beryllium metal, was placed into service in 2012 (Metal Bulletin, 2010; Materion Corp., 2021a, p. 62).

National Defense Stockpile.—The Defense Logistics Agency Strategic Materials, DOD, offered and sold selected beryllium materials from the National Defense Stockpile (NDS). The Annual Materials Plan for fiscal year 2020, which represented the maximum quantities of beryllium metal that could be upgraded or disposed of from October 1, 2019, through September 30, 2020, was 7 t, an increase from 5 t in fiscal year 2019. In calendar year 2020, the NDS sold 3 t of beryllium hot-pressed metal powder. The NDS also upgrades beryllium hot-pressed metal powder into hot isostatic pressing structured metal powder to meet product specifications for many modern DOD applications. NDS calendar yearend inventories of beryllium materials are listed in table 2 (U.S. Department of Defense, Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics, 2015, p. 5; Defense Logistics Agency Strategic Materials, 2019).

Production

Domestic production (tables 1, 4) and consumption data (table 1) for beryllium-containing ores were collected by the USGS from two voluntary surveys of U.S. beryllium operations. In 2020, both canvassed respondents replied to the survey. A small number of unidentified producers may have shipped minimal quantities of byproduct beryl, but these have not been included. In 2020, the only domestic beryllium mine shipped approximately 165 t of contained beryllium, 3% greater than shipments in 2019.

The United States was one of only three countries known to have processed beryllium ores and concentrates into beryllium products. The other two countries were China and Kazakhstan. 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. Most of the beryllium hydroxide was shipped to Elmore, OH, where Materion converted it into beryllium-copper master alloy (BCMA), metal, or oxide. Historically, some beryllium hydroxide has been sold to NGK Insulators, Ltd. of Japan. In 2020, 100% of Materion's beryllium hydroxide was produced from bertrandite (Materion Corp., 2021a, p. 28). Very-high-purity beryllium is produced exclusively from beryl, as beryl typically has fewer impurities (for example, fluorine and uranium) than bertrandite. Beryl-sourced high-purity beryllium was used in nuclear applications, where the absence of uranium in the beryllium allows for safe and timely disposal of nuclear waste-containing beryllium, and in foil for use as X-ray windows for medical applications (Keith Smith, Vice President, Technology and Government Business Development, Materion Corp., oral commun., April 4, 2016).

Based on the expectation that worldwide stockpiles of beryllium concentrate were being depleted, Materion increased its capacity to produce beryllium hydroxide at its Delta plant in 2013, and in 2015 invested $23 million to further develop its bertrandite pits in the Topaz-Spor Mountain region. In 2020, the capacity utilization of the Delta plant was 52%, 4% greater than that in 2019 (Materion Corp., 2014, p. 5; 2016, p. 2; 2021a, p. 28).

Consumption

In 2020, U.S. reported consumption of bertrandite ore and beryl for the production of beryllium hydroxide was 170 t of beryllium content, a 6% increase from that in 2019 (table 1). U.S. apparent consumption of all beryllium materials in 2020, as calculated from mine shipments, net trade, and changes in Government and industry stocks, was estimated to be 196 t of beryllium content, a 17% increase from 167 t in 2019. Beryllium mine shipments and net imports increased in 2020.

Materion produced beryllium hydroxide, beryllium products (including ceramics, metal, and metal-matrix composites), and beryllium strip and bulk products in its Performance Alloys and Composites segment. Materion produced two types of metal-matrix composites—one made from aluminum and beryllium and the other made from beryllium and beryllium oxide (BeO or beryllia). Foil, rod, sheet, tube, and a variety of customized shapes were produced at plants in Elmore, OH, and Fremont, CA. Beryllia ceramic products for aerospace, defense, electronics, medical, semiconductor, telecommunications, and wireless applications were produced at its plant in Tucson, AZ, and copper- and nickel-base alloy products, the majority of which contained beryllium, were produced at plants in Elmore, OH, and Shoemakersville, PA. These included 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).

In 2020, net sales from the Performance Alloys and Composites segment decreased by 21% from those in 2019 owing to reduced sales in all major end markets; the largest declines were in the aerospace and defense, energy, industrial, and telecom and data center end markets owing to the effects of the global coronavirus disease 2019 (COVID-19) pandemic. In 2020, the Performance Alloys and Composites value-added sales were distributed by application as follows: industrial, 24%; aerospace and defense, 19%; automotive, 14%; consumer electronics, 13%; and telecommunications and data center, 11%. The remaining sales were distributed as follows: energy, 5%; semiconductor, 1%; and other, 13% (Materion Corp., 2021a, p. 22; 2021b, p. 5).

IBC Advanced Alloys Corp. (Franklin, IN) manufactured beryllium-aluminum and beryllium-copper alloys and its proprietary alloys, which were castable beryllium-aluminum products, at plants located in Franklin, IN, Royersford, PA, and Wilmington, MA. IBC purchased beryllium from Materion and the NDS. IBC also had an agreement to purchase beryllium metal and BCMA from the Ulba Metallurgical Plant (UMP) in Kazakhstan lasting through 2021 (IBC Advanced Alloys Corp., 2021, p. 7–8, 23). The UMP was part of Kazatomprom JSC, the national operator for the nuclear industry in Kazakhstan.

Beryllium alloys also were manufactured domestically by Belmont Metals Inc. (Brooklyn, NY) and NGK Metals Corp. (Sweetwater, TN), a subsidiary of Japan's NGK Insulators, Ltd. American Beryllia Inc. (Haskell, NJ) manufactured beryllium oxide ceramic components and compound materials. American Elements (Los Angeles, CA) manufactured beryllium metal and beryllium oxide foil, sheet, and plate.

Recycling

Beryllium was recycled from new scrap generated during the manufacture of beryllium-containing components and from old scrap collected from end users. Detailed data on the quantities of recycled beryllium were not available but may have been as much as 20% to 25% of U.S. consumption. Beryllium products manufactured by Materion from recycled metal required only 20% of the full-cycle (mine through manufacture) energy as that of beryllium products manufactured from primary material. In 2012, Materion reported that it had a comprehensive recycling program for its beryllium products and indicated a 40%-beryllium recovery rate from processed 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 decreased slightly compared with those in 2019. The leading suppliers of beryllium materials to the United States were, in descending order by beryllium content, Kazakhstan, Latvia, and Japan. The leading suppliers of beryllium materials to the United States were, in descending order by gross weight, Japan, Kazakhstan, and Germany.

On the basis of estimated beryllium content, beryllium exports decreased by 32% compared with those in 2019. Canada was the leading recipient of beryllium exports, followed by Germany and France (table 3). The U.S. Census Bureau, however, only reported exported beryllium metal in its "Schedule B: Statistical Classification of Domestic and Foreign Commodities Exported from the United States." Exported BCMA and beryllium oxide and hydroxide did not have separate dedicated Schedule B numbers. In 2013, Materion reported that BCMA typically accounted for 85% of domestic beryllium exports, whereas beryllium metal typically accounted 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. Apparent consumption is defined as primary production plus secondary production from old scrap plus imports minus exports plus adjustments for Government and industry stock changes. For 2020, net import reliance as a percentage of apparent consumption for all forms of beryllium was 16%, an increase from 4% in 2019. Net import reliance as a percentage of apparent consumption decreased since its peak of 61% in 2010 owing primarily to the startup and operation of a beryllium metal plant in 2012 (Jaskula, 2015). There has been a commensurate decrease in beryllium imports and Government stockpile shipments.

World Review

China.—Two facilities in China processed beryllium ores and concentrates into beryllium products—Hunan Shuikoushan Nonferrous Metals Group Co., Ltd. in Xinjiang Uyghur Autonomous Region and Fuyun Hengsheng Beryllium Industry Co., Ltd. in Guangdong Province. For 2020, Antaike Information Development Co., Ltd. estimated that China produced 70 t of beryllium from domestic beryl ore (1,750 t gross weight), the same as that in 2019 and higher than that in 2016 through 2018. China's apparent consumption was reported to be 115 t of beryllium in the production of beryllium-copper alloys, beryllium oxide ceramics, and beryllium metal, a 5% increase from 110 t of apparent consumption in 2019 (Ying, 2020, p. 10, 15). China, on average, sourced one-half of its beryllium from domestic ore and one-half from Kazakhstan and other foreign sources (China Mining Association, 2016). China was thought to be the world's second ranked beryllium-processing country (after the United States), surpassing Kazakhstan (Ron Gilerman, Managing Director, A&R Merchants, Inc., oral commun., August 10, 2017).

Kazakhstan.—The UMP consumed 94.5 t of beryllium in the production of beryllium-copper alloys, beryllium oxide ceramics, and beryllium metal in 2017 (Kazatomprom JSC, 2018, p. 61–62). The USGS estimated that beryllium consumption was about the same in 2018 and 2019 and about 90 t in 2020, a decrease of 5%, owing to a 19% decrease in Kazatomprom's production of beryllium-containing products in 2020, the majority of which typically contain 0.2% to 2.0% beryllium (Kazatomprom JSC, 2021, p. 6). Since the early 1990s, the UMP's production was sourced from beryllium concentrate stockpiled in Kazakhstan, which had accumulated prior to the breakup of the Soviet Union. The beryllium concentrate stockpile in Kazakhstan was still present in 2020 but was thought to be nearly depleted. The UMP's current primary source of beryllium concentrate was from a Soviet-era stockpile located in Russia. In 2017, the Russian stockpile was forecast to support about 20 years of production, based on the UMP's then-current rate of consumption (Ron Gilerman, Managing Director, A&R Merchants, Inc., oral commun., August 10, 2017).

In 2017, the last year for which reported information was available, Ulba-China Co., Ltd., a subsidiary of the UMP based in Shanghai, China, accounted for 63% of Kazatomprom's sales of beryllium products by volume. The beryllium products were sold to customers in China, Japan, the Republic of Korea, and Malaysia. In addition, Germany's Tropag Oscar H. Ritter Nachf, GmbH; Japan's NGK Insulators, Ltd.; and IBC Advanced Alloys in the United States accounted for 18%, 10%, and 5%, respectively, of Kazatomprom's sales of beryllium products by volume (Kazatomprom JSC, 2018, p. 105).

Russia.—In an effort to augment the beryllium metal imported by Russia, JSC Mariinsky Mine, an enterprise located at the Malyshevskoye emerald-beryllium deposit in Sverdlovsk Province, announced plans in 2019 to produce beryllium metal by 2025. Gemstone beryl ore has historically been mined from this deposit. The Mariinsky Mine planned to reconstruct

the underground mine at the deposit and build beryllium-concentration and metal-production operations, presumably in the town of Krasnoturinsk (ITAR-TASS News Agency, 2019). In 2020, it was reported that a comprehensive geologic and economic assessment of the deposit was underway to more accurately assess its emerald-beryllium resources and reserves. The economic assessment was expected to be completed in early 2021 (JSC Mariinsky Mine, 2020).

Russia's Industry and Trade Ministry financed research on beryllium metal production. Tomsk Polytechnic University and the Rare Metals of Siberia Research and Production Association jointly produced a total of 1 kilogram of beryllium metal at yearend 2015. The Priargunsky Industrial Mining and Chemical Union in Krasnokamensk, Transbaikal Kray, was being considered for a concentrator, and the Siberian Chemical Combine in Seversk, Tomsk Province, was being considered for the beryllium hydrometallurgical plant. Bertrandite ore from the Ermakovskoe deposit in Buryatiya Republic was being considered for this project. As of 2015, the last year for which reported information was available, planned production capacity was expected to be 30 t/yr of beryllium metal (Dragomanovich, 2015; ITAR-TASS News Agency, 2015; Tomsk Polytechnic University, 2017).

Russia's reopening of the Ermakovskoe bertrandite operation in the Siberian Republic of Buryatiya has been reported to be on hold owing to a 2014 financial downturn in Russia. Kazakhstan's UMP was expected to continue supplying Russia with beryllium products (Ron Gilerman, Managing Director, A&R Merchants, Inc., oral commun., August 10, 2017). Ermakovskoe was thought to be the largest identified beryllium deposit in Russia, with 1.4 million metric tons of reported reserves (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 2020, Materion reported proven reserves in Juab County, UT, of 7.1 million metric tons of bertrandite having an average grade of 0.246% beryllium and containing more than 17,000 t of beryllium, representing a minimum of 75 years of future production at the current production rate. The company's proven and probable reserves totaled nearly 20,000 t of beryllium. Materion owned approximately 90% of its proven mineral reserves and leased the remainder from the State (Materion Corp., 2021a, p. 27; 2021b, p. 5).

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TABLE 1
SALIENT BERYLLIUM MINERAL STATISTICS[1]

(Metric tons, beryllium content)

	2016	2017	2018	2019	2020
United States, beryllium-containing ores:					
Mine shipments[2]	155	150	165	160	165
Imports for consumption, beryl[3]	12	5	2	(4)	--
Consumption, reported[5]	160	160	170	160	170
Stocks, December 31:					
Industry[2]	35	30	30	35	30
U.S. Government, beryl[3, 6]	(4)	(4)	(4)	(4)	(4)
World, production[3, 7]	215	210	256 r	238 r	253

-- Zero.
[1]Table includes data available through July 12, 2021.
[2]Data are rounded to the nearest 5 metric tons.
[3]Based on a beryllium content of 4%.
[4]Less than ½ unit.
[5]Data are rounded to the nearest 10 metric tons.
[6]Source: Defense Logistics Agency Strategic Materials.
[7]May include estimated data.

TABLE 2
U.S. GOVERNMENT NATIONAL DEFENSE STOCKPILE BERYLLIUM STATISTICS IN 2020[1]

(Metric tons, beryllium content)

Material	Annual Materials Plan	Inventory, December 31
Beryl ore[2]	--	(3)
Beryllium metal:		
Hot-pressed powder	(4)	58
Rods	--	(3)
Structural powder	--	7
Vacuum-cast	(4)	6
Total	7	72
Grand total	7	72

-- Zero.
[1]Table includes data available through July 12, 2021. Data were converted from gross weight reported in short tons; may not add to totals shown.
[2]Based on a beryllium content of 4%.
[3]Less than ½ unit.
[4]Annual Materials Plan for beryllium metal included in "Total."

Source: Defense Logistics Agency Strategic Materials.

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

Type and material	2019 Gross weight (kilograms)	2019 Beryllium content[2] (kilograms)	2019 Value (thousands)	2020 Gross weight (kilograms)	2020 Beryllium content[2] (kilograms)	2020 Value (thousands)	Principal destinations or sources based on gross weight, 2020
Exports:							
Beryllium, unwrought[3]	3,170	3,170	$120	5,250	5,250	$223	Germany, 46%; France, 20%; Malaysia, 19%; Canada, 7%.
Beryllium waste and scrap	9,410	9,410	282	4,000	4,000	177	Canada, 100%.
Beryllium, other[4]	24,200	24,200	26,700	15,700	15,700	19,700	Canada, 43%; Germany, 11%; Japan, 10%; France, 8%; Republic of Korea, 6%; Singapore, 6%.
Total	36,700	36,700	27,100	24,900	24,900	20,100	Canada, 47%; Germany, 9%; France, 8%; Japan, 6%.
Imports for consumption:							
Beryllium ores and concentrates[4]	139	6	7	--	--	--	--
Beryllium oxide and hydroxide	2,620	944	80	533	192	21	China, 94%; Japan, 6%.
Beryllium, unwrought[3]	9	9	6	--	--	--	--
Beryllium waste and scrap	--	--	--	1,430	1,430	5	Canada, 100%.
Beryllium, other[5]	33,700	33,700	2,750	36,400	36,400	2,980	Kazakhstan, 66%; Latvia, 19%; Canada, 6%; Sweden, 6%.
Beryllium-copper master alloy	83,700	3,350	2,070	75,400	3,010	1,850	Kazakhstan, 91%; Germany, 7%.
Beryllium-copper plates, sheets, and strip	711,000	10,700	12,500	450,000	6,750	8,180	Japan, 91%; Germany, 9%.
Total	831,000	48,600	17,400	564,000	47,800	13,000	Japan, 72%; Kazakhstan, 20%; Germany, 4%.

-- Zero.

[1]Table includes data available through June 30, 2021. Data are rounded to no more than three significant digits; may not add to totals shown.

[2]Estimated from gross weight.

[3]Includes powders.

[4]Data verified by U.S. Census Bureau.

[5]Includes articles not elsewhere specified.

Source: U.S. Census Bureau.

TABLE 4
BERYL: WORLD PRODUCTION, BY COUNTRY OR LOCALITY[1, 2]

(Metric tons, gross weight)

Country or locality[3]	2016	2017	2018	2019	2020
Brazil[e]	120	80	80	80	80
China	1,150	1,300	1,725	1,750	1,750 [e]
Madagascar[e, 4]	16	16	16	16	16
Mozambique	181	53	381	45 [r]	80
Nigeria	--	18 [e]	35	35 [e]	35 [e]
Rwanda	20	20 [e]	20 [e]	20 [e]	20 [e]
Uganda	14	--	24 [r]	15 [r]	190
United States[5]	3,870	3,760	4,130	3,990	4,150
Total	5,370	5,240	6,410 [r]	5,950 [r]	6,320

[e]Estimated. [r]Revised. -- Zero.
[1]Table includes data available through June 30, 2021. All data are reported unless otherwise noted, totals may include estimated data. Totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.
[2]Unless otherwise noted, figures represent beryl ore for the production of beryllium and exclude gem-quality beryl.
[3]In addition to the countries and (or) localities listed, Kazakhstan, Portugal, and Russia may have produced beryl ore, but available information was inadequate to make reliable estimates of output. Other nations that produced gemstone beryl ore may also have produced some industrial beryl ore.
[4]Beryl in quartz concentrates.
[5]Includes raw bertrandite ore, calculated as equivalent to beryl containing 11% beryllium oxide.

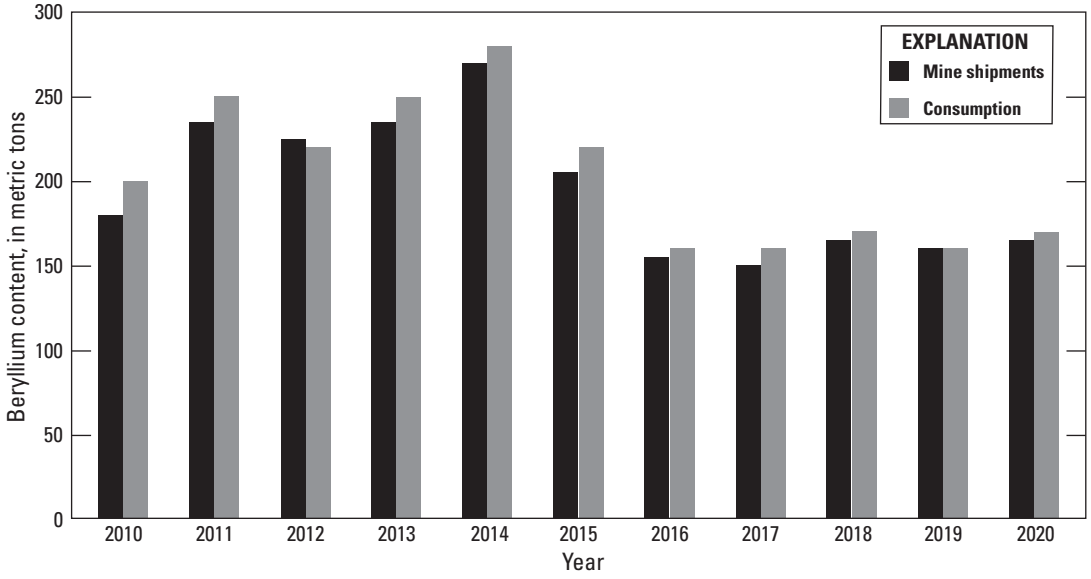

Figure 1. U.S. mine shipments and consumption of beryllium from 2010 through 2020.