BERYLLIUM

By Larry D. Cunningham

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Beryllium (Be), silver in color and one of the lightest of all metals, has one of the highest melting points (about 1,280° C) of all light metals. It has physical and chemical properties, such as its stiffness, resistance to corrosion from acids, and electrical and thermal conductivity, that make it useful for various applications in its alloyed, oxide, and metallic forms. Only two beryllium minerals, beryl and bertrandite, are of commercial importance; beryl contains about 4% Be and bertrandite contains less than 1% Be. Bertrandite is the principal beryllium mineral mined in the United States, and beryl is the principal mineral produced in the rest of the world.

In 2000, U.S. production of beryllium ore and total ore consumption for the production of beryllium alloys, beryllium metal, and beryllium oxide continued to decrease (table 1). Beryllium was used in applications such as computers, telecommunications, and automotive electronics.

The Defense National Stockpile Center (DNSC), U.S. Department of Defense, continued to offer and sell selected beryllium materials from the national defense stockpile (NDS). The Generalized System of Preferences (GSP), a renewable preferential trade program, was extended to September 30, 2001. Most beryllium price quotations remained unchanged. Overall U.S. exports of beryllium were down and overall imports of beryllium were up in 2000 compared with those in 1999.

Legislation and Government Programs

To ensure a supply of beryllium during an emergency, various materials have been purchased for the NDS. The stockpile goal, effective as of October 5, 1999, for beryllium metal was 45 metric tons (t), (table 2). For fiscal year (FY) 2000 (October 1, 1999, through September 30, 2000), the DNSC sold about 1,810 t of beryl ore valued at about $158,000; about 2,040 t of beryllium copper master alloy (BCMA) valued at about $12 million; and about 23 t of beryllium metal valued at about $4.15 million from the NDS. As of September 30, 2000, beryllium inventory sold but not shipped from the NDS included about 3,050 t of beryl ore; about 1,110 t of BCMA; and about 29 t of beryllium metal (U.S. Department of Defense, 2001, p. 13-14, 42, 47).

In its revised annual materials plan (AMP) for FY 2001 (October 1, 2000, through September 30, 2001) and proposed AMP for FY 2002 (October 1, 2001, through September 30, 2002), the DNSC had authority to sell about 3,630 t of beryl ore, about 2,000 t of BCMA, and about 36 t of beryllium metal (Defense National Stockpile Center, 2001a, b). The National Defense Authorization Act for FY 2000 (Public Law 106-65, October 5, 1999) authorizes the President of the United States to dispose of about 227 t of beryllium metal from the NDS. The President may not, however, dispose of the material to the extent that the disposal will result in "(1) undue disruption of the usual markets of producers, processors, and consumers of the materials proposed for disposal; or (2) avoidable loss to the United States" (U.S. Department of Defense, 2001, p. 31, 32). For FY 2001, through June 30, 2001, the DNSC sold about 1,260 t of BCMA valued at about $7.62 million and about 23 t of beryllium metal valued at about $3.62 million from the NDS.

Under the GSP, the United States grants duty-free access to eligible products from designated developing countries. In

Beryllium in the 20th Century

Beryllium was discovered in 1797 as a constituent of the mineral beryl. The metallic form was isolated in 1828 and named beryllium. It was not until 1926, however, that the true value of beryllium was realized. U.S. production of beryllium-copper alloys began in 1932, and in the 1940s, a commercial process was developed to produce beryllium metal. An early use for beryllium was in copper and nickel alloys, which were used in electrical components in machinery. In 1969, a beryllium mine opened in Utah that provided a large secure source of domestic raw material supply. Although statistics are not available for beryllium in the early years of its development, in 1940, U.S. mine shipments of beryllium ore (mostly from Colorado, Maine, and South Dakota) totaled about 110 metric tons valued at about $3,720. World production of beryllium ore was about 2,100 tons; Argentina was the major producer accounting for about 70% of the total. U.S. imports of beryllium ore totaled about 730 tons valued at about $24,000; Argentina and Brazil were the major sources.

In 2000, the United States was one of three countries that processed beryllium ores and concentrates into beryllium products. World beryllium ore production totaled about 6,000 tons; the United States, Russia, and Kazakhstan were the leading producers. Beryllium ore production in the United States was about 4,500 tons, mostly from Utah. Beryllium imports in the form of beryllium alloy and compounds totaled more than 150 tons valued at about $2.5 million. There were no imports of beryllium ore. U.S. beryllium consumption totaled about 300 tons of contained beryllium valued at about $110 million. The use of beryllium (as an alloy, metal, and oxide) in electronic and electrical components and aerospace and defense applications accounted for an estimated 80% of total U.S. consumption.

2000, U.S. import duties for selected beryllium materials ranged from duty free to 8.5% ad valorem for normal-trade-relations (NTR) status and from duty free to 45% ad valorem for non-NTR status (U.S. International Trade Commission, 1999). In March, the GSP program, which expired on June 30, 1999, was renewed through September 30, 2001, retroactive to July 1, 1999, by a provision in the Ticket To Work and Work Incentives Improvement Act of 1999. The U.S. Customs Service began processing refunds due to the renewal on January 7, 2000 (U.S. Customs Service, 2000).

In December, the U.S. Department of Energy (DOE) published a notice of intent to establish the Worker Advocacy Committee. The Committee would provide DOE with advice, information, and recommendations on programs to assist workers diagnosed with work-related illnesses (including ongoing beryllium medical surveillance programs) in filing state workers' compensation claims. The Committee would "(1) provide advice to the Department of Energy on workers' compensation policy issues of concern to the Department; (2) periodically review worker advocacy program initiatives and recommendations; and, (3) provide advice on plans, priorities, and strategies to improve advocacy practices and procedures of the worker advocacy program." Committee members would be chosen from workers and union representatives, State and federal workers' compensation specialists, occupational physicians, medical and public health organizations, academic researchers, and the public at large (U.S. Department of Energy, 2000).

"The Energy Employees Occupational Illness Compensation Act of 2000, Public Law 106-398, establishes a program to provide compensation to individuals who developed illnesses as a result of their employment in nuclear weapons production-related activities and at certain federally-owned facilities in which radioactive materials were used." On December 7, 2000, the President issued Executive Order 13179 directing DOE to publish in the Federal Register (no later than January 15, 2001) a list of covered facilities. The list would cover three categories defined by the act—atomic weapons employer facilities, DOE employer facilities, and facilities owned and operated by a beryllium vendor. The initial list was published on January 17, 2001. The list was revised on June 11, 2001, and contained 43 beryllium-related facilities. The list indicated private firms that processed, produced, or provided beryllium metal for the DOE. The information was taken from a variety of historical documents, to the extent that DOE was able to identify and locate records, and the DOE welcomed comments and additional information about its beryllium vendors (Clinton, 2000; U.S. Department of Energy, 2001a, b).

Production

The U.S. Geological Survey collects beryllium data from two voluntary surveys of U.S. operations. In 2000, five respondents to the "Beryllium" and the "Mineral Concentrate and Beryllium Ore" surveys produced 100% of total domestic mine shipments presented in tables 1 and 7. A small number of unidentified producers may have shipped negligible quantities of byproduct beryl, which have not been included.

The United States, one of only three countries that process beryllium ores and concentrates into beryllium products, supplies most of the rest of the world with these products. Brush Wellman Inc., Cleveland, OH, mined bertrandite and converted ore of this mineral, along with imported beryl, into beryllium hydroxide at its operations near Delta, UT. Beryllium hydroxide was shipped to the company's plant in Elmore, OH, where it was converted into beryllium alloys, oxide, and metal. Brush Wellman also operated a plant in Reading, PA, that produced thin precision strips of beryllium-copper and other alloys and beryllium-copper rod and wire. About $2.4 million was spent on an annealing furnace to increase production capacity at the facility, with completion anticipated for the second half 2001 (Brush Engineered Materials Inc., 2001a, p. 3, 19, 2001b, p. 4).

In May 2000, Brush Wellman's shareholders approved the reorganization of its corporate and capital structure, and the company became a wholly owned subsidiary of Brush Engineered Materials Inc., a holding company headquartered in Cleveland, OH. Each share of Brush Wellman's common stock was exchanged for one share of Brush Engineered Materials' common stock. Brush Engineered Materials owned operations in Asia, the United States, and Western Europe and employed about 2,500 people. Company operations were organized into two business segments, the Metals Systems Group and the Microelectronics Group. The Metals Systems Group included Brush Wellman, the company's largest subsidiary, which produced strip and bulk products (mostly beryllium-containing alloys) and beryllium metal and beryllium-aluminum products (Brush Engineered Materials Inc., 2001a, p. 1, 7, 13-14, 18, 28, 33).

NGK Metals Corp., headquartered in Reading, PA, a subsidiary of NGK Insulators, Ltd. of Japan, produced beryllium alloy products at a plant in Sweetwater, TN. Because NGK Metals does not have facilities to process beryllium ores and concentrates, the company purchases beryllium oxide from Brush Wellman.

Environment

Because of the toxic nature of beryllium, the industry must maintain careful control over the quantity of beryllium dust and fumes in the workplace. The U.S. Environmental Protection Agency issues standards for certain hazardous air pollutants, including beryllium, under the Clean Air Act, and the Occupational Safety and Health Administration issues standards for airborne beryllium particles. To comply with these standards, plants are required to install and maintain pollution-control equipment. In beryllium-processing plants, harmful effects are prevented by maintaining clean workplaces; requiring the use of safety equipment, such as personal respirators; collecting dust, fumes, and mists at the source of deposition in dust collectors; establishing medical programs; and implementing other procedures to provide safe working conditions. Standards for exposure to beryllium were under review (Petkof, 1985, p. 80; Rossman, Preuss, and Powers, 1991, p. 278-280; Kramer, 1998, p. 107-108; Brush Engineered Materials Inc., 2001a, p. 6, 7, 19). Control of potential health hazards adds to the final cost of beryllium products.

Consumption

In 2000, domestic mine shipments and beryllium-containing ore consumption continued to trend downward. According to

its annual report, Brush Engineered Materials' worldwide sales continued at a record pace, about $564 million in 2000 compared with about $456 million in 1999. Beryllium-containing products accounted for more than 50% of total company sales. The domestic market accounted for 73% of the company's revenue compared with 70% in 1999. Telecommunications (33%) was the leading revenue market. The Metal Systems Group (which included Brush Wellman's Alloy Products and Beryllium Products business units) had revenues of about $378 million, about 67% of total revenues. Alloy Products (primarily copper-beryllium alloys) sales increased to $270 million. Yield and equipment reliability issues at the Elmore plant, however, limited the company's ability to supply total product market demand. The alloys, sold in strip and bulk form, are used in applications such as computers, telecommunications, automotive electronics, oil and gas exploration, and undersea communications. Beryllium Products sales increased to $25 million, owing to increased second half year sales of beryllium aluminum alloy and beryllium metal products for defense related applications. Company international sales totaled about $150 million ($98.4 million from international operations, with facilities in England, Germany, Japan, and Singapore, and $51.2 million from U.S. operations' exports) compared with about $138 million in 1999 (Brush Engineered Materials Inc., 2001a, p. 2-3, 6, 13-14, 16; 2001b, p. 3).

During the year, Brush Wellman entered into a long-term supply arrangement with Kazatomprom National Atomic Co. and Ulba Metallurgical Plant Open Stock Co. in Kazakhstan and their marketing representative Nukem Inc. in New York for the supply of copper-beryllium master alloy and certain other beryllium-containing materials. Brush Wellman was to purchase the alloy and materials from Nukem, a wholly owned subsidiary of Tessag AG, Germany, which had a supply agreement with Ulba, a unit of Kazatomprom, who would produce the material. Annual purchase commitments for 2001 through 2009, totaled $5.8 million in 2001, $7.7 million in 2002, $9.7 million in 2003, $11.6 million in 2004, $13.5 million in 2005, and $15.4 million per year thereafter. Also, Brush Wellman was to purchase $3 million of beryllium ingot in 2001. The agreement could be terminated at any time with written notice for causes of action. The purchased material would be used by Brush Wellman in the manufacture of high-performance alloy products and would augment its U.S. beryllium sources (Brush Wellman Inc., 2000; Brush Engineered Materials Inc., 2001a, p. 22, 40).

U.S. apparent consumption of all beryllium materials was estimated to be about 300 t of contained beryllium in 2000 compared with about 385 t in 1999.

Beryllium-Copper Alloys.—Beryllium-copper alloys, most of which contain approximately 2% beryllium, are used in a wide variety of applications. These alloys are used because of their electrical and thermal conductivity, high strength and hardness, good corrosion and fatigue resistance, and nonmagnetic properties. Beryllium-copper strip is manufactured into springs, connectors, and switches for use in applications in automobiles, aerospace, radar and telecommunications, factory automation, computers, home appliances, and instrumentation and control systems. The principal use of large-diameter beryllium-copper tubing is in oil and gas drilling equipment and in bushings and bearings in aircraft landing gear and heavy machinery. Connectors in fiber-optic telecommunications systems are the main application for beryllium-copper rod. Small, pluggable sockets for joining integrated circuits to printed circuit boards are the main application for beryllium-copper wire. Beryllium-copper bar and plate are used in resistance-welding parts, components for machinery and materials-handling systems, and for molds to make metal, glass, and plastic components.

Beryllium also is used in small quantities in nickel- and aluminum-base alloys. Miniature electronic connector components that operate at high temperatures are the main use for beryllium-nickel alloys. These alloys also are used in automotive passive restraint systems (airbags). Beryllium-aluminum alloys are used as castings in the aerospace industry. The addition of small quantities of beryllium to magnesium alloys inhibits oxidation.

Beryllium Metal.—Beryllium metal is used principally in aerospace and defense applications. Its high level of stiffness, light weight, and dimensional stability within a wide temperature range make it useful in satellite and space vehicle structures, inertial guidance systems, military aircraft brakes, and space optical system components. Because beryllium is transparent to x rays, it is used in x-ray windows. In nuclear reactors, beryllium also serves as a canning material, as a neutron moderator, and in control rods. In the past, the metal had been used as a triggering device in nuclear warheads. Other applications for metallic beryllium include high-speed computer components, audio components, and mirrors. In the U.S. space shuttles, several structural parts and brake components use beryllium.

Beryllium Oxide.—Beryllium oxide (beryllia) is an excellent heat conductor, with high levels of hardness and strength. This material also acts as an electrical insulator in some applications. Beryllium oxide serves mainly as a substrate for high-density electronic circuits for high-speed computers, automotive ignition systems, lasers, and radar electronic countermeasure systems. Because it is transparent to microwaves, microwave communications systems and microwave ovens may use beryllium oxide.

Because the cost of beryllium is high compared with that of other materials, it is used in applications in which its properties are crucial. Graphite, steel, and titanium may be substituted for beryllium metal in some applications, and phosphor bronze may be substituted for beryllium-copper alloys, but these substitutions can result in substantial loss in performance. In some applications, aluminum nitride may be substituted for beryllium oxide.

Prices

Yearend price quotes for beryllium materials and products are shown in table 3. Published prices for most beryllium materials remained unchanged throughout the year, with the exception of beryllium metal and beryllium oxide. In June the price for 99% beryllium metal powder increased to $421 per pound, beryllium vacuum-cast ingot increased to $492 per pound, and beryllium oxide increased to $100 per pound. The American Metal Market published prices for other selected beryllium products were as follows: BCMA, $160 per pound of contained beryllium, unchanged since August 1987; beryllium-copper strip, $8.90 per pound, unchanged since January 1993; and

beryllium-aluminum alloy, $260 per pound, unchanged since January 1995. The Metal Bulletin published price for beryl ore, which ranged from $75 to $80 per short ton unit of contained BeO, has remained the same since 1990.

Significant events affecting beryllium prices since 1958 include the following: 1969, bertrandite mine established in the United States providing a significant raw materials source; 1977, effects of inflation, increased energy costs, and additional costs associated with complying with air emission standards resulted in increased prices; 1979, beryllium metal price set by one producer; 1988, purchase of beryllium metal for the NDS; 1990, conversion of NDS beryl ore to beryllium metal for the NDS; and 1991, recession and dissolution of the U.S.S.R (Cunningham, 1999).

Foreign Trade

Data for U.S. exports and imports are summarized in tables 4 and 5, respectively. Overall beryllium exports were down by about 14% compared with those of 1999. France, Germany, Japan, the Republic of Korea, the Netherlands, and the United Kingdom were the major recipients of the materials, with about 85% of the total. Overall beryllium imports increased by about 20%. BCMA imports were up by more than 40%, with Germany providing more than 70% of the imports. Metal imports were down by more than 10%, with China, Estonia, and the United Kingdom accounting for about 95% of the materials. There were no beryl ore imports in 2000. The schedule of tariffs applied during 2000 to U.S. imports of selected beryllium materials is found in the U.S. International Trade Commission's Publication 3249, 2000 Harmonized Tariff Schedule of the United States (U.S. International Trade Commission, 1999).

Net import reliance as a percent of apparent consumption is used to measure the adequacy of current domestic beryllium production to meet U.S. demand. For 2000, net import reliance as a percent of apparent consumption was estimated to be about 37% compared with about 48% in 1999. In descending order, Estonia, Germany, and China were the major sources for U.S. beryllium imports, on the basis of contained beryllium, accounting for more than 80% of the total. Other sources of imports were Belgium, Russia, and the United Kingdom.

The U.S. Census Bureau does not separately identify all imports and exports of beryllium products. The Journal of Commerce Port Import/Export Reporting Service (PIERS) provides some data on materials that are transported by ship. According to PIERS, about 890 t, gross weight, of beryllium products (mostly beryllium-copper) was imported in 2000, primarily from Japan. Exports of beryllium products (mostly beryllium-copper) totaled more than 600 t, gross weight; Japan received most of this material.

World Review

Annual world beryl production capacity (metric tons, contained beryllium) is listed in table 6. Estimated world beryl production (metric tons, gross weight) is listed in table 7. In 2000, estimated world beryl production (including bertrandite ore) decreased by about 9% compared with that of 1999. The two major producers, Russia and the United States, accounted for about 97% of total production.

Japan.—In November 1999, NGK Insulators completed a 2-year investment program that increased beryllium-copper alloy capacity at its plant in Handa, near Nagoya, to about 350 metric tons per month (t/mo) from about 300 t/mo. NGK indicated that Japanese and Asian demand for beryllium-copper alloys in 1999 was about 3,500 t. In addition to regional sales, NGK shipped semifinished products from Handa to its subsidiaries in Germany and the United States for fabrication. In 2000, Japanese demand for beryllium-copper alloys increased to a record level of about 300 t/mo, owing to increased use in portable telephones and automotive electrical equipment (Roskill's Letter from Japan, 2000; Metal Bulletin, 2001).

Kazakhstan.—Kazatomprom, Kazakhstan's national nuclear concern, reportedly invested about $36 million to develop beryllium, tantalum, and uranium production. Projects conducted included the introduction of carbothermy technology and the production of beryllium bars at the Ulba Metallurgical Plant. Kazatomprom owns 90% of Ulba shares. Kazatomprom's contract to supply Brush Wellman with beryllium, and for the exchange of technology, was reported to be worth more than $120 million (see consumption section of this report) (Interfax International Ltd., 2000a, b).

Russia.—At yearend 1999, the Chita region made a decision to join a federal program named Libton for the creation of a scientific production center for rare metals, including beryllium, in the Trans-Baikal region. The Chita region and TVEL, a producer and supplier of nuclear fuel controlled by the Russian Ministry of Atomic Energy, signed an agreement on liaison with the Priargunsky Mining and Chemicals Production Association, a uranium producer controlled by TVEL, and the Zabaikalsky Mining and Beneficiation Plant, a rare metal producer. The Ministry was to finance the program and coordinate efforts by Priargunsky and Zabaikalsky to produce materials for the nuclear sector (Interfax International, Ltd., 2000c).

Outlook

Beryllium alloys, primarily beryllium-copper, are expected to remain the dominant form of consumption for beryllium. Beryllium demand should rise owing to increased usage of beryllium-copper in automotive electronics, computers, and portable telephones. Also, the newer beryllium-aluminum alloys are expected to gain in importance in terms of beryllium demand, with usage in applications such as aerospace and computers. The beryllium-aluminum alloys contain up to about 60% beryllium, compared with beryllium-copper alloys, most of which contain about 2% beryllium (American Metal Market, 2000; Harben, 2000, p. 13, 14; Mining Journal, 2000).

The United States is expected to remain self-sufficient with respect to most of its beryllium requirements. In 2000, the United States consumed about 240 t of beryllium contained in beryllium-bearing ores, compared with about 260 t in 1999. Brush Engineered Materials Inc. (2001a, p. 20) reported proven bertrandite reserves in Juab County, UT, of about 7 million metric tons at yearend 2000, with an average grade of 0.263% beryllium. This represents about 18,300 t of contained beryllium, compared with about 18,700 t in 1999. About 87% of the beryllium is recovered from the ore during the extraction process.

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TABLE 1
SALIENT BERYLLIUM MINERAL STATISTICS

(Metric tons, beryllium metal equivalent)

	1996	1997	1998	1999	2000
United States:					
Beryllium-containing ores:					
Mine shipments	211	231	243	200	180
Imports for consumption, beryl 1/	1	9	13	1	--
Consumption, reported	234	259	272	260	240
Yearend stocks	139	110	81	17	114
World, production 1/	255	276	289	248	226

-- Zero.
1/ Based on a beryllium metal equivalent of 4% in beryl.

TABLE 2
BERYLLIUM IN GOVERNMENT INVENTORIES
AS OF DECEMBER 31, 2000

(Metric tons, beryllium content)

			National defense stockpile inventory	
Material	Stockpile goal 1/	Disposal authority	Uncommitted	Committed
Beryllium ore	--	280	280	33
Beryllium-copper master alloy	--	81	81	44
Beryllium metal	45	277	322	29

-- Zero.
1/ Goal effective as of October 5, 1999.

Source: Defense National Stockpile Center.

TABLE 3
YEAREND BERYLLIUM PRICES, 2000

(Dollars per pound unless otherwise specified)

Material		Price
Beryl ore	per short ton unit of contained BeO	$75-$80
Beryllium vacuum-cast ingot, 98.5% pure, in lots up to 1,000 pounds		492
Beryllium metal powder, in 1,000- to 4,999-pound lots and 99% pure		421
Beryllium-copper master alloy	per pound of contained Be	160
Beryllium-copper casting alloy		5.52-6.30
Beryllium-copper in rod, bar, wire		9.85
Beryllium-copper in strip		8.90
Beryllium-aluminum alloy, in lots up to 100 pounds; 62% Be, 38% Al		260
Beryllium oxide powder, in 10,000-pound lots		100

Sources: American Metal Market, Brush Wellman, Inc., Metal Bulletin, and Platt's Metals Week.

TABLE 4
U.S. EXPORTS OF BERYLLIUM ALLOYS, WROUGHT OR UNWROUGHT, AND WASTE AND SCRAP, BY COUNTRY 1/ 2/

Country	1999 Quantity (kilograms)	1999 Value (thousands)	2000 Quantity (kilograms)	2000 Value (thousands)
Canada	6,630	$190	1,670	$40
France	2,010	1,020	5,880	1,270
Germany	3,320	617	5,200	715
Israel	172	22	867	147
Japan	7,110	1,360	6,440	1,470
Korea, Republic of	68	57	3,260	82
Netherlands	3,760	220	4,860	226
United Kingdom	10,700	2,710	3,450	802
Other	5,830 r/	577 r/	2,290	654
Total	39,600	6,770	33,900	5,410

r/ Revised.
1/ Consisting of beryllium lumps, single crystals, powder; beryllium-base alloy powder; and beryllium rods, sheets, and wire.
2/ Data are rounded to no more than three significant digits; may not add to totals shown.

Sources: U.S. Census Bureau and U.S. Geological Survey.

TABLE 5
U.S. IMPORTS FOR CONSUMPTION OF BERYLLIUM ORE, METAL, AND COMPOUNDS 1/

Material	1999 Quantity (kilograms)	1999 Value (thousands)	2000 Quantity (kilograms)	2000 Value (thousands)
Beryl ore	20,400	$13	--	--
Beryllium-copper master alloy	103,000	1,530	149,000	$2,480
Beryllium oxide and hydroxide	1,020	14	4,790	31
Beryllium, unwrought and waste and scrap	11,900	1,060	10,400	753

-- Zero.
1/ Data are rounded to no more than three significant digits.

Sources: U.S. Census Bureau and U.S. Geological Survey.

TABLE 6
ANNUAL WORLD BERYL PRODUCTION CAPACITY, DECEMBER 31, 2000 1/

(Metric tons, beryllium content)

Continent and country	Capacity
North America: United States 2/	360
Africa:	
Madagascar	5
Mozambique	3
Rwanda	3
South Africa	3
Total	14
Asia, China	75
Europe:	
Kazakhstan	7
Portugal	3
Russia	70
Total	80
South America, Brazil	5
Grand total	534

1/ Includes capacity at operating plants as well as at plants on standby basis.
2/ Includes bertrandite ore.

TABLE 7
BERYL: ESTIMATED WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons, gross weight)

Country 3/	1996	1997	1998	1999	2000
Brazil	6 4/	7 4/	5 r/ 4/	11 r/	10
Kazakhstan	100	100	100	100	100
Madagascar 5/	11	28	30	30	30
Portugal	5	5	5	4	4
Russia	1,000	1,000	1,000	1,000	1,000
United States (mine shipments) 6/	5,260	5,770	6,080	5,070	4,510
Zambia 5/	-- r/	-- r/	-- r/	-- r/	--
Total	6,380 r/	6,910	7,220	6,220	5,650

r/ Revised. -- Zero.

1/ World totals, U.S. data, and estimated data are rounded to three significant digits; may not add to totals shown.

2/ Table includes data available through June 8, 2001.

3/ In addition to the countries listed, China produced beryl and Bolivia may also have produced beryl, but available information is inadequate for formulation of reliable estimates of production.

4/ Reported figure.

5/ Includes ornamental and industrial products.

6/ Includes bertrandite ore, calculated as equivalent to beryl containing 11% BeO.