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RARE EARTHS [ADVANCE RELEASE]

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Rare Earths

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In 2017, world rare-earth mine production was an estimated 132,000 metric tons (t) of rare-earth oxide (REO) (tables 1, 8). China continued to dominate global production and consumption of rare-earth metals and compounds. Most of the rare-earth mineral concentrates were produced in China, with smaller quantities produced in Australia, Brazil, India, Malaysia, Russia, Thailand, and Vietnam (table 8). The unique properties of rare earths make them useful in a wide variety of applications, such as alloys, batteries, catalysts, magnets, phosphors, and polishing compounds. In the United States, there was no production of rare-earth ores and concentrates.

At yearend, the rare-earth mining and processing operations in Mountain Pass, CA, were being restarted. The total value of U.S. imports of rare-earth compounds and metals was $137 million, and U.S. exports were about $31 million (tables 4–7). Following several years of declining prices, prices for most rare-earth metals and compounds used in magnet applications increased significantly relative to those in 2016 (table 3).

The rare earths are a group of moderately abundant elements comprising the 15 lanthanides, scandium (Sc), and yttrium (Y). The lanthanides are the elements with atomic numbers 57 through 71, in order of atomic number: lanthanum (La), cerium (Ce), praseodymium (Pr), neodymium (Nd), promethium (Pm), samarium (Sm), europium (Eu), gadolinium (Gd), terbium (Tb), dysprosium (Dy), holmium (Ho), erbium (Er), thulium (Tm), ytterbium (Yb), and lutetium (Lu). In rock-forming minerals, rare earths typically occur in compounds as trivalent cations in carbonates, oxides, phosphates, and silicates (Mason and Moore, 1982, p. 46). The principal economic rare-earth minerals are bastnäsite, loparite, monazite, xenotime, and the lateritic ion-adsorption clays. The percentage distribution of REOs in mineral concentrates varies significantly on the basis of mineral source and location (table 2).

Excluding scandium, a rare-earth element (REE) can be classified as either a light rare-earth element (LREE) or a heavy rare-earth element (HREE). The LREEs include the lanthanide elements from atomic number 57 (La) through atomic number 64 (Gd), and the HREEs include the lanthanide elements from atomic number 65 (Tb) through atomic number 71 (Lu). The division is based on the LREEs having unpaired electrons in the 4f electron shell and HREEs having paired electrons in the 4f electron shell.

Scandium (atomic number 21), a transition metal, is the lightest REE, but it is not classified as one of the group of LREEs nor one of the HREEs. Scandium is a soft, lightweight, silvery-white metal, similar in appearance and weight to aluminum. Although its occurrence in crustal rocks is greater than that of lead, mercury, and the precious metals, scandium rarely occurs in concentrated quantities because it does not selectively combine with the common ore-forming anions.

Yttrium (atomic number 39), a transition metal, is chemically similar to the lanthanides and commonly occurs in the same minerals as a result of its similar ionic radius. Yttrium is included as an HREE even though it is not part of the lanthanide series.

The elemental forms of rare earths are iron-gray to silvery lustrous metals that are typically soft, malleable, ductile, and usually reactive, especially at elevated temperatures or when finely divided. Melting points range from 798 degrees Celsius (°C) for cerium to 1,663 °C for lutetium.

Legislation and Government Programs

In October, the U.S. Department of Defense, Defense Logistics Agency Strategic Materials (DLA Strategic Materials) announced the fiscal year (FY) 2018 (October 1, 2017, through September 30, 2018) Annual Materials Plan (AMP) for the National Defense Stockpile (NDS). The AMP includes potential acquisitions of new NDS stocks. In FY 2018, these included 18 t of europium (unspecified form), 10 t of yttrium oxide, and 0.5 t of dysprosium metal (Defense Logistics Agency Strategic Materials, 2017). At calendar yearend 2017, the NDS inventory included 0.1 t of dysprosium, 24.5 t of yttrium oxide, and 0.5 t of ferrodysprosium.

Following on research from 2016, DLA Strategic Materials made two awards through the Small Business Innovation Research (SBIR) program aimed at demonstrating recovery or recycling of rare earths. Urban Mining Co. (Austin, TX) was awarded $934,000 to pursue a recycling system to produce magnetic powders from different grades and compositions of magnet scrap. Recycled magnets would then be produced from these powders. Xylon Technical Ceramics Inc. (Alfred, NY) was awarded about $999,000 to develop a process to recover rare earths from thermal barrier coating (TBC) wastes. TBCs are used in aviation and energy sectors. Xylon planned to develop a scalable manufacturing process to recycle rare earths from TBC waste (U.S. Small Business Administration, 2019).

In FY 2017, Rare Resource Recycling Inc. (Houston TX) entered the second phase of a SBIR project with the National Science Foundation to recycle REEs from neodymium magnets. The first phase of the project successfully demonstrated the feasibility of developing a process beyond laboratory scale to pilot scale. The second phase of the project was expected to result in a pilot scale production plant with product yields greater than 95% and purity greater than 99%. The first and second phase project awards totaled $900,000, and work was expected to be completed in 2019 (National Science Foundation, 2018).

Researchers at the Critical Materials Institute (CMI), funded by the U.S. Department of Energy (DOE), refocused their goals to diversify supply, develop substitutes, and improve reuse and recycling of rare earths. CMI's goal to diversify supply included efforts to demonstrate a domestic supply chain from mines to magnets and develop a commercial product based on aluminum-cerium alloys. CMI's goal in developing substitutes focused on magnets with reduced or no rare-earth content and alternate phosphors for lighting technologies. CMI's reuse and recycling projects included a demonstration of hard disk drive disassembly to speed recovery of magnets for recycling or reuse and a project to scale up a process to dissolve, refine, and separate critical elements (Critical Materials Institute, 2017, p. 6).

The DOE continued to fund research in pursuit of cost-effective methods to separate rare earths from coal and coal byproducts (including effluents), and in 2017, the DOE announced $17.4 million in research funding for bench-scale and pilot-scale projects. Bench-scale project awards were made to the University of North Dakota Institute for Energy Studies ($2.75 million) and West Virginia University Research Corp. ($2.66 million). Pilot-scale project awards were made to Physical Sciences, Inc. ($6 million) and the University of Kentucky Research Foundation ($6 million). All awards were for a second phase of research that is expected to be completed by 2020 (National Energy Technology Laboratory, 2017).

Production

Rare-earth mineral concentrates had not been produced in the United States since Molycorp, Inc. (Greenwood Village, CO) placed its mining operations at Mountain Pass, CA, on care-and-maintenance status and filed for bankruptcy protection in 2015. In 2017, the Mountain Pass operations were sold at auction and acquired by a group of investors. Two U.S. investment funds (JHL Capital Group LLC and QVT Financial LP) held a 90.01% interest in the Mountain Pass operations, and a China-based rare-earth producer, Shenghe Resources Holding Co., Ltd., held the remaining interest through a subsidiary. At yearend 2017, the new operator, MP Mine Operations LLC, was restarting mining operations, and exports of mineral concentrates were expected to begin in 2018. A Shenghe subsidiary, Singapore International Trade, was providing financial and technical support to help restart production and held product distribution rights (Asian Metal Inc., 2017d; Nuclear Regulatory Commission, 2017).

Rare-earth compounds and chemical intermediates were imported and processed into a variety of value-added products. Leading producers of rare-earth-bearing catalysts and chemical intermediates in the United States included Albemarle Corp. (Baton Rouge, LA), BASF Corp. (Florham Park, NJ), Solvay Chemicals, Inc. (Houston, TX), and W.R. Grace & Co. (Columbia, MD). Globe Metallurgical Inc. (Beverly, OH) and CC Metals and Alloys, LLC (Calvert City, KY) produced specialty ferroalloys containing REEs.

U.S. processors of rare-earth magnet alloys or rare-earth magnets included Arnold Magnetic Technologies Corp. (Rochester, NY), Electron Energy Corp. (Landisville, PA), Eutectix LLC (Troy, MI, and Tolleson, AZ), and Hitachi Metals America, Ltd. (China Grove, NC). TdVib, LLC (Ames, IA) produced the magneto-restrictive alloy Terfenol-D® containing dysprosium, iron, and terbium. A variety of alloys and compounds were produced from imported materials in limited quantities. All domestic, commercially produced scandium and yttrium products were derived from imported compounds.

In 2017, publicly traded companies with plans to develop domestic resources of rare earths included NioCorp Developments Ltd. at its Elk Creek project in Nebraska, Rare Element Resources Ltd. at its Bear Lodge project in Wyoming, Texas Mineral Resources Corp. at its Round Top project in Texas, and Ucore Rare Metals Inc. at its Bokan Mountain project in Alaska. NioCorp, Texas Mineral Resources, and Ucore were considering scandium recovery in their project plans.

In 2017, Niocorp completed a revised National Instrument 43–101-compliant feasibility study for its Elk Creek polymetallic (niobium-titanium-scandium) project in Nebraska. According to the report, the indicated resource was 90.9 million metric tons (Mt) containing 70 grams per metric ton (6,300 t) of elemental scandium using a cutoff based on a $180 per ton net smelter return (NSR). The NSR was based on revenue from niobium, titanium, and scandium oxides (NioCorp Developments Ltd., 2017, p. 443).

Rare Element Resources' Bear Lodge project continued a care-and-maintenance plan that began in 2016. In October, General Atomics Uranium Resources, LLC acquired an interest of about 33.5% in Rare Element Resources. The purchase was expected to allow the company to continue to advance the project. Measured and indicated resources at Bear Lodge were 16.3 Mt containing 3.07% (500,000 t) of REO equivalent using a 1.5%-REO cutoff (Rare Element Resources Ltd., 2018, p. 37, 41, 47).

Texas Mineral Resources was pursuing funding to advance its Round Top project and created a subsidiary named American Mineral Reclamation, LLC intended to develop a process to recover critical materials from coal byproducts, industrial wastewater, acid-mine drainage, and scrap-metal processing. In November, an agreement with an investment group was expected to be used to support a bankable feasibility study for the Round Top project (Texas Mineral Resources Corp., 2017a, b).

Ucore entered into agreement with Commerce Resources Corp. to conduct pilot separation trials of mixed rare-earth carbonate from Commerce Resources' Ashram Project. Ucore planned to construct a multimetal production facility based on molecular recognition technology (Ucore Rare Metals Inc., 2018, p. 4, 5).

Consumption

Owing to limited data transparency, industry estimates of global consumption of rare earths varied significantly and generally ranged from about 140,000 to 170,000 t of REO equivalent (Adamas Intelligence, 2016, p. 105; Roskill Information Services Ltd., 2016, p. 263; Kingsnorth, 2018, p. 5). Global consumption was led, in descending order of quantity, by magnets, catalysts, polishing, and metallurgical applications. Other end uses included ceramics, glass, phosphors, pigments, and miscellaneous other uses.

Based on trade data and excluding stock changes, U.S. apparent consumption of rare earths was estimated to be 9,100 t of REO equivalent in 2017. The estimated domestic use of rare earths in 2017 was primarily in catalysts (55%), with the remainder in ceramics and glass (15%), metallurgical applications and alloys (10%), polishing (5%), and other uses (15%).

The United States primarily consumed LREEs. Because the United States has limited capabilities to produce battery alloys, magnet alloys, and phosphors, most LREE consumption was in the form of cerium and lanthanum compounds used to produce catalysts, ceramics, glass, and polishing compounds; ferrocerium and rare-earth metals were used for alloys and other metallurgical applications. Most HREE consumption was in the form of yttrium compounds. Together, the remaining HREEs (Tb, Dy, Ho, Er, Tm, Yb, and Lu) were estimated to contribute less than 2% to domestic consumption.

The amount of specific REEs used varied significantly by market sector and application. In the catalysts sector, the primary REEs consumed were lanthanum and cerium, with lesser amounts of neodymium. Consumption in the magnet sector varied by the type of permanent magnet. Neodymium-iron-boron magnets primarily used neodymium and praseodymium with lesser amounts of dysprosium, gadolinium, and terbium; samarium-cobalt magnets used samarium and lesser amounts of gadolinium. Lanthanum had limited use in certain ferrite magnets. Polishing compounds primarily used cerium with lesser amounts of lanthanum. Batteries primarily used lanthanum and lesser amounts of cerium as well as other REEs. Ceramics were dominated by yttrium consumption with lesser amounts of cerium and other REEs. Metallurgical applications varied by element. Europium, yttrium, and terbium were the three REEs commonly associated with the phosphors sector, but other REEs also were used by that sector. The glass sector used lanthanum, cerium, and erbium, in descending order of consumption, as well as other REEs. The HREEs were often used in high-unit-value applications. For example, laser crystals were commonly based on neodymium and yttrium and were doped with the HREEs (particularly dysprosium, erbium, thulium, and ytterbium). Among its other uses, lutetium was used in positron emission tomography.

Global consumption of scandium was estimated to be about 10 to 20 metric tons per year (t/yr). Although not quantified, the domestic end uses of scandium were primarily for fuel cells and as an additive in aluminum alloys; however, scandium for these applications was thought to be imported in the form of value-added intermediate products rather than imported under the Harmonized Tariff Schedule of the United States (HTS) codes for rare-earth metals (2805.30) and rare-earth compounds (2846). Globally, the leading end uses for scandium were aluminum-scandium alloys, fuel cells, and lasers.

Prices

Prices for most rare-earth products increased compared with those in 2016 and reversed downward trends that began after price spikes in 2011. On a percentage basis, the largest increases in REO prices were led by gadolinium, praseodymium, and neodymium. The largest decreases in REO prices were led by yttrium and dysprosium. Based on information collected by the U.S. Census Bureau on imports, the estimated unit value of rare-earth compounds was $11.60 per kilogram, a 21% increase compared with $9.55 in 2016. Variations in the purity or mix of specific compounds imported from year to year affect the unit value of imports. The domestic price for scandium oxide quoted by a domestic supplier was unchanged compared with that in 2016.

Foreign Trade

Net imports (imports minus exports) of rare-earth metals and compounds totaled 9,060 t of REO equivalent, a 14% decrease compared with those of 2016 (table 1).

Total exports of rare-earth compounds and metals were 2,780 t of REO equivalent, a 70% increase compared with those in 2016. Exports of rare-earth compounds were about 1,740 t of REO equivalent with cerium compounds (66%) as the leading export category for compounds. Exports of rare-earth metals under HTS code 2805.30, including unalloyed and alloyed metals but excluding ferrocerium, were 55 t of REO equivalent and decreased by 46% compared with those of 2016. The leading export destinations of rare-earth metals (excluding ferrocerium) were Australia, China, and the United Kingdom. Exports of ferrocerium and other pyrophoric alloys under HTS code 3606.90 increased by 4% compared with those of 2016 (tables 4, 5).

U.S. imports totaled 11,800 t of REO equivalent, a 3% decrease compared with those of 2016. About 93% of REO equivalent imports were in the compound form, and 7% were metals (tables 6, 7). China continued to dominate most import HTS categories, and most of the rare-earth metals and compounds imported from other countries had been derived from China's mineral feedstocks. Cerium compounds and lanthanum compounds were the leading categories for specific rare earths, but most imports were in unspecified HTS categories. Scandium and yttrium compounds were estimated to be less than 1% of total REO equivalent imports.

Imports of rare-earth metals under HTS code 2805.30, including unalloyed and alloyed metals but excluding ferrocerium, were 524 t of REO equivalent, whereas imports of ferrocerium and pyrophoric alloys under HTS code 3606.90.30 were 348 t on a gross weight basis. Imports of unalloyed metals were 210 t and were primarily cerium or lanthanum. Imports of other rare-earth alloys were 273 t of total REO equivalent.

World Review

Australia.—Arafura Resources Ltd. continued feasibility work on its Nolan's Bore project in the Northern Territory with the goal of producing rare-earth, phosphate, and uranium products. In 2017, Arafura conducted multiple pilot studies of its beneficiation, phosphate extraction, and preleach units, and additional pilot studies of extraction and separation were planned for 2018. Measured resources at Nolan's Bore were 4.9 Mt containing 3.2% (160,000 t) REO, and indicated resources were 30 Mt containing 2.7% (810,000 t) REO, using a 1%-REO cutoff grade. Arafura planned to produce 14,000 t/yr of REO equivalent (Sherrington, 2017, p. 14, 15, 16, 22).

Alkane Resources Ltd. continued to develop its polymetallic Dubbo Zirconia project in New South Wales with planned production of hafnium, niobium, rare-earth, tantalum, and zirconium products. In 2017, Alkane continued feasibility studies and refined its plant design. Subject to financing, the project was expected to produce about 25,000 t/yr of various products, including about 6,660 t/yr of REO equivalent content. Proven reserves were updated in 2017 to include 18.9 Mt of polymetallic ore containing 0.87% (164,000 t) REO (including yttrium oxide), based on a resource block modeled value (Alkane Resources Ltd., 2017, p. 5; 2018, p. 5).

Australian Mines Ltd. acquired the remaining interest in the Sconi cobalt-nickel-scandium project in northern Queensland from Metallic Minerals Ltd. At yearend, Australian Mines was preparing to commission a pilot plant in support of a bankable feasibility study scheduled to be completed in 2018. The pilot plant was expected to demonstrate production of cobalt sulfate, nickel sulfate, and scandium oxide. Australian Mines also acquired the Flemington cobalt-scandium-nickel project that was in a prefeasibility stage of development and adjoined the Clean TeQ Holdings Ltd. Sunrise project (Australian Mines Ltd., 2018, p. 1).

Clean TeQ Holdings reported an increase in the resource estimate for its Syerston scandium project in New South Wales. Using a cutoff grade of 300 parts per million (ppm) scandium, the measured and indicated resources of the Syerston project were reported to be 12.3 Mt, containing about 7,900 t of scandium oxide equivalent. In 2017, a definitive feasibility study was in progress, based on a production capacity of 80 t/yr. At yearend, the company renamed the Syerston project Clean TeQ Sunrise (Clean TeQ Holdings Ltd., 2017a; 2017b, p. 9).

Hastings Technology Metals Ltd. updated its reserve and resource estimate for the Yangibana project in Western Australia. Reserves were 5.16 Mt containing 1.12% (57,800 t) REO equivalent, measured resources were 3.9 Mt containing 1.19% (46,400 t) REO equivalent, and indicated resources were 8.6 Mt containing 1.25% (110,000 t) REO equivalent. A definitive feasibility study released in 2017 was based on a production capacity of 15,000 t/yr of mixed rare-earth chloride (Hastings Technology Metals Ltd., 2018, p. 3–7).

Lynas Corp. Ltd. continued to operate its Mt Weld mining operations in Western Australia to support its processing operations in Malaysia. In December, Lynas began a second campaign to mine 590,000 t of ore containing about 15% REO equivalent. Ore was expected to be stockpiled prior to processing. A drilling program was underway to enable the update of reserves and resources in 2018 (Lynas Corp. Ltd., 2018, p. 7, 30).

Northern Minerals Ltd. pursued the development the Browns Range project in Western Australia and the Northern Territory. In 2017, the company commenced construction of a 10% of full-scale pilot plant and began a mining campaign to support production of about 600 t of REO equivalent over a 3-year trial. Production of mixed rare-earth carbonate was scheduled to begin in 2018. Indicated resources for the Browns Range project were estimated to be 4.69 Mt containing about 0.7% (32,900 t) REO, using a cutoff grade of 0.15% REO. Probable reserves were 3.75 Mt containing about 0.7% (26,400 t) REO (Northern Minerals Ltd., 2015, p. 1, 2; 2018, p. 3).

Platina Resources Ltd. continued feasibility studies for its Owendale polymetallic (scandium-cobalt) project in New South Wales. In August, Platina Resources announced that proven and probable reserve were 3.99 Mt containing 550 ppm (3,360 t) scandium using a 400-ppm scandium cutoff. Using a cutoff of 300 ppm scandium, measured resources were 6.9 Mt containing 440 ppm (3,040 t) scandium. In December, the company announced that plans for the initial plant size had been reduced to 20 t/yr from 42 t/yr of scandium oxide equivalent (Platina Resources Ltd., 2017a, p. 3; 2017b, p. 1; 2017c).

Scandium International Mining Corp. (Sparks, NV) scheduled production from its Nyngan scandium project in New South Wales to begin in 2020. In an offtake agreement with Alcereco Inc. (Kingston, Ontario, Canada), the company agreed to provide 225 t of aluminum-scandium master alloy over a 3-year period. Using a 100-ppm-scandium cutoff grade, measured and indicated resources were 16.9 Mt containing 235 ppm (3,980 t) scandium. Proven and probable reserves were estimated to be 1.44 Mt containing 409 ppm (589 t) scandium (Scandium International Mining Corp., 2016, p. 1.5–1.6; 2017).

Brazil.—Brazil exported an estimated 2,900 t of REE-bearing monazite concentrate to China in 2017, a decrease from 3,730 t exported in 2016 (Global Trade Information Services Inc., 2018). Although no production data were available for 2017, according to the Departamento Nacional de Produção Mineral (DNPM), Brazil's prior exports were derived from Indústrias Nucleares do Brasil (INB) inventories in Sao Francisco do Itabapoana (Andrade, 2018, p. 100, 101).

Burundi.—In December, Rainbow Rare Earths Ltd. was commissioning mining and production facilities for rare-earth mineral concentrates at its Gakara project in Bujumbura Rural Province. The concentration plant, near Lake Tanganyika, was about 20 kilometers from the mine. In December, the company produced 75 t of concentrates containing 62% REO equivalent. Production capacity was scheduled to increase to 5,000 t/yr by the end of 2018 (Rainbow Rare Earths Ltd., 2018).

Canada.—Commerce Resources continued prefeasibility work on its Ashram project in northern Quebec. In 2017, activities included a sampling program and an agreement with Ucore for a trial separation of carbonate produced from the Ashram deposit using Ucore's molecular recognition technology. Ashram's measured and indicated resources were estimated to be 29.3 Mt containing 1.9% (557,000 t) REO, using a 1.25%-REO cutoff grade. The project was based on a proposed production of 16,900 t/yr of REO primarily derived from monazite and to a lesser degree bastnäsite and xenotime using conventional processing methods (Commerce Resources Corp., 2018, p. 2–4).

In September, Matamec Explorations Inc. announced that, excluding research programs underway with universities or governmental agencies, it would stop all development activities at its Kipawa project in Quebec. Proven and probable reserves were previously estimated to be 20 Mt containing 0.41% (81,000 t) REO using a cutoff value of $48.96 per ton of ore (Matamec Explorations Inc., 2013, p. 7; 2018, p. 5).

Medallion Resources Ltd. continued plans to develop a processing facility to produce mixed rare-earth compounds from monazite. Medallion's proposed facility would purchase monazite byproduct from heavy-mineral-sand operations and produce rare-earth compounds. In 2017, the company continued its process development and, through a collaboration with Rare Earth Salts LLC, planned to begin producing in 2019 (Medallion Resources Ltd., 2017).

Search Minerals Inc. (North Vancouver, British Columbia) was conducting hydrometallurgical pilot-plant trials on ore from its Foxtrot project in southeastern Labrador. According to the company, most of the rare-earth mineralization occurred in allanite (a silicate mineral) and fergusonite (an oxide mineral). The company's project plan was based on a combined open pit and underground mining approach followed by processing to produce a mixed rare-earth concentrate. Indicated resources were 7.4 Mt containing 1.09% (81,000 t) REO equivalent. Production of a mixed rare-earth compound was projected to average 3,300 t/yr of REO equivalent (Search Minerals Inc., 2016, p. 14–1; 2017).

China.—China dominated the global production of rare-earth minerals, separated compounds, and metals. Based on China's production quota, China accounted for about 80% of global mine production in 2017; however, undocumented illegal production in China continued despite Government efforts (Asian Metal Inc., 2017c).

China's Ministry of Land and Resources production quotas for rare-earth mine production were unchanged compared with 2016 at 105,000 t of REO equivalent, of which 87,100 t was for light rare earths and 17,900 t was for medium and heavy rare earths. The production quotas for smelting and separation were 100,000 t, 95% of the mine production quotas. Nearly all mine, smelting, and separation quotas were allocated to the state-owned enterprises (Asian Metal Inc., 2017a, b).

China's imports of rare-earth compounds under the Harmonized System (HS) code 2846 were about 34,300 t (gross weight) in 2017 compared with 16,500 t in 2016. Increased imports from Burma were primarily responsible for the significant increase. China's imports of rare-earth metals under HS code 2805.30 were 81 t, and Vietnam was the leading source. Imports of thorium ores and concentrates (HS code 2612.20) containing REEs were 6,000 t, primarily from Brazil and Thailand (Global Trade Information Services Inc., 2018).

China's exports of rare-earth compounds (HS code 2846) were 45,700 t (gross weight) compared with 42,100 t in 2016. The top five destinations were, in descending order, the United States (31%), Japan (27%), the Republic of Korea (11%), the Netherlands (9%), and Germany (6%). China's exports of rare-earth metals under HS 2805.30 were 5,510 t (Global Trade Information Services Inc., 2018).

Greenland (Denmark).—Greenland Minerals and Energy Ltd. (GMEL) continued work on its polymetallic (REE-uranium-zinc) Kvanefjeld project in southern Greenland. In 2017, the company worked to improve its process design and address recommendations from the government of Greenland regarding environmental and social impact assessments. The Kvanefjeld project's proven and probable reserves were 108 Mt containing 1.43% REO (1.54 Mt) using a uranium oxide cutoff grade of 150 ppm. Measured and indicated resources were reported to be 451 Mt containing about 1.14% REO (5.14 Mt) (Greenland Minerals and Energy Ltd., 2017a, p. 3, 4; 2017b, p. 5, 6).

India.—India's producers of rare-earth-bearing heavy-mineral concentrates included Indian Rare Earths Ltd. (IREL) and Kerala Metals & Minerals Ltd. India's monazite production capacity was reported by the Indian Bureau of Mines to be 6,240 t/yr. In Odisha, IREL was commissioning a processing plant that used monazite to produce up to 11,000 t/yr of mixed rare-earth chlorides. In April, the processing plant was operating at about 25% to 30% of capacity. India imported rare-earth compounds (2,410 t) and rare-earth metals (486 t) (Indian Rare Earths Ltd., 2017, p. 2; Indian Bureau of Mines, 2018, p. 24–3).

Saraf Titanium Industry continued development of a project to process heavy-mineral concentrates to produce ferroalloys, titanium slag, titanium pigment, and rare-earth compounds in Chatrapur, Odisha. The project included plans to recover 2.4 t/yr of scandium oxide from the acid-waste stream of a titanium pigment operation containing about 228 ppm scandium oxide. By yearend, Saraf had completed construction of the titanium slag and titanium pigment plants and expected to begin production of scandium oxide after receiving environmental approvals (Saraf Agencies Pvt. Ltd., 2018, p. 25–27).

Japan.—Japan's Society of Newer Metals estimated the 2017 consumption of rare earths in Japan to be 18,100 t, an 8% increase compared with 16,806 t in 2016. Consumption included cerium (6,450 t), neodymium and praseodymium (4,400 t), mixed rare-earth metals (3,350 t), lanthanum (2,090 t), yttrium (900 t), other rare-earth compounds (830 t), samarium (80 t), and europium (12 t) (Japan Society of Newer Metals, 2018).

Kazakhstan.—In March, Kazakhstan's National Atomic Co. Kazatomprom JSC acquired the remaining 49% interest in Summit Atom Rare Earth Co. LLP (SARECO) from its joint venture with Japan's Sumitomo Metal Mining Co., Ltd. The SARECO operations in Stepnogorsk were reported to have a capacity of 1,500 t/yr of REO equivalent, although no production from the operation was reported in 2017. SARECO's REO was a byproduct of uranium mining and processing (National Atomic Co. Kazatomprom JSC, 2017, p. 76; 2018, p. 66).

Malaysia.—Lynas continued to increase production of rare-earth compounds at its Lynas Advanced Material Plant (LAMP) near the Port of Kuantan in the State of Pahang. Production of REO from the LAMP operations in 2017 was about 17,300 t, a 24% increase compared with production in 2016 (Lynas Corp. Ltd., 2019, p. 7).

Philippines.—In October, Japan's Sumitomo Metal Mining Co., Ltd. (SMM) completed construction and began commissioning a commercial-scale plant to produce a scandium intermediate product at its subsidiary Taganito HPAL Nickel Corp. on Palawan Island. The plant was expected to recover up to 7.5 t/yr of scandium oxide equivalent from a process stream following the leaching of nickel laterite for nickel-cobalt sulfide. Processing of the intermediate product into scandium oxide was performed at SMM's Harima operation in Japan (Sumitomo Metal Mining Co., Ltd., 2018, p. 15, 26).

Russia.—Imports of rare-earth compounds (HS 2846) into Russia were about 683 t in 2017, and exports were 5,910 t. Rare-earth-metal (HS 2805.30) imports and exports were 103 t and 2 t, respectively. China was Russia's leading import source, and Estonia was the leading export destination of rare-earth compounds (Global Trade Information Services Inc., 2018).

PJSC Acron commissioned a pilot plant to produce REO equivalent in the form of mixed and separated rare-earth compounds at its Veliky Novgorod facility. The feed for the operation was a byproduct apatite mineral concentrate sourced from the company's Oleniy Ruchey phosphate mine in the Murmansk Region. In 2017, Acron produced 94 t of REO equivalent (PJSC Acron, 2018, p. 44–45).

JSC Dalur began the recovery of up to 1.5 t/yr of scandium oxide equivalent at the Dalmatovskoye in situ uranium mining and processing operation in the Kurgan Region. The company was planning to commission a pilot plant to produce aluminum-scandium master alloys in 2018 (JSC Atomredmetzoloto, 2018, p. 56).

In 2017, JSC Solikamsk Magnesium Works (SMW) in Perm Krai reported consumption of about 8,930 t of loparite concentrates (containing 28% to 30% REO) sourced from the Lovozero GOK mining operations near Revda in the Murmansk Region. Loparite concentrate consumption increased slightly compared with that in 2016, continuing a positive trend that began in 2010. SMW reported that shipments of rare-earth compounds decreased to about 2,500 t of REO equivalent in 2017, an 18% decrease compared with its shipments in 2016. SMW was capable of processing up to 13,000 t/yr of loparite concentrate and producing compounds with up to 3,600 t/yr of REO equivalent (JSC Solikamsk Magnesium Works, 2018, p. 5–15).

United Company RUSAL Plc, one of the world's leading aluminum producers, was conducting pilot-plant studies in the Ural Mountains to recover scandium concentrate from red mud. RUSAL was reported to have produced scandium oxide with greater than 99% purity in 2017 and planned to complete a feasibility study in 2018 (United Company RUSAL Plc, 2018).

South Africa.—Steenkampskraal Holdings Ltd. continued work to reopen the Steenkampskraal (SKK) monazite mine that was active from 1952 to 1963. In 2017, the company was downsizing its mining and processing design plans, based on production of 2,700 t/yr of REO equivalent, and planned production of cerium and cerium-depleted mixed carbonates. Using a 1%-REO cutoff grade, SKK's measured and indicated resources were 605,000 t and contained about 14.4% (86,900 t) of REO equivalent (Steenkampskraal Holdings Ltd., 2018, p. iii).

Sweden.—Leading Edge Materials Corp. pursued reinstatement of its exploration license and mining lease for the Norra Karr project in southern Sweden (Leading Edge Materials Corp., 2018). Probable reserves were previously reported to be about 23.6 Mt containing 0.592% (140,000 t) REO. Using a 0.4%-REO cutoff grade, indicated resources were 31.1 Mt containing 0.61% (190,000 t) REO. Nearly all of the REE mineralization was eudialyte. A prefeasibility study was based on a production of about 5,000 t/yr of mixed REO and a 20-year mine life, using the 0.4%-REO cutoff grade (Tasman Metals Ltd., 2015, p. 42–43, 45; Leading Edge Materials Corp., 2018, p. 6–7).

Tanzania.—Peak Resources Ltd. continued the development of its Ngualla project with plans for mining operations in southwest Tanzania and processing operations in Tees Valley, United Kingdom. In 2017, a mining license was under review, and environmental approval was granted by Government regulators for the mine and mineral processing operations. The Ngualla operations in Tanzania were expected to produce 32,700 t/yr of mineral concentrate containing 45% REO. The Ngualla reserves were 18.5 Mt containing 4.80% (887,000 t) of REO equivalent using a 1% cutoff grade (Peak Resources Ltd., 2017, p. 5, 7, 11).

Outlook

Globally, the annual average growth rate of REE consumption is expected to range from 5% to 7% through 2022. In descending order, the leading end uses of rare earths are expected to be magnets, catalysts, and polishing compounds. The magnet materials sector is expected to have higher average growth, and the catalysts, ceramics, and phosphors sectors are expected to have lower average growth. As the leading producer and consumer of rare-earth minerals and most downstream products, China is expected to continue to dominate the global markets for rare-earth compounds and metal alloys.

Beyond 2022, increased global demand, tighter enforcement of environmental compliance, and reductions in illegal mining in China are expected to result in higher prices for some REE materials. This scenario may accelerate the development of mining and processing projects outside China.

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TABLE 1
SALIENT U.S. RARE EARTH STATISTICS[1]

		2013	2014	2015	2016	2017
Production of rare-earth concentrates, rare-earth-oxide (REO) basis[e, 2, 3]	metric tons	5,500	5,400	5,900	--	--
Exports, REO basis:[e]						
Compounds:						
Cerium compounds	do.	734	608	440	309	1,140
Other rare-earth compounds	do.	5,570	3,780	4,540	281 [r]	598
Metals:						
Ferrocerium and pyrophoric alloys	do.	1,420	1,640	1,220	943	982
Rare-earth metals, scandium, yttrium	do.	1,050	140	60	103	55
Imports for consumption, REO basis:[e]						
Compounds:						
Cerium compounds	do.	1,110	2,990	1,440	1,830	2,390
Other rare-earth compounds	do.	7,330	9,260	7,720	9,650	8,610
Metals:						
Ferrocerium and pyrophoric alloys	do.	313	371	356	268 [r]	309
Rare-earth metals, scandium, yttrium	do.	393	348	385	404	524
World production, REO basis	do.	107,000	124,000 [r]	129,000 [r]	129,000	132,000
Prices, yearend:						
Monazite concentrate, gross weight basis[e]	dollars per kilogram	2.00	3.50	2.56 [r]	2.57 [r]	2.70
Mischmetal, 65% cerium, 35% lanthanum, metal basis[4]	do.	9.00–10.00	9.00–10.00	5.20–6.00	4.65–5.60	5.90–6.15

[e]Estimated. [r]Revised. do. Ditto. -- Zero.

[1]Table includes data available through August 1, 2019. Data are rounded to no more than three significant digits.

[2]Includes only the rare earths derived from bastnäsite.

[3]Sources: Molycorp, Inc., 2015a, Form 10–K—2014: Greenwood Village, CO, Molycorp, Inc., 148 p.; Molycorp, Inc., 2015b, Form 10–Q—For the quarterly period ending June 30, 2015: U.S. Securities and Exchange Commission, 71 p.

[4]Source: Metal-Pages Ltd., Kingston, United Kingdom.

TABLE 2

RARE EARTH CONTENTS OF SELECTED SOURCE MINERALS[1, 2]

(Percentage of total rare-earth oxide)

			Rare earth element symbol														
Primary source	Country	Location	La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Y
Bastnäsite	China	Bayan Obo, Nei Mongol Autonomous Region[3]	23.00	50.00	6.20	18.50	0.80	0.20	0.70	0.10	0.10	NA	NA	NA	NA	NA	NA
Do.	do.	Dechang, Sichuan Province[4]	35.60	43.80	4.73	13.10	1.22	0.23	0.52	0.06	0.09	0.05	0.04	0.01	0.06	NA	0.40
Do.	do.	Maoniuping, Sichuan Province[4]	29.50	47.60	4.42	15.20	1.24	0.23	0.65	0.12	0.21	0.05	0.06	0.04	0.05	0.01	0.70
Do.	do.	Weishan, Shandong Province[4]	35.50	47.80	3.95	10.90	0.79	0.13	0.53	0.14	NA	NA	NA	NA	0.03	NA	0.76
Do.	United States	Mountain Pass, CA[5]	34.00	48.80	4.20	11.70	0.79	0.13	0.21	NA	NA	NA	NA	NA	NA	NA	0.12
Loparite	Russia	Revda, Murmansk Oblast[6]	25.00	50.50	5.00	15.00	0.70	0.09	0.60	NA	0.60	0.70	0.80	0.10	0.20	0.15	1.30
Monazite	Australia	Mount Weld Central Lanthanide, Western Australia[7]	23.90	47.60	5.16	18.10	2.44	0.53	1.09	0.09	0.25	0.03	0.06	0.01	0.03	NA	0.76
Do.	China	Nangang, Guangdong Province[4]	23.00	42.70	4.10	17.00	3.00	0.10	2.00	0.70	0.80	0.12	0.30	NA	2.40	0.14	2.40
Do.	India	Manavalakurichi, Tamil Nadu[8]	22.00	46.00	5.50	20.00	2.50	0.02	1.20	0.06	0.18	0.02	0.01	0.00	0.00	0.00	0.45
Rare-earth laterite	China	Xunwu, Jiangxi Province[4]	38.00	3.50	7.41	30.20	5.32	0.51	4.21	0.46	1.77	0.27	0.88	0.13	0.62	0.13	10.10
Do.	do.	Xinfeng, Jiangxi Province[4]	27.30	3.23	5.62	17.60	4.54	0.93	5.96	0.68	3.71	0.74	2.48	0.27	1.13	0.21	24.30
Do.	do.	Longnan, Jiangxi Province[4]	2.18	<1.09	1.08	3.47	2.34	<0.37	5.69	1.13	7.48	1.60	4.26	0.60	3.34	0.47	64.90
Xenotime	do.	Southeast Guangdong Province[9]	1.20	3.00	0.60	3.50	2.20	0.20	5.00	1.20	9.10	2.60	5.60	1.30	6.00	1.80	59.30

Do., do. Ditto. NA Not available.

[1]Table includes data available through August 1, 2019. Data are rounded to no more than three significant digits; rows may not add to 100 percent.

[2]Rare earths are listed in order of atomic number except for yttrium, which is listed after the last of the heavy rare earth lanthanide elements.

[3]Zang, Z.B., Lu, K.Y., King, K.C., Wei, W.C., and Wang, W.C., 1982, Rare-earth industry in China: Hydrometallurgy, v. 9, no. 2, p. 205–210.

[4]Zhi Li, L. and Yang, X., 2014, China's rare earth ore deposits and beneficiation techniques: ERES 2014—1st European Rare Earth Resources Conference, Milos, Greece, April 4–7, 11 p.

[5]Molycorp, Inc., 2015, Form 10–K—2014: Greenwood Village, CO, Molycorp, Inc., 145 p. (Accessed June 30, 2016, at http://www.molycorp.com/investors.)

[6]Hedrick, J.B., Sinha, S.P., and Kosynkin, V.D., 1997, Loparite, a rare-earth ore: Journal of Alloys and Compounds, v. 250, p. 467–470.

[7]Lynas Corp. Ltd., 2012, Increase in Mt Weld resource estimate for the Central Lanthanide deposit and Duncan deposit: Sydney, New South Wales, Australia, Lynas Corp. Ltd. news release, January 18, 5 p.

[8]Patra, R.N., 2014, Latest scenario in rare earth and atomic minerals in India: PDAC Convention 2014, Toronto, Ontario, Canada, March 2–4, 42 p.

[9]Nakamura, Shigeo, 1988, China and rare metals—Rare earth: Industrial Rare Metals, no. 94, May, p. 23–28.

TABLE 3

RARE-EARTH OXIDE PRICES[1]

(Dollars per kilogram)

Product (oxide)	Purity (percent)	2016	2017
Scandium[2]	99.990	4,600	4,600
Yttrium[3]	99.999	4	3
Lanthanum[3]	99.500	2	2
Cerium[3]	99.500	2	2
Praseodymium[3]	99.500	52	65
Neodymium[3]	99.500	40	50
Samarium[3]	99.500	2	2
Europium[3]	99.990	74	77
Gadolinium[3]	99.999	20	37
Terbium[3]	99.990	415	501
Dysprosium[3]	99.500	198 [r]	189

[r]Revised.

[1]Products are listed in order of atomic number.

[2]Source: Stanford Metals Corp.

[3]Source: Argus Media group – Argus Metals International.

TABLE 4

U.S. EXPORTS OF RARE-EARTH COMPOUNDS, BY COUNTRY OR LOCALITY[1]

Category and country or locality	HTS[2] code	2016 Gross weight (kilograms)	2016 Value	2017 Gross weight (kilograms)	2017 Value
Cerium compounds:	2846.10.0000				
China		17,300	$563,000	1,410,000	$2,950,000
Japan		33,800	445,000	48,600	361,000
Netherlands		211,000	305,000	24,700	53,700
Taiwan		67,400	370,000	83,100	429,000
Other		132,000 r	3,160,000 r	137,000	4,220,000
Total		461,000	4,840,000	1,710,000	8,010,000
Total estimated equivalent rare-earth-oxide (REO) content		309,000	XX	1,140,000	XX
Other rare-earth compounds:					
Oxides:					
Scandium or yttrium oxides:	2846.90.2015				
France		40	28,500	399	3,470
Germany		1,160	334,000	1,150	371,000
Netherlands		--	--	200	8,860
South Africa		686	12,500	--	--
Other		171 r	78,300 r	76	23,700
Total		2,060	453,000	1,820	407,000
Total estimated equivalent REO content		2,060	XX	1,820	XX
Other oxides:	2846.90.2040				
Argentina		--	--	8,780	54,000
China		19,300	773,000	2	7,240
Finland		--	--	3,780	20,600
India		19,500	42,800	13,800	50,100
Switzerland		1,450	908,000	2,740	1,710,000
Thailand		36,900	1,460,000	--	--
Other		3,890	2,090,000	3,950	741,000
Total		80,900	5,280,000	33,100	2,580,000
Total estimated equivalent REO content		80,900	XX	33,100	XX
Chlorides:	2846.90.2060				
Australia		--	--	9,740	47,500
China		4,210	29,300	5,230	41,900
Colombia		--	--	13,500	28,600
Mexico		12,100	1,210,000	90,300	177,000
Other		6,820	104,000	1,790	762,000
Total		23,100	1,350,000	121,000	1,060,000
Total estimated equivalent REO content		10,600	XX	55,500	XX
Unspecified rare-earth compounds:	2846.90.9000				
Canada		22,000	1,270,000	44,700	930,000
China		43,700	173,000	541,000	1,640,000
Italy		59,300	822,000	19,100	261,000
Japan		1,970	109,000	35,200	615,000
Korea, South		36,300	566,000	26,000	734,000
Mexico		19,800	259,000	53,500	1,530,000
Russia		23,500	414,000	56,000	1,060,000
South Africa		30,700	112,000	29,400	103,000
Other		103,000	1,470,000	112,000	1,640,000
Total		341,000	5,200,000	917,000	8,510,000
Total estimated equivalent REO content		187,000	XX	508,000	XX
Grand total		908,000	17,100,000	2,780,000	20,600,000
Grand total estimated equivalent REO content		590,000	XX	1,740,000	XX

[r]Revised. XX Not applicable. -- Zero.

[1]Table includes data available through August 1, 2019. Data are rounded to no more than three significant digits; may not add to totals shown.

[2]Harmonized Tariff Schedule of the United States.

Source: U.S. Census Bureau.

TABLE 5

U.S. EXPORTS OF RARE-EARTH METALS AND ALLOYS, BY COUNTRY OR LOCALITY[1]

		2016		2017	
		Gross weight		Gross weight	
Category and country or locality	HTS[2] code	(kilograms)	Value	(kilograms)	Value
Ferrocerium and other pyrophoric alloys:	3606.90.0000				
Aruba		10,900	$40,500	18,100	$51,700
Australia		22,100	296,000	107	6,120
Barbados		46,700	126,000	41,700	92,000
Canada		326,000	1,110,000	382,000	1,170,000
China		33,100	983,000	98,300	2,970,000
Costa Rica		11,200	74,400	109,000	240,000
Dominican Republic		194,000	277,000	47,800	96,400
Haiti		9,530	13,400	17,100	25,500
Honduras		1,370	5,640	44,000	47,500
Jamaica		48,300	307,000	13,400	34,100
Japan		16,200	605,000	8,600	308,000
Mexico		72,900	632,000	50,900	205,000
Panama		56,100	84,900	5,520	71,100
Trinidad and Tobago		48,000	65,800	40,500	78,300
United Kingdom		73,600	908,000	111,000	528,000
Other		92,400 r	2,740,000 r	118,000	2,500,000
Total		1,060,000	8,270,000	1,110,000	8,430,000
Total estimated equivalent rare-earth-oxide (REO) content		943,000	XX	982,000	XX
Rare-earth metals and alloys:	2805.30.0000				
Australia		6,810	47,700	6,340	56,000
Brazil		1,090	5,870	4,540	49,100
China		38,900	790,000	7,930	323,000
Germany		3,700	141,000	1,120	66,700
Hungary		1,510	135,000	1,390	89,900
India		12,000	517,000	2,940	119,000
Japan		1,570	128,000	1,310	81,200
Mexico		3,860	308,000	3,880	234,000
Saudi Arabia		--	--	4,060	85,700
United Kingdom		5,030	252,000	6,620	333,000
Other		6,510 r	791,000 r	3,480	565,000
Total		81,000	3,120,000	43,600	2,000,000
Total estimated equivalent REO content		103,000	XX	55,400	XX

[r]Revised. XX Not applicable. -- Zero.

[1]Table includes data available through August 1, 2019. Data are rounded to no more than three significant digits; may not add to totals shown.

[2]Harmonized Tariff Schedule of the United States.

Source: U.S. Census Bureau.

TABLE 6

U.S. IMPORTS FOR CONSUMPTION OF RARE-EARTH COMPOUNDS, BY COUNTRY OR LOCALITY[1]

		2016		2017	
Category and country or locality	HTS[2] code	Gross weight (kilograms)	Value	Gross weight (kilograms)	Value
Compounds:					
Cerium oxides:	2846.10.0010				
China		801,000	$1,770,000	324,000	$1,690,000
Japan		332,000	13,100,000	313,000	13,900,000
Other		18,700	723,000	41,900	975,000
Total		1,150,000	15,600,000	679,000	16,600,000
Total estimated equivalent rare-earth-oxide (REO) content		1,150,000	XX	679,000	XX
Cerium compounds, other than cerium oxide:	2846.10.0050				
China		424,000	3,600,000	1,870,000	7,190,000
Estonia		525,000	888,000	467,000	696,000
Other		68,800	1,540,000	227,000	1,460,000
Total		1,020,000	6,030,000	2,560,000	9,350,000
Total estimated equivalent REO content		681,000	XX	1,710,000	XX
Other rare-earth compounds:					
Carbonates:					
Lanthanum carbonates mixtures:	2846.90.8070				
China		2,330,000	4,290,000	657,000	2,270,000
Other		14	38,000	--	--
Total		2,330,000	4,330,000	657,000	2,270,000
Total estimated equivalent REO content		1,600,000	XX	450,000	XX
Other rare-earth carbonates mixtures:	2846.90.8075				
China		3,450	172,000	5,830	309,000
Germany		4	21,400	39	7,500
Total		3,450	193,000	5,870	316,000
Total estimated equivalent REO content		1,900	XX	3,230	XX
Chlorides:					
Scandium or yttrium chloride mixtures:	2846.90.2082				
Korea, Republic of		109	26,000	--	--
Japan		--	--	50	21,800
Russia		1	5,260	--	--
Total		110	31,300	50	21,800
Total estimated equivalent REO content		41	XX	19	XX
Unspecified mixtures of oxides or chlorides:	2846.90.2084				
China		345,000	946,000	402,000	1,350,000
Estonia		80,000	140,000	40,000	81,000
Other		41,300 r	1,360,000 r	47,200	1,210,000
Total		466,000	2,450,000	489,000	2,640,000
Total estimated equivalent REO content		256,000	XX	269,000	XX
Oxides:					
Lanthanum oxides:	2846.90.2005				
China		3,320,000	7,370,000	2,160,000	5,400,000
Other		11,300	56,200	53,000	277,000
Total		3,330,000	7,430,000	2,220,000	5,680,000
Total estimated equivalent REO content		3,330,000	XX	2,220,000	XX
Scandium or yttrium oxides:	2846.90.2015				
China		4,000	221,000	39,000	719,000
Korea, Republic of		3,660	333,000	2,310	467,000
Other		1,690	105,000	2,590	558,000
Total		9,340	659,000	43,900	1,740,000
Total estimated equivalent REO content		9,340	XX	43,900	XX
Other oxides:	2846.90.2040				
China		70,700	2,860,000	33,000	1,550,000
Russia		7	18,200	5,280	105,000
Other		8,980 r	547,000 r	1,690	88,800
Total		79,700	3,420,000	39,900	1,740,000
Total estimated equivalent REO content		79,700	XX	39,900	XX

See footnotes at end of table.

TABLE 6—Continued

U.S. IMPORTS FOR CONSUMPTION OF RARE-EARTH COMPOUNDS, BY COUNTRY OR LOCALITY[1]

Category and country or locality	HTS[2] code	2016 Gross weight (kilograms)	2016 Value	2017 Gross weight (kilograms)	2017 Value
Compounds:—Continued					
Other rare-earth compounds or mixtures:					
Unspecified compounds or mixtures:	2846.90.8090				
China		6,010,000	$31,800,000	8,650,000	$50,400,000
Estonia		341,000	717,000	560,000	2,120,000
France		644,000	14,500,000	357,000	12,400,000
Other		841,000 r	17,900,000 r	504,000	19,900,000
Total		7,830,000	64,900,000	10,100,000	84,700,000
Total estimated equivalent REO content		4,310,000	XX	5,540,000	XX
Yttrium materials and compounds content by weight greater than 19% but less than 85% oxide equivalent:	2846.90.4000				
China		114,000	2,900,000	68,100	1,080,000
Other		4,140	1,720,000	791	1,340,000
Total		118,000	4,620,000	68,900	2,420,000
Total estimated equivalent REO content		71,000	XX	41,300	XX

[r]Revised. XX Not applicable. -- Zero.

[1]Table includes data available through August 1, 2019. Data are rounded to no more than three significant digits; may not add to totals shown.

[2]Harmonized Tariff Schedule of the United States.

Source: U.S. Census Bureau.

TABLE 7

U.S. IMPORTS FOR CONSUMPTION OF RARE-EARTH METALS AND ALLOYS, BY COUNTRY OR LOCALITY[1]

		2016		2017	
Category and country or locality	HTS[2] code	Gross weight (kilograms)	Value	Gross weight (kilograms)	Value
Ferrocerium and other pyrophoric alloys:	3606.90.3000, 3606.90.3010, 3606.90.3090				
Austria		51,800	$525,000	41,400	$427,000
China		145,000	1,900,000	122,000	1,520,000
Spain		55,300	1,170,000	118,000	2,010,000
United Kingdom		--	--	52,400	271,000
Other		49,300 r	764,000 r	14,200	109,000
Total		302,000	4,360,000	348,000	4,340,000
Total estimated equivalent rare-earth-oxide (REO) content		268,000	XX	309,000	XX
Rare-earth metals and alloys:					
Cerium, unalloyed:	2805.30.0010				
China		64,700	370,000	65,900	482,000
Hong Kong		20,000	78,600	--	--
Other		301	17,800	2,810	99,900
Total		85,000	467,000	68,700	581,000
Total estimated equivalent REO content		104,000	XX	84,400	XX
Lanthanum, unalloyed:	2805.30.0005				
China		43,100	361,000	97,800	887,000
Other		352	35,000	1	3,860
Total		43,400	396,000	97,800	891,000
Total estimated equivalent REO content		50,900	XX	115,000	XX
Neodymium, unalloyed:	2805.30.0020				
China		4,060	147,000	1,820	61,600
Japan		601	97,400	81	13,000
United Kingdom		2,000	60,800	1,480	71,200
Other		500	21,000	--	--
Total		7,170	327,000	3,380	146,000
Total estimated equivalent REO content		8,360	XX	3,940	XX
Other rare-earth metals, unalloyed:	2805.30.0050				
China		37,500	865,000	36,300	1,430,000
Russia		5,910	472,000	3,500	280,000
Other		35 r	18,300 r	86	18,100
Total		43,400	1,360,000	39,900	1,720,000
Total estimated equivalent REO content		52,100	XX	47,900	XX
Other rare-earth metals, alloys:	2805.30.0090				
China		139,000	673,000	220,000	1,310,000
Other		17,600 r	640,000 r	7,350	679,000
Total		157,000	1,310,000	228,000	1,980,000
Total estimated equivalent REO content		188,000	XX	273,000	XX
Grand total		637,000	8,210,000	786,000	9,660,000
Grand total estimated equivalent REO content		672,000	XX	833,000	XX

[r]Revised. XX Not applicable. -- Zero.

[1]Table includes data available through August 1, 2019. Data are rounded to no more than three significant digits; may not add to totals shown.

[2]Harmonized Tariff Schedule of the United States.

TABLE 8

RARE EARTHS: WORLD MINE PRODUCTION, BY COUNTRY OR LOCALITY[1]

(Metric tons, rare-earth-oxide equivalent)

Country or locality[2]	2013	2014	2015	2016	2017
Australia[e]	3,000	8,000	12,000	15,000	19,000
Brazil	330	--	880 [e]	2,200 [e]	1,700 [e]
China[3]	93,800	105,000	105,000	105,000 [e]	105,000
India[e, 4]	1,700	1,700	1,700	1,500	1,800
Malaysia	180	240	310	1,100 [r]	180
Russia[e]	2,100 [r]	2,200 [r]	2,500 [r]	2,500 [r]	2,600
Thailand[5]	130	1,900	760	1,600 [e]	1,300 [e]
United States[e]	5,500	5,400	5,900	--	-- [6]
Vietnam[e, 7]	100	--	250	220	200
Total	107,000	124,000 [r]	129,000 [r]	129,000	132,000

[e]Estimated. [r]Revised. -- Zero.

[1]Table includes data available through September 13, 2018. All data are reported unless otherwise noted. Totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2]In addition to the countries and (or) localities listed, Indonesia, North Korea, Nigeria, and some Commonwealth of Independent States countries may have produced rare-earth minerals, but available information was inadequate to make reliable estimates of output.

[3]Official production quota. Illegal production could not be quantified.

[4]India's Department of Atomic Energy did not disclose monazite production data.

[5]Rare-earth-oxide content of exports.

[6]U.S. producers of heavy-mineral sands were reported to be producing and exporting mixed concentrates containing rare earths.

[7]Rare-earth-oxide content of exports.