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2013 Minerals Yearbook

RARE EARTHS [ADVANCE RELEASE]

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

February 2016

Rare Earths

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In 2013, world rare-earth mine production was 109,000 metric tons (t) of rare-earth oxide (REO) and was primarily from the minerals bastnäsite, loparite, monazite, and xenotime (tables 1, 6). Rare-earth ores were mined primarily in China, with smaller amounts mined, in descending order of tonnage, in the United States, India, Russia, Australia, Thailand, Brazil, Malaysia, and Vietnam (table 6). In the United States, mining and processing of rare-earth ores and concentrates took place at the Mountain Pass Mine in California, and production increased to 5,500 t. China continued to dominate the global production and consumption of rare-earth metals and compounds. Prices for most rare-earth products continued to decline following the price spike experienced in 2011 (table 3).

The rare earths are a moderately abundant group of 17 elements comprising the 15 lanthanides, scandium, and yttrium. The lanthanides are the elements with atomic numbers 57 through 71, in order of atomic number: lanthanum, cerium, praseodymium, neodymium, promethium, samarium, europium, gadolinium, terbium, dysprosium, holmium, erbium, thulium, ytterbium, and lutetium. At an average concentration in the Earth's crust of 60 parts per million (ppm), cerium is more abundant than copper at 50 ppm, followed by yttrium at 33 ppm, lanthanum at 30 ppm, and neodymium at 28 ppm. Thulium and lutetium, the least abundant of the lanthanides at 0.5 ppm, occur in the Earth's crust in higher concentrations than antimony, bismuth, cadmium, and thallium. 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).

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 (lanthanum) through atomic number 64 (gadolinium), and the HREEs include the lanthanide elements from atomic number 65 (terbium) through atomic number 71 (lutetium). 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. Yttrium is included as an HREE even though it is not part of the lanthanide series.

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. It is the 31st most abundant element in the Earth's crust, with an average crustal abundance of 22 ppm. 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. Its atomic radius places it in relative size between holmium and erbium.

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 °C for cerium to 1,663 °C for lutetium. The unique properties of rare earths make them useful in a wide variety of applications such as batteries, catalysts, magnets, and phosphors. The principal ore minerals of the rare earths are bastnäsite, loparite, monazite, xenotime, and the lateritic ion-adsorption clays (table 2).

Legislation and Government Programs

The U.S. Geological Survey (USGS) supported numerous projects related to rare earths though funding either wholly or in part by its Mineral Resources Program (MRP). MRP research and assessments provide information for land planners and decision makers about where resources of mineral commodities are known and suspected in the Earth's crust and the environmental issues associated with those commodities.

Scientists in the USGS Airborne Geophysics for Rare Earth Element Deposits (AGREED) project were coordinating with industry to use high-resolution airborne geophysical data collected over some of the advanced REE projects in the United States. The AGREED project objectives included plans to conduct a high-resolution magnetic and gravity survey of the Pea Ridge deposit in Missouri (U.S. Geological Survey, undated a).

In Alaska, a USGS research project was focused on understanding the mineralogy, genesis, and geochemistry of deposits at Bokan Mountain and the geology of the associated peralkaline intrusion. Some of the planned methodologies included fluid inclusions, microbeam mineralogical studies, uranium-lead geochronology, and whole-rock and laser ablation-mass spectrometry geochemistry (U.S. Geological Survey, undated b).

The USGS Eastern Mineral and Environmental Resources Science Center (EMERSC) was examining unconventional resources of REEs in residual deposits, including bauxites, clays, laterites, and weathered crusts and soils. The project was investigating the REE distribution in high-alumina alteration systems and the processes that led to their concentration in residual deposits that form in situ by weathering of igneous bedrock (U.S. Geological Survey, undated f).

In Missouri, EMERSC was investigating the geologic framework and origin of the iron-copper-cobalt-gold-rare-earth-element (IOCG-REE) deposits in southeast Missouri. The project was designed to delineate and characterize the subsurface Precambrian geology using ground and airborne geophysical data. One of the project's objectives was to create a database for new industry exploration in the region and future mineral resource assessments (U.S. Geological Survey, undated e).

The USGS Central Mineral and Environmental Resources Science Center studied the formation of sedimentary exhalative (sedex) deposits and sediment-hosted manganese, phosphate, iron, and phosphate-REE ore deposits. Sedex deposits are ore deposits believed to have been formed by the release of ore-bearing hydrothermal fluids into submarine sedimentary environments (U.S. Geological Survey, undated c).

The USGS Geology, Minerals, Energy, and Geophysics Science Center was investigating the geochemical and mineralogical distribution of REEs in magmatic-hydrothermal alteration systems in which quartz-alunite alteration is often associated with productive gold-silver-mercury mineralization. The research was focused on high-sulfidation gold-silver-mercury deposits that have previously been well documented for other elements but not REEs and may identify new resources of REEs (U.S. Geological Survey, undated d).

For the fiscal years 2013 and 2014, the U.S. Geological Survey's Mineral Resources External Research Program funded several initiatives to conduct research in topics related to nonfuel mineral resources. One initiative related to rare earths was an investigation by the University of Colorado, Boulder, of an unusual concentration of REEs in veins near Jamestown, CO. Understanding the geologic origin of these veins was expected to help assess where similar concentrations of REEs might occur (U.S. Geological Survey, 2014).

In its 2013 Strategic and Critical Materials Report on Stockpile Requirements, the U.S. Department of Defense assessed potential problems regarding strategic and critical nonfuel materials in the context of congressionally-mandated planning scenarios and recommended mitigation strategies for the problematic materials. Rare-earth materials that were identified as potential shortfall materials included dysprosium, erbium, scandium, terbium, thulium, yttrium, and one classified REO. Proposed mitigation strategies for resolving shortfalls included export reductions, stockpiling, substitution, and larger-than-normal domestic purchases from reliable countries during an emergency (U.S. Department of Defense, 2013, p. 5). In November, the National Defense Stockpile Market Impact Committee, co-chaired by the Departments of Commerce and State, was seeking public comments on a potential acquisition of dysprosium metal (0.5 t) and yttrium oxide (10 t) for the national stockpile (U.S. Department of Commerce, 2013).

September marked the official opening of the Critical Materials Institute (CMI), a U.S. Department of Energy (DOE) cooperative venture to spend up to $120 million over 5 years in support of research focused on ensuring a reliable supply of rare earths and other critical materials. Universities, national laboratories, nonprofit organizations, and private firms were eligible to submit proposals for research funding. The CMI was led by the Ames Laboratory which is operated for the DOE by Iowa State University (U.S. Department of Energy, 2013).

At yearend, World Trade Organization (WTO) consultations requested by the United States Trade Representative (USTR) regarding China's constraints on the export from China of various forms of rare earths, tungsten, and molybdenum were unresolved. The March 2012 request referred to 212 eight-digit Chinese Customs Commodity Codes and more than 30 measures. The USTR also cited a number of China's published and unpublished measures that imposed export restrictions. These restrictions included export duties, export quotas, minimum export price requirements, export licensing requirements, and additional requirements and procedures in connection with the administration of the quantitative restrictions. After the USTR action, the European Union, Canada, and Japan joined the request. In 2013, hearings before a WTO panel took place in February and June. A WTO decision was expected in 2014 (Office of the United States Trade Representative, 2013, p. 44).

Production

Molycorp, Inc. (Greenwood Village, CO) was the sole U.S. producer of rare-earth mineral concentrates from its mining and separation operations at Mountain Pass, CA. Market conditions and operational issues related to the startup of separation operations continued to hamper production output. Based on publicly reported data, mineral concentrate production was estimated to be 5,500 t (REO) compared with 3,000 t (REO) in 2012, when the company resumed mine production. In 2013, Molycorp reported a consolidated production of 3,473 t from the Mountain Pass facility that included unseparated LREE concentrates, HREE concentrates, separated REOs (lanthanum, cerium, and neodymium/praseodymium), and rare-earth-based water treatment products. At yearend, Molycorp's estimated proven and probable ore reserves were 18 million metric tons (Mt) with an average grade of 8.03% REO (Molycorp, Inc., 2014, p. 54).

Rare-earth compounds and chemical intermediates were imported by a number of companies 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 (Florham Park, NJ), Molycorp, 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 alloys containing REEs for the production of ductile iron. U.S. processors of rare-earth magnet alloys or rare-earth magnets included Arnold Magnetic Technologies Corp. (Rochester, NY), Electron Energy Corp. (Landisville, PA), Great Western Technologies (Troy, MI), Hitachi Metals America, Ltd. (China Grove, NC), and Molycorp. ETREMA Products (Ames, IA) was the sole producer of the magneto-restrictive alloy Terfenol-D® containing dysprosium, iron, and terbium. Sigma-Aldrich Co. LLC produced a variety of scandium compounds from imported materials. All domestic, commercially produced scandium and yttrium products were derived from imported compounds primarily sourced from China.

In 2013, Rare Element Resources Ltd. (Lakewood, CO) completed a drilling program at its Bear Lodge project in Wyoming with the intent of reclassifying some of its inferred resources to indicated resources and to further delineate enrichment zones within the deposits. In December, using a 1.5% cutoff grade, Rare Element Resources estimated 15.2 Mt of measured and indicated resources averaging 3.11% REO at Bear Lodge, including the Whitetail and Bull deposits. At yearend, none of the resources had yet been classified as reserves; however, permitting and prefeasibility studies on the project were underway (Rare Element Resources Ltd., 2013).

In December, Texas Rare Earth Resources Corp. (TRER; Sierra Blanca, TX) released a National Instrument (NI) 43–101-compliant preliminary economic assessment (PEA) for its Round Top project in Texas. The project was based on the development of a rhyolite-hosted deposit containing the minerals yttrofluorite, cerofluorite, and bastnäsite. The PEA was based on an operation with a processing rate of 7.3 million tons per year of ore with a 20-year life of mine (LOM). Using a cutoff grade of 428 grams per metric ton of yttrium equivalent, a preliminary resource estimate of measured and indicated resources was 529 Mt containing 307,000 t of REO. The proposed processing steps were expected to include crushing, heap leaching, removal of iron and radioactive impurities, and separation of individual REEs (Texas Rare Earth Resources Corp., 2013b, p. 90, 151). In 2014, TRER planned to continue development of the project through additional metallurgical testing and resource modeling (Texas Rare Earth Resources Corp., 2013a, p. 11).

In November, Ucore Rare Metals Inc. (Bedford, Nova Scotia, Canada) announced an update to its resource estimate for its Bokan Mountain project on Prince of Wales Island, AK. Using five individual REO cutoff grades and an overall 0.4% REO cutoff, indicated mineral resources were estimated to be 2.9 Mt averaging 0.61% REO. In its PEA, Ucore planned to use a nitric acid leach process to produce a rare-earth concentrate and a proprietary technology to produce individual REOs. In 2014, Ucore planned to progress in its permitting activities and to move towards the completion of a feasibility study on the project (Ucore Rare Metals Inc., 2014).

In 2013, U.S. Rare Earths, Inc. (Plano, TX) continued geologic mapping, exploratory drilling, and vein channel sampling on its exploration and development projects in Colorado, Idaho, and Montana. The dominant REE mineral source in these deposits was anticipated to be monazite. In 2014, the company expected to progress toward economic evaluation (U.S. Rare Earths, Inc., 2014).

Consumption

Data on domestic rare-earth consumption were developed by surveying known processors and manufacturers and evaluating industry reports and trade statistics. Based on import data and industry reports, U.S. consumption of REE metals and compounds was estimated to be 15,000 t of REO in 2013. Data retrieved from the PIERS trade database and other industry sources indicated that the estimated use of rare earths in 2013 was primarily in catalysts (65%), metallurgical applications and alloys (19%), permanent magnets (9%), glass polishing (6%), and other uses (1%) (JOC Group Inc., undated).

Although industry reports have estimated domestic consumption of yttrium oxide in excess of 500 t, import data suggest imports of yttrium oxide were about 200 t in 2013. Increased yttrium imports in 2013 compared with those of 2012 may be attributed to the replenishment of depleted consumer inventories. Yttrium compounds were used primarily in ceramics, phosphors, and metallurgical applications (JOC Group Inc., undated). Global consumption of scandium was estimated to be 10 to 15 t. Although not quantified, the domestic use of scandium was primarily for fuel cells and as an additive in aluminum alloys.

Prices

Prices for most rare-earth products experienced another year of decline following the price spike in 2011. In many instances, rare-earth price levels were comparable to the price levels before the 2011 price spike. In general, prices for REOs were undermined by excessive stocks and efforts by consumers to substitute or minimize consumption of these materials. Prices for cerium, lanthanum, and yttrium compounds were the most significantly affected by weak demand. Recycling of cerium oxide polishing abrasives, production of low-rare-earth catalyst formulations, and weak demand for fluorescent phosphors contributed to the reduced demand for cerium, lanthanum, and yttrium. Prices of rare-earth materials used in magnet applications experienced somewhat less severe declines. Prices for scandium materials were more stable and were largely supported by demand for fuel cells.

Foreign Trade

Data in this section are based on gross weight; data totals in the tables are also converted to REO content. U.S. exports of rare-earth metals and compounds totaled 8,770 t of REO valued at $86 million, approximately a 50% increase in quantity and a 28% decrease in value compared with those of 2012 (table 4). In contrast to total rare-earth imports, exports of ferrocerium and other pyrophoric alloys, primarily used for ductile irons and in steelmaking, increased significantly. Recently commissioned domestic production capacity of intermediate rare-earth compounds was believed to have resulted in increased exports and imports of rare-earth compounds to a Molycorp facility in Estonia.

In July, several changes to the U.S. Harmonized Tariff Schedule (HTS) were implemented. New codes provided more detailed classifications of imports of cerium, lanthanum, neodymium, praseodymium, scandium, and yttrium metals and compounds.

Changes to HTS section 2805.30 included the deletion of a single code for rare-earth metals (2805.30.0000) and the addition of separate codes for cerium (2805.30.0010), lanthanum (2805.30.0005), neodymium (2805.30.0020), praseodymium (2805.30.0015), and other rare-earth metals (2805.30.0050).

Changes to HTS section 2846.10.00 included the deletion of a single code for cerium compounds (2846.10.0000) and the addition of separate codes for cerium oxides (2846.10.0010) and other cerium compounds (2846.10.0050)

Changes to HTS section 2846.90.00 included the deletion of three codes: for other rare-earth oxides (2846.90.2010), for other rare-earth chlorides (2846.90.2050), and for other rare-earth compounds (2846.90.8000) and the addition of codes for lanthanum oxides (2846.90.2005), other oxides (2846.90.2045), other chlorides (2846.90.2080), other oxides and chlorides (2846.90.2090), oxides of yttrium or scandium (2846.90.8050), chlorides of yttrium or scandium (2846.90.8060), lanthanum carbonates (2846.90.8070), other rare-earth carbonates (2846.90.8075), and other rare-earth compounds (2846.90.8090) (U.S. International Trade Commission, undated).

U.S. imports totaled 10,100 t of REO equivalent valued at $257 million, a 91% increase in quantity and a 51% decrease in value compared with those of 2012. Despite the addition of several HTS codes, the largest import category was unspecified rare-earth compounds (table 5). China continued to dominate most import categories, especially for mixed and individual rare-earth compounds. Increased domestic production of mixed rare-earth compounds caused U.S. exports to increase. Estonia, the leading export destination of intermediate rare-earth compounds, was a leading import source of certain rare-earth carbonates and oxides. Japan was the leading source of yttrium compounds, and France was the leading source of ferrocerium and other pyrophoric alloys.

World Review

Australia.—In New South Wales, Alkane Resources Ltd. (Perth, Western Australia) continued to develop its Dubbo Zirconia project with planned production of hafnium, niobium, rare-earth, tantalum, and zirconium products. Reserves of REO as defined in the 2004 Edition of the Australasian Code for Reporting of Exploration were estimated to contain 316,000 t of REO (including yttrium oxide), based on a 1.5% cutoff grade [combined niobium oxide, REO, and zirconium oxide (ZrO_2)]. In 2013, Alkane released an update to its definitive feasibility study based on a production capacity to include about 6,000 t of REO concentrates. Alkane also submitted an environmental impact study to the government of New South Wales. Production was scheduled to be begin in late 2015, and reach full capacity in 2016 (Alkane Resources Ltd., 2013).

Arafura Resources Ltd. (Perth) continued to develop its Nolans Bore project in the Northern Territory. In 2013, the company worked to improve its process flow sheets and reconfigure the project to reduce costs. The company planned to reduce capital expenditures by relocating its separation plant offshore. Arafura sought technical assistance from several Chinese sources including the Institute of Multipurpose Utilization of Mineral Resources, the Chengdu Analytical and Testing Centre for Minerals and Rocks, and Shenghe Resources Holding Co. (Arafura Resources Ltd., 2014). Probable reserves of the project were estimated to contain 672,000 t of REO using a 1% cutoff grade (Arafura Resources Ltd., 2013).

Lynas Corp. Ltd. (Sydney, New South Wales) completed an expansion of mineral concentrate production capacity to 22,000 metric tons per year (t/yr) of REO from 11,000 t/yr of REO at its Mount Weld operation. The expansion plant was reported have been operated at 100% of capacity during a 2-month production campaign during the fourth quarter. In 2013, the company operated its Mount Weld operation on a campaign basis because it had produced sufficient stocks ahead of the rampup of its separation operations in Malaysia. At yearend, 15,400 t of concentrate containing 5,890 t of REO was bagged and ready for export to Malaysia (Lynas Corp. Ltd., 2014b, p. 2).

Brazil.—According to the Departamento Nacional de Produção Mineral (DNPM), in 2013 Brazil produced 600 t of monazite that was derived from Indústrias Nucleares do Brasil (INB) stocks of mineral concentrates in Sao Francisco do Itabapoana. The DNPM estimated that the INB held an additional 10,000 t of inventory (Andrade, 2015, p. 114–115).

MBAC Fertilizer Corp. (Toronto, Ontario, Canada) operated a pilot plant at its Araxá polymetallic project in the State of Minas Gerais. Hydrometallurgical pilot plant studies produced 175 kilograms of 98.5% REO concentrate and confirmed earlier bench-scale testing. In January, MBAC released an updated PEA with an assumed initial production of 8,750 t to commence in 2015. In 2014, MBAC planned to conduct pilot-plant-scale separation of REO from the concentrate produced in 2013. Using a 2% REO cutoff grade, measured and indicated mineral resources were estimated to contain 317,000 t of REO (MBAC Fertilizer Corp., 2014).

Canada.—In 2013, Avalon Rare Metals Inc. (Toronto) released a NI 43–101-compliant feasibility study on its Nechalacho project at Thor Lake, Northwest Territories. The study assumed a 20-year production average of 6,800 t/yr of separated REO with a target date for initial production set for late 2016. As of May 2013, proven and probable mineral reserves were about 15 Mt containing 1.7% REO using a cutoff value of $320 per metric ton of net metal return (NMR), in situ value of all payable metals (Avalon Rare Metals Inc., 2013b, p. 163–165). In December, Avalon announced it had updated flow sheets such that the overall recoveries of HREEs fed to the separation plant would be in excess of 80% compared to approximately 42% in the feasibility study. In 2014, Avalon planned to reexamine its process design and cost estimates (Avalon Rare Metals Inc., 2013a).

In Quebec, Matamec Explorations Inc. (Montreal, Quebec) announced the completion of a NI 43–101-compliant feasibility study on its Kipawa joint-venture project with Toyota Tsusho Corp. Proven and probable mineral reserves were estimated to be 20 Mt containing 0.41% (82,000 t) REO using a cutoff value of $48.96 per ton. When in full production, the mine was expected to produce an average of 3,760 t/yr of REO. In 2014, Matamet planned to conduct detailed engineering studies and pursue environmental permits. Mining operations were targeted to begin construction in 2015 and commence production by yearend 2016 (Matamec Explorations Inc., 2013).

Quest Rare Minerals Ltd. (Montreal) released a NI 43–101-compliant prefeasibility study for its polymetallic Strange Lake project in northern Quebec. As of October 2013, probable reserves were estimated to be 43.2 Mt containing 1.16% (502,000 t) REO, using a minimum “net smelter return” value of $286.29 per ton. The study assumed a 30-year LOM with a design capacity that included 13,700 t/yr of REO concentrates. The start of plant commissioning was scheduled for 2018 (Quest Rare Minerals Ltd., 2013, p. 19, 22, 23, 147).

China.—China continued to dominate the global supply of rare-earth minerals, separated compounds, and metals, accounting for nearly 90% of global mine production in 2013.

China also led in the global consumption of rare earths. LREE mine production was primarily from bastnäsite and monazite concentrates in Nei Mongol Autonomous Region and Sichuan Province. HREE mine production was primarily from ion-adsorption ores in Fujian, Guangdong, and Jiangxi Provinces in southeastern China.

For 2013, the Ministry of Land and Resources (MLR) set a production quota for rare-earth ores at 93,800 t of REO, of which 75,900 t was for light rare-earth ores and 17,900 t was for ion-adsorbed rare-earth ores. Although MLR did not release a comparable production quota for 2012, the quota was unchanged from 2011 (Metal-Pages Ltd., 2013).

According to China's customs statistics, China exported 22,493 t of rare-earth ores and concentrates, metals, and compounds, a 38% increase compared with 2012 but significantly less than the official export quota of 30,999 t. Owing to an oversupplied market, the value of rare-earth exports in 2013 decreased to $569 million compared with $906 million in 2012 (Shen, 2014).

In 2013, China continued its efforts to restrict exports of rare earths by limiting the authority to export rare-earth products to 28 approved companies. The Ministry of Commerce (MOFCOM) also allocated a total rare-earth export quota of 31,001 t with 27,384 t of light rare earths and 3,617 t of medium and heavy rare earths. Although not specified by MOFCOM, the medium rare-earth elements are sometimes defined to include samarium, europium, and gadolinium. When compared with 2012, the total export quota increased slightly, but the medium and heavy rare-earth quota decreased by 7%. In December, MOFCOM announced the first batch of export quotas for 2014 and a list of 28 companies authorized for exporting a total of 15,110 t of rare earths, including 13,314 t of light rare earths and 1,796 t of medium and heavy rare earths. Compared with the first batch of quotas from 2013, quotas for light rare earths decreased 2% while those for medium and heavy rare earths decreased 7% (Shen, 2013b).

The USTR requested WTO consultations regarding China's restraints on the export from China of various forms of rare earths, tungsten, and molybdenum in 2012. The request referred to 212 eight-digit Chinese Customs Commodity Codes and more than 30 measures. Hearings before a WTO panel took place in February and June. At yearend 2013, the WTO had yet to make a public ruling on the case (Office of the United States Trade Representative, 2013, p. 28).

China continued efforts to reduce illegal mining and processing of rare-earth products. According to the Ministry of Industry and Information Technology (MIIT), illegal mining of rare earths amounted to over 40,000 t in 2012, and illegal smelting separation of rare-earth products totaled 50,000 t. In 2013, a campaign to cut down on the illegal exploitation, production, and transportation of rare-earth metals was conducted by the MIIT, the Ministry of Public Security, the Ministry of Environmental Protection, and the MLR (Global Times, 2013).

With more than 110 rare-earth smelting and separation companies, China planned to consolidate its rare-earth industry through mergers, acquisitions, and closures into six largely Province-based state-owned enterprises. The consolidated companies included Baotou Rare Earth Hi-Tech Holding Co. Ltd., China Minmetals Corp., Aluminum Corporation of China Ltd., Ganzhou Mining Group, Guangdong Rare Earth Group, and Xiamen Tungsten Group. The large rare-earth groups were to receive preferential treatment to better develop the mineral resources (Xinhua News Agency, 2014).

Despite industry-wide efforts to restrict production, China's National Development and Reform Commission (NDRC) approved NFC Southern Rare Earth (Xinfeng) Co., Ltd.'s plans to construct a 7,000-t/yr rare-earth separation plant in Shaoguan, Guangdong Province. The plant was designed to separate ion-adsorbed rare earths and was reported to be the largest of its kind. Production was scheduled to begin in 2015 (Shen, 2013a).

France.—France is a major producer of separated rare-earth compounds and downstream rare-earth products as well as an importer of intermediate rare-earth compounds and metals. In 2013, France imported 5,500 t of rare-earth metals and 1,400 t of rare-earth compounds with a total value of $81 million (United Nations Statistics Division, 2015).

Greenland.—In October, Greenland's parliament voted to remove a 25-year-old ban on mining thorium and uranium. The policy change may allow for the development of thorium-bearing rare-earth deposits in Greenland including Greenland Minerals and Energy Ltd.'s Kvanefjeld mining project. In 2013, Greenland Minerals and Energy was conducting pilot plant studies of mineral concentration via froth flotation and lab-scale production of a mixed rare-earth carbonate via a sulfuric acid leach. The company continued environmental baseline studies in the Kvanefjeld area. Greenland Minerals and Energy planned to secure a mining license for Kvanefjeld in 2016 (Greenland Minerals and Energy Ltd., 2014, p. 2, 9, 10).

In southern Greenland, TANBREEZ Mining Greenland A/S, owned by Australia-based Rimbal Pty Ltd., was working on the development of the TANBREEZ project at Killavaat Alannguat (Kringlerne). TANBREEZ hoped to mine approximately 500,000 t/yr of ore producing a feldspar concentrate and rare-earth-bearing eudialite concentrate. In 2013, TANBREEZ announced it had filed an application for an exploitation license with Greenland's Bureau of Minerals and Petroleum (TANBREEZ Mining Greenland A/S, 2013).

India.—Although India reported no production of rare-earth compounds in 2013, India's producers of rare-earth-bearing mineral concentrates include Indian Rare Earths Ltd. (IREL) and Kerala Metals & Minerals Ltd. (KMML). IREL's Manavalakurichi (MK) division near Kanyakumari, Tamil Nadu State, is a heavy-mineral sands operation with a capacity to produce as much as 6,000 t/yr of monazite concentrate. KMML's production capacity at its Chavara, Kerala State, heavy-mineral sands operation is estimated to be 240 t/yr of monazite concentrate. IREL's Aluva Rare Earth Division (RED) in the Ernakulam district, Kerala State, is capable of processing monazite into rare-earth compounds and thorium hydroxide.

In 2013, IREL was in the process of adding a monazite processing plant at its OSCOM operation that was expected to produce several thousand metric tons of rare-earth and byproduct thorium compounds annually; however, the completion of the project was delayed by a cyclone (Indian Bureau of Mines, 2015).

Japan.—In response to concerns regarding supply restrictions, Japan's Government and industry were pursuing a number of efforts designed to diversify its rare-earth supply. Japan formed exploration and research cooperative agreements in several countries to provide for the development of mineral and metal resources, including rare earths. In Africa, Japan Oil, Gas and Metals National Corp. (JOGMEC) developed remote sensing analysis tools to identify the host rocks for deposits containing rare-earth minerals. In Brazil, JOGMEC continued its research on technologies to recover rare earths from the mine tailings and began demonstration testing associated with separation and refining. In Vietnam, JOGMEC continued to collaborate with the Vietnam Petroleum Institute to research methods for the extraction of REEs. Seabed deposits enriched in REEs were identified in Japan's exclusive economic zone near Minami-Tori-shima (Japan Oil, Gas and Metals National Corp., 2014, p. 22–24).

Kazakhstan.—Summit Atom Rare Earth Co. LLP (SARECO), a joint venture between Sumitomo Corp. and Kazakhstan's Government-owned National Atomic Co. (Kazatomprom), was preparing to commission a rare-earth-processing plant in Stepnogorsk. The SARECO plant was expected to recover REEs from uranium-ore residue and produce initially as much as 1,500 t/yr of rare-earth carbonates. Limited production was expected in 2014 (Ryall and Lange-Chenier, 2014).

Malaysia.—Lynas Corp. was commissioning crack-leach and separation units at its Lynas Advanced Material Plant (LAMP) near the Port of Kuantan in the State of Pahang. In 2013, Lynas Corp. completed an expansion to bring the design capacity of the LAMP operation to 22,000 t/yr of REO compounds from 11,000 t/yr. Production of REO from the LAMP operations in 2013 was 3,965 t. In 2014, the rampup of production capacity was expected to be tempered by market conditions (Lynas Corp. Ltd., 2014a, b).

South Africa.—Great Western Minerals Group Ltd. (GWMG) continued its efforts to develop its Steenkampskraal (SKK) project in the Western Cape. In December, GWMG announced the completion of an updated NI 43–101-compliant technical report on its SKK project. Using a 1% REO (including yttrium oxide) cutoff grade, measured and indicated resources were estimated to be 559,000 t containing 83,600 t of REO. Indicated resources attributed to mine tailings from prior mining operations were 46,000 t containing 3,300 t of REO. In 2013, mine tailings were relocated to facilitate rehabilitation and to centralize historic accumulations of radioactive materials. GWMG's exploration activities included geologic mapping, sampling in historic trenches, and magnetic and radiometric surveys. A NI 43–101-compliant feasibility study was expected to be completed in 2014 (Great Western Minerals Group Ltd., 2014, p. 22, 25, 26).

Sweden.—In February, Tasman Metals Ltd. released a NI 43–101-compliant report, including a resource estimate for the Tasman's Olserum project in southern Sweden. Using a 0.4% REO cutoff grade, indicated resources for the deposit were 4.5 Mt containing 0.6% (27,000 t) REO. The resource was reported to have less than 15 ppm each of uranium and thorium. In 2012, Tasman released a PEA on its Norra Karr project located 100 kilometers from the Olserum project. Using a 0.4% REO cutoff grade, the Norra Karr NI 43–101-compliant indicated mineral resource was 41.6 Mt containing 0.57% (230,000 t) REO as well as 1.70% ZrO_2 (Tasman Metals Ltd., 2012, 2013).

United Kingdom.—GWMG's wholly owned subsidiary, Less Common Metals Limited (LCM), commissioned a second strip casting furnace for the production of neodymium-iron-boron (NdFeB) alloys at its Hooton Park operations in Ellesmere Port. The new strip capacity brought the LCM's total capacity to more than 2,500 t/yr of metal alloy. LCM produced both NdFeB and samarium-cobalt alloys for the permanent magnet industry (Great Western Minerals Group Ltd., 2014, p. 12, 14).

Vietnam.—Rare-earth resources in Vietnam were reported to be concentrated in Nam Xe and Dong Pao (Lai Chau Province), Yen Phu (Yen Bai Province), and in some coastal Provinces from Thanh Hoa to Ba Ria-Vung Tau. In 2012, Lai Chau Rare Earth Co. and Japan's Dong Pao Rare Earth Development Co. agreed to develop the Dong Pao deposit in Lai Chau. If successful, the venture was targeted to mine and process 10,000 t/yr of REO. In 2013, there was some small-scale mining at Dong Pao, but the scale-up of mining operations had yet to be completed (Vietnam National Coal Mineral Industries Holding Co. Ltd., 2013). An unspecified amount of rare-earth minerals was reported to be produced from artisanal mining (Vietnam Breaking News, 2014).

Shin-Etsu Chemical Co., Ltd. completed construction of a rare-earth separation and refining facility in Hai Phong. Shin-Etsu Magnetic Materials Vietnam, a Shin-Etsu Chemical Co., Ltd. group company, began operations in 2013. The plant was expected to recycle postconsumer magnets and new scrap from the company's rare-earth magnet production facilities (Shin-Etsu Chemical Co., Ltd., 2012, 2014).

Outlook

China is expected to continue to dominate the global supply of rare earths. Mine production outside of China is expected to increase and to be led by new production capacity in Australia and the United States supplemented by byproduct production from heavy minerals, phosphate, uranium, and other mining operations. Global markets for rare-earth consumption are expected to be led by (in descending order by tonnage) permanent magnets, battery alloys, catalysts, polishing compounds, and phosphors. New design and technology advancements may reduce the weight per unit volume of certain rare earths in magnets and phosphors by 2015.

Consumption of rare-earth magnet materials will likely be driven by large downstream demand for permanent magnets in industrial applications (for example, motors and magnetic separation equipment), transportation (for example, automobiles and electric bicycles), and consumer electronics (for example, cell phones and hard disk drives). Consumption of NdFeB magnets in the power generation sector was forecast to double from 2011 to 2016. China is expected to remain the world's leading producer of NdFeB magnets, controlling at least 75% of the global supply (BCC Research, 2012, p. 11).

In 2013, of the more than 1.8 million hybrid electric vehicles (HEV) sold, most used REE-bearing nickel-metal hydride (NiMH) batteries. Although global HEV sales have been projected to reach more than 2.5 million units in 2015 and almost double that in 2020, the use of NiMH battery technology is expected to decrease significantly by 2020 from competition with lithium and other battery technologies (Pillot, 2014, p. 15, 18, 27).

Cerium, lanthanum, and yttrium lead the overall consumption of REEs. Rising prices in 2011 led companies to create recycling programs for batteries, phosphors, and polishing compounds and to pursue substitution with low-rare-earth or rare-earth-free catalysts, magnets, and phosphors; however, recent declines in prices for REEs are expected to lead to a resurgence in demand from polishing compounds, catalysts, and magnet markets. Demand for REEs in phosphors may be mitigated by changes in lighting technology that are less REE intensive.

Recent surges in prices for rare-earth materials compelled companies to explore and develop rare-earth deposits throughout the world. Few of these exploration projects are expected to develop into operating mines. Financing as well as obtaining environmental approvals and offtake agreements are expected to be key factors in the success of these projects. Pricing of rare-earth materials is expected to set the pace of exploration and development.

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TABLE 1

SALIENT U.S. RARE EARTH STATISTICS[1]

		2009	2010	2011	2012	2013
Production of rare-earth concentrates, rare-earth oxide (REO) basis[e, 2, 3]	metric tons	--	--	--	3,000	5,500
Exports, REO basis:[e]						
Compounds:						
Cerium compounds	do.	840	1,350	1,640	996 r	734
Other rare-earth compounds	do.	455	1,690	3,620	1,830	5,570
Metals:						
Ferrocerium and pyrophoric alloys	do.	2,970	3,460	2,010	960 r	1,420
Rare-earth metals, scandium, yttrium	do.	4,930	1,380	3,030	2,080	1,050
Imports for consumption, REO basis:[e]						
Compounds:						
Cerium compounds	do.	1,500	1,770	1,120	1,390	1,110
Other rare-earth compounds	do.	10,200	10,500	6,020	3,400	8,250
Metals:						
Ferrocerium and pyrophoric alloys	do.	102	131	186	276	313
Rare-earth metals, scandium, yttrium	do.	226	525	468	240	393
World production, REO basis[e]	do.	138,000 r	131,000 r	116,000 r	114,000 r	109,000
Prices, yearend:						
Bastnäsite concentrate, REO basis[e]	dollars per kilogram	5.73	6.87	NA	NA	NA
Monazite concentrate, REO basis[e]	do.	0.87	0.87	2.70	2.30 r	2.00
Mischmetal, 65% cerium, 35% lanthanum, metal basis[4]	do.	6.50–7.00	57.00–60.00	47.00–49.00	14.00–16.00	9.00–10.00

[e]Estimated. [r]Revised. do. Ditto. NA Not available. --Zero.

[1]Data are rounded to no more than three significant digits.

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

[3]Source: Molycorp, Inc. 2013 annual report, Form 10–K—2013.

[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)

	Bastnäsite		Monazite	
Rare earth	Mountain Pass, CA, United States[3]	Bayan Obo, Nei Mongol, China[4]	Mount Weld, Western Australia, Australia [5]	Nangang, Guangdong, China[6]
Yttrium	0.10	trace	trace	2.40
Lanthanum	33.20	23.00	26.00	23.00
Cerium	49.10	50.00	51.00	42.70
Praseodymium	4.34	6.20	4.00	4.10
Neodymium	12.00	18.50	15.00	17.00
Samarium	0.80	0.80	1.80	3.00
Europium	0.10	0.20	0.40	0.10
Gadolinium	0.20	0.70	1.00	2.00
Terbium	trace	0.10	0.10	0.70
Dysprosium	trace	0.10	0.20	0.80
Holmium	trace	trace	0.10	0.12
Erbium	trace	trace	0.20	0.30
Thulium	trace	trace	trace	trace
Ytterbium	trace	trace	0.10	2.40
Lutetium	trace	trace	trace	0.14
Total	100	100	100	100
	Loparite	Rare earth laterite		Xenotime
	Revda, Murmansk, Russia[7]	Xunwu, Jiangxi, China[8]	Longnan, Jiangxi, China[8]	Southeast Guangdong, China[9]
Yttrium	1.30	8.00	65.00	59.30
Lanthanum	25.00	43.40	1.82	1.20
Cerium	50.50	2.40	0.40	3.00
Praseodymium	5.00	9.00	0.70	0.60
Neodymium	15.00	31.70	3.00	3.50
Samarium	0.70	3.90	2.80	2.20
Europium	0.09	0.50	0.10	0.20
Gadolinium	0.60	3.00	6.90	5.00
Terbium	trace	trace	1.30	1.20
Dysprosium	0.60	trace	6.70	9.10
Holmium	0.70	trace	1.60	2.60
Erbium	0.80	trace	4.90	5.60
Thulium	0.10	trace	0.70	1.30
Ytterbium	0.20	0.30	2.50	6.00
Lutetium	0.15	0.10	0.40	1.80
Total	100	100	100	100

[1]Data are rounded to no more than three significant digits; may not add to totals shown.
[2]Rare earths are listed in order of atomic number.
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TABLE 3
RARE-EARTH OXIDE PRICES[1]
(Dollars per kilogram)

Product (oxide)	Purity (percentage)	2012	2013
Scandium[2]	99.990	4,700	5,000
Yttrium[3]	99.999	88	25
Lanthanum[3]	99.000	23	8
Cerium[3]	99.000	23	8
Praseodymium[3]	99.000	115	94
Neodymium[3]	99.000	117	70
Samarium[3]	99.000	62	14
Europium[3]	99.900	2,440	1,130
Gadolinium[3]	99.000	92	47
Terbium[3]	99.000	1,950	949
Dysprosium[3]	99.000	1,010	540

[1]Products are listed in order of atomic number.
[2]Source: Stanford Metals Corp.
[3]Source: Metal-Pages Ltd.

TABLE 4
U.S. EXPORTS OF RARE EARTHS, BY COUNTRY[1]

Category[2] and country	2012 Gross weight (kilograms)	2012 Value	2013 Gross weight (kilograms)	2013 Value
Compounds:				
Cerium compounds (2846.10.0000):				
Austria	36,100 r	$1,170,000 r	53,300	$1,330,000
Belgium	71,600	1,560,000	12,000	211,000
Brazil	13,900	196,000	26,400	188,000
China	131,000	2,060,000	122,000	2,260,000
Egypt	57,800	1,330,000	38,400	566,000
Estonia	160,000	155,000	--	--
Germany	90,900	950,000	108,000	1,210,000
India	15,000	222,000	29,300	294,000
Irland	57,200	1,200,000	24,700	545,000
Israel	163,000	2,060,000	134,000	1,450,000
Japan	48,400	1,590,000	25,500	601,000
Mexico	22,400 r	688,000 r	40,500	675,000
Netherlands	25,300	354,000	11,000	189,000
United Kingdom	24,100	646,000	25,700	359,000
Other	78,800 r	2,730,000 r	82,900	2,470,000
Total	996,000 r	16,900,000 r	734,000	12,300,000
Total estimated equivalent rare-earth oxide (REO) content	996,000 r	XX	734,000	XX
Other rare-earth compounds[3] (2846.90.0000):				
China	69,800	3,170,000	846,000	10,500,000
Czech Republic	247,000	6,260,000	176,000	2,670,000
Estonia	--	--	3,490,000	9,330,000
France	135,000	9,450,000	68,000	1,950,000
Germany	119,000	3,080,000	282,000	2,480,000
Japan	53,000	1,700,000	45,500	3,350,000
Mexico	40,700	3,440,000	76,500	4,350,000
Netherlands	328,000	2,320,000	109,000	622,000
Russia	71,600	2,460,000	27,200	579,000
Taiwan	179,000	4,320,000	29,100	1,560,000
United Kingdom	85,300	1,930,000	133,000	1,180,000
Vietnam	59,100 r	1,700,000	25,900	6,350,000
Other	445,000 r	26,600,000 r	262,000	4,760,000
Total	1,830,000 r	66,400,000 r	5,570,000	49,700,000
Total estimated equivalent REO content	1,830,000 r	XX	5,570,000	XX
Metals:				
Ferrocerium and other pyrophoric alloys (3606.90.0000):				
Argentina	367	15,100	25,800	76,800
Australia	21,200	3,340,000	12,400	2,900,000
Barbados	14,300	61,100	24,600	102,000
Brazil	936	73,700	57,400	210,000
Canada	407,000 r	2,220,000 r	452,000	2,040,000
Colombia	9,130	76,900	30,600	56,600
Costa Rica	16,300	42,000	13,900	36,300
Denmark	10,900	37,000	18,400	54,000
Dominican Republic	37,300	53,200	185,000	258,000
France	43,800	436,000	12,700	198,000
French Polynesia	10,400	25,700	14,300	37,300
Germany	13,300 r	339,000 r	13,400	347,000
Hong Kong	10,900	345,000	281,000	1,960,000
Italy	41,400	47,300	1,160	228,000
Japan	17,300	575,000	125,000	1,170,000
Mexico	92,300	431,000	21,000	324,000
Netherlands	53,000	168,000	20,000	46,000
Panama	19,300	3,200	21,500	85,500
Singapore	1,590	37,800	42,500	228,000

See footnotes at end of table.

TABLE 4—Continued

U.S. EXPORTS OF RARE EARTHS, BY COUNTRY[1]

Category[2] and country	2012 Gross weight (kilograms)	2012 Value	2013 Gross weight (kilograms)	2013 Value
Metals:—Continued				
Ferrocerium and other pyrophoric alloys (3606.90.0000):—Continued				
United Kingdom	132,000	3,130,000	114,000	303,000
Other	128,000 r	1,310,000 r	116,000	3,950,000
Total	1,080,000 r	$12,800,000 r	1,600,000	$14,600,000
Total estimated equivalent REO content	960,000 r	XX	1,420,000	XX
Rare-earth metals and alloys (2805.30.0000):				
China	65,500	476,000	404,000	2,340,000
Hong Kong	486,000	1,410,000	169,000	725,000
Japan	79,600	10,800,000	24,900	327,000
Netherlands	39,400	557,000	139,000	827,000
Philippines	1,010,000	8,900,000	--	--
Other	46,500 r	2,250,000 r	134,000	5,390,000
Total	1,730,000	24,400,000	871,000	9,600,000
Total estimated equivalent REO content	2,080,000	XX	1,040,000	XX

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

[1]Data are rounded to no more than three significant digits; may not add to totals shown.

[2]Harmonized Tariff Schedule of the United States category numbers.

[3]Inorganic and organic.

Source: U.S. Census Bureau.

TABLE 5

U.S. IMPORTS FOR CONSUMPTION OF RARE EARTHS, BY COUNTRY[1]

Category[2] and country	2012 Gross weight (kilograms)	2012 Value	2013 Gross weight (kilograms)	2013 Value
Compounds:				
Cerium compounds:				
Cerium compounds, unspecified (2846.10.0000):				
Austria	187,000	$8,030,000	73,400	$1,780,000
China	1,040,000	24,200,000	360,000	2,890,000
Estonia	428,000	6,020,000	30,200	416,000
Japan	189,000	10,300,000	77,200	3,580,000
Spain	80,300	816,000	--	--
Other	153,000 r	2,550,000 r	57,700	812,000
Total	2,080,000	52,000,000	598,000	9,480,000
Total estimated equivalent rare-earth oxide (REO) content	1,390,000	XX	400,000	XX
Cerium oxides (2846.10.0010):				
Austria	XX	XX	105,000	1,360,000
China	XX	XX	195,000	1,120,000
Japan	XX	XX	88,600	3,600,000
Other	XX	XX	28,700	1,340,000
Total	XX	XX	417,000	7,410,000
Total estimated equivalent (REO) content	XX	XX	417,000	XX
Cerium compounds, other than cerium oxide (2846.10.0050):				
Austria	XX	XX	23,200	428,000
China	XX	XX	187,000	1,060,000
Estonia	XX	XX	196,000	900,000
Germany	XX	XX	11,200	2,240,000
Other	XX	XX	14,700	431,000
Total	XX	XX	432,000	5,050,000
Total estimated equivalent (REO) content	XX	XX	289,000	XX
Other rare-earth compounds:				
Scandium or yttrium compounds:				
Scandium or yttrium oxides (2846.90.8050):				
China	XX	XX	46,300	994,000
Japan	XX	XX	4,870	588,000
Korea	XX	XX	9,240	213,000
Other	XX	XX	3,430	144,000
Total	XX	XX	63,800	1,940,000
Total estimated equivalent (REO) content	XX	XX	63,800	XX
Scandium or yttrium chlorides (2846.90.8060):				
China	XX	XX	12,000	264,000
Other	XX	XX	608	87,400
Total	XX	XX	12,600	351,000
Total estimated equivalent (REO) content	XX	XX	4,410	XX
Yttrium materials and compounds content by weight greater than 19% but less than 85% oxide equivalent (2846.90.4000):				
China	15,800	3,600,000	37,200	6,960,000
Germany	3,160	986,000	28,000	4,500,000
Japan	25,200	513,000	10,500	4,780,000
Other	1,130 r	770,000 r	889	535,000
Total	45,400	5,870,000	76,600	16,800,000
Total estimated equivalent (REO) content	27,200	XX	46,000	XX
Other rare-earth compounds, carbonates:				
Lanthanum carbonates (2846.90.8070):				
China	XX	XX	830,000	5,610,000
Other	XX	XX	58,200	538,000
Total	XX	XX	888,000	6,140,000
Total estimated equivalent (REO) content	XX	XX	608,000	XX
Other rare-earth carbonates (2846.90.8075):				
Estonia	XX	XX	58,800	428,000

See footnotes at end of table.

TABLE 5—Continued

U.S. IMPORTS FOR CONSUMPTION OF RARE EARTHS, BY COUNTRY[1]

Category[2] and country	2012 Gross weight (kilograms)	2012 Value	2013 Gross weight (kilograms)	2013 Value
Compounds:—Continued				
Other rare-earth compounds:—Continued				
Other rare-earth compounds, carbonates:—Continued				
Other rare-earth carbonates (2846.90.8075):—Continued				
Other	XX	XX	1,320	73,600
Total	XX	XX	60,100	501,000
Total estimated equivalent (REO) content	XX	XX	33,000	XX
Other rare-earth compounds, chlorides (2846.90.2050, 2846.90.2080, 2846.90.2090:				
China	717,000	$9,030,000	559,000	$5,520,000
France	236,000	1,790,000	36,700	1,430,000
Hong Kong	--	--	135,000	867,000
Other	123,000 r	16,900,000 r	44,700	6,240,000
Total	1,080,000	27,700,000	776,000	14,100,000
Total estimated equivalent (REO) content	XX r	XX	357,000	XX
Other rare-earth compounds, oxides:				
Lanthanum oxides (2846.90.2005):				
China	XX	XX	1,520,000	10,000,000
Other	XX	XX	98,900	4,200,000
Total	XX	XX	1,620,000	14,200,000
Total estimated equivalent (REO) content	XX	XX	1,620,000	XX
REOs except cerium oxide (2846.90.2010):				
China	331,000 r	9,700,000	352,000	3,950,000
Estonia	103,000	2,190,000	200,000	2,160,000
Italy	37,500	5,480,000	25,100	3,690,000
Other	62,100 r	8,310,000 r	21,300	319,000
Total	534,000 r	25,700,000	598,000	10,100,000
Total estimated equivalent REO content	534,000 r	XX	598,000	XX
REOs except cerium or lanthanum oxide (2846.90.2045):				
China	XX	XX	6,730	4,460,000
Estonia	XX	XX	156,000	1,500,000
United Kingdom	XX	XX	2,000	145,000
Other	XX	XX	3,800	568,000
Total	XX	XX	169,000	6,670,000
Total estimated equivalent REO content	XX	XX	169,000	XX
Other rare-earth compounds, unspecified (2846.90.8000):				
China	1,950,000	127,000,000	4,200,000	51,400,000
France	787,000	101,000,000	244,000	23,000,000
Japan	566,000	79,300,000	241,000	5,160,000
Other	480,000 r	71,300,000 r	158,000	17,500,000
Total	3,790,000	378,000,000	4,850,000	97,200,000
Total estimated equivalent REO content	2,840,000	XX	3,630,000	XX
Other rare-earth compounds (2846.90.8090):				
China	XX	XX	1,660,000	33,600,000
France	XX	XX	104,000	5,450,000
Japan	XX	XX	127,000	3,970,000
Other	XX	XX	139,000	6,990,000
Total	XX	XX	2,030,000	50,000,000
Total estimated equivalent REO content	XX	XX	1,110,000	XX
Metals:				
Ferrocerium and other pyrophoric alloys (3606.90.3000):				
Austria	69,700	936,000	88,200	1,010,000
China	85,900	1,270,000	113,000	1,870,000
France	155,000	6,390,000	140,000	4,930,000
Other	493	12,700	11,100	132,000
Total	311,000	8,610,000	353,000	7,940,000
Total estimated equivalent REO content	276,000	XX	313,000	XX

See footnotes at end of table.

TABLE 5—Continued

U.S. IMPORTS FOR CONSUMPTION OF RARE EARTHS, BY COUNTRY[1]

Category[2] and country	2012 Gross weight (kilograms)	2012 Value	2013 Gross weight (kilograms)	2013 Value
Metals:—Continued				
Rare-earth metals and alloys:				
Cerium, unalloyed (2805.30.0010):				
China	XX	XX	75,900	990,000
Total estimated equivalent REO content	XX	XX	91,100	XX
Lanthanum, unalloyed (2805.30.0005):				
China	XX	XX	7,500	$113,000
Estonia	XX	XX	250	3,750
Hong Kong	XX	XX	16,700	158,000
Total	XX	XX	24,400	275,000
Total estimated equivalent REO content	XX	XX	29,300	XX
Neodymium, unalloyed (2805.30.0020):				
China	XX	XX	202	41,100
Japan	XX	XX	11,600	744,000
Total	XX	XX	11,800	785,000
Total estimated equivalent REO content	XX	XX	14,100	XX
Other rare-earth metals, unalloyed (2805.30.0050):				
China	XX	XX	14,000	486,000
Other	XX	XX	415	95,800
Total	XX	XX	14,400	582,000
Total estimated equivalent REO content	XX	XX	17,300	XX
Other rare-earth metals, alloys (2805.30.0090):				
China	XX	XX	31,700	1,250,000
Japan	XX	XX	1,960	58,000
Other	XX	XX	2,080	223,000
Total	XX	XX	35,800	1,530,000
Total estimated equivalent REO content	XX	XX	42,900	XX
Unspecified rare-earth metals and alloys (2805.30.0000):				
China	153,000	$19,500,000	105,000	2,360,000
Japan	5,770	237,000	26,800	1,710,000
United Kingdom	17,800	231,000	1,560	289,000
Vietnam	5,000	87,300	16,000	618,000
Other	19,100 r	1,740,000 r	16,600	484,000
Total	200,000	21,800,000	166,000	5,460,000
Total estimated equivalent REO content	240,000	XX	199,000	XX

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

[1]Data are rounded to no more than three significant digits; may not add to totals shown.

[2]Harmonized Tariff Schedule of the United States category numbers.

Source: U.S. Census Bureau.

TABLE 6

RARE EARTHS: ESTIMATED WORLD MINE PRODUCTION, BY COUNTRY[1, 2]

(Metric tons of rare-earth oxide equivalent)

Country[3]	2009	2010	2011	2012	2013
Australia	--	--	2,188 [4]	3,222 [4]	2,000
Brazil	170 [4]	140 [4]	140 [r]	110 [r]	330
China	129,000	120,000	105,000	100,000	95,000
India	2,700	2,800	2,800	2,900	2,900
Malaysia	13	380	410 [r]	100	180
Russia	2,600	2,300	2,500	2,400	2,500
Thailand[5]	4,000	5,600	3,100	1,900	800
United States	--	--	--	3,000	5,500
Vietnam[5]	--	170	200	200	100
Total	138,000 [r]	131,000 [r]	116,000 [r]	114,000 [r]	109,000

[r]Revised. -- Zero.

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

[2]Includes data available through August 13, 2014.

[3]In addition to the countries listed, rare-earth minerals are thought to be produced in Indonesia, Nigeria, North Korea, and some Commonwealth of Independent States countries, but information is inadequate for formulation of reliable estimates of output levels.

[4]Reported figure.

[5]Estimated rare-earth oxide content of exports.