2012 Minerals Yearbook

RARE EARTHS

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Rare Earths

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In 2012, world rare-earth production was primarily from the minerals bastnäsite, loparite, and monazite. Rare-earth ores were primarily mined in China, with smaller amounts mined in Australia, India, Russia, and the United States, listed in order of decreasing production (table 6). Processing of intermediate rare-earth concentrates took place at the Mountain Pass Mine in California. In 2012, mining resumed at Mountain Pass for the first time since 2002.

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 that include the following 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 in decreasing order, 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).

Rare-earth elements (REE) can be classified as either light rare-earth elements (LREE) or heavy rare-earth elements (HREE). The LREE include the lanthanide elements from atomic number 57 (lanthanum) through atomic number 64 (gadolinium), and the HREE include the lanthanide elements from atomic number 65 (terbium) through atomic number 71 (lutetium). The division is based on the LREE having unpaired electrons in the 4f electron shell and HREE having paired electrons in the 4f electron shell. Yttrium is included as a 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 LREE nor one of the HREE. 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, and it is included as one of the HREE. Yttrium is the second most abundant rare earth in the Earth's crust. Yttrium is a bright silvery metal that is soft and malleable, similar in density to titanium.

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 economic ores of the rare earths are the minerals bastnäsite, loparite, monazite, and the lateritic ion-adsorption clays (table 2).

Legislation and Government Programs

For the fiscal year 2012, the U.S. Geological Survey's Mineral Resources External Research Program funded several initiatives related to rare earths. A total of $261,645 was awarded to the top six ranked proposals. Five of the six proposals were related to rare earths and included: (1) University of California, Santa Barbara, Evaluating mechanisms for rare earth phosphate mineralization in Proterozoic gneiss, Music Valley, CA; (2) University of Colorado, Collaborative Research with the University of Nebraska and the University of Colorado on the Age and Origin of the REE-rich Elk Creek Carbonatite, Southeast Nebraska (USA); (3) University of Nebraska-Lincoln, Collaborative Research with the University of Nebraska and the University of Colorado on the Age and Origin of the REE-rich Elk Creek Carbonatite, Southeast Nebraska (USA); (4) University of Texas at El Paso, Systematic investigation of REE mobility and fractionation during continental shale weathering; and (5) New Mexico Bureau of Geology and Mineral Resources, REE potential and origin of the Cambrian-Ordovician syenites/episyenites in the Caballo and Burro Mountains, southern New Mexico (U.S. Geological Survey, undated).

In May, the Department of Energy (DOE) announced the launch of its Critical Materials Hub and plans to spend $120 million over 5 years. The Hub was created to support 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 Hub is operated under the name the Critical Materials Institute and is led by the DOE's Ames Laboratory (U.S. Department of Energy, 2012).

In March, the United States Trade Representative (USTR) requested World Trade Organization (WTO) consultations regarding China's restraints on the export from China of various forms of rare earths, tungsten, and molybdenum. The 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 requested participation in the consultations. In July, the WTO's Dispute Settlement Body (DSB) established a panel to examine the dispute (World Trade Organization, 2014).

In February, the Defense Logistics Agency (DLA) Strategic Materials, U.S. Department of Defense, began offering as much as $150,000 for research and development initiatives to increase domestic mining and refining of critical materials as well as efforts to conserve critical materials and substitute other materials. Two initiatives receiving funding involved rare-earth mining and processing; a third initiative would assess domestic rare-earth magnets used in defense platforms. Landmark Alaska LLC (a subsidiary of Ucore Rare Metals Inc.) proposed studying the feasibility of recovering yttrium and other REEs from the Bokan Mountain deposit in southern Alaska. Great Western Technologies, Inc., was investigating a process for single-phase extraction of yttrium for defense applications (Reece, 2013).

Production

In 2012, Molycorp, Inc. resumed mining and began commissioning its new separation operations at Mountain Pass. Owing to market conditions and operational issues related to the startup of separation operations, production was limited. Molycorp reported that sales from its Mountain Pass operation in 2012 were 2,660 metric tons (t) of rare-earth oxide (REO) averaging $36 per kilogram compared with 3,760 t averaging $82 per kilogram in 2011. Although no breakdown of sales was available for 2012, prior year sales were dominated by neodymium and (or) praseodymium (26%), lanthanum (23%), and cerium (11%) products. When complete, the mine and processing capacity at the Mountain Pass operation was expected to increase to 19,100 metric tons per year (t/yr) of REO (Molycorp, Inc., 2013, p. 9).

U.S. processors of rare-earth permanent magnets and permanent magnet alloys included Arnold Magnetic Technologies Corp., Electron Energy Corp., Great Western Technologies, and Molycorp Metals and Alloys (formerly Santoku America, Inc.).

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. The principal source of these compounds was China.

In March, Rare Element Resources Ltd. (RER) announced that results from a prefeasibility study for its Bear Lodge project in Wyoming supported the development of a bankable feasibility study for the project. Based on the prefeasibility study, the Bear Lodge project would consist of an open pit mine and beneficiation plant at the Bull Hill Mine and a hydrometallurgical plant at Upton, WY. The prefeasibility study was based on a production rate of 10,400 t/yr of REO in the form of a carbonate concentrate (Rare Element Resources Ltd., 2012a). In April, RER filed a National Instrument (NI) 43–101-compliant mineral resource estimate for its Bear Lodge project. The updated estimate of the Bull Hill deposit consisted of 6.8 million metric tons (Mt) averaging 3.75%-REO in measured and indicated mineral resources, using a 1.5%-REO cutoff grade (Rare Element Resources Ltd., 2012b).

In November, Ucore announced the results of a preliminary economic assessment (PEA) for its Bokan Mountain project on Prince of Wales Island, AK. Ucore planned to use a nitric acid leach process to produce a rare-earth concentrate and an unconventional solid-phase extraction technology to produce high-purity individual REOs. The assessment was based on a production rate of 2,250 t/yr of REO during the first 5 years of full production. Using a 0.4%-REO cutoff, inferred resources were estimated to be 5.3 Mt, with an average grade of 0.65% REO. In 2012, the resource was classified as inferred owing to the limited sample data available within the deposit area (Ucore Rare Metals Inc., 2013).

U.S. Rare Earths, Inc. (USRE) contracted with Process Engineering to prepare a NI 43–101 (Form F1) technical report on its Diamond Creek Rare Earths property in Idaho. The report was to examine past exploration efforts and historic data, local geology, and data from current surface and drill-core sampling (U.S. Rare Earths, Inc., 2012b). In December, USRE initiated a drilling program at Diamond Creek. The company held over 12,000 acres of mining claims in Colorado and in the Lemhi Pass region of Idaho and Montana (U.S. Rare Earths, Inc., 2012a).

Hitachi Metals America, Ltd. proceeded with plans to begin production of neodymium-iron-boron (Nd-Fe-B) sintered magnets at its subsidiary in China Grove, NC. Although Hitachi had originally planned to produce rare-earth metals at the facility, the operation was expected to consume purchased rare-earth alloys for the production of magnets. The China Grove operation has produced arc-segment magnets for use in motors since the 1990s. The expansion was expected to produce Nd-Fe-B magnets primarily for use in hybrid and electric vehicles (Minn, 2011).

Molycorp announced that SRK Consulting had completed an updated reserve estimate for its Mountain Pass deposit. Using a cutoff grade of 5%, the estimated proven and probable reserves at Mountain Pass contained 1.3 Mt of REO. Using an average production rate of 19,000 t/yr of REO, the expected mine life was in excess of 30 years (Molycorp Inc., 2013, p. 40).

Consumption

Data on domestic rare-earth consumption were developed by surveying known processors and manufacturers and evaluating import and export data. Domestic consumption of rare earths was not calculated in 2012 because insufficient data were available to calculate apparent consumption. A study by Curtin University and Industrial Minerals Co. of Australia Pty Ltd estimated consumption of REO to be 115,000 t ±15% in 2012. Based on this and other industry reports, U.S. consumption was estimated to be 10% to 15% of global consumption in 2012 (China Rare Earth Information, 2013; Kingsnorth, 2013, p. 10).

Import data retrieved from the PIERS database indicated that the estimated use of rare earths in 2012 was primarily in catalysts (56%), metallurgical applications and alloys (28%), permanent magnets (6%), glass polishing (6%), and other uses (4%). Owing in part to reduced demand for phosphors, yttrium imports were estimated to have decreased by 66% in 2012 compared with those of 2011. Yttrium compounds were used primarily in ceramics, phosphors, and metallurgical applications

(JOC Group Inc., undated). Domestic use of scandium was primarily for fuel cells and as an additive in aluminum alloys.

Prices

Following spikes in mid-2011, prices for most rare-earth products declined significantly in 2012. Prices for REOs were lower in large part because of excessive stocks and efforts by consumers to substitute or minimize consumption of these materials. However, uncertainty with respect to the long-term supply of rare earths kept most prices generally higher compared with prices in 2010. Recycling of cerium oxide polishing abrasives and low-rare-earth catalyst formulations caused average yearend prices of cerium and lanthanum oxides to decrease by 74% and 80%, respectively. Weak demand from phosphor producers caused sharp declines in europium oxide, terbium oxide, and yttrium oxide prices. REEs used in Nd-Fe-B and samarium-cobalt permanent magnets experienced similar price declines.

Foreign Trade

Data in this section are based on gross weight; data in the tables are also converted to REO content. U.S. rare-earth exports totaled 5,630 t valued at $120 million, approximately a 44% decrease in quantity and a 52% decrease in value compared with those of 2011 (table 4). U.S. imports totaled 8,020 t valued at $519 million, a 20% decrease in quantity and a 35% decrease in value compared with those of 2011. On a gross-weight basis, rare-earth compounds (including oxides, hydroxides, nitrates, other compounds excluding chlorides and all cerium compounds) was the largest export category, accounting for 50% of total exports (table 5). Substitution, increased material efficiencies, and destocking caused U.S. imports and exports to fall to the lowest levels since the early 1990s. China continued to dominate most import markets, especially for mixed and individual rare-earth compounds. 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. continued to develop its Dubbo Zirconia project with planned production of hafnium, niobium, rare-earth, tantalum, and zirconium products. Proven and probable reserves of REO, including yttrium oxide, were estimated to contain 316,000 t of REO, based on a 1.5% cutoff grade (combined ZrO_2, Nb_2O_5, and REO) (Alkane Resources Ltd., 2011). In 2012, Alkane operated a demonstration plant to improve rare-earth recovery and entered into a toll processing agreement with Shin-Etsu Chemical Co., Ltd. to further process rare-earth concentrates into separated rare-earth oxides (Alkane Resources Ltd., 2012a). At yearend, Alkane's environmental impact statement neared completion and was scheduled to be completed in 2013 (Alkane Resources Ltd., 2012b).

Arafura Resources Ltd. announced a probable reserve estimate for its Nolans Bore project in the Northern Territory. Using a 1% cutoff grade, probable reserves were estimated to contain 672,000 t of REO. Based on a nominal capacity of 20,000 t/yr, the reserve was estimated to support a mine life of 22 years (Arafura Resources Ltd., 2012).

In May, Lynas Corp. temporarily idled its Mount Weld concentration plant because it had produced sufficient stocks ahead of the ramp up of separation operations in Malaysia. In September, Lynas announced an update of its ore reserves at Mount Weld, Western Australia. The ore reserves at the Central Lanthanide deposit were estimated to contain 1.14 Mt of REO. The new reserve estimate was a 260% increase in REO compared with the prior estimate from 2005. Based on a production capacity of 22,000 t/yr, the reserve was estimated to support a mine life of more than 25 years. At yearend, 15,200 t of concentrate containing 5,410 t of REO were bagged and ready for export. Lynas estimated that its expansion of concentrate to 22,000 t/yr of REO from 11,000 t/yr of REO was 84% complete (Lynas Corp. Ltd., 2012, p. 6, 7).

Brazil.—The Departamento Nacional de Produção Mineral Brazilian increased its estimate of Brazil's reserves to 22 Mt of contained REO. Companies who held these reserves included Companhia Brasileira de Metalurgia e Mineração (14 Mt of mineable reserves), Minas Gerais State-owned Companhia de Econômico Minas Gerais (8 Mt of mineable reserves), and Vale Fertilizantes S/A (unspecified reserves) (Andrade, 2013).

Canada.—Avalon Rare Metals, Inc. continued to develop its Nechalacho project, Thor Lake, Northwest Territories. In 2012, Avalon announced an updated resource estimate for the deposit based on drilling completed through November 2011. Using a $320 net metal return (NMR, in situ value of all payable metals) cutoff, the company estimated a measured resource of 120 Mt containing 1.5% REO. In January 2011, probable mineral reserves were estimated at 15 Mt containing 1.5% REO using a NMR cutoff value of $300 per ton projected to 2015. A target date for initial production was set for late 2016, subject to the completion of a feasibility study scheduled for 2013 (Avalon Rare Metals, Inc., 2012, p. 21, 25).

In March, Matmec Explorations Inc. announced the completion of a PEA by SGS Geostat Inc. on its Kipawa project. Based on a 0.2%-REO cutoff grade, the indicated resource was 18 Mt in the mineral forms of eudialyte (10 Mt), monsandrite (3.9 Mt), and britholite (3.4 Mt) containing a total of 77,000 t of REO. The PEA was based on the production of about 5,100 t/yr of mixed concentrate with a mine life of about 13 years. In May, Matamec awarded contracts for a full feasibility study and environmental and social impact assessments. In September, Matamec announced that a hydrometallurgical pilot plant for the Kipawa project had produced a 77% REO concentrate. The company amended a memorandum of understanding with Japan's Toyota Tsusho Corp. to provide Can$1.5 million for the development of the Kipawa deposit (Matamec Explorations Inc., 2012 a, b, c).

Molycorp acquired Canada-based Neo Material Technologies Inc., a producer of magnet materials and rare-earth metals and compounds including Nd-Fe-B magnetic powder. With the Neo Material acquisition, Molycorp expanded its operations to include joint ventures and majority-owned manufacturing facilities in China, Estonia, Germany, the Republic of Korea, Thailand, and the United States (Molycorp Inc., 2013, p. 6).

In October, Quest Rare Minerals Ltd. announced a revised NI 43–101-compliant resource estimate for the Strange Lake

B-Zone deposit. According to Quest, the resource would support a mine life of more than 30 years. Based on a 0.5% cutoff grade, the indicated resource of 280 Mt contained about 0.93% REO (Quest Rare Minerals Ltd., 2013, p. 5).

China.—China continued to dominate REE supply, accounting for more than 90% of global mine production in 2012. LREE mine production was primarily from bastnäsite and other rare-earth minerals 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. In 2012, REO mine production was estimated to be 100,000 t and consumption was estimated to be more than 84,000 t.

China's Ministry of Land and Resources (MLR) did not disclose mine production quotas for Chinese producers in 2012 as it had done in prior years. In 2011, the production quota was set at 93,800 t and the production quota for 2013 was expected to be similar to that of 2011 (Bloomberg News, 2013).

In April, the Association of China Rare Earth Industry was formed to promote consolidation and sustainable development in the rare-earth industry. The association consisted of more than 100 members and included companies throughout the rare-earth supply chain. The association reported to the Ministry of Industry and Information Technology (Yan, 2012).

In June, China's State Council published a report describing the rare-earth industry in China and plans to restructure its rare-earth industry. The report described China's plans to limit mine output, crack down on illegal operations, consolidate the REE industry, encourage technical development, and enforce environmental controls (State Council, 2012, p. 12–24).

In August, China initiated a minimum production threshold for rare-earth producers. Based on the new rule, each rare-earth mining company was expected to have capacity of at least 20,000 t/yr of REO, and for each rare-earth smelting company, the minimum capacity was set at 5,000 t/yr. Production capacity was expected to be reduced by 20% as a consequence of smaller operations closing to comply with the new ruling (Global Times, 2012).

China's Ministry of Commerce (MOFCOM) rare-earth export quota for 2012 was 30,996 t. Included in the quota were export quotas allocated to companies with foreign joint venture partners that were limited to 25% of the total. In December, MOFCOM announced that its first rare-earth export quota would be about 50% of the total quota for 2012. In contrast to 2012, MOFCOM specified quantities for light rare-earth products (13,561 t) and medium and (or) heavy rare earth products (1,938 t). The first round export quotas allocated to companies with foreign joint-venture partners increased compared with those in 2012 (Hatch, 2012).

India.—Indian Rare Earths Ltd. (IREL) neared completion of a monazite-processing plant at its Odisha Sands Complex (OSCOM), Chatrapur, Odisha State. Part of the mixed rare-earth chloride produced at OSCOM was expected to be processed into separated compounds by IREL's Udyogamandal plant, Aluva, Kerala State (Bhabha Atomic Energy Center, 2012, p. 2; Indian Bureau of Mines, 2014).

In July, Toyota Tsusho's subsidiary in India, Toyotsu Rare Earths Orissa Pvt. Ltd., started construction of an REO-processing plant in Odisha. When completed, the plant was expected to produce as much as 2,500 t/yr of REO derived from monazite produced at OSCOM's heavy-mineral sands operations (Toyota Tsusho Corp., 2012, p. 23).

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 India, Kazakhstan, Kyrgyzstan, Myanmar, and Vietnam to provide for the sustainable development of mineral and metal resources including rare earths. In 2012, the Japan Oil, Gas and Metals National Corp. (JOGMEC) established a recycling process for polishing compounds and phosphors containing REE. JOGMEC also was active in exploration of deep-sea mineral resources (Japan Oil, Gas and Metals National Corp., 2012, p. 5; 2013, p. 22–24). Japan Metals & Chemicals Co., Ltd. and Honda Motor Co., Ltd. began a program to recover rare earths from nickel-metal-hydride (NiMH) batteries (Honda Motor Co., Ltd., 2012).

Kazakhstan.—Summit Atom Rare Earth Co. LLP (SARECO), a joint venture between the Sumitomo Corp. and Kazakhstan's Government-owned National Atomic Co. (Kazatomprom), completed construction of a rare-earth-processing plant in Stepnogorsk. The SARECO plant was expected to recover REEs from uranium-ore residue and produce up to 1,500 t/yr of rare-earth carbonate with a high content of dysprosium and neodymium. An opening ceremony was held in November and an expansion to 5,000 to 6,000 t/yr was planned by 2017 (Sumitomo Corp., 2012).

Malaysia.—In September, Malaysia's Atomic Energy Licensing Board announced the issuance of the temporary operating license for the Lynas REO-processing plant near Kuantan. The commissioning of the 11,000-t/yr separation plant was delayed by appeals from environmental activists, but processing of imported concentrate began in November. Lynas reported that a project to double capacity to 22,000 t/yr was 90% complete at yearend (Lynas Corp. Ltd., 2012, p. 4–7).

South Africa.—Great Western Minerals Group Ltd. (GWMG) continued its efforts to recommission the abandoned Steenkampskraal Mine in the Western Cape. In 2012, GWMG formed a joint-venture agreement with China's Ganzhou Qiandong Rare Earth Group Co. Ltd. (GQD). Under the agreement, a mixed rare-earth chloride plant would be constructed at the Steenkampskraal mine site and a solvent extraction separation plant that would process mixed rare-earth chloride from Steenkampskraal on a toll basis would be constructed at Vredendal, approximately 25 kilometers west of Vanrhynsdorp, in the Western Cape. GWMG planned a feasibility study for the separation facility. At yearend, GWMG was in the process of updating its resource estimates. Using a 1% cutoff grade, the indicated resource was 32,100 t of REO, a significant increase compared with an indicated resource estimate published in May 2012 (Great Western Minerals Group Ltd., 2013, p. 5–9).

Vietnam.—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 expected to mine and process 10,000 t/yr of REO. No completion schedule was available for this project (Vietnam National Coal Mineral Industries Holding Co. Ltd., 2012). Although no official mine production was reported in 2012, an unspecified amount of rare-earth minerals was reported to be illegally mined in Lai Chau (TalkVietnam.com, 2012).

Shin-Etsu Chemical Co., Ltd. announced plans to construct a rare-earth separation and refining facility in Hai Phong. Scheduled for production in 2013, the facility was expected to recycle post-consumer magnets and new scrap from the company's rare-earth magnet production facilities. Feasibility studies were planned to expand the operation to process rare-earth ores (Shin-Etsu Chemical Co., Ltd., 2012).

Outlook

China is expected to continue to dominate the global consumption and production of rare earths, but production outside of China likely will increase. 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. Rare-earth materials are likely to continue to play an essential role in several critical weapons components and systems such as aircraft, communication systems, electric vehicles, lasers, naval vessels, and guided missiles.

Demand for Nd-Fe-B magnets was expected to increase to 78,000 t in 2015, compared with 63,000 t in 2012. Expanding requirements for Nd-Fe-B magnets are expected to increase demand for dysprosium, neodymium, and praseodymium. Although China is a dominant magnet producer, new production facilities are planned in Japan and the United States (Benecki, 2013).

Most hybrid electric vehicles (HEV) in 2012 used NiMH battery technology. Global HEV sales have been projected to reach more than $6 billion in 2015 and almost double that in 2020, but were expected to account for less than 5% of automotive sales. Some portion of these vehicles will likely use REE-bearing NiMH batteries for energy storage, although NiMH batteries will continue to compete with lithium and other battery technologies (Pillot, 2013, p. 29).

Increased prices for rare-earth materials in 2010 and 2011 initiated recycling programs for polishing compounds and created interest in substitution with low-rare-earth or rare-earth-free catalysts and phosphors. Consequently, future demand for rare earths in these application areas is expected to be influenced by rare-earth prices.

Recent shortages of rare earths have compelled companies to explore and develop rare-earth deposits throughout the world. Obtaining environmental approvals, financing, and offtake agreements are expected to be key factors in the success of these projects.

References Cited

Alkane Resources Ltd., 2011, Dubbo Zirconia project ore reserve upgrade: Perth, Western Australia, Australia, Alkane Resources Ltd. press release, November 16, 9 p. (Accessed April 23, 2014, at http://www.alkane.com.au/pdf/asx/2011/20111116.pdf.)

Alkane Resources Ltd., 2012a, MOU with Shin-Etsu Chemical for DZP rare earths: Perth, Western Australia, Australia, Alkane Resources Ltd. press release, July 16, 4 p. (Accessed April 23, 2014, at http://www.alkane.com.au/pdf/asx/2012/20120716.pdf.)

Alkane Resources Ltd., 2012b, Quarterly Report to 30 September 2012: Perth, Western Australia, Australia, Alkane Resources Ltd. press release, October 19, 14 p. (Accessed April 23, 2014, at http://www.alkane.com.au/pdf/quarter-reports/Alkane_Sep_12.pdf.)

Andrade, R.H.P., 2013, Summario mineral 2013—Terras raras: Brasilia, Brazil, Departamento Nacional de Produção Mineral, 2 p. (Accessed April 23, 2014, at https://sistemas.dnpm.gov.br/publicacao/mostra_imagem.asp?IDBancoArquivoArquivo=9006.)

Arafura Resources Ltd., 2012, Nolans rare earths project—Maiden JORC ore reserve: Perth, Western Australia, Australia, Arafura Resources Ltd. press release, December 11. (Accessed April 23, 2014, at http://clients2.weblink.com.au/clients/Arafura/article.asp?asx=ARU&view=6618048.)

Avalon Rare Metals Inc., 2012, Annual information form for the year ended August 31, 2012: Toronto, Ontario, Canada, Avalon Rare Metals Inc., November 28, 73 p. (Accessed April 23, 2014, at http://www.avalonraremetals.com/_resources/financials/AIF_2012_Final.pdf.)

Benecki, W.T., 2013, The permanent magnet market—2015: Magnetics 2013 Conference, Orlando, FL, February 7–8, 15 p. (Accessed April 22, 2014, at http://waltbenecki.com/uploads/Magnetics_2013_Benecki_Presentation.pdf.)

Bhabha Atomic Energy Center, 2012, Founder's Day 2012: Mumbai, India, Bhabha Atomic Energy Center newsletter, September–October, no. 328, 5 p. (Accessed April 23, 2014, at http://www.barc.gov.in/publications/nl/2012/2012091002.pdf.)

Bloomberg News, 2013, China sets first rare earth output quota for 2013 at 46,900 tons: Bloomberg News, January 7. (Accessed April 28, 2014, at http://www.bloomberg.com/news/2013-01-07/china-sets-first-rare-earth-output-quota-for-2013-at-46-900-tons.html.)

China Rare Earth Information, 2013, Rare earth supply and demand in the post-WTO era: Baotou, China, China Rare Earth Information Center, v. 19, no. 12, December, 8 p.

Global Times, 2012, New threshold set for rare-earth production: Global Times, August 7. (Accessed April 24, 2014, at http://www.globaltimes.cn/content/725496.shtml.)

Great Western Minerals Group Ltd., 2013, Annual information form—For the financial year ended December 31, 2012: Saskatoon, Saskatchewan, Canada, Great Western Minerals Group Ltd., April 21, 67 p. (Accessed April 28, 2014, at http://www.gwmg.ca/sites/default/files/financial-documents/20121231 WMG annual information Form FINAL.pdf.)

Hatch, Gareth, 2012, The first round of Chinese rare-earth export-quota allocations for 2013: Carpentersville, IL, Technology Metals Research, LLC, December 28. (Accessed April 28, 2014, at http://www.techmetalsresearch.com/2012/12/the-first-round-of-chinese-rare-earth-export-quota-allocations-for-2013/.)

Honda Motor Co., Ltd., 2012, Honda to reuse rare earth metals contained in used parts: Honda Motor Co., Ltd. news release, April 17, 2 p. (Accessed April 2, 2014, at http://world.honda.com/news/2012/c120417Reuse-Rare-Earth-Metals/.)

Indian Bureau of Mines, 2014, Rare Earths, *in* Indian minerals year book 2012, Part III—Mineral reviews: Nagpur, India, Indian Bureau of Mines, February, p. 43–1 to 43–7. (Accessed April 23, 2014, at http://ibm.nic.in/IMYB_2012_Rare Earths.pdf.)

Japan Oil, Gas and Metals National Corp., 2012, JOGMEC annual report: Tokyo, Japan, Japan Oil, Gas and Metals National Corp., December, 44 p. (Accessed April 28, 2014, at http://www.jogmec.go.jp/content/300075892.pdf.)

Japan Oil, Gas and Metals National Corp., 2013, JOGMEC annual report: Tokyo, Japan, Japan Oil, Gas and Metals National Corp., November, 49 p. (Accessed April 28, 2014, at http://www.jogmec.go.jp/content/300120179.pdf.)

JOC Group Inc., [undated], PIERS: Newark, NJ, JOC Group Inc. (Accessed March 5, 2013, via http://www.piers.com/.)

Kingsnorth, Dudley, 2013, Rare earths—Is supply critical in 2013?: AusIMM 2013 Critical Minerals Conference, Perth, Western Australia, Australia, June 4–5, presentation, 17 p. (Accessed on April 22, 2014, at http://investorintel.com/wp-content/uploads/2013/08/AusIMM-CMC-2013-DJK-Final-InvestorIntel.pdf.)

Lynas Corp. Ltd., 2012, Interim unaudited condensed consolidated financial report for the half year ended December 31, 2012: Sydney, New South Wales, Australia, Lynas Corp. Ltd., 26 p. (Accessed April 21, 2014, at

https://www.lynascorp.com/Annual Reports/Lynas - Interim Report 31 Dec 12 FINAL 1197760.pdf.)
Mason, Brian, and Moore, Carleton, 1982, Principles of geochemistry (4th ed.): New York, NY, John Wiley & Sons, 344 p.
Matamec Explorations Inc., 2012a, Matamec files Kipawa REE-Y-Zr project PEA technical report: Montreal, Quebec, Canada, Matamec Explorations Inc. news release, March 15. (Accessed April 30, 2014, at http://www.matamec.com/vns-site/pressdetail-2012_03_15_matamec_files_kipawa_reeyzr_project_pea_technical_report-en.html.)
Matamec Explorations Inc., 2012b, NI 43-101 report—Preliminary economic assessment study for Kipawa project: Montreal, Quebec, Canada, Matamec Explorations Inc., March 14. (Accessed April 30, 2014, via http://www.sedar.com/.)
Matamec Explorations Inc., 2012c, Toyota Tsusho gives Matamec $1.5M CAD and the MOUs binding on the parties: Montreal, Quebec, Canada, Matamec Explorations Inc. news release, March 12. (Accessed April 30, 2014, at http://www.matamec.com/vns-site/pressdetail-2012_03_12_toyota_tsusho_gives_matamec_15m_cad_and_the_mou_is_binding_on_the_parties-en.html.)
Minn, Karissa, 2011, Hitachi expansion smaller than planned: Salisbury [NC] Post, December 31. (Accessed April 23, 2014, at http://www.salisburypost.com/article/20111231/SP0101/312319979/0/SEARCH&slId=3.)
Molycorp, Inc., 2013, Year in review—2012: Greenwood Village, CO, Molycorp, Inc., 154 p. (Accessed April 23, 2014, at http://www.molycorp.com/wp-content/uploads/Molycorp-Year-End-Reivew-2012.pdf.)
Pillot, Christophe, 2013, The worldwide battery market 2012–2025: Batteries 2013 [Conference], Nice, France, October 14–16, 41 p. (Accessed April 22, 2014, at http://www.avicenne.com/pdf/The worldwide battery market 2012-2025 C Pillot BATTERIES 2013 Nice October 2013.pdf.)
Quest Rare Minerals Ltd., 2013, Quest Rare Minerals Ltd. annual report 2012: Montreal, Quebec, Canada, Quest Rare Minerals Ltd., 80 p. (Accessed April 30, 2014, at http://www.questrareminerals.com/pdfs/QRM-Annual-Report-2012.pdf.)
Rare Element Resources Ltd., 2012a, Rare Element announces positive economic results from pre-feasibility study at Bear Lodge: Lakewood, CO, Rare Element Resources Ltd., March 1. (Accessed April 14, 2014, at http://www.rareelementresources.com/investor-information/news-releases/2012-archive/2012/03/01/rare-element-announces-positive-economic-results-from-pre-feasibility-study-at-bear-lodge#.U0VDofldWgY.)
Rare Element Resources Ltd., 2012b, Rare Element files December 31 second quarter financial results and update on preliminary feasibility study for Bear Lodge project: Lakewood, CO, Rare Element Resources Ltd. press release, February 9. (Accessed March 5, 2013, at http://www.rareelementresources.com/investor-information/news-releases/2012-archive/2012/02/09/rare-element-files-december-31-second-quarter-financial-results-and-update-on-preliminary-feasibility-study-for-bear-lodge-project#.U2OlHvldXz8.)
Reece, Beth, 2013, Research and development: Defense Logistics Agency Loglines, September–October, p. 14–15. (Accessed April 22, 2014, at http://www.dla.mil/loglines/pdf documents/loglines september - october 2013.pdf.)
Shin-Etsu Chemical Co., Ltd., 2012, Shin-Etsu Chemical makes first investments in Vietnam establishing two production bases: Tokyo, Japan, Shin-Etsu Chemical Co., Ltd., January 24. (Accessed April 24, 2014, at http://www.shinetsu.co.jp/en/news/archive.php?id=301.)
State Council, 2012, Situation and policies of China's rare earth industry: Beijing, China, State Council, June, 20 p. (Accessed April 28, 2014, at http://ycls.miit.gov.cn/n11293472/n11295125/n11299425/n14676844.files/n14675980.pdf.)
Sumitomo Corp., 2012, Starting rare earth production in Kazakhstan: Sumitomo Corp. news release, November 5. (Accessed April 24, 2014, at http://www.sumitomocorp.co.jp/english/news/detail/id=25526.)
TalkVietnam.com, 2012, Rare earth minerals illegally stripped in Lai Chau: TalkVietnam.com, June 10. (Accessed April 24, 2014, at http://talkvietnam.com/2012/06/rare-earth-minerals-illegally-stripped-in-lai-chau/#.UqZRdz-ma9u.)
Toyota Tsusho Corp., 2012, Toyota Tsusho annual report 2012—Year ended March 31, 2012: Nagoya City, Japan, Toyota Tsusho Corp., August, 125 p. (Accessed April 24, 2014, at http://www.toyota-tsusho.com/english/ir/report/annual/pdf/TTC_E_AR2012_fin.pdf.)
Ucore Rare Metals Inc., 2013, Management's discussion and analysis for the year ended December 31, 2012: Bedford, Nova Scotia, Canada, Ucore Rare Metals Inc., 16 p. (Accessed April 14, 2014, at http://ucore.com/documents/Ucore December 31 2012 MDA.pdf.)
U.S. Department of Energy, 2012, Energy Department announces launch of Energy Innovation Hub for critical materials research: U.S. Department of Energy, May 31. (Accessed April 1, 2014, at http://energy.gov/articles/energy-department-announces-launch-energy-innovation-hub-critical-materials-research-0.)
U.S. Geological Survey, [undated], Mineral Resources External Research Program (MRERP) 2012: U.S. Geological Survey. (Accessed April 17, 2014, at http://minerals.usgs.gov/mrerp/2012.html.)
U.S. Rare Earths, Inc., 2012a, U.S. Rare Earths, Inc. commences drilling at Idaho rare earths property: U.S. Rare Earths, Inc. press release, December 4. (Accessed April 16, 2014, at http://investor.usrareearths.com/releasedetail.cfm?ReleaseID=834287.)
U.S. Rare Earths, Inc., 2012b, U.S. Rare Earths, Inc. engages NI 43–101 for Idaho rare earths property: U.S. Rare Earths, Inc. press release, December 6. (Accessed April 16, 2014, at http://investor.usrareearths.com/releasedetail.cfm?ReleaseID=834293.)
Vietnam National Coal Mineral Industries Holding Co. Ltd., 2012, Vinacomin & Japanese firm to exploit and process rare earth in Lai Chau: Hanoi, Vietnam, Vietnam National Coal Mineral Industries Holding Co. Ltd., August 10. (Accessed April 2, 2014, at http://www.vinacomin.vn/en/news/News-of-Vinacomin/Vinacomin-Japanese-firm-to-exploit-and-process-rare-earth-in-Lai-Chau-278.html.)
World Trade Organization, 2014, China—Measures related to the exportation of rare earths, tungsten and molybdenum: World Trade Organization, May 9. (Accessed May 15, 2014, at http://www.wto.org/english/tratop_e/dispu_e/cases_e/ds431_e.htm.)
Yan, Zhou, 2012, Rare earth association set for launch: The China Post, April 12. (Accessed April 28, 2014, at http://www.chinapost.com.tw/china/national-news/2012/04/02/336430/Rare-earth.htm.)

GENERAL SOURCES OF INFORMATION

U.S. Geological Survey Publications

Historical Statistics for Mineral and Material Commodities in the United States. Data Series 140.
Rare-Earth Elements. Ch. in United States Mineral Resources, Professional Paper 820, 1973.
Rare-Earth Metals (Ce, Dy, Eu, Gd, La, Nd, Pr, Sm, Sc, Tb, Y). Ch. in Metal Prices in the United States Through 2010, Scientific Investigations Report 2012–5188, 2013.
Rare-Earth Oxides. International Strategic Minerals Inventory Summary Report, Circular 930–N, 1993.
Rare Earths. Ch. in Mineral Commodity Summaries, annual.
Scandium. Ch. in Mineral Commodity Summaries, annual.
Thorium. Ch. in Mineral Commodity Summaries, annual.
Yttrium. Ch. in Mineral Commodity Summaries, annual.

Other

China Rare Earth Information (newsletter), monthly.
Economics of Rare Earths and Yttrium, The. Roskill Information Services Ltd., 2007.
Industrial Minerals, monthly.
Metal Bulletin, weekly.
Rare Earth Elements and Yttrium. Ch. in Mineral Facts and Problems, U.S. Bureau of Mines Bulletin 675, 1985.
Rare Earths. Ch. in Industrial Minerals and Rocks—Commodities, Markets, and Uses, Society for Mining, Metallurgy, and Exploration Inc., 7th ed., 2006.

TABLE 1

SALIENT U.S. RARE EARTH STATISTICS[1]

		2008	2009	2010	2011	2012
Production of rare-earth concentrates, rare-earth oxide (REO) basis[e, 2]	metric tons	--	--	--	--	3,000
Exports, REO basis:						
Cerium compounds	do.	1,380	840	1,350	1,640	992
Ferrocerium and pyrophoric alloys	do.	4,490	2,970	3,460	2,010	951
Rare-earth metals, scandium, yttrium	do.	1,390	4,930	1,380	3,030	2,080
Rare-earth compounds, organic or inorganic	do.	663	455	1,690	3,620	1,830
Imports for consumption, REO basis:[e]						
Cerium compounds	do.	2,080	1,500	1,770	1,120	1,390
Ferrocerium and pyrophoric alloys	do.	125	102	131	186	276
Mixtures of rare-earth chlorides except cerium chloride	do.	1,310	411	956	382	495
Mixtures of REOs except cerium oxide	do.	2,400	4,750	5,480	1,830	537
Rare-earth compounds, oxides, hydroxides, nitrates, other compounds except chlorides	do.	8,820	5,080	3,980	3,770	2,840
Rare-earth metals, whether intermixed or alloyed	do.	679	226	525	468	240
Yttrium compounds	do.	10	7	73	35	27
Prices, yearend:						
Bastnäsite concentrate, REO basis	dollars per kilogram	8.82	5.73	6.87	NA	NA
Monazite concentrate, REO basis	do.	0.48	0.87	0.87	2.70	NA
Mischmetal, f.o.b.[3] China[4]	do.	7.00–7.50 r	6.50–7.00 r	57.00–60.00 r	47.00–49.00 r	14.00–16.00

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

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

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

[3]Free on board.

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

TABLE 2

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

(Percent of total rare-earth oxide)

	Bastnäsite		Monazite	
Rare earth	Mountain Pass, CA, United States[3]	Bayan Obo, Nei Mongol, China[4]	Mount Weld, 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 Oblast, Russia[7]	Xunwu, Jiangxi Province, China[8]	Longnan, Jiangxi Province, 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.

[3]Johnson, G.W., and Sisneros, T.E., 1981, Analysis of rare-earth elements in ore concentrate samples using direct current plasma spectrometry—Proceedings of the 15th Rare Earth Research Conference, Rolla, MO, June 15–18, 1981: New York, NY, Plenum Press, v. 3, p. 525–529.

[4]Zang, Zhang Bao, Lu, Ke Yi, King, Kue Chu, Wei, Wei Cheng, and Wang, Wen Cheng, 1982, Rare-earth industry in China: Hydrometallurgy, v. 9, no. 2, p. 205–210.

[5]Kingsnorth, Dudley, 1992, Mount Weld—A new source of light rare earths—Proceedings of the TMS and Australasian Institute of Mining and Metallurgy, Rare Earth Symposium, San Diego, CA, March 1–5, 1992: Sydney, Australia, Lyncs Gold NL, 8 p.

[6]Xi, Zhang, 1986, The present status of Nd-Fe-B magnets in China—Proceedings of the Impact of Neodymium-Iron-Boron Materials on Permanent Magnet Users and Producers Conference, Clearwater, FL, March 2–4, 1986: Clearwater, FL, Gorham International Inc., 5 p.

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

[8]Introduction to Jiangxi rare-earths and applied products, 1985, Jiangxi Province brochure, 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 IN 2012[1]

Product (oxide)	Purity (percent)	Price (dollars per kilogram)
Scandium[2]	99.990	4,700
Yttrium[3]	99.999	88
Lanthanum[3]	99.000	23
Cerium[3]	99.000	23
Praseodymium[3]	99.000	115
Neodymium[3]	99.000	117
Samarium[3]	99.000	62
Europium[3]	99.900	2,440
Gadolinium[3]	99.000	92
Terbium[3]	99.000	1,950
Dysprosium[3]	99.000	1,010

[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	2011 Gross weight (kilograms)	2011 Value	2012 Gross weight (kilograms)	2012 Value
Cerium compounds (2846.10.0000):				
Austria	64,900	$3,780,000	36,000	$1,170,000
Belgium	9,060	378,000	71,600	1,560,000
Canada	39,600	513,000	10,400	370,000
China	139,000	1,780,000	131,000	2,060,000
Egypt	200	4,230	57,800	1,330,000
Estonia	378,000	6,380,000	160,000	155,000
France	69,700	3,490,000	17	23,200
Germany	141,000	1,800,000	90,900	950,000
Ireland	78,800	2,170,000	57,200	1,200,000
Israel	65,000	940,000	163,000	2,060,000
Japan	122,000	4,140,000	48,400	1,590,000
Mexico	80,000	2,130,000	18,400	684,000
Netherlands	102,000	637,000	25,300	354,000
United Kingdom	20,100	592,000	24,100	646,000
Vietnam	161,000	14,500,000	14,400	229,000
Other	166,000 r	7,700,000 r	82,900	2,520,000
Total	1,640,000	50,900,000	992,000	16,900,000
Total estimated equivalent rare-earth oxide (REO) content	1,640,000	XX	992,000	XX
Ferrocerium and other pyrophoric alloys (3606.90.0000):				
Australia	15,300	3,660,000	21,200	3,340,000
Canada	462,000	2,040,000	398,000	2,180,000
Chile	27,100	51,300	12,200	23,800
Dominican Republic	118,000	171,000	37,300	53,200
France	13,400	165,000	43,800	436,000
Germany	6,790	250,000	13,100	298,000
Hong Kong	16,300	567,000	10,900	345,000
Italy	572	27,600	41,400	47,300
Jamaica	33,200	51,100	18,200	51,500
Japan	31,300	559,000	17,300	575,000
Mexico	1,120,000	2,590,000	92,300	431,000
Netherlands	33,700	114,000	53,000	168,000
Panama	2,010	5,970	19,300	3,200
Saudi Arabia	1,650	87,200	20,200	104,000
United Arab Emirates	52,400	111,000	1,000	3,720
United Kingdom	153,000	5,540,000	132,000	3,130,000
Other	185,000 r	2,360,000 r	141,000	1,490,000
Total	2,270,000	18,300,000	1,070,000	12,700,000
Total estimated equivalent REO content	2,010,000	XX	951,000	XX
Rare-earth compounds[3] (2846.90.0000):				
Austria	134,000	4,150,000	25,900	835,000
Canada	88,900	1,360,000	47,000	1,410,000
China	61,900	3,150,000	69,800	3,170,000
Czech Republic	136,000	2,300,000	247,000	6,260,000
Estonia	1,010,000	19,100,000	--	--
France	123,000	2,470,000	135,000	9,450,000
Germany	50,600	2,510,000	119,000	3,080,000
Hong Kong	68,200	2,380,000	24,400	1,240,000
India	96,900	2,510,000	10,900	32,500
Japan	115,000	11,700,000	53,000	1,700,000
Mexico	351,000	4,570,000	40,700	3,440,000
Netherlands	569,000	9,040,000	328,000	2,320,000
Russia	13,600	536,000	71,600	2,460,000
Taiwan	1,750	242,000	179,000	4,320,000
Thailand	334,000	36,700,000	41,000	3,530,000
Vietnam	304,000	9,060,000	85,300	1,700,000

See footnotes at end of table.

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

Category[2] and country	2011 Gross weight (kilograms)	2011 Value	2012 Gross weight (kilograms)	2012 Value
Rare-earth compounds[3] (2846.90.0000):—Continued				
Total	3,620,000	116,000,000	1,830,000	66,400,000
Total estimated equivalent REO content	3,620,000	XX	1,830,000	XX
Rare-earth metals, including scandium and yttrium (2805.30.0000):				
China	951,000	2,750,000	65,500	476,000
Hong Kong	56,600	274,000	486,000	1,410,000
Japan	839,000	48,000,000	79,600	10,800,000
Philippines	394,000	3,400,000	1,010,000	8,900,000
Other	283,000 r	9,500,000 r	86,000	2,810,000
Total	2,520,000	63,900,000	1,730,000	24,400,000
Total estimated equivalent REO content	3,030,000	XX	2,080,000	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	2011 Gross weight (kilograms)	2011 Value	2012 Gross weight (kilograms)	2012 Value
Cerium compounds, including oxides, hydroxides, nitrates, sulfate, chlorides, oxalates (2846.10.0000):				
Austria	302,000	$10,400,000	187,000	$8,030,000
China	640,000	38,500,000	1,040,000	24,200,000
Estonia	182,000	10,600,000	428,000	6,020,000
India	192,000	7,370,000	150	17,200
Japan	168,000	8,710,000	189,000	10,300,000
Spain	923	20,300	80,300	816,000
Other	190,000 r	11,500,000 r	152,000	2,530,000
Total	1,670,000	87,100,000	2,080,000	52,000,000
Total estimated equivalent rare-earth oxide (REO) content	1,120,000	XX	1,390,000	XX
Ferrocerium and other pyrophoric alloys (3606.90.3000):				
Austria	28,200	646,000	69,700	936,000
China	44,100	801,000	85,900	1,270,000
France	133,000	2,440,000	155,000	6,390,000
Other	3,330	46,500	493	12,700
Total	209,000	3,930,000	311,000	8,610,000
Total estimated equivalent REO content	186,000	XX	276,000	XX
Mixtures of rare-earth chlorides, except cerium chloride (2846.90.2050):				
China	636,000	40,600,000	717,000	9,030,000
France	120,000	2,010,000	236,000	1,790,000
Korea, Republic of	29,300	1,820,000	38,600	1,560,000
Other	46,000 r	7,280,000 r	84,100	15,300,000
Total	831,000	51,700,000	1,080,000	27,700,000
Total estimated equivalent REO content	382,000	XX	495,000	XX
Mixtures of REOs except cerium oxide (2846.90.2010):				
China	1,740,000	92,600,000	334,000	9,700,000
Estonia	17,000	2,370,000	103,000	2,190,000
Other	78,100 r	7,240,000 r	99,600	13,800,000
Total	1,830,000	102,000,000	537,000	25,700,000
Total estimated equivalent REO content	1,830,000	XX	537,000	XX
Rare-earth compounds, including oxides, hydroxides, nitrates, other compounds except chlorides (2846.90.8000):				
Austria	171,000	15,900,000	194,000	19,900,000
China	3,340,000	279,000,000	1,950,000	127,000,000
France	425,000	52,500,000	787,000	101,000,000
Japan	701,000	74,200,000	566,000	79,300,000
Other	393,000 r	53,100,000 r	286,000	51,400,000
Total	5,030,000	475,000,000	3,790,000	378,000,000
Total estimated equivalent REO content	3,770,000	XX	2,840,000	XX
Rare-earth metals, whether intermixed or alloyed (2805.30.0000):				
Austria	13,400	870,000	11,600	924,000
China	282,000	54,600,000	153,000	19,500,000
Hong Kong	17,200	1,220,000	--	--
Japan	31,400	6,060,000	5,770	237,000
United Kingdom	3,070	510,000	17,800	231,000
Other	43,300 r	7,630,000 r	12,500	908,000
Total	390,000	70,800,000	200,000	21,800,000
Total estimated equivalent REO content	468,000	XX	240,000	XX
Yttrium compounds content by weight greater than 19% but less than 85% oxide equivalent (2846.90.4000):				
Austria	12,100	169,000	258	196,000
China	37,000	9,140,000	15,800	3,600,000
Japan	3,060	739,000	25,200	513,000
Other	5,730 r	1,730,000 r	4,030	1,560,000
Total	57,900	11,800,000	45,400	5,870,000
Total estimated equivalent REO content	34,700	XX	27,200	XX

See footnotes at end of table.

TABLE 5—Continued

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

[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]	2008	2009	2010	2011	2012
Australia	--	--	--	2,188 [4]	3,222 [4]
Brazil	460 [4]	170 [4]	140 [4]	160 [r, 4]	206 [p]
China	125,000	129,000	120,000	105,000	100,000
India	2,700	2,700	2,800	2,800	2,900
Malaysia	120	13	380 [r]	410 [r]	100
Russia	3,400	2,600	2,300	2,500	2,400
United States	--	--	--	--	3,000
Total	132,000 [r]	134,000 [r]	126,000 [r]	113,000 [r]	112,000

[p]Preliminary. [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 July 16, 2014.

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

[4]Reported figure.