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RARE EARTHS

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Rare Earths

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In 2006, world rare-earth production was primarily from the mineral bastnäsite. Rare earths were not mined in the United States in 2006; however, the mine and plant at Mountain Pass, CA, were kept on care-and-maintenance status and the company planned to reopen in 2007. Rare-earth ores were primarily mined in China, with lesser amounts coming from Brazil, India, and Russia. Domestic stocks of previously produced bastnäsite concentrates, intermediate rare-earth concentrates, and separated products were available for purchase from Molycorp, Inc. at Mountain Pass. Consumption was estimated to have increased, as did imports of individual rare-earth compounds and mixed rare-earth compounds. U.S. imports of cerium compounds, rare-earth chlorides, rare-earth compounds, and mixtures of rare-earth oxides excluding cerium oxide increased.

Domestic use of scandium increased slightly in 2006. Overall consumption of the commodity remained small. Demand was primarily for aluminum alloys used in baseball and softball bats. Scandium alloys, compounds, and metals were used in analytical standards, metallurgical research, and sports equipment. Minor amounts of high-purity scandium were used in semiconductors and specialty lighting.

Yttrium consumption was estimated to have increased by about 28% in 2006 compared with that of 2005. Yttrium was used primarily in lamp and cathode-ray tube phosphors; lesser amounts were used in structural ceramics and oxygen sensors.

The rare earths are a moderately abundant group of 17 elements comprising the 15 lanthanides, scandium, and yttrium. The elements range in crustal abundance from cerium, the 25th most abundant element of the 78 common elements in the Earth's crust at 60 parts per million (ppm), to thulium and lutetium, the least abundant rare-earth elements at about 0.5 ppm (Mason and Moore, 1982, p. 46). In rock-forming minerals, rare earths typically occur in compounds as trivalent cations in carbonates, oxides, phosphates, and silicates.

The lanthanides comprise a group of 15 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. Cerium, which is more abundant than copper (average concentration in the Earth's crust 50 ppm), is the most abundant member of the group at 60 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.

Scandium, whose atomic number is 21, is the lightest rare-earth element. 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. It is represented by the chemical symbol Sc and has one naturally occurring isotope. Although its occurrence in crustal rocks is greater than 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, whose atomic number is 39, is chemically similar to the lanthanides and often occurs in the same minerals as a result of its similar ionic radius. It is represented by the chemical symbol Y and has one naturally occurring isotope. Yttrium's average concentration in the Earth's crust is 33 ppm and 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 are used in a wide variety of applications. The principal economic rare-earth ores are the minerals bastnäsite, loparite, and monazite and lateritic ion-adsorption clays.

Legislation and Government Programs

The last of the U.S. Government stocks of rare earths in the National Defense Stockpile (NDS) was shipped in 1998. Periodic assessments of the national defense material requirements may necessitate the inclusion of rare earths, including scandium and yttrium, in the NDS at a future date.

Production

In 2006, Molycorp, Inc. (a wholly owned subsidiary of Chevron Corporation), remained open on a care-and-maintenance basis. Although Molycorp was not actively mining rare earths in 2006, the sales operation at the mine site remained open and sold from its stockpile of bastnäsite concentrates, intermediate concentrates, and separated compounds previously processed at its open pit operations at Mountain Pass. Substantial stocks of lanthanide concentrates and intermediate and refined compounds were available. Lanthanide products available in 2006 from Molycorp were bastnäsite concentrate, cerium nitrate, lanthanum chloride, lanthanum hydrate, lanthanum-rich nitrate, and the oxides of cerium, erbium, europium, gadolinium, praseodymium, samarium, and yttrium.

Three companies processed intermediate rare-earth compounds to lanthanides in 2006, Grace Davison (a subsidiary of W.R. Grace & Co.), Rhodia Electronics and Catalysis (a subsidiary of Rhodia Group of France), and Santoku America, Inc. (a subsidiary of Sanoku corporation of Japan).

Grace Davison processed intermediate rare-earth compounds to produce cerium- and lanthanum-rich compounds used in making fluid-cracking catalysts for the petroleum refining industry in Chattanooga, TN; the company also processed zirconia-stabilized ceria compounds for supports for automotive catalysts, fluid catalytic cracking additives, and oxidation of organic compounds in wastewater. Grace Davison also produced several grades of cerium oxide polishing compounds under the trade names Vitrox and Rareox. At yearend 2006, Grace Davison reported that sales revenues increased $130 million, or 9.5%, compared with those of 2005 (W.R. Grace & Co., 2007).

Rhodia Group of France organized its corporation into seven enterprises with the rare-earth unit Rhodia Electronics and Catalysis and the performance silica unit Rhodia Silica Systems under Rhodia Silcea (Rhodia Group, undated). In the United States, Rhodia's rare-earth corporate headquarters is in Cranbury, NJ, and its finishing plant is in Freeport, TX.

Rhodia Electronics and Catalysis, Inc. (67%) continued its joint venture Anan Kasei Ltd. with Santoku Corporation (33%) in 2006. The joint-venture operations, located in Anan, Japan, produced ceramic capacitors; ferrites; fuel additive emission-reduction catalysts; microwave filters; phosphors used in CRTs, lamps, and PDP televisions; polishing compounds for electronic components, hard disks, lenses, mirrors, ophthalmic glass, and semiconductors; rare-earth-base nontoxic colorants and coatings for plastics; resistors; and three-way catalytic converter catalysts (Rhodia Japan—Anan Kasei Ltd., undated).

Rhodia also produced rare-earth-containing catalysts for automotive emission applications, fluid cracking catalysts for oil refining, desulfurization catalysts, styrene monomer catalysts, chemical catalysts for oxidation, dehydrogenation, and hydrogenation, and polymerization catalysts to promote the drying of paints. Rhodia's other operations produced finished rare-earth products from imported materials at its plant in Freeport, TX, and produced high-purity rare earths at its separation plant in La Rochelle, France. Additional rare-earth capacity was operated through Anan Kasei in Kobe, Japan. In 2006, Rhodia reported net sales of rare earths by region as follows: Asia-Pacific, €80 million; Europe, €60 million; and North America and Latin America, €25 million.

In 2006, Santoku America, Inc. (a subsidiary of Santoku Corporation of Japan) produced rare-earth magnet and rechargeable battery alloys at its operations in Tolleson, AZ. Santoku America produced two types of high-strength permanent magnets—neodymium-iron-boron (NIB) and samarium-cobalt magnets. For the rechargeable battery industry, Santoku produced nickel-metal hydride (NiMH) alloys that incorporate specialty rare-earth mischmetals. The plant also produced a full range of high-purity rare-earth metals, including scandium and yttrium, in cast and distilled forms, as foils, and as sputtering targets.

The principal domestic producer of NIB magnet alloys was Santuko America. Leading U.S. producers of rare-earth magnets were Electron Energy Corporation (EEC), Landisville, PA, and Hitachi Metals North Carolina, China Grove, NC.

EEC produced samarium-cobalt (SmCo) and NIB permanent magnets and designed and manufactured magnet assemblies, including actuators, Halbach arrays (magnetic field focusing assemblies), high-speed rotors, and other components. Hitachi Metals manufactured SmCo and NIB magnets and also maintained engineering and design capabilities.

Two scandium processors operated in 2006. High-purity products were available in various grades, with scandium oxide having up to 99.999% purity. Boulder Scientific Co. processed scandium at its Mead, CO, operations. It refined scandium primarily from imported oxides to produce high-purity scandium compounds, including carbide, chloride, diboride, fluoride, hydride, nitride, oxalate, and tungstate.

Scandium also was purified and processed from imported oxides at Aldrich-APL, LLC in Urbana, IL, to produce high-purity scandium compounds, including anhydrous and hydrous chloride, fluoride, iodide, and oxide. The company also produced high-purity scandium metal.

All commercially produced purified yttrium products were derived from imported compounds. The principal source was China.

Consumption

Data on domestic rare-earth consumption were developed by surveying various processors and manufacturers, evaluating import and export data, and analyzing U.S. Government stockpile shipments. Domestic apparent consumption of rare earths increased in 2006 compared with that of 2005.

Demand for rare earths used in nickel-metal hydride (NiMH) batteries increased in 2006 as did overall demand for rechargeable batteries. Rechargeable batteries are used in camcorders, cellular telephones, PDAs, portable computers, and other portable devices. The principal world markets for rechargeable batteries are laptop computers and cellular telephones.

In 2006, yttrium consumption was estimated to have increased to 742 metric tons (t) from 582 t in 2005, based on data retrieved from the Port Import Export Reporting Service database. Yttrium compounds and metal were imported from several sources in 2006. Yttrium compounds and metal were imported, in descending order of quantity, from China (94%), Japan (3%), Belgium (2%), and Austria and the United Kingdom (less than 1% each). The estimated use of yttrium, based on imports, was primarily in lamp and cathode-ray tube phosphors, ceramics, and electronics (84%), electronics (7%), ceramics (7%), and specialty alloys (2%) (Commonwealth Business Media, Inc., undated).

Prices

The prices of most rare-earth materials increased in 2006 compared with those of 2005. The following estimates of prices were based on trade data from various sources or were quoted by rare-earth producers. All rare-earth prices remained nominal and subject to change without notice. The competitive pricing policies in effect in the industry caused most rare-earth product prices to be quoted on a daily basis from the producers and processors. The average price of imported rare-earth chloride in 2006 was $1.28 per kilogram, a decrease from $2.37 per kilogram in 2005. Imported rare-earth metal prices averaged $8.79 per kilogram, an increase from $6.66 per kilogram in 2005. Mischmetal and specialty mischmetals comprised most of the rare-earth metal imports. (Mischmetal is a natural mixture of rare-earth metals typically produced by metallothermic reduction of a mixed rare-earth chloride). The price of praseodymium-neodymium (didymium) mischmetal in 2006 increased to ¥220 ($28.12) per kilogram in December from ¥100 ($12.40) per kilogram in January. The domestic price of basic mischmetal at $10.00 per kilogram (when purchased in metric ton quantities) was higher than the Chinese price because of higher shipping costs related to its classification as a pyrophoric hazardous material. The average price for imported cerium compounds, excluding cerium chloride, decreased to $2.80 per kilogram in 2006 from $3.27 per kilogram in 2005. The primary cerium compound imported was cerium carbonate. Battery-grade cerium-lanthanum alloy from China was priced at $5 to $6 per kilogram, when purchased in metric ton quantities (China Rare Earth Information, 2007d).

The 2006 nominal price for bastnäsite concentrate was $5.51 per kilogram of contained lanthanide oxide ($2.50 per pound of contained lanthanide oxide), unchanged from that of 2005. The price of monazite concentrate, typically sold with a minimum 55% rare-earth oxide (REO) content, including contained thorium oxide, free on board (f.o.b.), quoted in U.S. dollars and based on U.S. import data increased to $480.00 per metric ton ($0.87 per kilogram of contained rare-earth oxide) in 2006 from $400.00 per metric ton ($0.73 per kilogram of contained rare-earth oxide). Prices for monazite remained depressed from their historical levels because the principal international rare-earth processors continued to process only thorium-free feed materials.

The nominal price range for neodymium metal for metric ton quantities, f.o.b. shipping point, increased to ¥220 to ¥225 ($28.12 to $28.76) in December 2006, from ¥95 to ¥100 ($11.78 to $12.40) per kilogram in January 2006.

Most NIB alloy was sold with addition of cobalt (typically 4% to 6%) or dysprosium (no more than 4%). The cost of the addition was based on pricing before shipping and alloying fees, with the average cobalt price increasing to $37.96 per kilogram in 2006. The cost would be about $0.38 per kilogram for each percentage point addition. The nominal price range of dysprosium metal, f.o.b. shipping point, increased to ¥870 to ¥890 ($111.22 to $113.78) in December 2006, from ¥540 to ¥570 ($66.97 to $70.69) per kilogram in January 2006. Costs for the addition of about $1.14 per kilogram for each percentage point would be incurred (China Rare Earth Information, 2007a).

Rhodia Electronics and Catalysis quoted rare earth prices net 30 days, f.o.b. New Brunswick, NJ, or duty paid at point of entry, in effect at yearend 2006 are listed in table 3. No published prices were available for scandium. Yearend 2006 nominal prices for scandium oxide were compiled from information provided by several domestic suppliers and processors. Prices in 2006 were higher for the lower high-purity oxides but lower for the higher purity oxides than those of 2005. The 2006 scandium oxide prices were as follows: 99% purity, $700 per kilogram; 99.9% purity, $1,400 per kilogram; 99.99% purity, $1,450 per kilogram; and 99.999% purity, $1,500 per kilogram.

Scandium metal prices for 2006 increased from those of 2005 and were as follows: 99.9% purity, metal pieces, distilled dendritic, ampouled under argon, $325 per 2 grams; 99.9% purity, metal ingot, $124 per gram; scandium rod, 12.7-millimeter (mm) diameter, 99.9% (metals basis excluding tantalum), $497 per 10 mm; and 99.9% REO purity foil, 0.025-mm thick, ampouled under argon, 25 mm by 25 mm, $149 per sheet (Alfa Aesar, undated).

Scandium compound prices were unchanged from those of 2005 and were as follows: scandium acetate 99.9% purity, $70.30 per gram; scandium chloride hydrate 99.9% purity, $68.60 per gram; scandium fluoride anhydrous powder 99.9% purity, $98.80 per gram; scandium iodide anhydrous powder, 99.999% purity, $130.50 per gram; scandium nitrate hydrate 99.9% purity, $77.60 per gram; and scandium sulfate pentahydrate 99.9% purity, $72.50 per gram. Prices for standard solutions for calibrating analytical equipment were $27.00 per 100 milliliters of scandium atomic absorption standard solution (Aldrich Chemical Co., 2005, p. 2083-2084).

Prices for kilogram quantities of scandium metal in ingot form have historically averaged about twice the cost of scandium oxide, and higher purity distilled scandium metal prices have averaged about five times that price.

Foreign Trade

U.S. exports decreased and imports increased in quantity in 2006 compared with those of 2005. Data in this section are based on gross weight, while data in the tables may be converted to equivalent REO content, as specified. U.S. exports totaled 9,490 t valued at $55.1 million, a 1.9% decrease in quantity and an 8% increase in value compared with those of 2005 (table 4). Imports totaled 26,700 t valued at $104 million, a 19% increase in quantity and a 4% increase in value compared with those of 2005 (table 5).

In 2006, U.S. exports of rare earths increased in quantity in two out of four trade categories. Principal destinations in 2006, in descending order, were Germany, Estonia, Canada, Japan, India, the United Kingdom, the Netherlands, and Egypt. The United States exported 611 t of rare-earth metals valued at $6.96 million, a 15% increase in quantity and a 34% increase in value compared with that of 2005. Principal destinations of the rare-earth metals, in descending order by quantity, were Japan (received 93% by weight), China, Germany, and India. Exports of cerium compounds, primarily for glass polishing and automotive catalytic converters, decreased in quantity by 9% to 2,010 t and increased in value 46% to $19.8 million. Major destinations, in descending order of quantity, were India, Egypt, Mexico, Turkey, and Japan.

Exports of inorganic and organic rare-earth compounds increased by 30% to 2,700 t in 2006 from 2,070 t in 2005, and the value of the shipments increased by 23% to $17.3 million. Shipments, in descending order of quantity, were to Estonia, Canada, the United Kingdom, and China.

In 2006, U.S. exports of ferrocerium and other pyrophoric alloys decreased to 4,180 t valued at $11.0 million from 4,860 t valued at $18.0 million in 2005. Principal destinations, in descending order of quantity, were Germany, Canada, the United Kingdom, the Netherlands, and the United Arab Emirates.

In 2006, U.S. imports of compounds and alloys increased in quantity for four out of the seven categories listed in table 5. China dominated the import market, especially for mixed and individual rare-earth compounds, followed by Japan, France, Russia, and Austria (fig. 1). These five countries accounted for more than 99% of the domestic imports.

Imports of cerium compounds totaled 3,870 t valued at $10.8 million. The quantity of cerium compounds imported increased by 19% as a result of increased demand for automotive exhaust catalysts, and the value increased by 2%. China was the major supplier for the 11th consecutive year, followed by Japan, France, and Hong Kong.

Imports of yttrium compounds that contained between 19 and 85 weight-percent yttrium (yttrium concentrate) decreased by 25% to 279 t in 2006, and the value decreased by 33% to $2.3 million. China was the leading supplier of yttrium compounds, followed by Japan and France.

Imports of individual rare-earth compounds, traditionally the major share of rare-earth imports, increased by 24% compared with those of 2005. Rare-earth compound imports increased to 14,100 t valued at $66.3 million. The major sources of individual rare-earth compounds, in decreasing order by quantity, were China, Japan, France, Russia, and Austria.

Imports of mixtures of rare-earth oxides, other than cerium oxide, increased in quantity by 146% to 1,570 t from 640 t in 2005 and increased in value to about $8.7 million. The principal source of the mixed rare-earth oxides was China, with much smaller quantities imported from Italy, the United Kingdom, Austria, and Japan.

Imports of rare-earth metals and alloys into the United States totaled 723 t valued at about $6.3 million in 2006, a slight decrease in quantity compared with that of 2005. The value, however, increased by 30% from that of 2005. The principal rare-earth metal source was China, with much smaller amounts from Japan and the United Kingdom.

In 2006, imports of rare-earth chlorides increased by 3% to 5,980 t, but the value declined by 44% to $7.7 million. Supplies of rare-earth chloride, in descending order by quantity, came from China, with minor amounts from Hong Kong, Belgium, the United Kingdom, and Japan. In the United States, rare-earth chloride was used mainly as feed material for manufacturing fluid cracking catalysts.

Imports of ferrocerium and pyrophoric alloys decreased by 3% in quantity to 143 t valued at $2.1 million from 147 t valued at $2.0 million in 2005. Principal sources of these alloys, in descending order by quantity, were France, Austria, China, and Denmark.

World Review

Australia.—Lynas Corporation Ltd. announced that it had secured funding of A$75 million to develop its Mount Weld rare-earth deposit in Western Australia (Lynas Corporation Ltd., 2006a). The funding will be used to repay outstanding debt of $A5.6 million to Ashton Mining (WA) Pty. Ltd. and the balance to develop the Mount Weld Rare Earths Project. The company planned to mine 1 million metric tons per year (Mt/yr) of ore during a 35-year mine life. Processing of the ore was planned for Lynas' future plant near Zibo City in Shandong Province, China. Capital expenses at Mount Weld were estimated to be US$434 million, and annual operating expenses, US$438 million. Annual revenue for the operation was estimated to be US$546 million with an annual operating income of US$198 million.

On March 1, Lynas announced that it had signed an agreement with Rhodia Electronics and Catalysis of France to supply a significant share [40% by value of Lynas' planned production of 10,500 metric tons per year (t/yr)] of Rhodia's rare-earth requirements (Industrial Minerals, 2006). Rhodia's principal rare-earth solvent extraction (SX) separation plant is in La Rochelle, France. Lynas reported that it will also be a customer to Rhodia's Liyang SX plant in Jiangsu Province, China.

Reserves at Mount Weld are 6.2 million metric tons (Mt) grading 12.4% REO for a total content of 769,000 t of REO. Inferred resources are an additional 1.5 Mt grading 9.8% REO (Lynas Corporation Ltd., undated b). The total resource at Mount Weld was 7.7 Mt grading 11.9% REO, a contained rare-earth content of 917,000 t of REO.

A separate group of polymetallic ore bodies in the north and northeast region of the Mount Weld carbonatite, designated the Crown Polymetallic Project, contains additional mineral resources, including rare earths. The Crown deposit contains resources of 1.5 Mt of titanium oxide, 470,000 t of REO, 400,000 t of niobium oxide, 110,000 t of zirconium oxide, and 9,070 t of tantalum oxide. The Mount Weld Crown Polymetallic Project is the second ranked niobium deposit in the world behind the niobium deposit at Araxa, Brazil, and has an average grade of 1.07% niobium oxide (Lynas Corporation Ltd., undated a).

Australia remained one of the world's major potential sources of rare-earth elements from its alkaline intrusive deposits, heavy-mineral sands deposits, and rare-earth lateritic deposits. Monazite is a constituent in essentially all of Australia's heavy-mineral sands deposits. It is normally recovered and separated during processing but, in most cases, is either returned to tailings because of a lack of demand or stored for future sale.

Alkane Exploration Ltd. announced that it had received a grant of $A3.29 million to establish process optimization and construct and operate a pilot plant at its Dubbo Zirconia Project (DZP) in New South Wales (Alkane Exploration Ltd., 2006a).

The DZP ore body is located within a vertical alkaline igneous intrusive with surface dimensions of 900 meters (m) by 550 m. The majority of the resource drilling on DZP was done in 2001, and the top 100 m was drilled to fulfill the requirements of the Australasian Joint Ore Reserves Committee guidelines for publicly traded companies. Alkane reported that the ore body is open at depth. The total resources of DZP are 73.2 Mt and split evenly between measured and inferred with the measured reserves to 55 m (Alkane Exploration Ltd., 2006b). A feasibility study developed a mine plan for 200,000 t/yr of ore during a 400-year mine life. The initial plan was to mine three principal products—a range of zirconium products, a niobium-tantalum concentrate, and an yttrium-rare earth concentrate. Alkane expected about 50% of the DZP's revenue to come from the range of zirconium products, 40% to 45% from the niobium-tantalum concentrate, and 5% to 10% from the yttrium-rare earth concentrate.

Brazil.—Reserves of rare earths were 44,000 t contained in various types of deposits, including alkaline intrusives, carbonatites, fluvial or stream placers, lateritic ores, and marine placers. The reserves, comprising measured and indicated quantities of contained rare-earth in monazite, were distributed in deposits primarily in the States of Minas Gerais (11,730 t), Bahia (4,333 t), and Rio de Janeiro (1,874 t) (National Department of Mineral Production [Brazil], 2006, p. 76-77). Brazil produced 958 t of monazite in 2005 (Resende and Rodrigues dos Santos Cardoso, 2007).

Canada.—Development and drilling of several rare-earth deposits was ongoing in the Northwest Territories and Saskatchewan.

Avalon Ventures Ltd. continued to investigate its rare-metal peralkaline igneous intrusion at Thor Lake. Five zones of mineralization in the ring complex host beryllium, niobium, rare-earth elements including yttrium, tantalum, and zirconium. Rare-earth minerals at Thor Lake are allanite, bastnäsite, fergusonite, xenotime, and lesser amounts in monazite, parasite, and synchysite (Avalon Ventures Ltd., undated). Total indicated reserves are 1,136,000 t grading 0.71% REO, 0.48% beryllium oxide, and 0.53% niobium oxide.

Great Western Minerals Group Ltd. (GWMG) drilled 92 holes at its rare-earth deposit in Saskatchewan. The iron-oxide-copper-gold type deposit at Hoidas Lake continued to be developed and contained rare earths primarily in apatite and allanite, and lesser amounts in bastnäsite and chevkinite. GWMG reported measured reserves of 120,000 t grading 2.96% REO and indicated reserves of 430,000 t grading 2.76% REO. Total reserves were 570,000 t grading 2.71% REO. Rare-earth mineralization occurs in veins that parallel the Nisikkatch-Hoidas Lake fault (Billingsley, Pearson, and Halpin, 2008).

China.—Production of rare-earth concentrates in China was estimated to be 119,000 t of REOs in 2006, essentially unchanged from that of 2005 (table 6). China consumed 62,800 t of equivalent REO in a variety of applications in 2006, an increase from the 51,900 t consumed in 2005 (China Rare Earth Information, 2007c). Production of separated and smelted rare-earth products was 157,000 t in 2006, a significant disparity from the 119,000 t REO in rare-earth concentrates produced. Mine production was primarily from bastnäsite mined in Inner Mongolia and Sichuan Province, while ion adsorption ore was produced primarily in the southeastern Provinces of Jiangxi, Guangdong, and Fujian (Grauch and Mariano, 2008).

China exported 52,230 t of rare-earth compounds and metals in 2006, a slight increase from the 52,223 t in 2005. Prices for most compounds and metals, except for europium and yttrium oxide, increased. In 2006, China exported the following quantities of rare-earth metals: neodymium metal, 3,302 t; mischmetal for batteries, 1,015 t; and dysprosium metal, 46 t. Exports of rare-earth compounds were as follows: mixed rare-earth oxides, 39,458 t; cerium carbonate, 13,250 t; lanthanum oxide, 6,653 t; cerium oxide, 4,104 t; yttrium oxide, 2,555 t; rare-earth fluoride, 1,911 t; cerium hydroxide, 1,199 t; neodymium oxide, 925 t; and europium oxide, 62 t (Roskill's Letter from Japan, 2007c).

Production of NIB permanent magnets in China, based on finished products, was 40,900 t in 2006, and included 39,000 t of sintered magnets and 1,900 t of bonded magnets. China exported 11,248 t of NIB to 68 countries in 2006; principal destinations, in decreasing order of volume, were Hong Kong, the United States, Japan, and Singapore. Global production of sintered and bonded NIB magnets reached 55,540 t in 2006, with China producing 40,900 t (China Rare Earth Information, 2007b).

China's exports of battery-grade rare-earth hydrogen storage alloys for NiMH batteries decreased by 27% to 1,015 t in 2006 compared with 1,385 t in 2005. Exports of other rare-earth alloys increased by 11% to 7,328 t. Rare-earth oxide exports were essentially unchanged from those of 2005 at 39,458 t (China Rare Earth Information, 2007a).

Japan.—Rare earths were produced from imported ores and intermediate raw materials. Imports of refined rare-earth products were 41,964 t, a 35% increase from the 31,106 t imported in 2005. The value of imports increased to ¥43.070 billion in 2006 from a revised ¥24.426 billion in 2005. Japanese imports of refined rare-earth products increased for cerium compounds, cerium oxide, lanthanum oxide, rare-earth compounds, rare-earth metals, and yttrium oxide, and decreased for ferrocerium (Roskill's Letter from Japan, 2007b).

Japanese production of sintered NIB magnets in 2006 was 10,500 t, an increase from the 8,500 t produced in 2005 (China Rare Earth Information, 2007c). Magnet production consumed an estimated 6,580 t of neodymium metal and 210 t to 420 t of dysprosium metal (China Rare Earth Information, 2007c).

Japanese imports of rare earths in 2006, all from China, were as follows: cerium oxide, 11,489 t; rare-earth metals, 9,449 t; rare-earth compounds, 7,664 t; rare-earth concentrates; 7,664 t; lanthanum oxide, 2,141 t; yttrium oxide, 1,603 t; and ferrocerium, 548 t (Roskill's Letter from Japan, 2007e). China continued to be the leading source of rare-earth imports of refined and intermediate products for Japan with 45,000 t in 2006, an increase from the revised 27,017 t imported in 2005.

Japanese imports of rare-earth refined products in 2006 from China were 41,964 t, classified as follows: cerium oxide, 11,489 t; rare-earth metals, 9,450 t; cerium compounds (other than cerium oxide), 9,069 t; rare-earth compounds, 7,664 t; lanthanum oxide, 2,141 t; yttrium oxide, 1,603 t; and ferrocerium, 548 t (Roskill's Letter from Japan, 2007b).

Japan, the leading producer of rechargeable batteries in the world, produced 327 million units of rare-earth-containing NiMH batteries in 2006, an increase from the revised 303 million units produced in 2005 (Roskill's Letter from Japan, 2007d). In 2005, production of consumer electronics containing rare-earths was estimated to be 810,000 plasma televisions, 4.1 million LCD televisions, and 2.1 million DVDs and VCRs (Roskill's Letter from Japan, 2007a).

Malaysia.—Australian company Lynas Corporation Ltd. announced that had reassessed the proposed location of its rare-earth separation plant from its original site in China to a new location in Malaysia (Lynas Corporation Ltd., 2006b). The proposed site is located on the east coast of Malaysia at Kemaman, Terengganu. The separation plant would process rare-earth concentrate produced from Lynas' rare-earth deposit at Mount Weld. The advantages of the new location are a potential 10-year tax-free period (in process), an infrastructure with deepwater port facilities and existing utilities, a skilled labor force fluent in English and Mandarin, and the availability of chemical reagent manufacturers adjacent to the site.

Outlook

Rare-earth use in automotive pollution control catalysts, permanent magnets, and rechargeable batteries are expected to continue to increase as consumption for conventional and hybrid automobiles, computers, electronics, and portable equipment increases. Rare-earth markets are expected to require greater amounts of higher purity mixed and separated products to meet the demand. Strong demand for cerium and neodymium for use in automotive catalytic converters and catalysts for petroleum refining is expected to lead to increases in consumption of 6% to 8% per year for the next 5 years. Rare-earth magnet consumption is expected to increase by 10% to 16% per year through 2012, increasing to 45,000 to 50,000 t by 2012 (Kingsnorth, 2008). Future growth for rare earths is expected in rechargeable NiMH batteries, especially those used in hybrid vehicles, increasing to 10,000 to 20,000 t REO by 2012. NiMH consumption is also expected to increase (moderated by use of lithium-ion batteries) for use in portable equipment such as cell phones, laptop computers, portable DVD, CD, and MP3 players, and digital cameras and camcorders. Increased rare-earth use is expected in fiber optics, medical applications that include dental and surgical lasers, magnetic resonance imaging, medical contrast agents, medical isotopes, and positron emission tomography scintillation detectors. Future growth in the use of rare-earth alloys is projected for use in magnetic refrigeration (Gschneidner and Pecharsky, 2008).

World reserves are sufficient to meet forecast world consumption well into the next decade. Several very large rare-earth deposits in Australia and China have yet to be fully developed. Existing production is currently not sufficient to meet increases in world consumption, and shortages exist for neodymium and dysprosium for magnet alloys and europium and terbium for phosphors. Although the Mountain Pass deposit in the United States contains sufficient resources to meet domestic consumption for the light-group rare-earth elements for the next two decades, the deposit does not contain enough quantities of heavy-group rare-earth elements to meet existing or expected future consumption over this period.

Domestic companies have shifted away from using naturally occurring radioactive rare-earth ores. This trend has had a negative impact on monazite-containing mineral sands operations worldwide causing mine closures and reduced revenues. In the future, demand for monazite as an ore of rare earths is expected to increase because it will be more cost effective to recover owing to its abundance and availability as a low-cost byproduct during processing for zircon and titanium minerals. Thorium's use as a nonproliferative nuclear fuel is considered a likely substitute for uranium in the future, especially in a world concerned with the threat of nuclear terrorism. If consumption of thorium increases, monazite could resume its role as a major source of rare earths. Space requirements and permitting to dispose of radioactive waste products in the United States is expensive, severely limiting domestic use of low-cost monazite and other thorium-bearing rare-earth ores.

Rare-earth producers outside of China, accounting for less than 5% of the world's production, were expected to continue to struggle in competition with China's lower wages, inexpensive utilities, and less restrictive environmental and permitting requirements. China was expected to remain a major world rare-earth supplier. Increasing prices, export limits, increasing consumption within China, and a ban on new mining permits were expected to make rare-earth deposits outside of China more economic. Economic growth in several developing countries could provide new and potentially large markets in India, Southeast Asia, and Eastern Europe.

The long-term outlook appears to be for an increasingly competitive and diverse group of rare-earth suppliers. As research and technology continue to advance the knowledge of rare earths and their interactions with other elements, the economic base of the rare-earth industry is expected to broaden as new applications that use rare earths are commercialized. New applications are expected to continue to be discovered and developed, especially in areas that are considered essential, such as energy and defense.

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

		2002	2003	2004	2005	2006
Production of rare-earth concentrates, rare-earth oxide (REO) basis[e, 2]	metric tons	W	--	--	--	--
Exports, REO basis:						
Cerium compounds	do.	2,740	1,910	2,280	2,220	2,010
Rare-earth metals, scandium, yttrium	do.	1,300	730	1,010	636	611
Rare-earth compounds, organic or inorganic	do.	1,340	1,790	4,800	2,070	2,700
Ferrocerium and pyrophoric alloys	do.	2,830	2,880	3,720	4,320	3,710
Imports for consumption, REO basis:[e]						
Cerium compounds	do.	2,540	2,430	1,880	2,170	2,590
Ferrocerium and pyrophoric alloys	do.	89	102	105	130	127
Metals, alloys, oxides, other compounds	do.	11,600	14,100	15,300	13,000	16,000
Prices, yearend:						
Bastnäsite concentrate, REO basis[e]	dollars per kilogram	$5.51	$5.51	$5.51	$5.51	$5.51
Monazite concentrate, REO basis[e]	do.	$0.73	$0.73	$0.73	$0.73	$0.73
Mischmetal, metal basis	do.	$16.00 [3]	$10.00 [4]	$10.00 [4]	$10.00 [4]	$10.00 [4]

[e]Estimated. W Withheld to avoid disclosing company prorietary data. -- Zero.
[1]Data are rounded to no more than three significant digits.
[2]Includes only the rare earths derived from bastnäsite as obtained from Molycorp, Inc.
[3]Source: Elements, TradeTech, Denver, CO.
[4]Source: Hefa Rare Earths Canada Co. Ltd., Vancouver, British Columbia, Canada.

TABLE 2
RARE EARTH CONTENTS OF MAJOR AND POTENTIAL SOURCE MINERALS[1]

(Percentage of total rare-earth oxide)

Rare earth	Bastnäsite: Mountain Pass, CA, United States[2]	Bastnäsite: Bayan Obo, Inner Mongolia, China[3]	Monazite: North Capel, Western Australia, Australia[4]	Monazite: North Stradbroke Island, Queensland, Australia[5]	Monazite: Green Cove Springs, FL, United States[6]	Monazite: Nangang, Guangdong, China[7]
Cerium	49.10	50.00	46.00	45.80	43.70	42.70
Dysprosium	trace	0.1	0.7	0.60	0.9	0.8
Erbium	trace	trace	0.2	0.2	trace	0.3
Europium	0.1	0.2	0.053	0.8	0.16	0.1
Gadolinium	0.2	0.7	1.49	1.80	6.60	2.00
Holmium	trace	trace	0.053	0.1	0.11	0.12
Lanthanum	33.20	23.00	23.90	21.50	17.50	23.00
Lutetium	trace	trace	trace	0.01	trace	0.14
Neodymium	12.00	18.50	17.40	18.60	17.50	17.00
Praseodymium	4.34	6.20	5.00	5.30	5.00	4.10
Samarium	0.8	0.8	2.53	3.10	4.90	3.00
Terbium	trace	0.1	0.035	0.3	0.26	0.7
Thulium	trace	trace	trace	trace	trace	trace
Ytterbium	trace	trace	0.1	0.1	0.21	2.40
Yttrium	0.10	trace	2.40	2.50	3.20	2.40
Total	100	100	100	100	100	100

Rare earth	Monazite—Continued: Eastern coast, Brazil[8]	Monazite—Continued: Mount Weld, Western Australia, Australia[9]	Xenotime: Lahat, Perak, Malaysia[2]	Xenotime: Southeastern Guangdong, China[10]	Rare earth laterite: Xunwu, Jiangxi Province, China[11]	Rare earth laterite: Longnan, Jiangxi Province, China[11]
Cerium	47.00	51.00	3.13	3.00	2.40	0.4
Dysprosium	0.4	0.2	8.30	9.10	trace	6.70
Erbium	0.1	0.2	6.40	5.60	trace	4.90
Europium	0.1	0.4	trace	0.2	0.5	0.10
Gadolinium	1.00	1.00	3.50	5.00	3.00	6.90
Holmium	trace	0.1	2.00	2.60	trace	1.60
Lanthanum	24.00	26.00	1.24	1.20	43.4	1.82
Lutetium	not determined	trace	1.00	1.80	0.1	0.4
Neodymium	18.50	15.00	1.60	3.50	31.70	3.00
Praseodymium	4.50	4.00	0.5	0.6	9.00	0.7
Samarium	3.00	1.80	1.10	2.20	3.90	2.80
Terbium	0.1	0.1	0.9	1.20	trace	1.30
Thulium	trace	trace	1.10	1.30	trace	0.7
Ytterbium	0.02	0.1	6.80	6.00	0.3	2.50
Yttrium	1.40	trace	61.00	59.30	8.00	65.00
Total	100	100	100	100	100	100

[1]Data are rounded to no more than three significant digits; may not add to totals shown.
[2]Source: 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.
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[4]Source: Westralian Sands Ltd., 1979, Product specifications, effective January 1980: Capel, Australia, Westralian Sands Ltd. brochure, 8 p.
[5]Analysis from Consolidated Rutile Ltd.
[6]Analysis from RGC Minerals (USA), Green Cove Springs, FL.
[7]Source: 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.
[8]Source: Krumholz, Pavel, 1991, Brazilian practice for monazite treatment: Symposium on Rare Metals, Sendai, Japan, December 12-13, 1991, Proceedings p. 78-82.
[9]Source: 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, Lynas Gold NL, 8 p.
[10]Source: Nakamura, Shigeo, 1988, China and rare metals—Rare earth: Industrial Rare Metals, no. 94, May, p. 23-28.
[11]Source: Introduction to Jiangxi rare-earths and applied products, 1985, Jiangxi Province brochure, 42 p.

TABLE 3
RARE-EARTH OXIDE PRICES IN 2006

Product (oxide)	Purity (percentage)	Standard package quantity (kilograms)	Price (dollars per kilogram)
Cerium	96.00	20	40.00
Do.	99.50	20	45.00
Dysprosium	99.00	20	150.00
Erbium	96.00	20	160.00
Europium	99.99	20	1,000.00
Gadolinium	99.99	20	140.00
Holmium	99.90	10	650.00
Lanthanum	99.99	20	30.00
Lutetium	99.99	1 or 10	3,500.00
Neodymium	95.00	20	45.00
Praseodymium	96.00	20	50.00
Samarium	99.90	20	250.00
Do.	99.99	20	400.00
Scandium	99.99	NA	NA
Terbium	99.99	20	800.00
Thulium	99.90	5	2,500.00
Ytterbium	99.00	10	400.00
Yttrium	99.99	20	50.00

NA Not available.

Source: Rhodia Electronics & Catalysis, Inc.

TABLE 4

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

Category[2] and country	2005 Gross weight (kilograms)	2005 Value	2006 Gross weight (kilograms)	2006 Value
Cerium compounds (2846.10.0000):				
Australia	--	--	20	$7,040
Austria	104,000	$633,000	139,000	739,000
Belgium	2,400	23,600	2,400	25,200
Brazil	123,000	661,000	78,700	419,000
Canada	22,900	263,000	8,790	105,000
China	78,600	582,000	26,900	365,000
Egypt	378,000	1,700,000	270,000	1,220,000
France	41,700	248,000	35,100	274,000
Germany	98,700	494,000	56,200	289,000
Hong Kong	92,100	793,000	58,300	657,000
India	508,000	2,690,000	580,000	3,050,000
Japan	165,000	1,410,000	144,000	1,060,000
Korea, Republic of	197,000	594,000	19,100	76,700
Malaysia	55,800	199,000	--	--
Mexico	1,410,000	964,000	178,000	739,000
Netherlands	13,900	164,000	92,100	398,000
Singapore	4,290	26,900	13,700	99,000
Taiwan	17,800	141,000	19,100	156,000
United Kingdom	54,100	582,000	14,700	200,000
Other	116,000	1,390,000	269,000	9,960,000
Total	2,220,000	13,600,000	2,010,000	19,800,000
Total estimated equivalent rare-earth oxide (REO) content	2,220,000	13,600,000	2,010,000	19,800,000
Rare-earth compounds[3] (2846.90.0000):				
Argentina	17,600	117,000	3,220	17,600
Austria	--	--	4,640	78,000
Brazil	51,100	363,000	100,000	1,080,000
Canada	266,000	719,000	428,000	1,080,000
China	273,000	1,170,000	125,000	1,350,000
Colombia	3,730	56,100	--	--
Estonia	846,000	406,000	1,310,000	577,000
France	47,900	1,190,000	43,500	732,000
Germany	20,400	497,000	5,320	152,000
Guatemala	63,900	30,900	600	24,000
Hong Kong	28,900	818,000	5,490	66,800
India	6,160	37,000	6,910	45,900
Italy	2,720	24,500	38,600	140,000
Japan	28,400	5,740,000	59,900	7,580,000
Korea, Republic of	63,200	508,000	117,000	1,690,000
Mexico	20,400	146,000	108,000	869,000
Netherlands	570	22,900	20,700	218,000
Poland	21,300	439,000	2,500	34,000
Singapore	523	71,600	12,000	114,000
Taiwan	30,400	712,000	14,300	345,000
United Kingdom	184,000	643,000	126,000	385,000
Other	92,900	389,000	169,000	681,000
Total	2,070,000	14,100,000	2,700,000	17,300,000
Total estimated equivalent REO content	2,070,000	14,100,000	2,700,000	17,300,000

See footnotes at end of table.

TABLE 4—Continued

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

Category[2] and country	2005 Gross weight (kilograms)	2005 Value	2006 Gross weight (kilograms)	2006 Value
Rare-earth metals, including scandium and yttrium (2805.30.0000):				
Belgium	750	$29,300	2,010	$99,800
Brazil	300	10,800	--	--
China	24,700	340,000	19,100	123,000
Germany	5,970	326,000	6,990	544,000
Hong Kong	660	17,300	--	--
India	1,790	87,300	4,450	204,000
Indonesia	17,200	26,700		
Japan	475,000	3,910,000	569,000	5,380,000
Mexico	1,660	70,100	875	51,900
Switzerland	305	69,600	17	14,000
Taiwan	955	67,600	--	--
Other	485	224,000	8,590	536,000
Total	530,000	5,180,000	611,000	6,960,000
Total estimated equivalent REO content	636,000	5,180,000	733,000	6,960,000
Ferrocerium and other pyrophoric alloys (3606.90.0000):				
Argentina	24,600	$37,700	43,600	$65,800
Australia	19,600	2,630,000	12,600	997,000
Bahrain	36,600	38,300	23,900	26,100
Canada	762,000	1,950,000	827,000	2,010,000
Cyprus	18,300	21,100	17,200	26,600
Egypt	105,000	104,000	140,000	154,000
France	115,000	474,000	78,100	201,000
Germany	1,510,000	2,080,000	1,430,000	2,020,000
Greece	52,000	113,000	57,500	99,300
Hong Kong	144,000	624,000	142,000	483,000
Israel	68,000	73,300	98,800	112,000
Japan	135,000	4,830,000	24,900	571,000
Jordan	60,800	60,100	18,100	18,500
Korea, Republic of	35,200	605,000	91,400	1,190,000
Kuwait	166,000	150,000	--	--
Mexico	23,900	146,000	34,600	146,000
Morocco	24,600	23,500	39,400	40,500
Netherlands	585,000	1,870,000	303,000	1,080,000
New Zealand	24,700	40,700	--	--
Portugal	21,500	42,500	--	--
Russia	46,200	73,300	81,800	119,000
Saudi Arabia	306,000	518,000	45,000	70,600
Singapore	7,560	90,000	2,470	80,200
Taiwan	8,840	60,600	308	88,700
Thailand	22,900	116,000	--	--
United Arab Emirates	195,000	223,000	218,000	283,000
United Kingdom	301,000	613,000	310,000	620,000
Other	32,000	422,000	144,000	524,000
Total	4,860,000	10,000,000	4,180,000	11,000,000
Total estimated equivalent REO content	4,320,000	18,000,000	3,710,000	11,000,000

[r]Revised. -- 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]

	2005		2006	
Category[2] and country	Gross weight (kilograms)	Value	Gross weight (kilograms)	Value
Cerium compounds, including oxides, hydroxides, nitrates, sulfate chlorides, oxalates (2846.10.0000):				
Austria	18,300	$188,000	36,400	$235,000
China	2,840,000	4,890,000	3,540,000	6,350,000
France	83,700	1,000,000	73,600	884,000
Hong Kong	36,000	77,500	64,000	127,000
Ireland	13,900	350,000	--	--
Japan	211,000	3,850,000	135,000	3,090,000
Korea, Republic of	25,900	59,500	2,760	26,700
Netherlands	449	13,400	--	--
United Kingdom	17,200	175,000	159	20,700
Other	1,220	11,100	10,700	86,800
Total	3,250,000	10,600,000	3,870,000	10,800,000
Total estimated equivalent rare-earth oxide (REO) content	2,170,000	10,600,000	2,590,000	10,800,000
Yttrium compounds content by weight greater than 19% but less than 85% oxide equivalent (2846.90.4000):				
China	360,000	1,630,000	273,000	1,090,000
France	535	33,800	420	26,000
Japan	11,600	1,800,000	5,850	1,180,000
Other	140	26,000	34	30,000
Total	372,000	3,480,000	279,000	2,320,000
Total estimated equivalent REO content	223,000	3,480,000	168,000	2,320,000
Rare-earth compounds, including oxides, hydroxides, nitrates, other compounds except chlorides (2846.90.8000):				
Austria	126,000	5,460,000	85,200	3,510,000
Canada	18,000	58,200	76	36,800
China	9,430,000	25,500,000	12,500,000	37,100,000
Estonia	76,000	80,000	--	--
France	518,000	9,290,000	618,000	11,700,000
Germany	8,000	521,000	551	145,000
Hong Kong	400	104,000	37,000	257,000
Japan	695,000	12,200,000	685,000	11,800,000
Russia	377,000	680,000	145,000	721,000
South Africa	10,600	63,600	--	--
United Kingdom	147,000	5,540,000	5,780	749,000
Other	366	92,300	600	213,000
Total	11,400,000	59,600,000	14,100,000	66,300,000
Total estimated equivalent REO content	8,550,000	59,600,000	10,600,000	66,300,000
Mixtures of REOs except cerium oxide (2846.90.2010):				
Austria	7,760	157,000	9,320	154,000
China	578,000	1,960,000	1,520,000	4,340,000
Germany	3,380	448,000	407	14,900
Ireland	1,270	141,000	--	--
Italy	34,500	3,720,000	30,800	4,110,000
Japan	3,540	140,000	6,480	60,700
Russia	51	10,800	46	17,000
United Kingdom	10,100	43,600	10,300	47,400
Other	1,780	103,000	--	--
Total	640,000	6,320,000	1,570,000	8,740,000
Total estimated equivalent REO content	640,000	6,320,000	1,570,000	8,740,000

See footnotes at end of table.

TABLE 5—Continued

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

Category[2] and country	2005 Gross weight (kilograms)	2005 Value	2006 Gross weight (kilograms)	2006 Value
Rare-earth metals, whether intermixed or alloyed (2805.30.0000):				
Austria	28,500	$1,530,000	159	$29,800
China	664,000	2,880,000	672,000	4,700,000
Germany	62	3,560	3	6,610
Japan	31,100	206,000	30,900	701,000
Russia	979	117,000	402	56,900
United Kingdom	7,660	164,000	19,100	434,000
Other	600	2,390	221	51,700
Total	733,000	4,900,000	723,000	5,980,000
Total estimated equivalent REO content	880,000	4,900,000	867,000	5,980,000
Mixtures of rare-earth chlorides, except cerium chloride (2846.90.2050):				
Belgium	10,000	26,200	10,000	26,200
China	5,760,000	6,420,000	5,950,000	7,030,000
Germany	138	92,700	425	157,000
Japan	22,700	6,990,000	3,410	132,000
Mexico	960	28,800	80	2,640
Russia	54	98,700	87	122,000
United Kingdom	13,600	92,300	6,840	61,200
Other	19	17,800	10,000	134,000
Total	5,810,000	13,800,000	5,980,000	7,670,000
Total estimated equivalent REO content	2,670,000	6,330,000	2,750,000	7,670,000
Ferrocerium and other pyrophoric alloys (3606.90.3000):				
Austria	14,300	289,000	16,100	405,000
China	12,300	86,100	3,350	37,900
France	119,000	1,640,000	120,000	1,650,000
South Africa	522	23,100	--	--
Other	392	7,520	3,210	21,900
Total	147,000	2,050,000	143,000	2,110,000
Total estimated equivalent REO content	130,000	2,050,000	127,000	2,110,000

-- 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]	2002		2004	2005	2006
Brazil	--	--	731 [r, 4]	730 [r, 4]	730
China	88,000	92,000	98,000	119,000	119,000
Commonwealth of Independent States	-- [r]	-- [r]	-- [r]	-- [r]	--
India	2,700	2,700	2,700	2,700	2,700
Kyrgyzstan:					
Compounds	NA	NA	NA	NA	NA
Metals	100	NA	NA	NA	NA
Other	2,000	2,000	NA	NA	NA
Malaysia	240	360	800	150 [r]	200
United States[5]	W	--	--	--	--
Total	93,000	97,100 [r]	102,000 [r]	123,000 [r]	123,000

See footnotes at end of table.

TABLE 6—Continued

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

[r]Revised. NA Not available. W Withheld to avoid disclosing company proprietary data; not included in "Total." -- Zero.

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

[2]Table includes data available through June 8, 2007.

[3]In addition to the countries listed, Indonesia, Kazakhstan, Nigeria, North Korea, Russia, and Vietnam are believed to produce rare-earth minerals, but information is inadequate for formulation of reliable estimates of output levels.

[4]Reported figure.

[5]Comprises only the rare earths derived from bastnäsite.

TABLE 7

MONAZITE CONCENTRATE: ESTIMATED WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons, gross weight)

Country[3]	2002	2003	2004	2005	2006
Brazil	--	--	731 [4]	800	800
India	5,000	5,000	5,000	5,000	5,000
Malaysia	441 [4]	795 [4]	1,683 [4]	320 [r]	700
Total	5,440	5,800	7,410	6,120 [r]	6,500

[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]Table includes data available through April 18, 2007.

[3]In addition to the countries listed, China, Indonesia, Nigeria, North Korea, the Republic of Korea, and countries of the Commonwealth of Independent States may produce monazite; available general information is inadequate for formulation of reliable estimates of output levels.

[4]Reported figure.

FIGURE 1

TOP FIVE SOURCES, BY WEIGHT, OF U.S. IMPORTS OF RARE EARTHS IN 2006