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RARE EARTHS [ADVANCE RELEASE]

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Rare Earths

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In 2009, world rare-earth production was primarily from the mineral bastnäsite. Rare earths were not mined in the United States in 2009. Rare-earth ores were primarily mined by China, with smaller amounts mined in India, Brazil, and Malaysia, listed in order of decreasing production. Throughout 2009, processing of intermediate rare-earth concentrates took place at the Mountain Pass Mine in California.

Domestic use of scandium decreased in 2009 and overall consumption 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.

Based on import data from the Port Import Export Reporting Service (PIERS) database of Commonwealth Business Media, Inc. (undated), domestic yttrium consumption decreased by 8.8% in 2009 compared with that of 2008. Yttrium was used primarily in fluorescent lamp and cathode-ray tube (CRT) 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 lanthanoids, 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 (REE), 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 lanthanoids (sometimes referred to as 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.

Rare earths can be classified as either light rare-earth elements (LREE) or heavy rare-earth elements (HREE). This division between 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 lanthanoid LREE having unpaired electrons in the 4f electron shell and HREE having paired electrons in the 4f electron shell. Gadolinium has a very stable one-half filled 4f electron shell with seven unpaired electrons. Proceeding with terbium and continuing along the series through lutetium, paired electrons are progressively added to the 4f electron shell for each respective element in the HREE lanthanoid series until there is a full complement of 14 electrons in the 4f electron shell of lutetium. The division between LREE and HREE lanthanoids falls between gadolinium and terbium. Yttrium is included as a HREE even though it is not part of the lanthanoid contraction 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. It is represented by the chemical symbol Sc and has one naturally occurring isotope. 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 often occurs in the same minerals as a result of its similar ionic radius. Its atomic radius of 104 picometers in the trivalent state places it in relative size between the ionic radii of holmium and erbium (104.1 and 103, respectively). It is included as one of the HREE. It is represented by the chemical symbol Y and has one naturally occurring isotope. 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 are used in a wide variety of applications. The principal economic ores of the rare earths are the minerals bastnäsite, loparite, and monazite and the lateritic ion-adsorption clays (table 2).

Production

In 2009, the Mountain Pass operation of Molycorp Mining LLC (formerly Molycorp Minerals LLC) remained open, although rare earths were not actively mined. The company processed holdings of lanthanum-rich feedstock contained on site. Production was in the form of lanthanum-rich hydrates and neodymium-praseodymium oxides, which are precipitated as carbonates and then oxalates and finally calcined to oxide form.

Two companies processed intermediate rare-earth compounds to lanthanides in 2009. Grace Davison (a subsidiary of W.R. Grace & Co.) processed intermediate rare-earth compounds to produce cerium- and lanthanum-rich compounds used in making fluid-cracking catalysts for the petroleum refining industry. The company also processed zirconia-stabilized ceria compounds for supports for automotive catalysts, fluid catalytic cracking additives, and oxidation of organic compounds in wastewater, and produced several grades of Vitrox and Rareox cerium oxide polishing compounds. Grace Davison's Refining Technologies operating segment's sales were down 26% from those of the prior year quarter (Grace News, 2010). Sales of catalysts and chemical additives were unfavorably affected by the deconsolidation of the Advanced Refining Technologies (ART) LLC joint venture and lower sales volumes, but partly offset by improved pricing in fluid catalytic cracking (FCC) catalysts and additives. Reported sales of this product group include $17.8 million related to the ART joint venture in the fourth quarter of 2009 and $77.3 million in the prior year fourth quarter.

Santoku America, Inc. (a subsidiary of Santoku Corporation of Japan) produced rare-earth metals and magnet alloys at its operations in Tolleson, AZ. Santoku America produced two types of alloys used in high-strength permanent magnets—neodymium-iron-boron (NIB) and samarium-cobalt (SmCo)—and was the sole domestic producer of NIB magnet alloys. 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 only U.S. producer of rare-earth permanent magnets was Electron Energy Corp. (EEC) of Landisville, PA. EEC produced SmCo permanent magnets and designed and manufactured magnet assemblies, including actuators, Halbach arrays (magnetic field focusing assemblies), high-speed rotors, and other components.

One U.S. scandium processor operated in 2009. Aldrich-APL, LLC in Urbana, IL, purified and processed imported oxides to produce high-purity scandium compounds, including anhydrous and hydrous chloride, fluoride, iodide, and oxide. The company also produced high-purity scandium metal. High-purity products were available in various grades, with scandium oxide having up to 99.999% purity.

Boulder Scientific Co., another processor, had scandium facilities on standby at its Mead, CO, operations. Boulder Scientific previously refined scandium primarily from imported oxides and domestic ores to produce high-purity scandium compounds, including carbide, chloride, diboride, fluoride, hydride, nitride, oxalate, and tungstate.

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

Rare Element Resources Bear Lodge (Wyoming) is a large alkaline-igneous complex of disseminated LREE. Rare Element has continued exploring the Bull Hill carbonatite deposit with drill-hole information obtained from 2004 to 2009. Metallurgical test work has been conducted and an effort is ongoing to upgrade the National Instrument N.I. 43–101-compliant resource of the rare-earth elements deposits. The principal rare earth containing deposit is comprised of carbonatite bodies composed of unweathered sovite or silicocarbonatite dikes approximately 15 meters (m) wide cross cut by altered oxidized rare-earth-bearing iron-manganese (FMR) veins and dikes. The main rare-earth-bearing minerals are ancylite, $Sr(REE)(CO_3)_2(OH)(H_2O)$, and bastnaesite, $(REE)CO_3(F,OH)$. A N.I. 43–101-compliant inferred mineral resource reportedly was estimated for the Bull Hill Southwest deposit using a cutoff grade of 1.5%. This estimate totaled 9.8 million metric tons (Mt) averaging 4.1% total rare-earth oxides (TREO) (Rare Element Resources Ltd., 2009).

In previous U.S. Geological Survey Minerals Yearbook chapters, resources in other States are described. Information on reserves and deposits in Alaska and Utah is published in the 2008 Rare Earths chapter of the U.S. Geological Survey Minerals Yearbook, volume I, Metals and Minerals, and information on reserves and deposits in Colorado, Idaho, Montana, Missouri, and Wyoming is published in the U.S. Geological Survey Minerals Yearbook 2007 Rare Earths chapter.

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 was not calculated in 2009 because data were withheld to avoid disclosing company proprietary data.

In 2009, yttrium consumption was estimated to have decreased to 448 metric tons (t) from 616 t in 2008. Yttrium information was based on data retrieved from the Port Import Export Reporting Service database. Yttrium compounds and metal were imported from the following sources in 2009: China (90%), Austria (4%), Japan (3%), and Belgium (3%). The estimated use of yttrium, based on imports, was primarily in fluorescent lamp and CRT phosphors, ceramics, and specialty alloys, with a minor amount for metal casting (Commonwealth Business Media, Inc., undated).

Stocks

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 result in the inclusion of rare earths, including scandium and yttrium, in the NDS at a future date.

Prices

The prices of most rare-earth materials, as provided by Rhodia Group of France quoted rare-earth oxide (REO) prices, net 30 days, free on board New Brunswick, NJ, or duty paid at point of entry, in effect at yearend 2009, were lower or the same in 2009 compared with those of 2008 (table 3). All rare-earth prices remained nominal and subject to change without notice. The competitive pricing policies that are in effect for the industry result in most rare-earth product prices being quoted on a daily basis from the producers and processors. Domestic prices were higher than Chinese prices because of shipping costs related to its classification as a pyrophoric hazardous material. Prices for monazite remained depressed from their historical levels because the principal international rare-earth processors continued to process only thorium-free feed materials.

In 2009, Rhodia provided prices for scandium in the years of 2008 and 2009. Prices in 2009 were lower for the high-purity oxides and mid- to ultrahigh-purity oxides than the prices for those materials in 2008.

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

In the following discussion, where necessary, values have been converted from the Chinese Yuan Renminbi to U.S. dollars at exchange rates for the date of posting of each reference cited concerning those nominal values.

With the founding of Inner Mongolia Baogang Rare Earth International Trading Co., Ltd. in December 2008, pricing of rare-earth raw material began to stabilize in Northern China. In 2008 the global rare-earth market was stagnant, and many Chinese rare-earth enterprises did not operate at full production in the first half of 2009, which led to a low supply of yttrium-medium and europium-rich minerals in southern China. However, the market rebounded in the second half of 2009. Price of yttrium and europium minerals increased from a range of $5,700 to $6,300 per metric ton at the beginning of the year to $9,500 to $9,700 per ton at yearend in 2009, an annual growth rate of 70% (China Rare Earth Information, 2010a).

Owing to low demand in 2008 in the automobile sector, demand for neodymium iron boron (NdFeB) magnets decreased in the United States and Europe. In 2009, demand for NdFeB permanent rare-earth magnets began to recover and prices of rare earths increased. The highest price of didymium (a mixture of the elements praseodymium and neodymium) oxide in 2009 was $17,600 per ton, an increase of 150% more than the yearend price of 2008, but was still 30% lower than the highest price of 2008. Price of didymium mischmetal also increased from $11,700 per ton at the beginning of 2009 to $23,500 per ton, a growth rate of 100%. The price of cerium oxide kept rising in 2009, from a range of $1,600 to $1,800 per ton at the beginning of the year to $2,900 per ton in December, an increase of 80%. Demand for other cerium related products such as cerium chloride, remained stable, but prices for those products increased. In 2009, the price of lanthanum oxide decreased from a range of $4,000 to $4,400 per ton at the beginning of 2009 to $3,100 to $3,200 per ton through June, a decrease of 30%, but then recovered to a price range of $4,100 to $4,400 per ton by yearend, still below year-average prices of 2008 (China Rare Earth Information, 2010a).

Rare-earth carbonate was in short supply and began to increase in price significantly during the second half of 2009. After the first half of 2009, the price of yttrium and europium minerals increased from a range of $6,300 to $7,900 per ton to $7,800 to $8,700 per ton. From January to December 2009, prices of neodymium oxide, didymium oxide, neodymium metal, and didymium metal increased from $10,000 to 19,800 per ton (98%), $8,500 to $18,400 per ton (116%), $13,600 to $25,000 per ton (84%), and $12,000 to $24,200 per ton (101%), respectively (China Rare Earth Information, 2010d).

Foreign Trade

U.S. exports of rare earths increased and imports decreased with regard to quantity in 2009 compared with those of 2008. 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 8,746 t valued at $58 million, approximately a 6% increase in quantity and a 3% decrease in value compared with those of 2008 (table 4). Imports totaled 15,000 t, gross weight, valued at $113 million, an almost 28% decrease in quantity and a 39% decrease in value compared with those of 2008 (table 5).

In 2009, U.S. exports of rare earths decreased in quantity in three out of four trade categories. The United States exported 4,100 t of rare-earth metals valued at $15.7 million, a 255% increase in quantity and a 15% decrease in value compared with that of 2008. Exports of cerium compounds, primarily for glass polishing and automotive catalytic converters, decreased in quantity by 39% to 840 t and decreased in value by 34% to $8 million.

Exports of inorganic and organic rare-earth compounds decreased by 31% to 455 t in 2009 from 663 t in 2008, and the value of the shipments decreased by 18% to $6.2 million from $7.6 million.

U.S. exports of ferrocerium and other pyrophoric alloys decreased by 34% to 3,350 t valued at $28 million in 2009 from 5,050 t valued at $21.2 million in 2008.

Mischmetal and specialty mischmetals comprised most of the U.S. rare-earth metal imports. (Mischmetal is a natural mixture of rare-earth metals typically produced by metallothermic reduction of a mixed rare-earth chloride).

In 2009, U.S. imports of compounds and alloys decreased in quantity for six out of the seven categories listed in table 5. China dominated the import market, especially for mixed and individual rare-earth compounds, except for the category of ferrocerium and other pyrophoric alloys, where France dominated. In decreasing order of import quantity, the leading supply countries were China, France, Austria, and Japan. These five countries accounted for 95% of the domestic imports.

Imports of cerium compounds totaled 2,200 t valued at $9.1 million. The quantity of cerium compounds imported decreased by 28% as a result of a decreasing demand for automotive exhaust catalysts, and the value decreased by 29%. China was the major supplier for the 14th consecutive year, followed by Austria, Japan, the United Kingdom, and France.

Imports of yttrium compounds that contained between 19 and 85 weight-percent yttrium (yttrium concentrate) decreased by 30% to 11.5 t in 2009, and the value decreased by 92% to $565,000. 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, decreased by 42% compared with those of 2008. Rare-earth compound imports decreased to 6,800 t valued at $67.5 million, a decrease in value of 43%. The major sources of individual rare-earth compounds, in decreasing order by quantity, were China, France, Japan, Austria, South Africa, and Germany.

In 2009, imports of mixtures of REOs, other than cerium oxide, increased in quantity by 98% to 4,750 t in 2009 from 2,390 t in 2008, and increased in value 4% to $23.5 million. The principal source of the mixed REOs was China, with much smaller quantities, in decreasing order of tonnage, imported from Italy, Japan, and Germany.

Imports of rare-earth metals and alloys into the United States totaled 188 t valued at about $4.9 million in 2009, a 67% decrease in quantity compared with that of 2008. The value also decreased slightly from that of the previous year. The principal rare-earth metal source was China, with much smaller amounts, in decreasing order of tonnage, from Japan, the United Kingdom, Russia, and Austria.

In 2009, imports of rare-earth chlorides decreased by 69% to 894 t, and the value decreased by 72% to $4.9 million. Supplies of rare-earth chloride, in descending order by quantity, came from China, with minor amounts from Japan, the United Kingdom, and others. 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 19% in quantity to 114 t, with a 10% increase in value at $2.6 million from 141 t valued at $2.4 million in 2008. Principal sources of these alloys were, in descending order by quantity, France, Austria, and China.

World Review

Supply of cerium oxide was restricted in the market, driven by a stable demand in the glass industry; China's centralized sales of Baogang Rare Earth International Trading Co., Ltd.'s products from major separation plants in northern China; and reduced supply of rare-earth products by the separation plants. In the first half of 2009, China reduced the price of crude oil, which led to a decrease in demand for lanthanum oxide used in fluid catalytic cracking by the petroleum industry. Outside of China, however, the petroleum refinery industry began to replenish stock inventories, which resulted in an increase in demand. Early in 2009, there was a reduction in the demand for phosphor yttrium and europium products that increased slightly by the yearend (China Rare Earth Information, 2010a).

Australia.—Arafura Resources Ltd. and the Jiangsu Eastern China Non-Ferrous Metals Investment Holding Company signed an equity investment agreement delivering Jiangsu [a subsidiary of the East China Exploration and Development Bureau (ECE)], up to a 25% interest in Arafura. The proceeds from the ECE investment were to be used for developing the company's Nolans Rare Earths-Phosphate-Uranium Project in the Northern Territory (Arafura Resources Ltd., 2009).

West Australian Alkane Resources Ltd. reported a measured resource of 37.5 Mt and an inferred resource totaling 73.2 Mt grading 0.14% yttrium oxide, and 0.75% REO. Also, Dubbo Zirconia Project in New South Wales recently produced its first rare-earth and yttrium-heavy rare-earth products from the demonstration pilot plant at Lucas Heights, located south of Sydney. The planned open pit resource was expected to have a mine life of up to 200 years, with alternative plans for a mining rate of 200,000 or 500,000 metric tons per year (t/yr) yielding 1,300 t/yr or 3200 t/yr of TREO, respectively (Alkane Resources Ltd., 2009).

Lynas Corporation Ltd., owner of the Mount Weld rare-earth deposit near Laverton in Western Australia, signed a binding heads agreement with China Nonferrous Metal Mining (Group) Company Ltd. (CNMC) in May 2009 for provision of a multimillion dollar investment to renew construction and commissioning of its mine in Australia and processing plant in Malaysia. Lynas Malaysia Sdn Bhd (a subsidiary of Lynas Corp.) also had an advanced materials plant for processing the mine concentrates from Mount Weld under construction in the Gebeng Industrial Estate in Kuantan, Pahang, Malaysia. In September 2009, CNMC terminated the deal after Australia's Foreign Investment Review Board (FIRB) insisted on reducing CNMC's proposed stake in Lynas from 51.6% to less than 50% and reducing its Board positions to less than one-half. Lynas renewed the search for fresh sources of funding for the mine and processing plant, which has been on care-and-maintenance status since February (West Australian, The, 2009).

At Jervois Mining Ltd.'s (Melbourne) The Gilgai resource, 25 kilometers (km) from Nyngan, which is about 160 km northwest of Dubbo, New South Wales, a total measured plus indicated scandium resource at the Nyngan deposit was reported to be about 12,000,000 t of ore with a grade of 261 ppm scandium. The deposit was considered minable via open pit method, with the capacity of producing 30 t/yr of 99.9% scandium oxide. The proposed open mine pit and treatment facility would be positioned on land owned by Jervois (Jervois Mining Ltd., 2009).

Canada.—Matamec Explorations Inc. completed the 2009 drilling campaign on the heavy rare-earth-yttrium-zirconium Kipawa deposit located on the Zeus property in the Kipawa Alkaline Complex in Temiscamingue, Quebec. The deposit occurred across most of the Kipawa Alkaline complex, which was hosted in a peralkaline syenite and granite about 200 m thick. Metamec acquired deposit holdings of its present size of 259 claim cells in April 2009. At Kipawa, mineralization is contained in three main minerals in decreasing order of rare earth abundance: eudialyte, britholite, and zircon, which is a mineralogy similar to other major deposits not currently in production, such as the Lovozero and Khibiny loparite massifs of Russia, the Ilimaussaq intrusion located in east Greenland, and the Parajito Mountain deposit of New Mexico. Historical resources calculated by Unocal in 1991 were estimated to be 1.26 Mt at grades of 0.15% yttrium oxide in the west zone, and 1.009 Mt at 0.14% Y_2O_3 and 1.01 Mt at a grade of 0.14% Y_2O_3 in the east zone.

China.—Mine production of REE was primarily from bastnäsite and other rare-earth minerals in Inner Mongolia and Sichuan Province, and from ion adsorption ore in the southeastern Provinces of Fujian, Guangdong, and Jiangxi (Grauch and Mariano, 2008).

About one-third of all rare earths produced in China were consumed by the iron and steel industries. Principal products were rare-earth-ferrosilicon (rare-earth-silicide) and rare-earth-magnesium-ferrosilicon.

In December 2008, the first batch of export quotas was released for 2009 and was set at 15,000 t granted to 20 enterprises that met application conditions based on export performances between 2006 and 2008 (China Rare Earth Information, 2009a). On June 29, 2009, in accordance with regulations on import and export of mineral commodities, the Ministry of Commerce released the second batch of rare-earth export quotas of 16,300 t of rare-earth minerals (China Rare Earth Information, 2009b).

By comparison, in 2008, the rare-earth export quota was 22,780 t in the first tranche (half-year quantity) and 11,376 t in the second tranche. It totaled 34,156 t in 2008. In 2009, the total export quota for common trade was 33,300 t, including 15,043 t in the first tranche, and 16,267 t in the second tranche along with 1,990 t of supplemented quotas. The quota decreased by 856 t in 2009, which was a decrease of 3% (China Rare Earth Information, 2010b).

Chinese exports of rare-earth metals to Japan fell sharply in 2008. Exports of neodymium oxide decreased in 2009 by 21%. Exports of terbium dropped by 74% to as low as 2.48 t and exports of dysprosium almost ceased. Chinese exports of other ferroalloys to Japan increased by 32% to 25,000 t in 2008 (Roskill's Letters from Japan, 2009d).

The Chinese Government also issued production quotas for rare earths in 2009. The light rare-earths quota was 72,300 t REO equivalents. The medium and heavy rare-earths quotas were 10,020 t REO equivalents. The total 2009 quota was 82,320 t REO (Roskill's Letters from Japan, 2009d).

China Rare Earth Holdings Limited announced a joint venture with OSRAM of Siemens in October 2009 to research, develop, and produce trichromatic phosphors with a capacity of up to 2,000 t upon completion of operations (China Rare Earth Information, 2009c).

In the Chinese domestic market, rare-earth consumption in the steel industry increased to 10,400 t, comprising 15.3% of China's total rare-earth consumption in 2008. To place this in perspective, in 2008, the total amount of rare-earth treated steel that was produced was nearly 1.65 Mt. Private enterprises produced 750,000 t, representing 45.4%, the balance produced by state-owned steel plants in China (China Rare Earth Information, 2010c).

In 2009, Inner Mongolia Baotou Steel Rare Earth (RE) International Trade Company began formal business operations with the implementation of a centralized purchase and marketing strategy for rare-earth oxides and metals produced in Baotou. Baogang Group (Inner Mongolia region-based Chinese steelmaker Baotou Iron and Steel), the largest iron and steel production center in China, began large volume export of steel rail to the Americas in 2009. Production of steel in Baogang was 10 Mt in 2009. Export of 59,000 t of 115 RE rail steel produced in 2009 was shipped to North America and South America (China Rare Earth Information, 2010e).

The Chinese domestic market had strong demand for permanent rare-earth magnets in 2009. Production and consumption in this sector were 55,000 t and 23,000 t, which were increases of 13% and 14%, respectively, from that of 2008. Magnet exports, totaling 9,400 t, decreased by 13% from that of 2008 (China Rare Earth Information, 2010d).

Beginning in 2008, the Chinese Government had taken significant steps to promote rare-earth (RE) three-prime color lights. RE tricolor lamps, including RE compact fluorescent lamps and RE tubular T5 and T8 lamps, were promoted as primary products in the medium and long term energy-saving program of the State, especially in government buildings. In April 2009, the Economic and Construction Department of the Ministry of Finance and Energy Saving, and the Environmental Protection Department of the National Development and Reform Commission, announced the "tender results for high efficiency illumination product promotion project." There was an increase from 13 to 22 enterprises that were subsidized by the Government in this project for consumption of 50 million energy saving lamps in 2008 to 120 million units in 2009. Output of RE tricolor phosphors in China were 5,500 t in 2008 and production exceeded 6,000 t in 2009, an increase of 9%. Approximately one ton of rare-earth tricolor phosphor can be used to produce 3 million T2–8W spiral fluorescent tubes (China Rare Earth Information, 2010f).

A 15% export tax was also imposed on exports of ferroalloys in December 2008. The Chinese Government reduced export quotas for rare earths in the first half of 2009. Quotas for Chinese companies have been cut by 34% year-on-year between 2008 and 2009 to 15,000 t, while quotas for companies with foreign investment were reduced by 19% to 6,600 t (Roskill's Letters from Japan, 2009d).

France.—Rhodia was organized into seven enterprises, with the rare-earth unit, Rhodia Electronics and Catalysis, and the performance silica unit, Rhodia Silica Systems, under Rhodia Silcea. Rhodia produced rare-earth-containing catalysts for automotive emission applications, fluid-cracking catalysts for oil refining, desulfurization catalysts, styrene monomer catalysts, chemical catalysts for oxidation, catalysts for dehydrogenation and hydrogenation, and polymerization catalysts used in paints and tires. Rhodia's other operations produced high-purity rare earths at its separation plant in La Rochelle. Additional rare-earth capacity was operated through Anan Kasei in Kobe, Japan.

Japan.—There were three Japanese NIB alloy producers, one of which used neodymium exclusively, with the other two using didymium, a mixture of mostly neodymium and praseodymium.

Toyota Tsusho, a trading house affiliated with Toyota Motor, showed interest in developing the Dong Pao bastnaesite deposit in Northern Vietnam which has elevated LREE content that would be used in the production of magnets for hybrid electric vehicles produced by Toyota Motor. In November 2009, Toyota Tsusho purchased Wako Bussan that had sales rights for rare earths produced by the state-owned Indian Rare Earths Ltd. (IREL) in India. The company was renamed Toyotsu Rare Earths and established their headquarters at Toyota Tsusho's main office in Marunouchi, Tokyo. IREL planned to restart production of rare-earth oxides in 2010. In the first quarter of 2009, Toyota Tsusho announced signing a memorandum of understanding with VINACOMIN Group to acquire 49% of mining rights at the Dong Pao deposit and all of the product sales rights (Roskill's Letters from Japan, 2009a).

Showa Denko (SDK) started a new company in Vietnam named Showa Denko Rare Earth Vietnam in October 2008, with 90% ownership, leaving 10% to Tokai Trade. In 2009, SDK had a total capacity for producing 8,000 t/yr of rare-earth magnet alloys. The breakdown of production was 5,000 t at the Chichibu plants in Japan, along with 1,000 t at Baotou Showa

Rare Earth Hi-tech New Material in Inner Mongolia, and 2,000 t at Ganzhou Zhaori Rare Earth New Material in Jiangxi Province (Roskill's Letters from Japan, 2009a).

Bonded rare-earth magnets by Japanese producers worldwide decreased by 5% in 2008, and the value of overseas production dropped by 7%. This was the first published reduction in production (Roskill's Letters from Japan, 2009b).

During 2008, average prices of Japanese imports of light rare earths increased, specifically for cerium, lanthanum, and samarium. The price increases were attributed to the strengthening of export regulations by the Chinese government. Prices of magnet raw materials decreased during 2008, reflecting lower demand for neodymium-iron boron (NdFeB) magnets in China and in electronic products and vehicles in Japan since the summer of 2008. The average value of Chinese exports of neodymium peaked in September 2007, but was reduced to one-half from $40 per kilogram in July 2008, to $19 per kilogram in December 2008 (Roskill's Letters from Japan, 2009c).

Japanese imports of rare earths decreased by 13% to 35,000 t in 2008, including the largest decrease ever for rare-earth metals, which declined by 6,300 t (32%). The decrease was owing to lower demand for magnets, phosphors and polishing materials used in the automotive and electronics industries at yearend, and a buildup of stocks by Japanese buyers in 2007 anticipating stricter Chinese export regulations. Japanese demand for rare-earth metals in neodymium-iron-boron magnets and hydrogen storage alloys remained stable in 2008. Demand for neodymium-iron-boron magnets increased at a rate of 20% from the year to date through October 2007 until October 2008, and then decreased in November 2008. Production of NdFeB magnets totaled 10,500 to 11,000 t, consuming some 18,000 t of magnet alloys in 2008. Magnet alloys contained some 27% to 28% didymium and 3% dysprosium; and therefore, Japanese consumption of these metals was estimated to be 4,600 to 5,000 t and 600 to 700 t, respectively, in 2008. Japanese production of hydrogen storage alloys used in nickel-metal hydride batteries totaled 7,000 to 8,000 t in 2008. The alloys contained nearly 30% mischmetal; Japanese consumption of mischmetal in this market was estimated to be 2,500 t in 2008. Approximately 1,000 to 2,000 t of mischmetal was used as steel additives. Production of hybrid electric vehicles (HEVs) by Japanese producers increased by 7% compared with that of 2007. This was equal to 460,000 vehicles in 2008. An HEV was estimated to require 1 kilogram (kg) of neodymium-iron-boron magnets on average. Demand for rare earths in this market was forecast to rise, although from a low base. Honda reported record sales of Insight HEVs in February 2009, and Toyota initiated sales of its third generation Prius in May. Japanese demand for yttrium oxide in phosphors remained steady until August 2008, and then decreased. Japanese consumption of rare-earth oxides in phosphors was estimated to be 700 to 800 t yttrium oxide, 60 to 65 t europium oxide, and 50 to 55 t terbium oxide in 2008. Chinese exports of europium oxide to Japan rose by 160% to 104 t in 2008, but the average value of exports dropped. Consumption of cerium oxides and compounds in polishing materials remained stable. Japanese production of liquid crystal display (LCD) glass decreased between January and March 2009. Japanese optical glass producers have relocated their production bases to China. Japanese production of ceramic capacitors decreased in 2008 along with lanthanum oxide in dielectrics (Roskill's Letters from Japan, 2009d).

Japanese prices for imported neodymium, praseodymium, and didymium increased briefly by 10% in April 2009 and then decreased by 2% to 4% in May before leveling off in June. There was little trade between China and Japan in the first half of 2009. Total Chinese exports of rare-earth metals decreased by 72% year-on-year for the period January through May. Chinese exports of neodymium metal decreased by 57% year-on-year to 556 t, while exports of other metals dropped by 78% to 99%. Chinese exports of terbium were only 25 kg in January through May 2009. Exports of cerium compounds also decreased by 56% year-on-year to 2,667 t in the first 5 months of 2009, while exports of other rare-earth compounds decreased by 75% to 2,673 t (Roskill's Letters from Japan, 2009e).

Japanese prices of imported magnetic rare-earth materials—neodymium, praseodymium, and didymium—rose by 23% to 25% in November 2009 compared with prices at yearend 2008. Demand for neodymium in neodymium-iron-boron magnets in China, a principal competitive market for Japanese production, increased in April and had recovered to 80% of its peak level. Production rates in Japan recovered to 60% to 70% of capacity in October 2009. Chinese exports of rare earths to Japan fell by 43% year-on-year between 2008 and 2009 to 22,742 t in January through October. The average value of exports of rare-earth metals and compounds dropped by 46% to 47% year-on-year (Roskill's Letter from Japan, 2010).

Vietnam.—The Dong Pao Mine in the northern part of Vietnam has large resources of rare earths. The ownership included six Vietnamese companies. VIMICO (Vietnam National Minerals) and VINACOMIN (Vietnam National Coal-Mineral Industries Group) jointly held 55% of the shares. The mining rights were owned by LARESCO and Lai Chau Rare Earth in a joint venture. Two other Japanese companies—Toyota Tsusho and Sojitz—also held an interest in the Dong Pao Mine (Roskill's Letters from Japan, 2010).

Outlook

Rare-earth use in automotive pollution control catalysts, permanent magnets, and rechargeable batteries is expected to continue to rise as future global demand 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. Demand for cerium and neodymium for use in automotive catalytic converters and catalysts for petroleum refining was expected to increase for the next 5 years (Kingsnorth, 2008). Rare-earth magnet production worldwide was expected to decrease to 58,000 t in 2009, with 23,300 t of contained RE oxides, from a level of 66,000 t in 2008, distributed mostly to NdFeB magnets, and to a lesser extent SmCo magnets. Production was projected to have a compound annual growth rate (CAGR) of 8% to 9% through the next 5 years, increasing to 86,000 t by 2014 (BCC Research, 2009). Future growth was expected for rare earths in rechargeable NiMH batteries, especially those used in hybrid vehicles, increasing from 11,000 t in 2009 to 26,000 t REO by 2014, with a CAGR of 18% (BCC Research, 2009). NiMH demand was also expected to increase (moderated by increasing demand for lithium-ion batteries), with increased use in portable equipment, such as camcorders, cellular telephones, compact disk players, digital cameras, digital video disk players, laptop computers, and MPEG audio-layer-3 players. Increased rare-earth use was 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. Ceramics consumption of 7,000 to 8,000 t REO in 2010, with a CAGR of 9%, was forecast from a base level of 5,500 t REO in 2006 in applications such as high temperature strength material ceramics, electrical and electronic ceramics, and engineering ceramics such as yttria-stabilized-zirconia (YSZ), with yttrium oxide accounting for as much as 5,000 to 6,000 t of 2010 ceramic use (Roskill Information Services Ltd., 2007).

World reserves are sufficient to meet forecast world consumption well into the 21st century. Several large rare-earth deposits in Australia and China (for example, Mianning in China and Mount Weld in Australia) have yet to be fully developed. Existing production is currently not sufficient to meet world demand, 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 demand for light-group REEs, the deposit does not contain sufficient HREE to meet demand for those elements.

All domestic and most foreign companies have currently shifted away from using naturally occurring radioactive rare-earth ores. This trend has a negative impact on monazite-containing mineral sands operations worldwide, causing mine closures and reduced revenues. Long-term demand for monazite, however, is expected to increase because of the mineral's abundant supply and low-cost byproduct recovery. Thorium's use as a nonproliferative nuclear fuel is considered a likely substitute for uranium in the future. If consumption of thorium increases, monazite could resume its role as a major source of rare earths. Storage requirements and permits to dispose of radioactive waste products in the United States are expensive, however, severely limiting domestic use of low-cost monazite and other thorium-bearing rare-earth ores.

Rare-earth producers outside of China, generating less than 5% of the world's supply, were 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, rising demand within China, and a ban on new mining permits in China were expected to make rare-earth deposits outside of China more economic. China's export quotas in 2009 were reduced from levels in 2008. Economic growth in several developing countries could provide new and potentially large markets for rare earths in eastern Europe, India, and southeastern Asia.

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 continue to increase. 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]

		2005	2006	2007	2008	2009
Production of rare-earth concentrates, rare-earth oxide (REO) basis[e, 2]	metric tons	--	--	--	--	--
Exports, REO basis:						
Cerium compounds	do.	2,220	2,010	1,470	1,380	840
Rare-earth metals, scandium, yttrium	do.	636	611	1,470	1,390	4,930
Rare-earth compounds, organic or inorganic	do.	2,070	2,700	1,300	663	455
Ferrocerium and pyrophoric alloys	do.	4,320	3,710	3,210	4,490	2,970
Imports for consumption, REO basis:[e]						
Cerium compounds	do.	2,170	2,590	2,680	2,080	1,500
Ferrocerium and pyrophoric alloys	do.	130	127	123	125	102
Metals, alloys, oxides, other compounds	do.	13,000	16,000	15,000	13,200	10,500
Prices, yearend:						
Bastnäsite concentrate, REO basis[e]	dollars per kilogram	5.51	6.06	6.61	9.00 r	9.00
Monazite concentrate, REO basis[e]	do.	0.73	0.73	0.73	0.48	0.48 e
Mischmetal, metal basis[3]	do.	5.00–6.00 r	5.00–6.00 r	7.00–8.00	10.00	10.00 e

[e]Estimated. [r]Revised. do. Ditto. -- 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: 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)

	Bastnäsite		Monazite			
Rare earth	Mountain Pass, CA, United States[2]	Bayan Obo, Inner Mongolia, China[3]	North Capel, Western Australia[4]	North Stradbroke Island, Queensland, Australia[5]	Green Cove Springs, FL, United States[6]	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
	Monazite—Continued		Xenotime		Rare earth laterite	
	Eastern coast, Brazil[8]	Mount Weld, Australia[9]	Lahat, Perak, Malaysia[2]	Southeast Guangdong, China[10]	Xunwu, Jiangxi Province, China[11]	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.

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TABLE 3

RARE-EARTH OXIDE PRICES IN 2009[e]

Product (oxide)	Purity (percentage)	Standard package quantity (kilograms)	Price (dollars per kilogram)
Cerium	96.00	20	30.00
Do.	99.50	20	30.00
Dysprosium	99.00	20	170.00
Erbium	96.00	20	100.00
Europium	99.99	20	1,600.00
Gadolinium	99.99	20	150.00
Holmium	99.90	10	750.00
Lanthanum	99.99	20	30.00
Lutetium	99.99	1 or 10	1,800.00
Neodymium	95.00	20	42.00
Praseodymium	96.00	20	38.00
Samarium	99.90	20	130.00
Do.	99.99	20	130.00
Scandium	99.99	NA	2,500.00
Terbium	99.99	20	900.00
Thulium	99.90	5	1,500.00
Ytterbium	99.00	10	325.00
Yttrium	99.99	20	44.00

[e]Estimated. Do. Ditto. NA Not available.

Source: Rhodia Electronics & Catalysis, Inc.

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

Category[2] and country	2008 Gross weight (kilograms)	2008 Value	2009 Gross weight (kilograms)	2009 Value
Cerium compounds (2846.10.0000):				
Australia	--	--	1,920	$13,300
Austria	104,000	$708,000	43,800	437,000
Belgium	1,950	28,300	1,800	21,800
Brazil	8,690	65,800	11,400	95,900
Canada	15,300	149,000	15,300	151,000
China	72,400	893,000	72,800	878,000
Egypt	116,000	606,000	--	--
France	18,100	169,000	3,950	47,200
Germany	120,000	1,040,000	94,800	731,000
Hong Kong	20,200	251,000	3,930	128,000
India	41,700	292,000	60,600	402,000
Japan	226,000	1,850,000	114,000	1,320,000
Korea, Republic of	248,000	288,000	15,800	79,400
Mexico	82,200	423,000	192,000	800,000
Netherlands	48,800	337,000	43,300	241,000
Singapore	--	--	10,100	64,600
Taiwan	77,900	3,290,000	7,340	96,700
United Kingdom	14,500	179,000	14,200	99,500
Other	168,000	1,640,000	133,000	2,430,000
Total	1,380,000	12,200,000	840,000	8,030,000
Total estimated equivalent rare-earth oxide (REO) content	1,380,000	12,200,000	840,000	8,030,000
Rare-earth compounds[3] (2846.90.0000):				
Argentina	40	10,000	20	5,000
Austria	2	12,000	491	3,470
Brazil	59,800	258,000	13,400	122,000
Canada	48,200	773,000	53,900	479,000
China	134,000	311,000	43,200	488,000
Colombia	17,100	35,900	1,640	29,200
France	50,600	1,340,000	28,500	543,000
Germany	11,700	525,000	18,200	502,000
Guatemala	2,000	4,910	211	6,980
Hong Kong	10	6,000	2,050	125,000
India	4,960	47,900	4,190	49,600
Italy	9,730	86,100	8,110	89,700
Japan	27,400	1,030,000	63,900	1,870,000
Korea, Republic of	164,000	857,000	74,000	405,000
Mexico	40,800	850,000	43,900	502,000
Netherlands	17,000	197,000	9,370	44,400
Poland	309	37,900	164	3,700
Singapore	3,880	72,500	6,190	94,500
Taiwan	3,060	246,000	1,810	46,800
United Kingdom	32,600	381,000	3,620	229,000
Other	35,500	530,000	78,100	579,000
Total	663,000	7,610,000	455,000	6,210,000
Total estimated equivalent REO content	663,000	7,610,000	455,000	6,210,000

See footnotes at end of table.

TABLE 4—Continued

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

Category[2] and country	2008 Gross weight (kilograms)	2008 Value	2009 Gross weight (kilograms)	2009 Value
Rare-earth metals, including scandium and yttrium (2805.30.0000):				
Belgium	4,850	$193,000	268	$24,600
Brazil	86	64,600	16,800	221,000
China	114,000	1,630,000	365,000	1,370,000
Germany	50,000	398,000	4,800	232,000
Hong Kong	3	5,000	62,800	283,000
India	5,020	285,000	3,130	228,000
Japan	479,000	11,400,000	303,000	5,330,000
Mexico	297	132,000	150	80,800
Switzerland	20	8,600	48	28,400
Taiwan	40,000	502,000	1,190	46,600
Other	465,000	4,010,000	3,350,000	7,870,000
Total	1,160,000	18,600,000	4,100,000	15,700,000
Total estimated equivalent REO content	1,390,000	18,600,000	4,920,000	15,700,000
Ferrocerium and other pyrophoric alloys (3606.90.0000):				
Argentina	13,400	74,300	29,100	162,000
Australia	73,000	167,000	19,100	984,000
Canada	667,000	2,470,000	494,000	1,620,000
China	675,000	6,050,000	169,000	1,960,000
Egypt	29,000	42,600	451	77,700
France	48,600	111,000	66,300	1,170,000
Germany	12	7,040	342	14,200
Greece	633	21,600	888	274,000
Hong Kong	19,000	439,000	26,100	306,000
Israel	29,400	48,100	75	3,230
Japan	31,700	1,240,000	17,200	461,000
Jordan	124	45,400	--	--
Korea, Republic of	4,000	131,000	4,240	255,000
Mexico	2,640,000	5,470,000	1,890,000	4,200,000
Netherlands	56,100	180,000	33,100	171,000
New Zealand	27,600	56,100	--	--
Portugal	7,820	16,600	--	--
Saudi Arabia	20	7,740	1,020	33,700
Singapore	12,000	89,300	477	14,500
Taiwan	4,710	54,200	164	5,970
United Arab Emirates	748	29,300	1,680	32,100
United Kingdom	365,000	2,840,000	296,000	14,000,000
Other	348,000	1,570,000	299,000	2,290,000
Total	5,050,000	21,200,000	3,350,000	28,000,000
Total estimated equivalent REO content	4,490,000	21,200,000	2,970,000	28,000,000

-- Zero.

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

[2]Harmonized Tariff Schedule of the U.S. 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	2008 Gross weight (kilograms)	2008 Value	2009 Gross weight (kilograms)	2009 Value
Cerium compounds, including oxides, hydroxides, nitrates, sulfate, chlorides, oxalates (2846.10.0000):				
Austria	78,700	$734,000	386,000	$1,140,000
China	2,890,000	9,980,000	1,720,000	5,030,000
France	36,800	421,000	17,700	208,000
Japan	43,600	1,440,000	51,600	1,800,000
Korea, Republic of	34	21,600	--	--
United Kingdom	40,000	112,000	17,300	68,100
Other	13,200	113,000	49,200	812,000
Total	3,100,000	12,800,000	2,240,000	9,070,000
Total estimated equivalent rare-earth oxide (REO) content	2,080,000	12,800,000	1,500,000	9,070,000
Yttrium compounds content by weight greater than 19% but less than 85% oxide equivalent (2846.90.4000):				
China	8,650	202,000	8,690	136,000
France	916	61,500	945	29,800
Japan	6,860	6,490,000	1,710	362,000
Other	115	10,500	190	37,500
Total	16,500	6,770,000	11,500	565,000
Total estimated equivalent REO content	9,920	6,770,000	6,920	565,000
Rare-earth compounds, including oxides, hydroxides, nitrates, other compounds except chlorides (2846.90.8000):				
Austria	67,600	2,980,000	58,200	2,650,000
Canada	3,460	139,000	3,000	15,000
China	10,500,000	79,900,000	5,590,000	38,600,000
France	390,000	19,200,000	331,000	13,000,000
Germany	1,750	845,000	35,300	304,000
Hong Kong	234,000	2,320,000	600	5,990
Japan	234,000	10,900,000	143,000	9,350,000
Russia	96,300	470,000	109	95,300
South Africa	48,400	522,000	39,600	426,000
United Kingdom	4,030	118,000	157	49,000
Other	94,800	1,510,000	565,000	3,060,000
Total	11,600,000	119,000,000	6,770,000	67,500,000
Total estimated equivalent REO content	8,810,000	119,000,000	5,120,000	67,500,000
Mixtures of REOs except cerium oxide (2846.90.2010):				
China	2,300,000	16,000,000	4,700,000	19,100,000
Germany	450	33,300	934	108,000
Italy	56,200	6,150,000	42,500	4,190,000
Japan	1,730	312,000	6,130	64,900
Russia	1	3,800	111	66,900
United Kingdom	5	6,530	--	--
Other	32,000	56,900	--	--
Total	2,390,000	22,600,000	4,750,000	23,500,000
Total estimated equivalent REO content	2,390,000	22,600,000	4,750,000	23,500,000

See footnotes at end of table.

TABLE 5—Continued

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

	2008		2009	
Category[2] and country	Gross weight (kilograms)	Value	Gross weight (kilograms)	Value
Rare-earth metals, whether intermixed or alloyed (2805.30.0000):				
Austria	1,570	$189,000	227	$36,100
China	540,000	3,740,000	167,000	3,790,000
Germany	5	6,750	--	--
Japan	12,600	458,000	10,800	481,000
Russia	2,690	226,000	2,110	182,000
United Kingdom	9,010	317,000	7,870	368,000
Other	--	--	81	6,450
Total	566,000	4,940,000	188,000	4,870,000
Total estimated equivalent REO content	679,000	4,940,000	226,000	4,870,000
Mixtures of rare-earth chlorides, except cerium chloride (2846.90.2050):				
China	2,580,000	16,100,000	887,000	4,560,000
Germany	5,230	203,000	129	112,000
Hong Kong	211,000	618,000	--	--
Japan	3,940	76,700	5,550	108,000
Korea, Republic of	114	10,500	--	--
Russia	38	97,100	59	127,000
Taiwan	18,000	170,000	--	--
United Kingdom	3,220	19,200	787	10,700
Other	34,300	317,000	638	12,500
Total	2,850,000	17,600,000	894,000	4,930,000
Total estimated equivalent REO content	1,310,000	17,600,000	411,000	4,930,000
Ferrocerium and other pyrophoric alloys (3606.90.3000):				
Austria	18,700	356,000	21,000	457,000
China	6,950	124,000	4,280	90,300
France	116,000	1,900,000	89,100	2,080,000
Total	141,000	2,380,000	114,000	2,620,000
Total estimated equivalent REO content	125,000	2,380,000	102,000	2,620,000

-- Zero.

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

[2]Harmonized Tariff Schedule of the U.S. 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]	2005	2006	2007	2008	2009
Brazil	527 [4]	527 [4]	645 [4]	550	550
China	119,000	133,000	120,000	125,000	129,000
India	2,700	2,700	2,700	2,700	2,700
Kyrgyzstan:					
Compounds	NA	NA	NA	NA	NA
Metals	NA	NA	NA	NA	NA
Other	NA	NA	NA	NA	NA
Malaysia	150	430	380	233 r	25
Total	122,000	137,000	124,000	128,000 r	132,000

[r]Revised. NA Not available.

[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 October 4, 2010.

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

[4]Reported figure.

TABLE 7

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

(Metric tons, gross weight)

Country[3]	2005	2006	2007	2008	2009
Brazil	958 [4]	958 [4]	1,173 [4]	1,200	1,200
India	5,000	5,000	5,000	5,000	5,000
Malaysia	320 [4]	894 [4]	682 [4]	700	600
Total	6,280	6,850	6,860	6,900	6,800

[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 May 9, 2010.

[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 information is inadeguate for formulation of reliable estimates of ouput levels.

[4]Reported figure.