RARE EARTHS

By James B. Hedrick

The rare earths are a relatively abundant group of elements that range in crustal abundance from cerium, the 25th most abundant element of the common elements at 60 parts per million, to lutetium, the 61st most abundant element at 0.5 parts per million. The rare earths were discovered in 1787 by Swedish Army Lieutenant Karl Axel Arrhenius when he collected the black mineral ytterbite (later renamed gadolinite) from a feldspar and quartz mine near the village of Ytterby, Sweden. With similar chemical structures, the rare-earth elements proved difficult to separate. It was not until 1794 that the first element, an impure yttrium oxide, was isolated from ytterbite by Finnish chemist Johann Gadolin. The elemental form 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 rare earths' unique properties are used in a wide variety of applications.

Domestic mine production of rare earths increased in 1995. The domestic economy continued to improve and inflation, based on the Bureau of Labor Statistics consumer price index, increased at the low rate of 2.8%. Estimated domestic apparent consumption increased substantially in 1995 as demand increased for rare-earth compounds used in automotive catalytic converters, permanent magnets, and rechargeable rare-earth-nickel hydride batteries. Earnings by the major domestic processor also reportedly increased amid gains in sales. *(See table 1.)* Demand also increased for rare earths used in petroleum fluid cracking catalysts, while rare-earth phosphors for television, x-ray intensifying, and fluorescent and incandescent lighting remained stable. Yttrium was used primarily in lamp and cathode ray tube phosphors, structural ceramics, and oxygen sensors.

The domestic use of scandium in 1995 remained small. Commercial demand remained extremely small, with most metal and compounds sold for metallurgical research and analytical standards. Minor amounts were used in specialty lighting and semiconductors.

Legislation and Government Programs

Public Law 103-337, the National Defense Authorization Act for Fiscal Year 1995, was enacted on October 5, 1994, and covered fiscal year 1995 (through September 30, 1995). It continued the previous authorization for disposal of all stocks of rare earths in the National Defense Stockpile (NDS). The National Defense Authorization Act for Fiscal Year 1996, Public Law 104-106, was not enacted until February 10, 1996, because of significant delays in the Congressional budget process. It did not change previous authorizations for the disposal of 457 metric tons of rare earths in sodium sulfate classified as excess to goal.

Public Law 104-106 also legislated that the Secretary of Energy, in consultation with the Secretary of Defense, shall transfer to the NDS those materials in the Department of Energy's stockpile which are classified for the production of defense-related items and are considered excess, uncontaminated, and determined suitable for transfer.

In fiscal year 1996, the NDS Manager was authorized to obligate up to $77.1 million in the U.S. Treasury's NDS Fund for authorized uses of such funds under section 9(b)(2) of the Strategic and Critical Materials Stock Piling Act (50 U.S.C. 98h(b)(2).

Production

Domestic mine production data for rare earths are developed by the USGS from a voluntary survey of U.S. operations entitled, "Rare Earths". The one mine to which a survey form was sent responded, representing 100% of domestic mine production. Mine production data from one source, which is typically withheld to avoid disclosing company proprietary data, was authorized for release by Molycorp, Inc. (bastnasite concentrate only).

The United States remained a major world producer of rare earths in 1995 with only one domestic mine in operation. Domestic production was entirely from Molycorp, Inc., a wholly owned subsidiary of Unocal Corp. Bastnasite, a rare-earth fluorocarbonate mineral, was mined by open pit methods at Mountain Pass, CA. Molycorp's mine was the second leading producer of rare earths in the world. Mine production, as reported from company sources, increased from the previous year's level of 20,664 tons of rare-earth oxide (REO) to 22,239 tons REO in 1995.

RGC (USA) Minerals Inc. ceased recovery of monazite, a rare-earth-thorium-phosphate mineral, at the end of 1994. Monazite was previously recovered for its rare-earth content as a byproduct during processing for titanium and zirconium minerals. RGC (USA) ceased recovery of monazite as world demand for radioactive thorium-bearing ores declined, primarily due to increased thorium disposal costs. RGC (USA), a wholly owned subsidiary of the Australia-based Renison Goldfields Consolidated Ltd. (RGC), continued to operate at Green Cove Springs, FL, producing other heavy minerals from sands, including ilmenite, rutile, and zircon.

Refined lanthanides were produced by three companies in

1995. Molycorp produced refined compounds from bastnasite at its separation plant at Mountain Pass, CA. Rhône-Poulenc Basic Chemicals Co. produced lanthanide compounds from rare earth intermediate compounds at its facility at Freeport, TX, and Grace Davison refined rare earths for petroleum fluid cracking catalysts from rare-earth chlorides and other rare-earth compounds at Chattanooga, TN.

Except for minor amounts of yttrium contained in domestically produced bastnasite concentrates, essentially all purified yttrium was derived from imported compounds.

Three scandium processors operated in 1995. High-purity products were available in various grades with scandium oxide produced up to 99.999% purity.

Sausville Chemical Co. refined scandium concentrates at its facilities in Garfield, NJ, to produce scandium oxide, fluoride, nitrate, chloride, and acetate. Sausville announced plans to move its operations by midyear 1996 to east Tennessee. The company will share facilities at Rock Hill Laboratories in Newport, TN, with its joint-venture research partner Recovery Dynamics of Johnson City, TN. The joint venture expected to start production of scandium compounds by yearend 1996 on a larger scale than previously available.

Boulder Scientific Co. processed scandium at its Mead, CO, operations. Boulder recovered scandium primarily from the scandium-yttrium silicate mineral, thortveitite, contained in tailings from the mined-out Crystal Mountain fluorite mine near Darby, MT.

Scandium was also purified and processed by APL Engineered Materials in Urbana, IL, to produce compounds and metal.

Principal domestic producers of neodymium-iron-boron magnet alloys were Magnequench International, Inc. (previously the Delco Remy Div. of General Motors), Anderson, IN; Neomet Corp., West Pittsburg, PA; and Rhône-Poulenc Basic Chemicals Co., Phoenix, AZ. Leading U.S. producers of rare-earth magnets were Magnequench International, Anderson, IN; Hitachi Magnetics, Edmore, MI; Crucible Materials, Elizabethtown, KY; and Ugimag, Valparaiso, IN.

Consumption

Statistics on domestic rare-earth consumption are developed by surveying various processors and manufacturers, evaluating import-export data, and analyzing U.S. Government stockpile shipments. Domestic apparent consumption of rare earths increased in 1995 compared with that of 1994, created by increased domestic production and strong imports for the second year in a row. Domestic production of mischmetal, rare-earth silicide, and other rare-earth alloys in 1995 was essentially the same as in 1994, while consumption of the alloys increased 300% to supply increased demand for oil and gas pipeline alloying agents. Shipments of mixed rare-earth alloys declined 19%. Consumption of mixed rare-earth compounds showed a gain of 4% as demand continued for mixed intermediates for petroleum fluid cracking catalysts and automotive catalytic converters. Domestic shipments of mixed compounds increased 10% in 1995.

The approximate distribution of rare earths by use, based on information supplied by U.S. rare-earth refiners, selected consumers, and analysis of import data, was as follows: automotive catalytic converters, 44%; petroleum refining catalysts, 25%; permanent magnets, 11%; glass polishing and ceramics, 9%; metallurgical additives and alloys, 8%; rare-earth phosphors for lighting, televisions, computer monitors, radar, and x-ray intensifying film, 3%; and miscellaneous, <1%.

Yttrium consumption was estimated by the U.S. Geological Survey (USGS) rare-earths commodity specialist at 365 metric tons for 1995, an increase of 21 tons from the previous year. The approximate distribution of yttrium by end use, based on analysis of import data, was as follows: lamp and cathode ray tube (CRT) phosphors, 66%, structural ceramics and components, 29%, and oxygen sensors and miscellaneous, 5%. Yttrium compounds were sourced from China, 68.6% and Japan, 31.4%.

Tariffs

U.S. tariff rates, specific to the rare earths, including scandium and yttrium, were changed slightly in 1995. Revisions to the Harmonized Tariff Schedule for cerium compounds (2846.10.00) decreased for most-favored-nation status from 6.9% ad valorem to 6.5% ad valorem. Special rare-earth tariffs for Canada and Mexico, were the result of Presidential Proclamation 6641, implementing the North American Free Trade Agreement (NAFTA), effective January 1, 1994. Under the agreement, Mexico's tariff for rare-earth metals, including yttrium and scandium, whether intermixed or interalloyed (2805.30.00) decreased from 3.0% ad valorem to 2.0% ad valorem. For all other rare-earth Harmonized Tariff Schedule classifications, Canada and Mexico were granted free status. Tariff rates for most other foreign countries were negotiated under the Generalized Agreement on Tariffs and Trade (GATT) Uruguay Round of Multilateral Trade Negotiation. New staged rate schedules taking effect January 1, 1995, were negotiated at the GATT Uruguay Round of negotiations in 1994. U.S. tariff rates for rare earths are listed in the Harmonized Tariff Schedule of the United States (1995), publication 2831, with supplement, and the Harmonized Tariff Schedule of the United States (1996), publication 2937, as compiled by the United States International Trade Commission (ITC). U.S. tariffs are available in Publication 2937 from the Government Printing Office under document number 949-011-00000-3.

Stocks

U.S. Government stocks of rare earths in the NDS remained at 457 tons throughout 1995. Rare-earth stocks held in the stockpile were contained in sodium sulfate and were inventoried on a contained-REO basis. NDS stocks of rare earths are available for sale from the U.S. Department of Defense's Defense Logistics Agency, Fort Belvoir, VA.

Prices

Rare-earth prices were mixed in 1995. Domestic prices for cerium and neodymium compounds increased, while prices decreased slightly for yttrium and a few other oxides. Domestic prices for rare-earth chlorides, which increased in 1994, remained unchanged in 1995. Neodymium carbonate prices continued to increase as demand for neodymium-containing permanent magnets continued to expand . All rare-earth prices remained nominal and subject to change without notice. Competitive pricing policies remained in effect with prices for most rare-earth products quoted on a daily basis.

Prices quoted by Molycorp for unleached, leached, and calcined bastnasite in standard quantities, containing 60%, 70%, and 85% REO, remained unchanged from the previous year's level of $2.87, $3.20, and $3.86 per kilogram ($1.30, $1.45, and $1.75 per pound) of contained REO, respectively.

The price range of Australian monazite (minimum 55% rare-earth oxide including thoria, f.o.b./f.i.d.),[1] as quoted in Australian dollars (A$),[2] remained unchanged at A$300-A$350 per ton at yearend 1995. Changes in the United States-Australia foreign exchange rate in 1995, resulting from a slightly stronger U.S. dollar on world markets, caused the U.S. dollar to be up $0.02 against the Australian dollar at yearend. Converted from Australian dollars, the U.S. price range for monazite decreased slightly to US$222-US$259[3] per ton in 1995 from US$227-US$265[4] per ton at yearend 1994.

The nominal price for basic neodymium-iron-boron alloy, compiled by the author from several U.S. producers, was $28.43 per kilogram ($12.90 per pound) at yearend, free-on-board (f.o.b.) shipping point, 1,000-pound minimum. Most alloy was sold with additions of cobalt (up to 15%, typically 4% to 6%) or dysprosium (up to 3%). The cost of the additions was based on market pricing; with the average cobalt price in 1995 at $64.40 per kilogram (average $29.21 per pound) the cost would be about $0.64 for each percent addition per kilogram ($0.29 for each percent addition per pound).

Standard-grade domestic mischmetal was priced slightly lower than the previous year at $12.13 per kilogram.

Rare-earth metal prices were essentially stable, except for increases for neodymium. Prices for high-purity rare-earth metals varied from $29 per kilogram for magnet-grade neodymium to $24,000 per kilogram for distilled-grade lutetium.

Molycorp quoted prices for lanthanide (rare earth) and yttrium oxides, net 30 days, f.o.b. Mountain Pass, CA, in effect at yearend 1995, as shown in table 2.

Molycorp also quoted prices for lanthanide (rare earth) compounds, net 30 days, f.o.b. Mountain Pass, CA, in effect at yearend 1995 as shown in table 3.

Rhône-Poulenc quoted rare-earth prices, per kilogram, net 30 days, f.o.b. New Brunswick, NJ, or duty paid at point of entry, in effect at yearend 1995, as shown in table 4.

No published prices for scandium oxide in kilogram quantities were available. Yearend 1995 nominal prices for scandium oxide per kilogram were compiled by the author from information from several domestic suppliers and processors. Prices decreased slightly from the previous year for most grades and were listed as follows: 99% purity, $1,500; 99.9% purity, $3,300; 99.99% purity, $5,100; and 99.999% purity, $7,650.

Scandium metal prices, as listed by the Johnson Matthey Alfa Aesar catalog, were as follows: 99.99% REO purity, sublimed dendritic lump, ampouled under argon, $169.00 per gram; 99.9% REO purity, <250-micron powder, ampouled under argon, $559.00 per 2 grams; and 99.9% purity, sublimed dendritic lump, ampouled under argon, $442.00 per 2 grams; 99.9% REO purity, foil, 0.025 millimeters thick, ampouled under argon, 25 millimeters by 25 millimeters, $95.00 per item.[5]

Scandium compounds prices, as listed by Aldrich Chemical Co., were as follows, scandium acetate hydrate 99.9% purity, $37.00 per gram; scandium chloride hydrate $99.99% purity, $49.75 per gram; scandium nitrate hydrate 99.9% purity, $54.80; and scandium sulfate pentahydrate 99.9% purity, $56.65 per gram. Prices for standard solutions for calibrating analytical equipment were $19.80 per 100 milliliter of scandium atomic absorption standard solution and $304.40 per 100 milliliter of scandium plasma standard solution.[6]

Prices for kilogram quantities of scandium metal in ingot form have historically averaged about twice the cost of the oxide while higher purity distilled scandium metal have averaged about five times the cost.[7]

Foreign Trade

Imports of rare earths increased in 1995. Imports totaled 17,000 tons gross weight valued at $121 million, a 68% increase in quantity and 39% increase in value compared with 1994. U.S. exports totaled 10,941 tons valued at $67 million, a 4% increase in quantity and 33% increase in value.

Imports of compounds, alloys, and metal increased in all categories. U.S. imports are shown in table 5. As in the previous 5 years, France dominated the import market, especially for rare-earth compounds.

Cerium compounds accounted for 4,090 tons of imports valued at $25.4 million. The quantity of cerium compounds imported increased 116% due to a large increase in demand for automotive exhaust catalysts. China was the major supplier in 1995, overtaking France for the first time.

Individual rare-earth compounds, excluding cerium compounds, accounted for the major share of rare-earth imports. Imports increased 69% in 1995 to 8,666 tons valued at $56.9 million. The major sources of individual rare-earth compounds were China and France with the value of rare-earth compound imports increasing 28%.

Imports of mixtures of rare-earth oxides, other than cerium oxide, increased 91% to 678 tons valued at $16.7 million. Principal sources were China, France, and the United Kingdom. Imports of rare-earth metals and alloys into the United States totaled 754 tons in 1995, a 166% increase from the 1994 level. Valued at $7.7 million, the principal rare-earth metal sources were China and the United Kingdom. Metal imports increased primarily to meet increased demand for permanent magnet

alloys.

Imports of rare-earth chlorides gained 12.5% in 1995 to 2,716 tons valued at $12.4 million. Supplies of rare-earth chloride came primarily from India, China, and Estonia. Rare-earth chloride was used mainly as feed material for manufacturing fluid cracking catalysts. Imports of ferrocerium and pyrophoric alloys increased 14% to 88 tons valued at $1.4 million. Principal suppliers were France, Austria, and Brazil.

Exports of rare earths increased in three out of four trade categories in 1995. U.S. exports are shown in table 6. The United States exported 370 tons of rare-earth metals, a 35% increase from 1994, valued at $3.7 million. Principal destinations were Taiwan, Japan, Canada, and France. Exports of cerium compounds, primarily for glass polishing and automotive catalytic convertors, totaled 5,117 tons valued at $35.5 million. Major destinations were the Republic of Korea, Singapore, and Canada.

Exports of inorganic and organic rare-earth compounds declined from 2,415 tons in 1994 to 1,546 tons in 1995; however, the value of the shipments increased 7% to $13.4 million. Shipments, in order of quantity, were to Brazil, China, Canada, and Japan.

U.S. exports of ferrocerium and other pyrophoric alloys increased from 3,398 tons to 3,909 tons valued at $14.2 million. Principal destinations were Canada, Peru, and Germany.

The approximate distribution of imports based on analysis of Journal of Commerce data was as follows: automotive catalytic converters, 46%; petroleum refining catalysts, 20%; phosphors for lighting, televisions, computer monitors, radar, and X-ray intensifying film, 10%; metallurgical additives and alloys, 9%; permanent magnets, 8%; glass polishing and ceramics, 6%; and miscellaneous, 1%.

World Review

Demand continued to increase for thorium-free rare-earth compounds for use as refinery feed material. China, India, and the United States were major sources of rare-earth chlorides, nitrates, and other concentrates and compounds. Demand for rare earths increased in Asia, Europe, and the United States as most world economies continued to improve.

Australia.—RGC's Mineral Sands Division operated four mineral sands mines in 1995. According to RGC's 1995 annual report, three mines operated in Western Australia, the Eneabba West, Eneabba North, and Capel, and one mine in the United States at Green Cove Springs, FL. The Eneabba North Mine, which operated at 75% of capacity in 1994, returned to full capacity in 1995. RGC initiated upgrades to increase the capacity at its Eneabba North plant to allow mining of lower grade dunal material. Increased capacity at Eneabba North was expected to be operational in 1996. RGC continued its feasibility study of the Old Hickory heavy mineral sands deposit near Stony Creek, VA. If developed, the Old Hickory deposit was not expected to produce any rare-earth minerals.[8]

Westralian Sands Limited (WSL) produced heavy-mineral concentrates from two mines in Western Australia. Production was 181,000 tons from the Yoganup Extended Mine and 378,000 tons from the Yoganup North operation. Recovery of monazite decreased substantially to near zero in 1995 as a result of decreased demand for thorium-bearing rare-earth concentrates. WSL produced 350 tons of monazite concentrate in 1994. Rehabilitation of mined lands continued at both mine sites with 14 hectares restored at the Yoganup Extended and 21 hectares at the Yoganup North. The rehabilitated lands were returned to agricultural use and to native plants.[9]

Stradbroke Island, which suspended operations in March 1994 because of the sinking of its 3,000 metric ton per hour dredge, resumed operation by midyear. CRL operated two mines, the Gordon Mine and the Bayside Mine in Queensland, at full capacity in 1995. Due to decreased demand, CRL did not resume monazite production during the year.[10]

Broken Hill Proprietary Co. Ltd. (BHP) announced it would develop the Beenup heavy-mineral sands deposit. Located in the Scott River area of Western Australia, the Beenup deposit would likely be mined by BHP's subsidiary Mineral Deposits Ltd. (MDL). BHP was scheduled to begin development of the plant in January with completion slated for the last half of 1996.[11]

China.—China was the world's leading producer of rare earths in 1995, according to the China Rare Earth Information newsletter, producing a record 48,002 tons REO.[12] Rare-earth production in China, which was up 56.6%, was primarily from the Bayan Obo iron ore rare-earth mine in Nei Monggol Autonomous Region. Production of rare-earth concentrates at Baotou, Nei Monggol Autonomous Region was 26,905 tons REO, while Sichuan Province and Shandong Province produced 8,500 tons REO and 963 tons REO, respectively. Production of rare earths from ion-adsorption-type clays in southern China's provinces of Jiangxi, Guangdong, Hunan, and Fujian was 9,770 tons.

France.—Rhône-Poulenc S.A. (RP) has reinitiated its study to build a rare-earth separation plant in Pinjarra, Western Australia.[13] RP had previously considered the project when monazite prices had escalated in the mid to late 1980's and other countries were considering construction of similar plants within Australia. The project was reportedly canceled when RP was unable to secure permits to dispose of byproduct radioactive thorium. With the price of monazite concentrate depressed for the last 4 years, the economics of the project appear favorable. The cost of disposing of the thorium waste and the acquisition of the required permits will be the principal factors determining Pinjarra's feasibility.

Reserves.—World reserves of rare earths were estimated by the USGS at 100 million metric tons of contained REO. China has the largest share of world reserves with 43%.

Outlook

Rare earth usage in the United States and the rest of the world continues to grow in volume and diversity. As the U.S. economy improved in 1995, consumption of rare earths

increased substantially. Rare-earth markets are expected to continue to use greater amounts of higher purity mixed and separated products. The largest growth has been for rare earths used in automotive catalytic converters and permanent magnets, a trend that is expected to continue into the next decade. Future growth is forecast for rare earths in rechargeable nickel hydride batteries, fiber optics, and medical applications, including magnetic resonance imaging (MRI) contrast agents, and dental and surgical lasers. Growth was also seen in individual and mixed rare-earth compounds as intermediate products for automotive catalytic converters, permanent magnets, ceramics, and phosphors for lighting and CRT's. Strong growth is expected to continue in the areas of permanent magnets, automotive catalytic converters, and rechargeable batteries.

World reserves are sufficient to meet forecast world demand well into the 21st century. Several world-class rare-earth deposits in Australia and China have yet to be developed as world demand is currently being satisfied by existing production. Coupled with the likelihood that new deposits will continue to be located, world resources should be adequate to fulfill demand for the foreseeable future.

Domestic companies have shifted away from radioactive-bearing rare-earth ores. This trend has had a negative impact on monazite-producing mineral sands operations worldwide. Future long-term demand for monazite, however, is expected to increase due to its abundant supply and recovery as a low cost byproduct. The cost and space to dispose of radioactive waste products in the United States is expected to continue to increase, severely limiting domestic use of monazite and other thorium-bearing rare-earth ores.

Domestic demand in 1996 is expected to exhibit moderation after the strong growth seen in 1995. World markets are expected to continue to be very competitive based on lower wages and fewer environmental and permitting requirements. Australia, China, and the United States are expected to remain significant rare-earth suppliers, while the future economic restructuring of Eastern Europe and Asia has a large potential for both new sources and new consumers.

The long-term outlook is for an increasingly competitive and diverse group of rare-earth suppliers. As research and technology continues to advance the knowledge of rare earths and their interactions with other elements, the economic base of the rare-earth industry continues to grow. It is likely that new applications will continue to be discovered and developed.

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[1] Free-on-board/free into a container depot.

[2] Metal Bulletin (London). Non-ferrous Ores. No. 8041, Dec. 29, 1995, p. 21.

[3] Values have been converted from Australian dollars (A$) to U.S. dollars (US$) at the exchange rate of A$1.3510=US$1.00 based on yearend 1995 foreign exchange rates reported by the U.S. Department of the Treasury, Financial Management Service.

[4] Values have been converted from Australian dollars (A$) to U.S. dollars (US$) at the exchange rate of A$1.3200=US$1.00 based on yearend 1994 foreign exchange rates reported by the U.S. Department of the Treasury, Financial Management Service.

[5] Alfa Aesar, 1995-96 Catalog. Available from Johnson Matthey, 30 Bond Str., Ward Hill, MA 01853-8099, p. 1661.

[6] Aldrich Catalog Handbook of Fine Chemicals 1994-95. Available from Aldrich Chem. Co., P.O. Box 14508, St. Louis, MO 63178-9916, p. 1244.

[7] Hedrick, J. B. Rare-Earth Metals. Ch. in Nonferrous Metal Prices in the United States through 1988. U.S. Bureau of Mines, 1990, pp. 81-98.

[8] Renison Goldfields Consolidated 1995 Annual Report. pp. 10-29.

[9] Westralian Sands Limited. 1995 Annual Report, pp. 6-14.

[10] Consolidated Rutile Limited 1995 Annual Report, p. 48.

[11] Industrial Minerals (London). BHP's Beenup Minsand Project to Go Ahead. No. 329, Feb. 1995, p. 8.

[12] China Rare Earth Information. China Rare Earth-1995. V. 2, No. 3, June 1996, p. 4.

[13] Industrial Minerals (London). Rhône-Poulenc to Revive Rare Earths. No. 333, June 1995, p. 9.

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Renison Goldfields Consolidated annual report (Australia).

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TABLE 1
SALIENT U.S. RARE-EARTH STATISTICS 1/

(Metric tons of rare-earth oxides (REO) unless otherwise specified)

	1991	1992	1993	1994	1995
Production of rare-earth concentrates 2/	16,500	20,700	17,800	20,700	22,200
Exports:					
Cerium compounds	1,370	1,940	1,620	4,460	5,120
Rare-earth metals, scandium, and yttrium	71	44	194	329	444
Ores and concentrates	459 3/	--	--	--	--
Rare-earth compounds, organic or inorganic	1,790	1,310	1,090	2,420	1,550
Ferrocerium and pyrophoric alloys	2,100	2,430	4,270	3,020	3,470
Imports for consumption: e/					
Monazite	--	--	--	--	--
Metals, alloys, oxides, compounds	6,110	5,330	6,670	7,840 r/	14,100
Stocks, producers and processors, yearend	W	W	W	W	W
Consumption, apparent e/	22,100	21,400	17,000	17,800	W
Prices, yearend, dollars per kilogram:					
Bastnasite concentrate, REO basis	2.87	2.87	2.87	2.87	2.87
Monazite concentrate, REO basis	.93	.41	.40	.46	.44
Mischmetal, metal basis	11.02	12.68	12.68	12.68	9.50
Employment, mine and mill 4/	411	372	352	NA	NA
Net import reliance 5/ as a percent of apparent consumption	25	33	(6/)	(6/)	(7/)

e/ Estimated. r/ Revised. NA Not available. W Withheld to avoid disclosing company proprietary data.

1/ Data are rounded to three significant digits, except prices.

2/ Comprises only the rare earths derived from bastnasite as obtained from Molycorp, Inc., company representative.

3/ Source: The Journal of Commerce Trade Information Service.

4/ Employment at a rare-earth mine in California and at a mineral sands operation in Florida, and a mineral sands tailings operation in New Jersey. The latter mines produced monazite as a byproduct and employees were not assigned to specific commodities. The mineral sands operation in Florida ceased recovery of REO at the end of 1994.

5/ Imports minus exports plus adjustments for Government and industry stock changes.

6/ Net exporter.

7/ Net importer.

TABLE 2
MOLYCORP RARE-EARTH OXIDE PRICES IN 1995

Product (oxide)	Percent purity 1/	Standard package quantity (pounds)	Price per pound
Cerium (5310)	96.00	200.00	$8.45
Cerium (5350)	99.00	200.00	11.25
Dysprosium	96.00	50.00	60.00
Erbium	98.00	50.00	65.00
Europium	99.99	25.00	450.00
Gadolinium	99.99	55.00	55.00
Lanthanum	99.99	300.00	8.75
Neodymium (5405)	96.00	300.00	10.50
Neodymium (5410)	99.90	50.00	40.00
Praseodymium	96.00	300.00	16.80
Samarium	96.00	55.00	30.00
Terbium	99.90	44.10	375.00
Yttrium	99.99	50.00	50.00

1/ Purity expressed as percent of total REO.

TABLE 3
MOLYCORP RARE-EARTH COMPOUND PRICES IN 1995

Product (compound)	Percent purity 1/	Standard package quantity (pounds)	Price per pound 2/
Cerium carbonate	99.0	150	$10.45 3/
Cerium nitrate	96.0	300	3.10
Lanthanide chloride	46.0	250	1.45
Lanthanum carbonate	99.9	175	5.90
Lanthanum-lanthanide carbonate	(Ce <1%)	150	2.15
Lanthanum-lanthanide chloride	46.0	250	1.05
Lanthanum-lanthanide nitrate	(Ce <1%)	250	1.75
Neodymium carbonate	96.0	300	5.35
Yttrium acetate	99.9	55	22.50
Yttrium nitrate	99.9	55	18.00

1/ Purity expressed in terms of REO equivalent.

2/ Priced on contained REO basis.

3/ Priced per pound CeO_2 basis.

TABLE 4
RHÔNE-POULENC RARE-EARTH OXIDE PRICES IN 1995

Product (oxide)	Percent purity	Standard package quantity (kilograms)	Price per kilogram
Cerium	99.50	25	$22.95
Cerium	99.95	25	37.00
Dysprosium	95.00	20	85.00
Erbium	96.00	20	190.00
Europium	99.99	10	700.00
Gadolinium	99.99	50	130.00
Holmium	99.90	10	485.00
Lanthanum	99.99	25	23.00
Lutetium	99.99	2	5,500.00
Neodymium	95.00	20	25.00
Praseodymium	96.00	20	32.00
Samarium	96.00	25	75.00
Terbium	99.90	5	685.00
Thulium	99.90	5	3,600.00
Ytterbium	99.00	10	230.00
Yttrium	99.99	50	85.00

TABLE 5
U.S. IMPORTS FOR CONSUMPTION OF RARE EARTHS, BY COUNTRY 1/

Country	1994 Quantity (kilograms)	1994 Value	1995 Quantity (kilograms)	1995 Value
Cerium compounds, including oxides, hydroxides, nitrates, sulfate chlorides, oxalates: (2846.10.0000)				
Austria	28,000	$290,000	33,200	$406,000
Belgium	12,000	43,700	--	--
China	718,000	3,150,000	2,480,000	13,300,000
France	879,000	7,590,000	1,440,000	8,810,000
Germany	8,940	204,000	21,000	362,000
India	60,600	67,300	--	--
Japan	173,000	4,010,000	99,100	2,280,000
Russia	91	1,350	22,100	158,000
United Kingdom	3,700	54,100	302	6,590
Other	7,220	19,700	478	14,300
Total	1,890,000	15,400,000	4,090,000	25,400,000
Rare-earth compounds, including oxides, hydroxides, nitrates, and other compounds except chlorides: (2846.90.5000)				
China	397,000	4,300,000	5,380,000	14,100,000
France	4,410,000	22,100,000	2,930,000	23,600,000
Germany	16,800	1,290,000	14,100	971,000
Hong Kong	45,100	640,000	4,000	125,000
Japan	190,000	8,940,000	222,000	9,630,000
Norway	19,700	3,420,000	5,210	2,990,000
Russia	6,610	154,000	19,900	381,000
South Africa	123	204,000	--	--
United Kingdom	47,400	2,900,000	72,500	4,680,000
Other	6,280 r/	414,000 r/	15,300	455,000
Total	5,140,000	44,400,000	8,670,000	56,900,000
Mixtures of rare-earth oxide except cerium oxide: (2846.90.2010)				
Austria	7,680	363,000	21,800	812,000
China	202,000	4,410,000	524,000	8,850,000
France	51,800	3,120,000	70,900	4,120,000
Germany	9,600	149,000	--	--
Hong Kong	1,100	84,400	1,100	258,000
Japan	9,470	994,000	11,500	1,940,000
Russia	2,050	55,800	7,200	113,000
United Kingdom	70,900	1,130,000	40,600	574,000
Other	46 r/	6,850 r/	351	9,100
Total	354,000	10,300,000	678,000	16,700,000

See footnotes at end of table.

TABLE 5--Continued
U.S. IMPORTS FOR CONSUMPTION OF RARE EARTHS, BY COUNTRY 1/

Country	1994 Quantity (kilograms)	1994 Value	1995 Quantity (kilograms)	1995 Value
Rare-earth metals, whether intermixed or alloyed: (2805.30.0000)				
Austria	--	--	17,600	$156,000
Belgium	--	--	33,400	288,000
Brazil	29,900	$197,000	2,000	19,900
China	169,000	2,230,000	593,000	4,380,000
Japan	3,880	127,000	3,170	64,700
Kazakstan	16,400	74,900	14,000	70,500
Russia	14,100	74,400	5,540	267,000
United Kingdom	50,200	1,670,000	84,400	2,360,000
Other	620	83,000	882	63,400
Total	284,000	4,450,000	754,000	7,670,000
Mixtures of rare-earth chlorides, except cerium chloride: (2846.90.2050)				
Belgium	24,000	183,000	19,700	232,000
China	317,000	4,020,000	325,000	4,330,000
Estonia	--	--	67,600	664,000
France	7,670	101,000	4,910	366,000
India	1,840,000	1,560,000	2,160,000	2,250,000
Japan	77,200	3,190,000	56,000	3,320,000
Russia	16,000	288,000	18,100	353,000
United Kingdom	132,000	1,920,000	64,600	756,000
Other	1,620	85,400	1,570	108,000
Total	2,410,000	11,400,000	2,720,000	12,400,000
Ferrocerium and other pyrophoric alloys: (3606.90.3000)				
Austria	8,140	195,000	6,740	180,000
Belgium	9,390	181,000	2,670	51,300
Brazil	23,200	294,000	4,500	77,900
France	36,000	489,000	72,800	1,090,000
Netherlands	--	--	1,080	23,000
Other	651	7,100	454	18,100
Total	77,400	1,170,000	88,300	1,440,000

r/ Revised.
1/ Data are rounded to three significant digits; may not add to totals shown.

Source: Bureau of the Census.

TABLE 6
U.S. EXPORTS OF RARE-EARTHS, BY COUNTRY 1/

Country	1994 Quantity (kilograms)	1994 Value	1995 Quantity (kilograms)	1995 Value
Cerium compounds: (2846.10.0000)				
Belgium	34,700	$194,000	23,600	$138,000
Brazil	133,000	542,000	25,200	207,000
Canada	516,000	4,700,000	499,000	5,950,000
Egypt	--	--	36,000	221,000
France	33,100	186,000	9,730	55,200
Germany	38,400	247,000	78,200	573,000
Hong Kong	68,400	448,000	51,600	394,000
India	49,400	165,000	17,500	96,100
Italy	8,160	472,000	7,540	63,600
Japan	441,000	4,880,000	492,000	6,630,000
Korea, Republic of	1,480,000	5,350,000	1,660,000	8,600,000
Malaysia	51,000	616,000	218,000	4,610,000
Mexico	80,100	469,000	33,900	267,000
Singapore	771,000	3,100,000	1,490,000	5,380,000
South Africa	3,380	53,800	41,400	223,000
Taiwan	650,000	2,330,000	373,000	1,500,000
Thailand	47,600	203,000	1,440	11,900
United Kingdom	23,900	159,000	10,500	278,000
Other	36,400 r/	236,000 r/	44,000	307,000
Total	4,460,000	24,400,000	5,120,000	35,500,000
Rare-earth compounds: (2846.90.0000)				
Austria	1,480	38,600	6,510	147,000
Belgium	163,000	184,000	830	237,000
Brazil	790,000	1,880,000	561,000	1,370,000
Canada	149,000	416,000	230,000	814,000
Chile	1,000	7,650	1,810	382,000
China	910	15,400	332,000	676,000
Finland	16,000	392,000	8,250	240,000
France	349,000	502,000	32,400	345,000
Germany	11,300	615,000	52,200	1,960,000
Hong Kong	57,300	115,000	2,160	415,000
Israel	19,500	44,900	114	109,000
Japan	212,000	2,950,000	151,000	2,600,000
Korea, Republic of	83,000	2,340,000	18,500	1,110,000
Switzerland	1,420	50,200	2,190	156,000
Taiwan	151,000	1,900,000	104,000	1,640,000
United Kingdom	277,000	745,000	15,400	638,000
Other	133,000 r/	296,000 r/	28,000	562,000
Total	2,420,000	12,500,000	1,550,000	13,400,000
Rare-earth metals, including scandium and yttrium: (2805.30.0000)				
Canada	52,800	325,000	60,500	386,000
China	--	--	37,200	20,000
France	2,460	73,900	40,700	83,200
Germany	86,300	75,300	2,360	106,000
Japan	1,310	118,000	72,400	1,320,000
Korea, Republic of	1,330	117,000	1,920	145,000
Mexico	81,900	37,000	499	2,880
Netherlands	6	2,700	5,490	171,000
Sweden	3,380	260,000	--	--
Taiwan	32,900	46,300	79,800	123,000
United Kingdom	11,300	449,000	28,300	1,060,000
Other	495 r/	65,100 r/	40,400	269,000
Total	274,000	1,570,000	370,000	3,690,000

See footnotes at the end of table.

TABLE 6--Continued
U.S. EXPORTS OF RARE-EARTHS, BY COUNTRY 1/

Country	1994 Quantity (kilograms)	1994 Value	1995 Quantity (kilograms)	1995 Value
Ferrocerium and other pyrophoric alloys: (3606.90.0000)				
Australia	77,900	$334,000	119,000	$264,000
Belgium	43,200	73,400	3,140	109,000
Canada	581,000	2,130,000	1,040,000	2,110,000
Cyprus	40,800	42,600	2,870	45,400
Egypt	146	732,000	402	7,550
France	135,000	517,000	83,300	500,000
Germany	500,000	984,000	452,000	2,090,000
Greece	139,000	139,000	91,500	102,000
Hong Kong	266,000	621,000	194,000	789,000
India	15,200	20,900	24,700	207,000
Italy	11,100	227,000	5,230	291,000
Jamaica	73,000	118,000	27,000	52,900
Japan	164,000	2,100,000	62,900	1,550,000
Korea, Republic of	20,200	314,000	13,900	148,000
Kuwait	38,400	54,600	63,100	103,000
Mexico	89,000	217,000	137,000	504,000
Netherlands	93,300	395,000	22,100	326,000
New Zealand	41,400	114,000	55,100	98,200
Peru	291,000	169,000	495,000	378,000
Russia	6,980	160,000	2,090	140,000
Saudi Arabia	91,100	201,000	101,000	396,000
Singapore	119,000	331,000	83,800	270,000
Sweden	436	22,300	1,580	457,000
Switzerland	2,060	105,000	28,700	153,000
Taiwan	27,600	115,000	105,000	197,000
Thailand	4,750	38,300	29,600	381,000
United Arab Emirates	172,000	216,000	208,000	335,000
United Kingdom	55,300	192,000	101,000	417,000
Other	300,000 r/	1,310,000 r/	352,000	1,800,000
Total	3,400,000	12,000,000	3,910,000	14,200,000

r/ Revised.
1/ Data are rounded to three significant digits; may not add to totals shown.

Source: Bureau of the Census.

TABLE 7
MONAZITE CONCENTRATE: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons, gross weight)

Country 3/	1991	1992	1993	1994	1995 e/
Australia e/	7,000	6,000	3,000 r/	-- r/	-- 4/
Brazil	1,308	1,400	1,400 e/	1,400 e/	1,400
China e/	1,185 4/	1,800	1,800	1,800	1,800
India e/	4,000	4,000	4,600	4,600	5,000
Malaysia	1,981	777	407	425	814 4/
South Africa e/	430 r/	430 r/	430 r/	131 r/	--
Sri Lanka e/	200	200	200	200	200
Thailand	400 e/	89	220	57 r/	60
United States	W	W	W	W	--
Zaire e/	120	50	20 r/	20 r/	30
Total	16,600 r/	14,700 r/	12,100 r/	8,630 r/	9,300

e/ Estimated. r/ Revised. W Withheld to avoid disclosing company proprietary data; excluded from "Total."

1/ Table includes data available through June 27, 1996.

2/ World totals and estimated data are rounded to three significant digits; may not add to totals shown.

3/ In addition to the countries listed, Indonesia, North Korea, the Republic of Korea, Nigeria, and the former U.S.S.R. may produce monazite, but output, if any, is not reported quantitatively, and available general information is inadequate for formulation of reliable estimates of output levels.

4/ Reported figure.

TABLE 8
RARE EARTHS: WORLD MINE PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons of REO equivalent)

Country 3/	1991	1992	1993	1994	1995 e/
Australia e/	3,850	3,300	1,650 r/	-- r/	--
Brazil	719	396	400 e/	400 e/	400
China e/	16,150	21,340	22,100	23,000	25,000
India e/	2,200	2,200	2,500	2,500	2,700
Madagascar:					
Bastnasite	-- r/	-- r/	-- r/	-- r/	--
Monazite	-- r/	-- r/	-- r/	-- r/	--
Malaysia	1,090	427	224	234	448 4/
South Africa e/	240 r/	240 r/	240 r/	72 r/ 4/	-- 4/
Sri Lanka e/	110	110	110	120	120
Thailand	235	89	220	57 r/	--
U.S.S.R. e/ 5/	8,500	8,000	7,000	6,000	6,000
United States 6/	16,500	20,700	17,800	20,700	22,200 4/
Zaire e/	66	28	11 r/	11 r/	11
Total	49,600 r/	56,800 r/	52,200 r/	53,100 r/	56,900

e/ Estimated. r/ Revised.

1/ World totals, U.S. data, and estimated data have been rounded to three significant digits; may not add to totals shown.

2/ Table includes data available through Aug. 5, 1996.

3/ In addition to the countries listed, rare-earth minerals are believed to be produced in Indonesia, Mozambique, North Korea, and Vietnam, but information is inadequate to formulate reliable estimates.

4/ Reported figure.

5/ Dissolved in Dec. 1991; however, information is inadequate to formulate reliable estimates for individual countries.

6/ Comprises only the rare earths derived from bastnasite as reported from company sources.