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 part 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 rare earths are iron gray to silvery lustrous metals; typically soft, malleable, and ductile; and usually reactive, especially at elevated temperatures or when finely divided. Melting points range from 798° C for cerium, which at atmospheric pressure is denser as a liquid than as a solid, 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 1994. The domestic economy rebounded strongly in 1994, and inflation rose a modest 2.1%. Estimated domestic apparent consumption increased 5%; with earnings by the major domestic processor reportedly increasing amid gains in sales. *(See table 1.)* Demand increased for rare earths used in petroleum fluid cracking catalysts, automotive catalytic converters, and permanent magnets, while phosphors for television, X-ray intensifying, and lighting remained stable. Yttrium was used primarily in lamp and cathode ray tube phosphors and in structural ceramics and oxygen sensors.

The domestic use of scandium in 1994 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

The calendar year 1994 included the U.S. Government fiscal years for 1994 and 1995. Public Law 103-160, the National Defense Authorization Act for fiscal year 1994, was enacted on November 30, 1993, and covered the year 1994 through September 30. It continued specific previous authorizations for disposal of stocks in the National Defense Stockpile (NDS) classified as excess to goal. The National Defense Authorization Act for fiscal year 1995, Public Law 103-337, was enacted on October 5, 1994, and covered the last 3 months of 1994. Stocks of rare earths in sodium sulfate were all classified as excess to goal throughout 1994 and were inventoried at 457 metric tons.

U.S. tariff rates, specific to the rare earths, including scandium and yttrium, are unchanged for 1994, except for certain special tariff revisions for Canada and Mexico. Revisions to 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. Except for certain staged reductions for Canada and Mexico as designated under NAFTA, tariff rates for other foreign countries were negotiated under the Generalized Agreement on Tariffs and Trade (GATT) Uruguay Round of Multilateral Trade Negotiation. The GATT Uruguay Round of negotiations were completed in November 1994 with new staged rate schedules taking effect January 1, 1995. U.S. tariff rates for rare earths are listed in the Harmonized Tariff Schedule of the United States (1994), publication 2690, with supplement, and the Harmonized Tariff Schedule of the United States (1995), publication 2831, with a July supplement, as compiled by the United States International Trade Commission. Publication 2831 is available from the Government Printing Office under document number 949-011-00000-3.

Production

Domestic mine production data for rare earths are developed by the U.S. Bureau of Mines (USBM) from a voluntary survey of U.S. operations entitled, "Rare Earths, Thorium, and Scandium." The two mines to which a survey form was sent, responded, representing 100% of known mine production. Mine production data are withheld to avoid disclosing company proprietary data. Two domestic mines produced rare earths in 1994. The United States was the world's second largest producer of rare earths for the second consecutive year. Producers were Molycorp, Inc., a wholly owned subsidiary of Unocal Corp., and RGC (USA) Minerals Inc. Bastnasite was mined by open pit methods by Molycorp at Mountain Pass, CA. Molycorp's mine was the leading producer of rare earths in the United States and second in the rest of the world. According to company spokesperson, mine production increased from the previous year's level of 17,754 tons rare earth oxides (REO) to 20,664 tons REO in 1994.

RGC (USA) Minerals Inc. recovered monazite for its rare-earth content as a byproduct during processing for titanium and zirconium minerals. RGC (USA), a wholly owned subsidiary of the Australia-based Renison Goldfields Consolidated Ltd. (RGC), operated a dredging operation at Green Cove Springs, FL. Byproduct monazite production decreased 27% in 1994 as demand for thorium-bearing rare-earth ores declined.

Refined lanthanides were produced by three companies in 1994. 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 (formerly Davison Specialty Chemical Co.) refined rare earths for fluid cracking catalysts from rare-earth chloride and other intermediate rare-earth compounds at Chattanooga, TN.

Except for minor amounts of yttrium contained in monazite and other rare-earth minerals, essentially all yttrium was derived from imported compounds.

Three scandium processors operated in 1994. High-purity products were available in various grades with scandium oxide produced up to 99.999% purity. Sausville Chemical refined scandium concentrates at its facilities in Garfield, NJ, to produce scandium oxide, fluoride, nitrate, chloride, and acetate. Boulder Scientific Co. processed scandium at its Mead, CO, operations. Scandium concentrates were derived from a variety of ores. Boulder's main ore source was thortveitite-bearing tailings from the mined-out Crystal Mountain fluorite mine near Darby, MT. Scandium also was processed by APL Engineered Materials in Urbana, IL, to produce compounds and metal.

Reactive Metals and Alloys Corp. (REMACOR) was the principal domestic producer of mischmetal. Production of mischmetal, rare-earth silicide, and other rare-earth alloys decreased 25% in 1994. Production of high-purity metals also decreased.

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

Consumption

Statistics on domestic thorium consumption are developed by surveying various processors and manufacturers, evaluating import-export data, and analyzing Government stockpile shipments. Domestic apparent consumption of rare earths increased 5% in 1994 compared with that of 1993. The producers of mischmetal, rare-earth silicide, and other rare-earth alloys produced 25% less rare earths in 1994 than they did in 1993, while consumption of the alloys decreased 66%. Shipments of the mixed rare-earth alloys declined 63%. Consumption of mixed rare-earth compounds showed a strong gain of 216% as demand continued to surge for mixed intermediates for petroleum fluid cracking catalysts and automotive catalytic converters. Domestic shipments of mixed compounds, which increased only 7% in 1993, caught up to demand in 1994 with a 285% increase.

The approximate distribution of rare earths by use, based on information supplied by primary processors and some consumers, was as follows: catalysts in petroleum refining, 34%; metallurgical uses as iron and steel additives and as alloys, 8%; glass polishing compounds, glass additives, and ceramics, 37%; permanent magnets, 14%; lighting, phosphors, mantles, research, and miscellaneous, 6%.

Yttrium consumption was estimated by the USBM commodity specialist at 344 metric tons for 1994. The approximate distribution of yttrium by end use, based on analysis of import data, was as follows: lamp and cathode ray tube (CRT) phosphors, 68%, structural ceramics and components, 29%, and oxygen sensors and miscellaneous, 3%. Yttrium compounds were sourced from China, 62.8%; the United Kingdom, 29.3%; Hong Kong, 4.75%; Japan, 2.18%; and France, 0.96%.

Stocks

U.S. Government stocks of rare earths in the NDS remained at 457 tons throughout 1994. 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.

Prices

Prices for rare earths were mixed in 1994. Domestic prices for lanthanide and yttrium oxides were unchanged from the 1993 levels, except for increases in cerium oxide. Prices for rare-earth chlorides increased in response to strong demand for thorium-free feed materials. Neodymium carbonate prices also increased as demand for neodymium-containing permanent magnets remained strong. 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$), remained unchanged at A$300 to A$350 per ton at yearend 1994.[2] Changes in the United States-Australia foreign exchange rate in 1994, resulting from a weaker U.S. dollar on world markets, caused the U.S. dollar to be down $0.10 against the Australian dollar at yearend. Converted from Australian dollars, the U.S. price range for monazite increased significantly from US$204 to US$238[3] per ton in 1993 to US$233 to US$272[4] per ton in 1994.

The nominal price for basic neodymium-iron-boron alloy, compiled by the author from several U.S. producers, was $26.68 per kilogram ($12.10 per pound) at yearend, f.o.b. shipping point, 1,000-pound minimum. Most alloy was sold with additions of cobalt (up to 15%) or dysprosium (up to 5%). The cost of the additions was based on market pricing; with cobalt at $54.37 per kilogram (average $24.66 per pound) the cost would be about $0.54 for each percent addition per kilogram ($0.25 for each percent addition per pound).

The price for standard-grade domestic mischmetal remained unchanged from the previous year at $12.68 per kilogram. Market prices were stable at $9 to $13 per kilogram.

Rare-earth metal prices were mixed with yttrium and neodymium increasing slightly while dysprosium and samarium prices edged lower. Most other rare-earth metal prices were unchanged. 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 1994, 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 1994 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 1994, as shown in table 4.

No published prices for scandium oxide in kilogram quantities were available. Yearend 1994 nominal prices for scandium oxide per kilogram were compiled by the author from information from several domestic suppliers and processors. Prices increased slightly from the previous year for most grades and were listed as follows: 99% purity, $1,600; 99.9% purity, $3,300; 99.99% purity, $5,200; and 99.999% purity, $9,000.

Scandium metal prices, as listed by the Johnson Matthey Aesar Group, were as follows: 99.99% purity, lump, sublimed dendritic, ampouled under argon, $191.00 per gram; 99.9% purity, 250-micron powder, ampouled under argon, $559.00 per 2 grams; and 99.9% purity, lump, vacuum remelted, ampouled under argon, $257.00 per 2 grams; 99.9% purity, foil, 0.025 millimeters (mm) thick, ampouled under argon, 25 mm by 25 mm, $117.00 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 hydrate 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 ICP/DCP 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 1994. Imports gained 14% compared with 1993 and totaled 6,670 metric tons valued at $41 million. Exports of rare earths also increased in 1994. Domestic shipments of rare-earth materials climbed 41% to about 10,000 tons valued at $50 million.

World Review

Demand continued to increase for thorium-free rare-earth compounds for use as refinery feed material. China was a major source of rare-earth chlorides and nitrates. Demand for rare earths increased in Asia, Europe, and the United States as most world economies improved. *(See tables 8 and 9.)*

Australia.—The Mount Weld Rare-Earth project was not approved for further development.[8] According to Ashton Rare Earths Ltd.'s project manager, the project was halted until demand for cerium and world economic conditions improved. Markets for Mount Weld's principal commodity, cerium, improved in 1994, however, supplies of cerium remained adequate to meet demand in glass polishing, automotive catalytic converters, and glass additives. The Mount Weld project is scheduled for future periodic review as market conditions warrant.

Tioxide Group Ltd. (TGL), a wholly owned subsidiary of ICI, divested itself of its 44.5% holdings in Westralian Sands Ltd. (WSL).[9] The Japanese company, Ishihara Sangyo Kaisha Ltd. (ISK), also sold its 18.9% interest in WSL. Both TGL and ISK reportedly retained long-term contracts for the purchase of minerals sands from WSL, but decided to concentrate investments in other areas. WSL reopened its Yoganup Extended Mine in the first quarter of 1994 as markets for mineral sands improved. A new mineral sands concentrator was commissioned at the reopened mine in March to improve recovery rates.

Minproc Holdings, a 50% owner in the Tiwest mineral sands joint venture at Cooljarloo, Western Australia, changed its name to Ticor Ltd. The joint venture, which includes Kerr-McGee Corp.'s (U.S.) Australian subsidiary, KMCC Western Australia Pty. Ltd., produced heavy mineral sands near Cataby and operated a dry separation plant and synthetic rutile plant at Chandala. A Kerr-McGee's spokesperson said the Minproc name change would not affect its KMCC joint venture.[10]

Consolidated Rutile Ltd.'s (CRL), Gordon Mine on North Stradbroke Island suspended operation in March 1994 due to the sinking of its 3,000 ton per hour dredge.[11] The dredge was refloated at midyear and resumed operation. CRL's other mineral sands operation, the Bayside Mine in Queensland, continued to operate. CRL noted it had ceased recovery of monazite due to decreased world demand and problems in storing radioactive materials.

Cable Sands announced the opening of the Jangardup minerals sands operation in Western Australia.[12] The operation, located 60 kilometers south of Nannup in southern Western Australia, has a capacity to produce 230,000 tons of mineral sands per year.

BHP Ltd. continued to assess development of the Beenup mineral sands deposit.[13] Located in the Scott River area of Western Australia, the Beenup deposit would likely be mined by BHP's subsidiary Mineral Deposits Ltd. (MDL). MDL presently operates three mines in New South Wales.

Renison Goldfields Consolidated Ltd. operated four mineral sands mines in 1994. According to RGC's 1994 annual report, three mines were operated in Western Australia, the Eneabba West, Eneabba North, and Capel.[14] RGC's fourth mine produced mineral sands at Green Cove Springs, FL, in the United States. Except for the Eneabba North Mine operating at 75% of capacity, all other RGC mines reportedly operated at full capacity. With improvement in the world markets for mineral sand products, RGC is reassessing development of its principal undeveloped U.S. deposit, the Old Hickory in Virginia.

China.—China was the world's leading producer of rare earths in 1994, according to the China Rare Earth Information newsletter, producing 30,650 tons of REO.[15] Rare earth production in China, which was up 38.7%, was primarily from the Bayan Obo iron ore-rare earth mine in Nei Monggol Autonomous Region. Most ore from the deposit was processed and refined at facilities at Baotou, 135 kilometers to the south. Smaller quantities of bastnasite were produced in Shandong Province and at a new deposit at Sichuan Province.

Canadian-based Advanced Material Resources Ltd. (AMR) entered into another joint venture to produce rare earths from a bastnasite-bearing carbonatite at Mianning, Sichuan Province. AMR reportedly retained an 80% interest in the project which will have an initial capacity of 3,500 tons of REO per year. AMR's other interests in Chinese rare-earth processing plants are in Jiangyin, Jiangsu Province and Zibo, Shandong Province.[16]

France.—Rhône-Poulenc S.A. (RP) has switched feed materials for its La Rochelle separation plant from monazite to thorium-free intermediate rare-earth compounds. According to a U.S. spokesperson for the company, thorium waste generated during processing for the rare earths was previously sent to an approved disposal site in northern France until 1991. A 3 year extension of disposal privileges was extended to RP at a temporary storage facility through 1994.[17]

Malaysia.—The Far Eastern Economic Review reported that the joint venture Asian Rare Earth Sdn. Bhd. plant in Ipoh, Perak State, would close because of strong world competition, mainly from China.[18] The joint-venture operation was 35% owned by Mitsubishi Chemical Industries Ltd. of Japan.

Outlook

The shift towards higher purity mixed and separated products was evident in 1994, a trend that is expected to continue through the year 2010. A large increase in demand for rare-earth metals and alloys was noted for high-strength permanent magnets in 1994. 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, automobile catalytic converters, and rechargeable batteries.

World reserves are sufficient to meet world demand well into the 21st century. The fact that several large rare-earth deposits have yet to be developed 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 in the rest-of-world, however, is expected to increase due to its abundant supply and low cost byproduct recovery. 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 ores.

Domestic demand in 1995 is expected to exhibit strong growth as the domestic economy shows signs of continued strength. 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 new sources.

The long-term outlook is for an increasingly

competitive and diverse group of rare-earth suppliers. The economic base of the rare-earth industry has continued to broaden as the industry matures and diversifies.

---

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

[2]Metal Bulletin (London). Non-ferrous Ores in Europe. No. 7744, Dec. 31, 1992, p. 25.

[3]Values have been converted from Australian dollars (A$) to U.S. dollars (US$) at the exchange rate of A$1.4725=US$1.00 based on yearend 1993 foreign exchange rates reported in the Wall Street Journal.

[4]Values have been converted from Australian dollars (A$) to U.S. dollars (US$) at the exchange rate of A$1.2878=US$1.00 based on yearend 1994 foreign exchange rates reported in the Wall Street Journal.

[5]ALPHA/AESAR 1994 Catalog. Available from AESAR/Johnson Matthey, P.O. Box 8247, Ward Hill, MA. p. 556.

[6]Aldrich Catalog Handbook of Fine Chemicals 1994-1995. 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. BuMines, 1990, pp. 81-98.

[8]Personal communication with Dudley J. Kingsnorth, Project manager, Ashton Rare Earths Ltd.

[9]Westralian Sands Limited. 1994 Annual Report.

[10]Personal communication with A. Barry Brandt, vice president of investor relations and communications, Kerr-McGee Corp.

[11]Personal communication with Consolidated Rutile Ltd. company representative.

[12]Min. J. (London). Jangardup Opened. V. 323, No. 8285, July 22, 1994, p. 59.

[13]Ind. Min. (London). Scott River Mineral Sands Interests. No. 265, Oct. 1994, p. 12.

[14]Renison Goldfields Consolidated Limited. 1994 Annual Report. 47 pp.

[15]China Rare Earth Information. China Rare Earth 1994. No. 37, May 1995, 4 pp.

[16]Ind. Min. (London). AMR Second Rare Earth JV. No. 316, Jan. 1994, p. 9.

[17]———. RP Switches Rare Earth Ore. No. 319, Apr. 1994, pp. 15-16.

[18]Min. J. (London). Malaysian Rare Earth Plant to Close. v. 322, No. 8262, Feb. 11, 1994, p. 106.

OTHER SOURCES OF INFORMATION

U.S. Bureau of Mines Publications

Hedrick, J.B. Rare Earths: The Lanthanides, Yttrium, and Scandium-1993. BuMines Annual Report, Mar. 1995, 27 pp.

Hedrick, J.B. Rare Earths: The Lanthanides, Yttrium, and Scandium - 1992. BuMines Annual Report, Dec. 1993, 27 pp.

Hedrick, J.B. Thorium Annual Review-1994. BuMines Mineral Industry Surveys, July 1995, 4 pp.

Hedrick, J.B. Thorium Annual Review-1993. BuMines Mineral Industry Surveys, June 1994, 5 pp.

Hedrick, J.B. Rare Earth Elements and Yttrium. Preprint from BuMines Mineral Facts and Problems 1985, Bull. 675, 18 pp.

Other Sources

China Rare Earth Information Newsletter. (China)

Elements: Rare Earths, Specialty Metals, and Applied Technology.

Rare-earth Information Center Insight.

Rare-earth Information Center News.

Unocal Corp. annual report

Kerr-McGee annual report.

Renison Goldfields Consolidated annual report. (Australia)

Westralian Sands annual report. (Australia)

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

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

	1990	1991	1992	1993	1994
Production of rare-earth concentrates	22,700 2/	16,500 3/	20,700 3/	17,800 3/	20,700 3/
Exports:					
Cerium compounds	1,730	1,370	1,940	1,620	4,460
Rare-earth metals, scandium, and yttrium	241	71	44	194	329
Ores and concentrates	NA	459 4/	--	--	--
Rare-earth compounds, organic or inorganic	1,460	1,790	1,310	1,090	2,420
Ferrocerium and pyrophoric alloys	83	2,100	2,430	4,270	3,020
Imports for consumption: e/					
Monazite	440	--	--	--	--
Metals, alloys, oxides, compounds	4,490	6,110	5,330	6,670	7,620
Stocks, producers and processors, yearend	W	W	W	W	W
Consumption, apparent: e/	28,700	22,100	21,400	17,000	17,800
Prices, yearend, dollars per kilogram:					
Bastnasite concentrate, REO basis	2.87	2.87	2.87	2.87	2.87
Monazite concentrate, REO basis	1.19	0.93	0.41	0.40	0.46
Mischmetal, metal basis	11.02	11.02	12.68	12.68	12.68
Employment, mine and mill 5/	397	411	372	352	NA
Net import reliance 6/ as a percent of apparent consumption	20	25	33	(7/)	NA

e/ Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data.
1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits, except prices.
2/ Comprises only the rare earths derived from bastnasite, as reported in Unocal Corp. annual reports.
3/ Comprises only the rare earths derived from bastnasite as obtained from Molycorp, Inc., company representative.
4/ Source: The Journal of Commerce Trade Information Service.
5/ 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.
6/ Imports minus exports plus adjustments for Government and industry stock changes.
7/ Net exporter.

TABLE 2
MOLYCORP RARE-EARTH OXIDE PRICES

Product (oxide)	Percent 1/ purity	Quantity (pounds)	Price per pound
Cerium (5310)	96.00	200.00	$7.90
Cerium (5350)	99.00	200.00	10.50
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 (5400)	96.00	300.00	6.75
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	52.50

1/ Purity expressed as percent of total REO.

TABLE 3
MOLYCORP RARE-EARTH COMPOUND PRICES

Product (compound)	Percent purity 1/	Quantity (pounds)	Price per pound 2/
Cerium carbonate	99.0	150	$9.75 3/
Cerium nitrate	96.0	300	2.90
Lanthanide chloride	46.0	250	1.25
Lanthanum carbonate	99.9	175	5.90
Lanthanum-lanthanide carbonate	60.0	150	2.15
Lanthanum-lanthanide chloride	46.0	250	1.05
Lanthanum-lanthanide nitrate	39.0	250	1.75
Neodymium carbonate	96.0	300	4.50

1/ Purity expressed in terms of REO equivalent.
2/ Priced on contained REO basis.
3/ Priced per pound CeO_2 basis.

TABLE 4
RHONE-POULENC RARE-EARTH OXIDE PRICES

Product (oxide)	Percent purity	Quantity (kilograms)	Price per kilogram
Cerium	99.50	25	$22.95
Cerium	99.95	25	37.80
Dysprosium	95.00	20	110.00
Erbium	96.00	20	190.00
Europium	99.99	10	990.00
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	19.70
Praseodymium	96.00	20	36.80
Samarium	96.00	25	125.00
Terbium	99.90	5	685.00
Thulium	99.90	5	3,600.00
Ytterbium	99.00	10	230.00
Yttrium	99.99	50	88.00

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

Country	1993 Quantity (kilograms)		1993 Value		1994 Quantity (kilograms)	1994 Value
Cerium compounds, including oxides, hydroxides, nitrate, sulfate chloride, oxalate: (2846.10.0000)						
Austria	24,600		$262,000		28,000	$290,000
Belgium	7,900		59,000		12,000	43,700
China	669,000		2,850,000		718,000	3,150,000
France	281,000		2,670,000		879,000	7,590,000
Germany	2,310		62,800		8,940	204,000
India	128,000		168,000		60,600	67,300
Japan	148,000		3,860,000		173,000	4,010,000
Russia	2,310		7,670		91	1,350
United Kingdom	4,320		39,900		3,700	54,100
Other	1,410		37,300		7,220	19,700
Total	1,270,000		10,000,000		1,890,000	15,400,000
Rare earth compounds, including oxides, hydroxide, nitrate, and other compounds except chlorides: (2846.90.5000)						
Brazil	9,000		38,100		--	--
China	382,000		3,620,000		397,000	4,300,000
France	4,420,000		26,100,000		4,410,000	22,100,000
Germany	4,080		502,000		16,800	1,290,000
Hong Kong	--		--		45,100	640,000
Japan	145,000		8,200,000		190,000	8,940,000
Norway	731		140,000		19,700	3,420,000
Russia	3,960		362,000		6,610	154,000
United Kingdom	4,600		268,000		47,400	2,900,000
Other	7,480	r/	219,000	r/	6,410	618,000
Total	4,980,000		39,400,000		5,140,000	44,400,000
Mixtures of rare-earth oxide except cerium oxide: (2846.90.2010)						
Austria	4,460		179,000		7,680	363,000
Belgium	9,000		26,100		--	--
China	60,000		1,260,000		202,000	4,410,000
Estonia	9,040		26,700		--	--
France	71,100		4,810,000		51,800	3,120,000
Germany	6,900		837,000		9,600	149,000
India	28,900		92,900		--	--
Japan	38,200		1,930,000		9,470	994,000
United Kingdom	14,300		802,000		70,900	1,130,000
Other	7,670	r/	597,000	r/	3,200	147,000
Total	249,000		10,600,000		354,000	10,300,000
Rare-earth metals, whether intermixed or alloyed: (2805.30.0000)						
Brazil	20,400		142,000		29,900	197,000
China	161,000		1,550,000		169,000	2,230,000
Japan	1,230		140,000		3,880	127,000
Kazakhstan	--		--		16,400	74,900
Russia	3,280		113,000		14,100	74,400
United Kingdom	9,650		674,000		50,200	1,670,000
Other	360	r/	27,900	r/	620	83,000
Total	196,000		2,640,000		284,000	4,450,000
Mixtures of rare-earth chlorides, except cerium chloride: (2846.90.2050)						
Belgium	--		--		24,000	$183,000
China	315,000		$4,150,000		317,000	4,020,000
France	1		8,000		7,670	101,000
India	1,900,000		1,580,000		1,840,000	1,560,000
Japan	24,000		1,360,000		77,200	3,190,000
Russia	7,210		61,200		16,000	288,000
Sweden	51,200		391,000		--	--
United Kingdom	56,200		427,000		132,000	1,920,000
Other	3,470	r/	115,000	r/	1,620	85,400
Total	2,360,000		8,090,000		2,410,000	11,400,000
Ferrocerium and other pyrophoric alloys: (3606.90.3000)						
Austria	15,800		292,000		8,140	195,000
Belgium	14,100		223,000		9,390	181,000
Brazil	34,800		450,000		23,200	294,000
France	50,200		612,000		36,000	489,000
Germany	3,200		66,400		--	--
Other	82	r/	10,100	r/	651	7,100
Total	118,000		1,650,000		77,400	1,170,000

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines 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	1993 Quantity (kilograms)		1993 Value		1994 Quantity (kilograms)	1994 Value
Cerium compounds: (2846.10.0000)						
Belgium	17,900		$87,800		34,700	$194,000
Brazil	84,300		430,000		133,000	542,000
Canada	385,000		3,440,000		516,000	4,700,000
France	40,000		423,000		33,100	186,000
Germany	64,600		589,000		38,400	247,000
Hong Kong	86,100		618,000		68,400	448,000
India	5,180		66,400		49,400	165,000
Italy	19,000		171,000		8,160	472,000
Japan	237,000		2,470,000		441,000	4,880,000
Korea, Republic of	211,000		1,420,000		1,480,000	5,350,000
Malaysia	467		87,000		51,000	616,000
Mexico	19,500		197,000		80,100	469,000
Netherlands	3,810		47,500		11,400	52,300
Singapore	229,000		834,000		771,000	3,100,000
South Africa, Republic of	7,170		37,700		3,380	53,800
Taiwan	141,000		542,000		650,000	2,330,000
Thailand	29,600		56,800		47,600	203,000
United Kingdom	6,290		39,400		23,900	159,000
Other	34,800	r/	163,000	r/	25,000	184,000
Total	1,620,000		11,700,000		4,460,000	24,400,000
Rare-earth compounds: (2846.90.0000)						
Bahamas, The	21,400		30,000		24,900	15,800
Belgium	791		231,000		163,000	184,000
Brazil	55,000		224,000		790,000	1,880,000
Canada	99,800		335,000		149,000	416,000
Chile	88,100		104,000		1,000	7,650
Finland	34,800		819,000		16,000	392,000
France	241,000		420,000		349,000	502,000
Germany	55,000		2,070,000		11,300	615,000
Hong Kong	5,690		232,000		57,300	115,000
Israel	--		--		19,500	44,900
Japan	366,000		5,780,000		212,000	2,950,000
Korea, Republic of	14,800		646,000		83,000	2,340,000
Panama	--		--		11,900	27,100
Phillipines	--		--		80,000	16,000
Taiwan	59,200		1,740,000		151,000	1,900,000
United Kingdom	26,100		379,000		277,000	745,000
Other	19,200	r/	1,120,000	r/	20,000	341,000
Total	1,090,000		14,100,000		2,420,000	12,500,000
Rare-earth metals, including scandium and yttrium: (2805.30.0000)						
Canada	39,300		283,000		52,800	325,000
China	14,000		58,300		--	--
Germany	65,300		131,000		86,300	75,300
Mexico	200		2,620		81,900	37,000
Taiwan	633		25,300		32,900	46,300
United Kingdom	25,000		124,000		11,300	449,000
Other	17,000	r/	1,770,000	r/	8,980	637,000
Total	161,000		2,400,000		274,000	1,570,000
Ferrocerium and other pyrophoric alloys: (3606.90.0000)						
Argentina	77,300		530,000		31,500	108,000
Australia	96,900		249,000		77,900	334,000
Bahrain	42,500		59,800		15,100	22,100
Barbados	44,100		48,300		30,900	32,800
Belgium	42,400		201,000		43,200	73,400
Brazil	41,800		80,200		1,210	35,500
Canada	378,000		1,880,000		581,000	2,130,000
China	110,000		130,000		1,480	34,200
Cyprus	26,900		35,500		40,800	42,600
Denmark	62,100		114,000		2,430	30,400
Dominican Republic	47,100		164,000		348	8,910
France	99,300		385,000		135,000	517,000
Gambia, The	113,000		1,580,000		--	--
Germany	284,000		826,000		500,000	984,000

See footnotes at the end of table.

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

Country	1993		1994	
	Quantity (kilograms)	Value	Quantity (kilograms)	Value
Ferrocerium and other pyrophoric alloys--Continued: (3606.90.0000)				
Greece	124,000	$94,200	139,000	$139,000
Guatemala	137,000	166,000	2,640	8,980
Honduras	35,700	124,000	--	--
Hong Kong	437,000	931,000	266,000	621,000
Iceland	19,300	499,000	10,900	17,000
Indonesia	9,040	32,600	11,700	11,900
Ireland	21,000	48,700	16,000	13,300
Italy	4,120	34,200	11,100	227,000
Jamaica	96,300	123,000	73,000	118,000
Japan	696,000	4,440,000	164,000	2,100,000
Jordan	31,500	17,700	60,600	67,000
Korea, Republic of	5,000	22,000	20,200	314,000
Kuwait	61,000	111,000	38,400	54,600
Mexico	45,500	207,000	89,000	217,000
Netherlands	90,100	1,200,000	93,300	395,000
New Zealand	40,800	59,000	41,400	114,000
Peru	--	--	291,000	169,000
Portugal	--	--	14,200	20,000
Romania	31,300	132,000	--	--
Russia	381	66,900	6,980	160,000
Saudi Arabia	295,000	1,640,000	91,100	201,000
Singapore	358,000	1,280,000	119,000	331,000
Taiwan	119,000	587,000	27,600	115,000
Thailand	30,100	91,900	4,750	38,300
Trinidad and Tobago	29,200	42,600	4,410	11,600
United Arab Emirates	229,000	310,000	172,000	216,000
United Kingdom	255,000	923,000	55,300	192,000
Uruguay	634	14,600	90	10,000
Venezuela	16,900	36,500	1,220	54,300
Other	123,000 r/	861,000 r/	113,000	1,700,000
Total	4,810,000	20,400,000	3,400,000	12,000,000

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines 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/	1990	1991	1992	1993	1994 e/
Australia e/	11,000	7,000	6,000 r/	16,000 r/	6,000
Brazil	1,660	1,310	1,400	1,400 e/	1,400
China	2,380	1,190	1,800 e/	1,800 e/	1,800
India e/	4,500	4,000	4,000	4,600	4,600
Malaysia	3,320	1,980	777	407 r/	425 4/
South Africa, Republic of e/	1,320 4/	1,300	1,300	1,300	1,300
Sri Lanka e/	200	200	200	200	200
Thailand	377	400 e/	89	220 r/	200
United States	W	W	W	W	W
Zaire e/	124 4/	120	50	50	60
Total	24,900	17,500	15,600 r/	26,000 r/	16,000

e/ Estimated. r/Revised. W Withheld to avoid disclosing company proprietary data; excluded from "Total."
1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.
2/ Table includes data available through June 23, 1995.
3/ In addition to the countries listed, Indonesia, North Korea, 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/	1990	1991	1992	1993	1994 e/
Australia e/	6,050	3,850	3,300 r/	8,800 r/	3,300
Brazil	911	719	396 r/	400 r/ e/	400
China e/	16,500	16,200	21,300	22,100	23,000
India e/	2,500	2,200	2,200	2,500	2,500
Malaysia	1,830	1,090	427	224	234 4/
Madagascar:					
Bastnasite	5	5	5	5 e/	5
Monazite	(5/)	(5/)	(5/)	(5/) e/	(4/)
South Africa, Republic of e/	724 4/	400 r/	400 r/	400 r/	400
Sri Lanka e/	110	110	110	110	120
Thailand	221	235	89 r/	220 r/	150
U.S.S.R. e/ 6/	8,500	8,500	8,000	7,000	6,000
United States 7/	22,700	16,500	20,700	17,800	20,700
Zaire e/	68	66	28	28	28
Total	60,100	49,800 r/	57,000 r/	59,500 r/	56,800

e/ Estimated. r/ Revised.
1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.
2/ Table includes data available through June 30, 1995.
3/ In addition to the countries listed, rare-earth minerals are believed to be produced in Indonesia, North Korea, Mozambique, and Vietnam, but information is inadequate to formulate reliable estimates.
4/ Reported figure.
5/ Less than 1/2 unit.
6/ Dissolved in Dec. 1991; however, information is inadequate to formulate reliable estimates for individual countries.
7/ Comprises only the rare earths derived from bastnasite as reported in Unocal Corp. annual report, 1990 and from company sources.