

67 Rare Earths

The rare earth group contains 17 elements namely scandium, yttrium and lanthanides (15 elements in the periodic table with atomic numbers 57 to 71 namely: lanthanum (La), cerium (Ce), praseodymium (Pr), neodymium (Nd), promethium (Pm), samarium (Sm), europium (Eu), gadolinium (Gd), terbium (Tb), dysprosium (Dy), holmium (Ho), erbium (Er), thulium (Tm), ytterbium (Yb) and lutetium (Lu)). Although they tend to occur together, the - 15 lanthanid elements are divided into two groups. The light elements are those with atomic numbers 57 through 63 (La, Ce, Pr, Nd, Pm, Sm and Eu) and the heavy elements are those with atomic numbers from 64 to 71 (Gd, Tb, Dy, Ho, Er, Tm, Yb and Lu). Generally the light rare earth elements are more common and more easily extracted than heavies. In spite of its low atomic weight yttrium has properties more similar to the heavy lanthanides and is included with this group. Scandium is found in a number of minerals although it may also occur with other rare earth elements.

Rare earths are characterised by high density, high melting point, high conductivity and high thermal conductance. A number of rare-earth minerals contain thorium and uranium in variable amounts but thorium and uranium do not constitute essential components in the composition of the minerals.

The principal sources of rare earth elements are bastnaesite (a fluorocarbonate which occur in carbonatites and related igneous rocks), xenotime (yttrium phosphate) commonly found in mineral sand deposits and loparite which occurs in alkaline igneous rocks and monazite (a phosphate). The rare earths occur in many other minerals and are recoverable as by-products from phosphate rock and from spent uranium leaching. In India, monazite is the principal source of rare earths and thorium.

RESOURCES

The mineral monazite is a prescribed substance as per the notification under the Atomic Energy Act, 1962. AMD has been carrying out its resource evaluation for over five decades. It occurs in association with other heavy minerals, such as

ilmenite, rutile, zircon, etc. in concentrations of 0.4 - 4.3% of total heavies in the beach and inland placer deposits of the country.

The resource estimation for the areas explored by AMD during the period 2002-2005 is mostly complete. The resource estimates of monazite in the beach and inland placer deposits have been enhanced from 7.90 million tonnes in 2002 to 10.21 million tonnes in 2005. The statewide resources are given in Table - 1.

Table -1 : Resources of Monazite

(In million tonnes)

State	Resources*
All India	10.21
Andhra Pradesh	3.73
Bihar	0.22
Kerala	1.37
Orissa	1.82
Tamil Nadu	1.85
West Bengal	1.22

Source: Department of Atomic Energy, Mumbai.

** Inclusive of indicated, inferred and speculative resources.*

EXPLORATION & DEVELOPMENT

IREL has carried out exploration in beach sands to assess the heavy-mineral contents like ilmenite, rutile, zircon, monazite, etc. in the Manavalakurichi deposit in Tamil Nadu. For details of exploration carried out by IREL, AMD, State DGMs, etc., the review on 'Ilmenite and Rutile' may be referred.

PRODUCTION AND PRICES

IREL, a Government of India Undertaking and KMML, a Kerala State Government Undertaking, are actively engaged in mining and processing of beach sand minerals from placer deposits. IREL produced 35 tonnes rare earths viz, RE fluoride, cerium oxide, cerium hydrate from conversion of rare earths chloride, in 2007-08 against 4,500 tpy installed capacity. The production and prices of rare earths in India during 2005-06 to 2007-08 are given in Tables - 2 and 3, respectively.

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**Table - 2 : Production and Value of Rare Earths*
2005-06 to 2007-08**

Year	Quantity (tonnes)	Value (Rs. lakh)
2005-06	93**	157
2006-07	45**	48
2007-08	35**	65

* Produced by IREL.

**Mainly Rare Earths fluoride, cerium oxide & cerium hydrate from conversion of Rare Earths chloride.

Source: Department of Atomic Energy, Mumbai.

**Table - 3 : Domestic Prices of Rare Earths
2005-06 to 2007-08**

(In Rs. per kg)

Year	Grade	Price	Remarks
2005-06	RE chloride	50	Ex-works, packed
	to RE fluoride	135	Ex-works, packed
2007-08	RE carbobate	72	Ex-works, packed
	Cerium oxide A	145	Ex-works, packed
	Cerium oxide B	300	Ex-works, packed

Source: Department of Atomic Energy, Mumbai.

MINING AND PROCESSING

Mining of beach sand is being carried out by IREL and KMML. The installed capacity of monazite (96% pure) separation plant of IREL at Manavalakurichi is 6,000 tpy while that of KMML at Chavara is 240 tpy. For details regarding mining and processing, etc., review on 'Ilmenite and Rutile' may be referred.

INDUSTRY

IREL has a plant at Udyogamandal, Alwaye in Ernakulam district, Kerala wherein the monazite obtained from Manavalakurichi is chemically treated to separate rare earths in its composite chloride form and thorium as hydroxide upgrade. Ground monazite is digested with caustic soda lye to produce trisodium phosphate (TSP) and mixed hydroxide slurry. This slurry is used for production of diverse rare-earth compounds. Elaborate solvent extraction and ion exchange facilities were built up to produce individual R.E. oxides, like oxides of Y, Ce, Nd, Pr and La in

adequate purities. India is the second-largest supplier of yttrium in the world produced from this plant. Uranium value present in monazite is recovered in the form of Nuclear grade ammonium diuranate (ADU) to supplement the indigenous supply for uranium. Thorium is separated in its pure oxalate form. A part of it is taken to OSCOM for its further processing by solvent extraction to produce thorium nitrate. A small part of the purified thorium nitrate is converted to nuclear grade thorium oxide powder to meet the requirement of Bhabha Atomic Research Centre (BARC) and Nuclear Fuel Complex (NFC) for developing thorium based fuel for nuclear reactors. IREL has built up large stockpile of impure thorium hydroxide upgrade associated with rare earths and unreacted materials.

IREL is setting up a 10,000 tpy monazite processing plant at OSCOM at an investment of Rs.96 crore and the project was likely to be completed within 18 months.

POLICY

Exploitation of beach sand minerals and participation of private sector with or without foreign companies is subject to conditions stipulated in the Beach and Mineral Policy notified by the Government of India in October 1998. As per the Foreign Trade Policy, 2004-2009 and the policy on export and import effective from 1.4.2008, the export and import of ores and concentrates of rare earth metals (under code No. 25309040) and of rare-earth oxides including rutile sand (code No. 26140031) are permitted freely.

USES & CONSUMPTION

The lanthanides elements as a group have magnetic, chemical and spectroscopic properties that have led to their application in wide range of end-uses. Cerium finds application in polishing of glass items like lenses and display screens of cathode-ray tubes, liquid-crystal displays and plasma-display panels, in petrol and diesel fuels as fuel additive and along with lanthanum for replacement of cadmium in red pigments. Mixed salts of the cerium group of elements, other than fluorides, are used in medicine, non-irritating antiseptic dressings, waterproofing agents and

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fungicides in textile manufacture. The principal uses of commercially pure cerium compounds are in the form of nitrate in the manufacture of incandescent gas mantles, and as oxide, as a polishing agent of glass. Cerium compounds are also used in ceramic and glass as colouring pigments and also as catalysts in chemical industry.

Cerium, lanthanum and neodymium are used as glass additive in optical lenses and display screens, as catalysts in automobiles, in multilayer capacitors and along with yttrium in magnesium, aluminium and hydrogen storage alloys. Misch metal which is an alloy of cerium with small amounts of other rare-earth metals is used in lighter flints, for desulphurisation in steel and foundry, and with lanthanum alloys, in batteries and hydrogen storage systems meant for electronics and hybrid cars.

Lanthanum oxide and neodymium compounds are used in special glass manufacture. Lanthanum finds application in X-ray films as phosphors; yttrium in advanced ceramics like nitrides, Y-stabilised ceramics, etc. and gadolinium in magnet alloys. Yttrium, europium and terbium are used as phosphors in displays of computers, TV, etc. and with lanthanum, cerium and gadolinium as phosphors in fluorescent and halogen lamps. Neodymium, samarium, dysprosium, praseodymium and terbium have application as high intensity magnets in electronics, electric motors and audio equipment. Lanthanum, erbium and ytterbium have application in fibre optics and lasers. Lanthanum and yttrium find application as solid oxide fuel cells. Scandium is used mainly in aluminium alloys for sporting goods. Scandium in minor amounts is used in semiconductors and speciality lighting including halogen bulbs. Mixed rare-earth products find use as catalysts in petroleum refining and fluid cracking.

The main application for neodymium-iron-boron (Nd-Fe-B) magnets are in small automobile to anti-lock brakes, and in computer hard disk drives, videos, CD-ROMs used in many small-size electronic consumer products, such as digital cameras, where major advantage is their small sizes. Nickel metal hydride (Ni MH) batteries, containing misch metal, a mixture of rare-earth

compounds, are used mainly in portable electronic equipment, such as laptops, camcorders and mobile phones. The market for batteries for portable electronic equipment is growing strongly but Ni MH batteries face competition from lithium-ion batteries.

Monazite contains about 25.28% P_2O_5 which can be recovered from it as a by-product for manufacture of fertilizers or elemental phosphorus or its salts. Besides, rare earths, thorium is recovered from monazite. It is a source of atomic energy. An important use of thorium is for addition to tungsten in minute quantity (about 0.75%) to increase the ductility of tungsten wire and thus to facilitate its drawing into filaments used in electric lamps. Metallic thorium is also used in photoelectric cells and X-ray tubes and in certain alloys. Thoria is used as catalytic agent for various processes. Amongst thorium salts, thorium nitrate is used largely in the manufacture of incandescent gas mantles. Mesothorium, the chief radioactive element recovered as a by-product in the chemical treatment of monazite, is marketed usually in the form of its bromide and used in self-luminous paints or enamels. Mesothorium is also used in the treatment of certain types of cancer and skin diseases.

The total consumption of Rare Earths in 2007-08 was estimated at 222 tonnes. Paints Driers/Pigments industry was the main consumer accounting for about 53% of the total consumption followed by cinema arc carbon industry (42%) (Table-4).

**Table - 4 : Consumption* of Rare Earths
2005-06 to 2007-08
(By Industries)**

Industry	(In tonnes)		
	2005-06	2006-07	2007-08
All Industries	265	269	222
Paints Driers/Pigments	142	158	118
Cinema Arc Carbon	103	85	94
Catalysts	4	2	-
Glass/Optical Polishing	5	18	2
Glassware decolouring	4	1	2
R&D & Others	7	5	5

* Consumption relates to sales figures of IREL.
Source: Department of Atomic Energy, Mumbai.

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FOREIGN TRADE

In 2007-08, IREL exported five tonnes of monazite valued at Rs. 8.22 lakhs to Japan as against twenty tonnes valued at Rs.35.12 lakhs in the previous year.

WORLD REVIEW

The world reserve base contains 150 million tonnes of rare-earth oxides (REO) of which China alone accounts for 89 million tonnes followed by CIS, USA and India (Table - 5).

China holds the leading position among producers of rare earths followed by Brazil, Malaysia and India (Table - 6). Rare earths are also produced in Russia, Kazakhstan, Kyrgyzstan and Thailand. Concentrates/partially processed intermediate products are further processed at many locations in Europe, USA, Japan and China.

In China, the principal production centres of rare earths are located at Baotou, Inner Mangolia and in Jiangxi and Sichuan provinces. At Baotou, bastnaesite is recovered as a by-product of iron ore mining while in Sichuan and in Gansu, bastnaesite occurs as primary mineral. In Jiangxi, Guangdong, Hunan and Jiangsu provinces, the ion adsorption clays are the source of the greater proportion of world yttrium production.

The Russian rare earth industry is based on loparite, a titanium - tantalum niobate mined from lozero massif in the Murmansk region. Rare earth minerals have been recovered as by-products from titanium-bearing heavy sands, particularly in Australia and from tin dredging in Malaysia.

Table - 5 : World Resources of Rare Earths (By Principal Countries)

(In '000 tonnes of REO content)

Country	Reserve base
World : Total	150000
Australia	5800
China	89000
Commonwealth of Independent States	21000
India*	1300
Malaysia	35
Thailand	NA
USA	14000
Other countries	23000

Source: Mineral Commodity Summaries, 2008.

* As per Department of Atomic Energy, Mumbai, the total resources of monazite, a source of rare earths, are estimated at 10.21 million tonnes.

Table - 6 : World Production of Rare Earths (By Principal Countries)

(In tonnes)

Country	2005	2006	2007
Brazil (Monazite)	958	958	1173
China #	119000	119000	120000(e)
India (Monazite)@	122	NA	NA
Malaysia (Monazite)	320	894	682

Source: World Mineral Production, 2003-2007.

Relates to REO content; assumed to be 60% of concentrates produced.

@ As per Department of Atomic Energy, Mumbai, the total production of rare earths in 2005-06, 2006-07 and 2007-08 was 93 tonnes, 45 tonnes and 35 tonnes, respectively.

FUTURE OUTLOOK

Demand for rare earths is centered around countries which manufacture components like automotive catalyst systems, fluorescent lighting tubes and display panels. The demand, therefore, emanates mainly from Europe, USA, Japan, China and Republic of Korea.