

Rare Earth Elements Fund

Bloomberg: RAEELS SW | ISIN: CH0111943673

Investing in the whole value chain of the Rare Earth Elements sector

15 elements

Lanthanides

Heavy Rare Earth (HREE)

Difficult to extract due to their affinity with Yttrium

Light Rare Earth (LREE)

more common 80-90% of RE Basket

Never alone in minerals but within a basket of REE's

Trapped in minerals

15% HREE

85% LREE

Never found as free metals, but as a mix of REE, which need to be separated for commercial use.

Liberation Extraction

Limited by mineral phases and fraction sizes

Relative abundance at the surface of our planet, but difficult to extract

Products

High purity powder
99.99...%

where impurity types need to be compliant with industrial requirements

REE's are commercialized principally as high purity oxides, high purity metals, powder and mishmetal.

THE BASIC learning of REE's

The rare earth elements (REE) include **15 elements** with atomic numbers 57 through 71, and are named: lanthanum, cerium, praseodymium, neodymium, promethium, samarium, europium, gadolinium, terbium, dysprosium, holmium, erbium, thulium, ytterbium, and lutetium. Yttrium (atomic no. 39) and scandium (atomic no. 21) are sometimes included in the same group.

The lanthanides elements have similar radii and oxidation states, which allow for number of substitution into various crystal lattices causing a **wide dispersion in the earth's crust and generating multiple occurrences of REE's**.

Within the fifteen chemical elements of the lanthanides, we differentiate the **Light Rare Earth (LREE: atomic number 57 to 62)** and the **'Heavies' (HREE: atomic number 63 to 71)**.

These categories are defined based on their ionic radii and their atomic number, which is known as the 'lanthanide contraction'. This makes the chemistry of lanthanides predominantly ionic and the HREE have a higher affinity to Yttrium, being chemically associated. The **rarity of HREE is not explained by their content in rocks but by the difficulty to separate them from Yttrium** and to finely get the desired oxide powder.

The elements scandium (21), yttrium (39), lanthanum (57) and thorium (90) usually occur with the rare earths and are commonly classed with them.

Dispersed in 100's of minerals but rarely extractable

More than 160 minerals are known to contain one or more of the rare lanthanides. Only two of these minerals, monazite and bastnaesite, are commercially important and four are currently exploited. The challenge with rare earths is their natural concentration to form a deposit and then the separation of rare earth elements. A mineral like monazite may contain half a dozen or more different rare earth elements.

The most common lanthanides in these minerals are: cerium, lanthanum, neodymium, and praseodymium. Monazite mineral also contains thorium and yttrium.

4 Principal commercial sources of REE

1 Monazite (REE phosphate)
(Ce,La,Nd,Th)PO₄;(Nd,La,Ce)PO₄

2 Bastnaesite (fluorocarbonate)
(Ce, La)CO₃F

3 Xenotime (yttrium phosphate)
YPO₄

4 Loparite (titanate) perovskite group (Ce,La,Na,Ca,Sr)(Ti,Nb)O₃

Periodic Table of the Chemical Elements

H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Cn						
Lanthanides		La	Ce	Pr	Nd	Pm*	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	REE
Actinides		Ac	Th	Pa	U	Np	Pu	Am*	Cm*	Bk*	Cf*	Es*	Fm*	Md*	No*	Lr*	Radioactive REE

Assimilated to REE due to similar chemical properties: Sc, Y, La, Ce, Pr, Nd, Pm, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, Ac, Th, Pa, U, Np, Pu, Am, Cm, Bk, Cf, Es, Fm, Md, No, Lr

Legend: LREE (Light Rare Earth Elements) - Grey; HREE (Heavy Rare Earth elements) - Black; Radioactive REE - Red; Italic - unstable elements; * - isotopes are radioactive; Light blue - Gaseous elements; Yellow - Liquid elements

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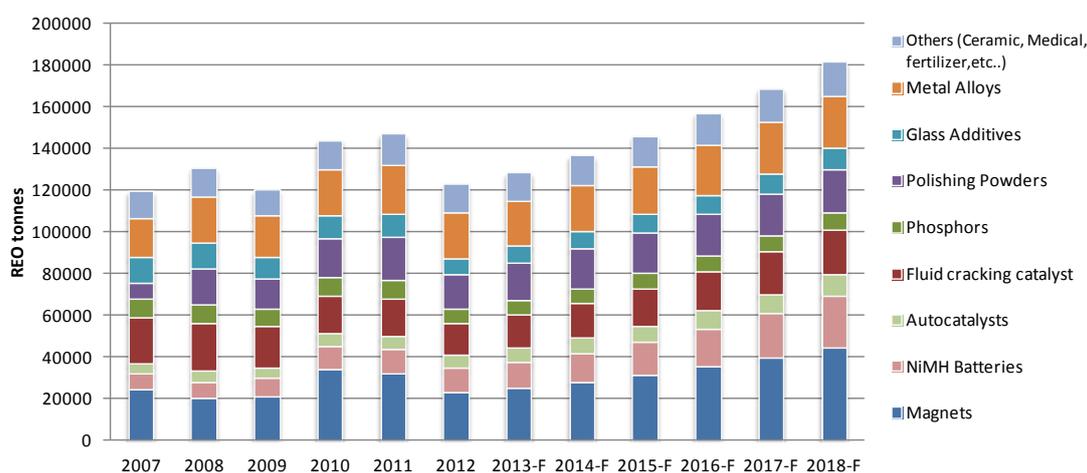
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Name	Symbol	Atomic number	Some End Uses
Lanthanum	La	57	Used in battery systems of some hybrid vehicles. Cracking catalysts for oil refineries. Ceramics, Glasses, Phosphors and Pigments, hydrogen storage batteries.
Cerium	Ce	58	Cracking catalysts for oil refineries, Ceramics and glasses (yellow colors), Misch Metal, Phosphors and Polishing Powders, self-cleaning ovens
Praseodymium	Pr	59	Ceramics, Glasses and Pigments, colour televisions, fluorescent lamps, energy-saving lamps, welding goggles.
Neodymium	Nd	60	Fundamental basis for neodymium-iron-boron (Nd ₂ Fe ₁₄ B) permanent magnets used in Wind turbine and some hybrid vehicles. Crucial to the miniaturisation of devices such as cellular phones, MP3, computers and cameras. Also present in catalysts,
Promethium	Pm	61	Phosphors and Miniature Nuclear Batteries (for guided missiles) and Measuring Devices (watches, pacemakers and rados),beta radiation source in luminous paint
Samarium	Sm	62	Guidance modules in defense systems. Microwave Filters, Nuclear Applications and Permanent Magnets.
Europium	Eu	63	Red and blue phosphors, luminescence properties for LED screens in TV's, for the medical, surgical and biochemical applications, in nuclear reactors control rods (as a neutron adsorber)
Gadolinium	Gd	64	Ceramics, Glasses, Optical and Magnetic Detection and Medical Image Visualization, magnetic refrigeration
Terbium	Tb	65	Phosphors, fluorescent lamps , TV screen (high intensity green emitter) , lasers, semiconductor devices and in solid-state devices, fuel cells (as stabilizer)
Dysprosium	Dy	66	Essential additive in NdFeB production (highest magnetic moments of any of the rare earths) , Ceramics, Phosphors and Nuclear Applications
Holmium	Ho	67	Ceramics, Lasers, solid state lasers (for medical and dental applications) and Nuclear Applications
Erbium	Er	68	Ceramics, Glass coloring, Optical Fibers, Lasers and Nuclear Applications
Thulium	Tm	69	Electron Beam Tubes and Medical Image Visualization
Ytterbium	Yb	70	Chemical Industry and Metallurgy, in fiber amplifier and in fiber optic technologies. Ytterbium fluoride as an X-ray opacifier for the dental market.
Lutetium	Lu	71	Single Crystal Scintillators, high refractive index glass
Scandium	Sc	21	Aerospace, sporting equipment for baseball bats, lacrosse sticks, and bicycle frames), Nuclear Applications, Lighting systems and Semiconductors.
Yttrium	Y	39	Satellite communications systems. Capacitors, Phosphors (CRT and Lamp), Radars and Superconductors

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Demand of REO



End use categories

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