



Rare Earth Elements

RC Inspection Group

Rare Earth Elements

Application

Rare-earth elements (REE) are necessary components of more than 200 products across a wide range of applications, especially high-tech consumer products, such as cellular telephones, computer hard drives, electric and hybrid vehicles, and flat-screen monitors and televisions. Significant defense applications include electronic displays, guidance systems, lasers, and radar and sonar systems. Although the amount of REE used in a product may not be a significant part of that product by weight, value, or volume, the REE can be necessary for the device to function. For example, magnets made of REE often represent only a small fraction of the total weight, but without them, the spindle motors and voice coils of desktops and laptops would not be possible.

Chemical

Chemically, rare earths are strong reducing agents. Their compounds are generally ionic and they display high melting and boiling points. Rare earths are relatively soft when in their metallic state while those with a higher atomic number tend to be harder. Rare earths react with other metallic and non-metallic elements to form compounds each of which has specific chemical behaviours. This makes them indispensable and non-replaceable in many electronic, optical, magnetic, and catalytic applications. Rare earth compounds are commonly fluorescent under ultraviolet light, which can assist in their identification. Rare earths also react with water or diluted acid to produce hydrogen gas.

Yttrium (Y)

Phosphors, ceramics,
metal alloys

Lanthanum (La)

Batteries, catalysts for petroleum
refining

Cerium (Ce)

Autocatalysts, chemical catalysts

Praseodymium (Pr)

High power magnets,
yellow ceramic pigments

Neodymium (Nd)

High power magnets

Holmium (Ho)

Highest power magnets in
existence

Erbium (Er)

Lasers, glass colourant

Lutetium (Lu)

PET scanners

Promethium (Pm)

Beta radiation source

Samarium (Sm)

High temperature magnets

Europium (Eu)

Fluorescent lighting

Gadolinium (Gd)

Magnetic resonance imaging
contrast agent, nuclear
reactor rods

Terbium (Tb)

Phosphors for lighting, high
power high temperature
magnets

Dysprosium (Dy)

High power high temperature
magnets, lasers

Thulium (Tm)

Ceramic magnetic materials which
are still under development

Ytterbium (Yb)

Fibre optic technology, solar
panels

Period	Group	1	2	13	14	15	16	17	18										
1		1 H 1.008							2 He 4.003										
2		3 Li 6.941	4 Be 9.012																
3		11 Na 22.99	12 Mg 24.31																
4		19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.88	23 V 50.94	24 Cr 52	25 Mn 54.94	26 Fe 55.85	27 Co 58.47	28 Ni 58.69	29 Cu 63.55	30 Zn 65.39	31 Ga 69.72	32 Ge 72.59	33 As 74.92	34 Se 78.96	35 Br 79.9	36 Kr 83.8
5		37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc (98)	44 Ru 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3
6		55 Cs 132.9	56 Ba 137.3	57 La 138.9	72 Hf 178.5	73 Ta 180.9	74 W 183.9	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.1	79 Au 197	80 Hg 200.5	81 Tl 204.4	82 Pb 207.2	83 Bi 209	84 Po (210)	85 At (210)	86 Rn (222)
7		87 Fr (223)	88 Ra (226)	89 Ac (227)	104 Rf (257)	105 Db (260)	106 Sg (263)	107 Bh (262)	108 Hs (265)	109 Mt (266)	110 Ds (271)	111 Rg (272)	112 Uub (285)	113 Uut (284)	114 Uuq (289)	115 Uup (288)	116 Uuh (292)	117 Uus (210)	118 Uuo 0
	6	58 Ce 140.1	59 Pr 140.9	60 Nd 144.2	61 Pm (147)	62 Sm 150.4	63 Eu 152	64 Gd 157.3	65 Tb 158.9	66 Dy 162.5	67 Ho 164.9	68 Er 167.3	69 Tm 168.9	70 Yb 173	71 Lu 175				
	7	90 Th 232	91 Pa (231)	92 U (238)	93 Np (237)	94 Pu (242)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (249)	99 Es (254)	100 Fm (253)	101 Md (256)	102 No (254)	103 Lr (257)				

- Nonmetals
- Alkali metals
- Alkaline Earth metals
- Transition elements
- Other metals
- Metalloids
- Halogenes
- Noble gases
- Lanthanides
- Actinides

A BREAKDOWN OF THE CRITICAL METALS IN A SMARTPHONE

Some vital metals used to build these devices are considered at risk due to geological scarcity, geopolitical issues or trade policy.

This infographic details the critical metals that you carry in your pocket.

ALKALI METAL ALKALINE EARTH TRANSITION METAL BASIC METAL LANTHANOID

TOUCH SCREEN

It contains a thin layer of **indium** tin oxide, highly conductive and transparent, allowing the screen to function as a touch screen.



MICROPHONE, SPEAKERS, VIBRATION UNIT

Nickel is used in the microphone diaphragm (that vibrates in response to sound waves). Alloys containing **neodymium**, **praseodymium** and **gadolinium** are used in the magnets contained in the speaker and microphone. **Neodymium**, **terbium** and **dysprosium** are used in the vibration unit.



DISPLAY

The display contains several **rare earth elements**. Small quantities are used to produce the colors on the liquid crystal display. Some give the screen its glow.



ELECTRONICS

Nickel is used in electrical connections. **Gallium** is used in semiconductors. **Tantalum** is the major component of micro capacitors, used for filtering and frequency tuning.



CASING

Nickel reduces electromagnetic interference. **Magnesium** alloys are superior at electromagnetic interference (EMI) shielding.



BATTERY

The majority of smartphones use **lithium-ion** batteries.

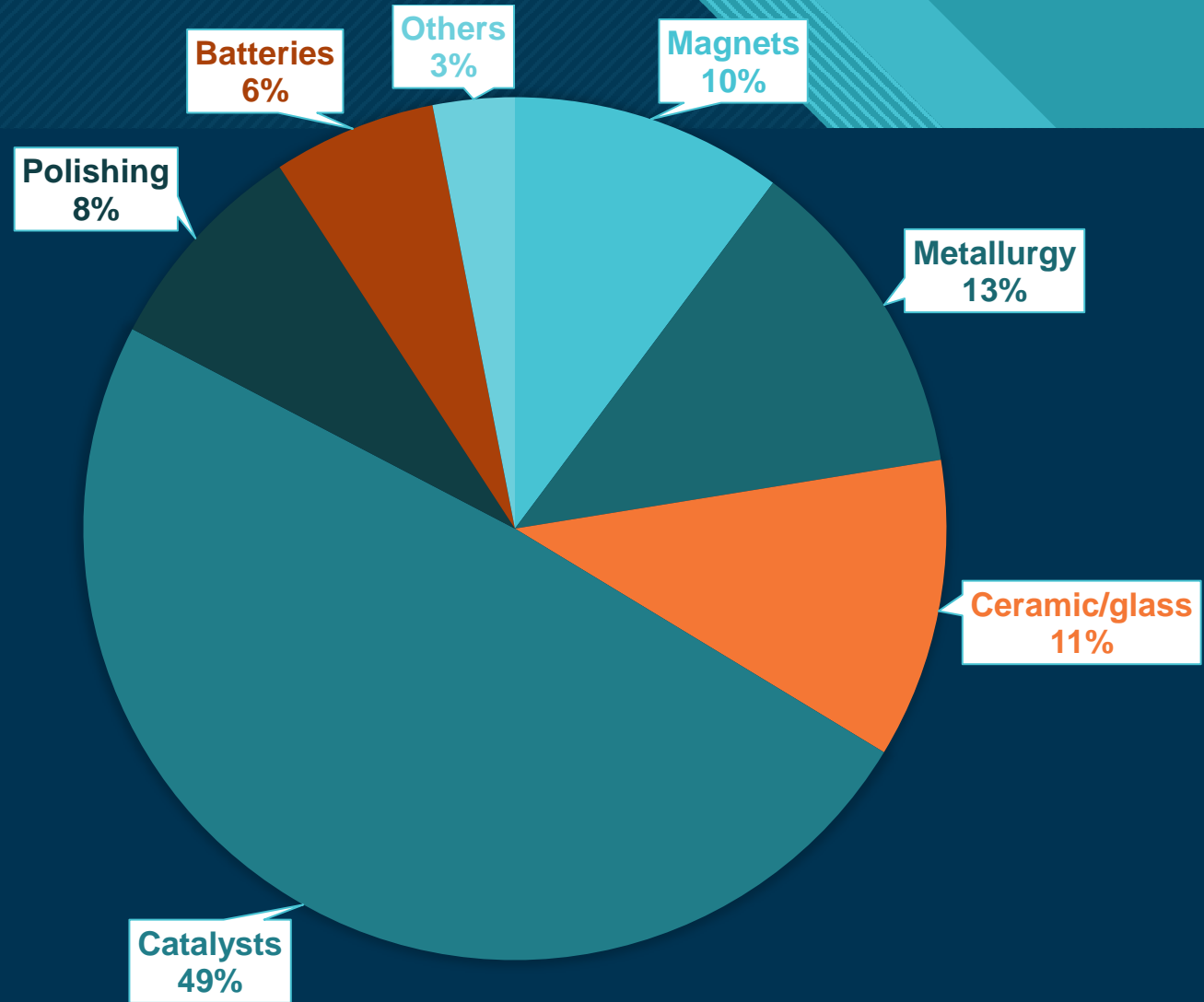


Source: University of Birmingham

ELEMENTS
elements.visualcapitalist.com

The Earth's natural resources power our everyday lives. VC Elements breaks down the building blocks of the universe.

We live in a material world.



Have your REE analyzed at RC Inspection

Praseodymium Neodymium

TREO, Nd₂O₃, Pr₆O₁₁, Al₂O₃, C, CaO, Cl, Fe₂O₃, MgO, S, SiO₂, La₂O₃, Ce₂O₃, Sm₂O₃, Gd₂O₃, Tb₄O₇, Dy₂O₃, Y₂O₃

Europium Oxide

Gandolinium Oxide

Gd₂O₃, TREO, Li, Be, B, C, N, S, H, F, Na, Mg, Al, Si, P, Cl, K, Ca, Sc, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Ga, Ge, As, Se, Br, Rb, Sr, Y₂O₃

Terbium Oxide

Tb₄O₇, TREO, Li, Be, B, F, Na, Mg, Al, Si, P, S, Cl, K, Ca, Sc, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Ga, Ge, As, Se, Br, Rb, Sr, Y₂O₃, Zr, Nb, Mo, Ru

Ferro Dysprosium

Al, Ba, Bi, C, Ca, Ce, Co, Cr, Cu, Dy, Fe, Ge, Hf, Ho, K, La, Lu, Mg, Mn, Mo, N, Na, Zr

Erbium

TREM, ER/TREM

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Scandium Oxide

Sc₂O₃, TREO, H₂O

Yttrium Metal

Y, Li, Be, B, C, N, O, H, F, Na, Mg, Al, Si, P, S, Cl, K, Ca, Sc, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Ga, Ge, As, Se, Br, Rb, Sr, Zr, Nb, Mo, Ru, Rh

Neodymium Oxide

Nd₂O₃, TREO, Li, Be, B, C, N, S, H, F, Na, Mg, Al, Si, P, Cl, K, Ca, Sc, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Ga, Ge, As, Se, Br, Rb, Sr, Zr, Nb, Mo

Tellurium

Cl, FI, NH₄, So₂

Germanium

Cl, FI, NH₄, So₂

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Monazite

TREO, ThO₂, Sn, CeO₂, Er₂O₃, Lu₂O₃, Dy₂O₃, Eu₂O₃, Nd₂O₃, Ho₂O₃, La₂O₃, Gd₂O₃, Sc₂O₃, Tb₄O₇, Sm₂O₃, Tm₂O₃, Y₂O₃, Pr₆O₁₁, Yb₂O₃

Indium

Y, La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, Fe, Mg,

Tantalite

ThO₂, Ta₂O₅, Nb₂O₅, U₃O₈

Columbite

U₃O₈, Ta₂O₅, ThO₂, Nb₂O₅

Lanthanum

Cl, F, NH₄, SO₂

Rare earth element ("REE") – A set of seventeen metallic elements with unique properties: chemical, catalytic, magnetic, metallurgical and phosphorescent. While not particularly rare, their geochemical properties usually result in them being dispersed and not found in concentration significant enough to be recovered economically.

The elements include Scandium (Sc), Yttrium (Y), 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).

Critical rare earth elements ("CREE") – In a study undertaken by the US Department of Energy, *Critical Materials Study, December 2011*, undertook a criticality assessment of rare earths evaluating two dimensions, importance to clean energy and supply risk. They identified five rare earths as "critical" – Dy, Tb, Eu, Nd and Y – and two elements as "near-critical" – Ce and La. Rare Element includes Pr in its CREE list because of its ability to be substituted for Nd in high-intensity permanent magnets.

Heavy rare earth elements ("HREE") – defined as the elements Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu and Yb. Eu, Sm and Y are sometimes included because they behave like the other HREE.

Rare earth oxide ("REO") – the oxide form of rare earth elements

Total rare earth oxide ("TREO") – refers to the sum total of REO present in a deposit