

# RARE EARTHS, RECOVERY IS THE FUTURE

RARE EARTHS ARE KEY ELEMENTS FOR TECHNOLOGICAL DEVICES. THE WORLD DEPENDENCE ON ONE PRODUCING COUNTRY (CHINA) AND THE STEADY INCREASE IN GLOBAL DEMAND OBLIGE EUROPE TO FIND STRATEGIES THAT AIM TO INNOVATE AND CREATE NEW BUSINESS MODELS, TYPICAL OF CIRCULAR ECONOMY.

The objects we use every day are composed of very familiar elements, such as metals, ceramics and plastics. The chemical elements contained in these materials are also familiar (iron, aluminium, carbon, etc.). Other objects of everyday use, such as smartphones or fluorescent and Led lamps, contain tiny amounts of chemical elements less known to most consumers/final users. Rare earths are examples of elements contained in very limited amounts in many high-tech devices we commonly use; their properties are fundamental for the functioning of these devices.

Rare earths are a group of 17 metal elements including scandium (Sc) and yttrium (Y), plus the entire series of lanthanides, chemical elements with atomic number 57 through 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), lutetium (Lu) (figure 1). They are classified according to their atomic number in “light rare earth elements” (scandium and all the elements from lanthanum to samarium), and “heavy rare earth elements” (from europium to lutetium). Despite the adjective “rare”, these metals are quite plentiful in the Earth’s crust (with the exception of radioactive promethium, very scarce in nature): the two rarest elements of the series (thulium and lutetium) are 200 times more abundant than gold. However, mineral deposits contain many of these elements at the same time, and in very low concentrations (a few percentage points), making very complex separation processes necessary<sup>1</sup>. In such conditions, economic exploitation of deposits is cost-effective only in a few areas of our planet. China currently has the majority of rare earths deposits (figure 2): the United

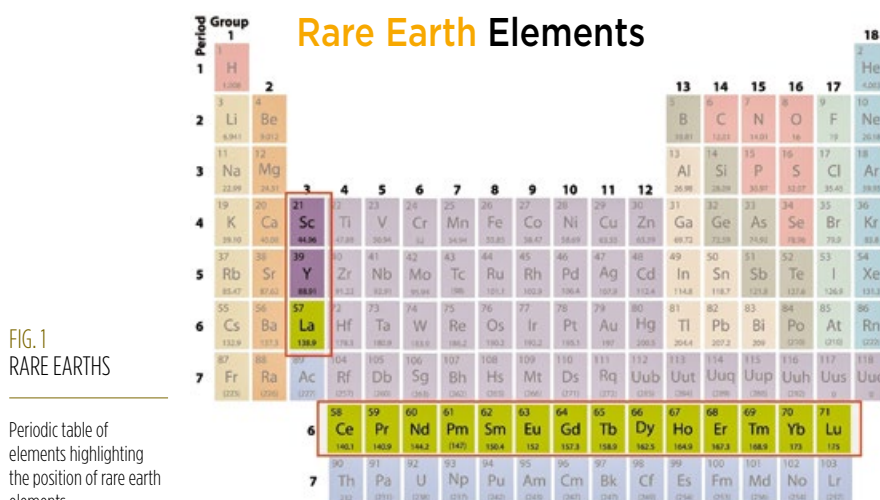


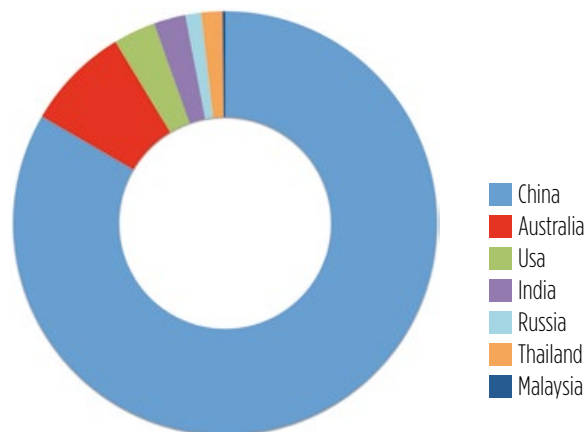
FIG. 1  
RARE EARTHS

Periodic table of elements highlighting the position of rare earth elements.

FIG. 2  
RARE EARTHS PRODUCTION

World production of rare earth elements.

Source: USGS, 2016.



States Geological Survey in 2016 estimated that over 80% of the world’s rare earths come from China, with very few countries competing for only some percentage points of production<sup>2</sup>. The United States were the largest producer of rare earth oxides until mid-1980’s, when the primary production started to decline and the US and the rest of the world became dependent on exports from China. In 2002, the closure of the Mountain Pass mine (in the US) marked the beginning of China’s monopoly in the world, and this happened when the industrial applications of such elements started to increase remarkably.

The world dependence on one single producing country and the constant increase of global demand for rare earths triggered the “perfect storm” of the 8th of July 2010, when China announced a substantial cut in export quotas. As a consequence, the price of rare earths recorded a huge hike. This scenario of dependence on China and the related “crisis of rare earths” – largely predictable and anticipated by some experts at the beginning of the 2000s – still continues, although with much lower price levels. Today, rare earths are contained in smartphones, in Tv displays, in the lamps we use at home and in our offices, in

batteries, in cars and in some substances used for medical diagnostics. Rare earths have such electrical, magnetic and optic properties, that substituting them with other substances is very difficult or unattractive from an economic point of view. The wide range of technological applications makes these elements strategically important for advanced economies. In addition, the recycling rate of rare earths is currently lower than 1%, due to the difficulty in separating such elements, their presence in complex products such as electrical and electronic appliances, and the lack of suitable infrastructure to collect and process them.

In this scenario of uncertainty and instability, Europe in recent years has launched diplomatic initiatives with the aim to reach agreements to reduce the dependence of European industries on imports, while stressing the importance to invest in research and innovation to fill the technological gap with China. Rare earths are still in the list of “critical raw materials” prepared by the European Commission in 2014<sup>3</sup>. The criticality index of these raw materials is measured in relation to the procurement risk and the economic importance of raw materials. In 2013, the Erecon (European Rare Earths Competency Network) was established to take a snapshot of scientific, technological, and market-related aspects of rare earths<sup>4</sup>.

One key aspect underlined by the Erecon report concerns the forecasts on market demand for rare earths in the next few years. The increase in the sales of electrical cars might drive the demand for rare earths, with an expected double-digit growth. This radical change would entail, for instance, an increase in demand for magnetic materials containing neodymium for permanent magnets based on NdFeB. Demand for rare earths is steadily increasing also due to the continuous developments in low-carbon emission technologies to produce energy from renewable sources (e.g. photovoltaic panels, magnets for wind turbines). In the aftermath of the crisis of 2011, a change was recorded in the use of rare earths in various applications, thanks to the increasing efficiency in the use of such elements and the effort for substitution, where possible, with a significant contribution to demand restraint.

The large-scale application of basic concepts of circular economy, though not being significantly widespread yet, might further optimize the use of rare



earths. Shifting from a linear model to the circular model entails an increase not only in the recycling rate of materials, but also a radical restructuring of the value chain and the way products are conceived when it comes to their design, use, and end-of-life.

To tackle these challenges and boost innovation in circular economy, another initiative was the setting up of KICs (Knowledge Innovation Communities) for raw materials promoted by Eit, the European Institute of Innovation and Technology. The KIC for Raw Materials<sup>5</sup> is the world's largest network in the field of raw materials. It groups together over 120 partners, including leading businesses, research institutes, and universities, which collaborate to foster the introduction of innovative products and services. As for rare earths, this means, for instance, new processes with low environmental impact for the recycling of rare earths from electronic goods, new processes for the re-use or processing of materials for permanent magnets containing rare earths, substitution with innovative materials, business models allowing an efficient use of resources, new technologies for the exploration and exploitation of primary resources in Europe. This initiative has different goals, including the support to the creation of start-ups in the sector, and paves the way for the mitigation of Europe's dependence on rare earths imports by taking advantage of young

people's creativity, innovation and new business models typical of circular economy.

**Pier Luigi Franceschini,  
Floriana La Marca, Giorgio Recine**

Eit Raw Materials

#### NOTE

<sup>1</sup> Haxel G., Hedrick J., Orris J., 2006, *Rare earth elements critical resources for high technology*, Reston (VA), United States Geological Survey, Usgs Fact Sheet: 087-02 (pdf), access on 6 April 2016.

<sup>2</sup> United States Geological Survey, 2016, *Mineral commodity summaries 2015*, access on 10 April 2016, <http://minerals.usgs.gov/minerals/pubs/mcs/2015/mcs2015.pdf>

<sup>3</sup> Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, COM(2014) 297, <http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52014DC0297&from=EN>, access on 10 April 2016.

<sup>4</sup> Erecon, 2014, *Strengthening the European rare earths supply chain: Challenges and policy options*, J. Kooroshy, G. Tiess, A. Tukker, A. Walton (eds.).

<sup>5</sup> Website of Eit Raw Materials: [www.eitrawmaterials.eu](http://www.eitrawmaterials.eu)