

EMERGING TECHNOLOGY SNAPSHOT RARE EARTH ELEMENTS

The rare earth elements (REEs) are a group of 17 chemically-similar metals that have comparable properties and are found in the same ore deposits. REEs are critical to many high-tech devices and military equipment, from smart phones and flat screen TVs to night-vision goggles and missile defence systems. While not all that rare, REEs are difficult and costly to extract.



ENABLING SCIENCE AND TECHNOLOGY

Extraction and Separation

A growing domain of research concerns the use of organic acids as leaching agents, which offer advantages in terms of handling, degradability, and fewer toxic gases. Another area of focus is extraction chromatography, a technique that combines the selectivity of solvent extraction with the operational ease of chromatographic methods.

Recycling

Globally, 20-50 million metric tonnes of waste electrical and electronic equipment (WEEE) is generated annually, but only 12.5% is recycled. This makes WEEE a rich source of rare earths, as some metals have been estimated to be more concentrated in WEEE than in primary ores. Industrial waste such as phosphogypsum, bauxite residue and coal ash are also significant sources of REEs.

Alternatives

Given their unique properties, it is difficult to replace REEs with comparable materials. Nevertheless, there is an increasing amount of R&D in the area of REE alternatives, with much of the research focused on non-REE permanent magnets (PMs). Substitutes typically produce a lower maximum energy, but due to their low cost and wide availability they are being actively investigated for less-demanding applications.

New Deposits

Japan has found a massive deposit of rare earths, enough yttrium to meet the global demand for 780 years, dysprosium for 730 years, europium for 620 years and terbium for 420 years. However, the challenge will be getting it out of the ground economically.

“Rare earth elements are sometimes described as the “vitamins of chemistry,” as small doses produce powerful salutary effects. A sprinkle of cerium here and a pinch of neodymium there makes TV screens brighter, batteries last longer, and magnets stronger.”

James Vincent, *The Verge*, May 23, 2019. www.theverge.com/2019/5/23/18637071/rare-earth-china-production-america-demand-trade-war-tariffs

SIGNALS

Academic



University of Toronto researchers are investigating a REE recycling process that relies on supercritical fluid extraction. The technique runs at low temperature and does not produce hazardous waste, while recovering about 90% of the rare earths.

Government



There is increasing concern about the REE supply chain, since China has a near monopoly on the market. Any disruption to the availability of REEs could have serious economic and political impacts around the world.

Collaboration



The Critical Materials Institute and Ames Lab are investigating REE-free paramagnets. By adding certain alloys, paramagnets have been transformed into ferromagnets, or regular permanent magnets.

Defence



Rare earths are crucial for national security as they are key ingredients in a variety of defence-related components and systems, such as GPS equipment, lasers, sensors and aircraft engines.

Corporate



Apple invented a robot named Daisy that can disassemble up to 200 iPhones per hour in order to reclaim and reuse critical materials.

“While not a current producer of REEs, Canada is host to a number of advanced exploration projects and has some of the largest reserves in the world, estimated at over 15 million tonnes.”

Natural Resources Canada, *Rare earth elements facts*, November 27, 2019. www.nrcan.gc.ca/our-natural-resources/minerals-mining/minerals-metals-facts/rare-earth-elements-facts/20522.

IMPACT



Social

There are growing social concerns about rare earths mining, given the impacts on communities in China, where soil and groundwater has been contaminated by REE mining by-products.



Policy

In June, the Trump administration announced the U.S. critical minerals strategy, affirming that the nation needs a stable supply of REEs to ensure economic prosperity and national security.



Economic

The size of the global REE market is expected to reach \$9 billion by 2025, driven mainly by the growth in electric vehicles and electronic devices.



Environmental

In order to minimize the environmental impact of extracting and separating rare earths, much of the recent R&D is focused on less toxic methods of REE separation, such as bioleaching.



Defence

The U.S. Defense Department accounts for only about 1% of the U.S. requirement for rare earths, but that in turn accounts for about 9% of the global demand for the metals.

“It will take many years for the U.S. to rebuild its rare earth industry and reduce its dependence on China. That’s long enough for China to win a trade war against the US...and help Beijing control the lifeblood of the US high-technology sector.”

Hu Weijia, *Global Times*, May 16, 2019. www.globaltimes.cn/content/1150281.shtml

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