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email: econz@otago.ac.nz

FROM THE EDITORS

This issue of *EcoNZ@Otago* has its usual eclectic mix of articles, but something they have in common is they are all authored or co-authored by your humble editors. The other thing that makes this issue (number 43) unique is that, sadly, it's our last ... The first issue appeared in July 1998 – two months before Google was founded! – and two issues, usually with four articles and Alan King's commentary on the New Zealand economy (40 of them!), have appeared every year since then. What germinated as a "magazine for schools" ripened into "a magazine about contemporary economic issues for everyone". But time (and technology) moves on, and so it is with smiles on our faces and tears in our eyes that we bid you farewell. From all seven editors over the last 22 years, thank you to our authors and especially to our readers for having supported *EcoNZ@Otago*, proudly brought to you by the University of Otago's Department of Economics. And many thanks to Judy Robinson for her excellent design work. Güle güle and goodbye!

MURAT ÜNGÖR, PAUL HANSEN
Department of Economics
University of Otago
Dunedin 9054

Rare-earth elements: A primer

Murat Üngör
murat.ungor@otago.ac.nz

For many of us, smartphones and other battery-powered and electronic equipment are indispensable in our daily lives. Many of these devices and other technologies, such as hybrid electric vehicles (see Figure 1), depend on rare-earth elements. This article introduces the rare-earth elements and discusses the roles played by China and the US, the world's main producers.

Figure 1: Rare-earth elements used in a hybrid electric vehicle

Source: http://americanresources.org/what-the-auto-industry-rare-earth-elements-have-in-common

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THE MAGNIFICENT SEVENTEEN

Depending on how they are defined, there are 17 rare-earth elements – each with a place on the periodic table divided into 'light' and 'heavy' elements reflecting their atomic numbers. Table 1 presents the rare-earth elements and examples of their uses.

Table 1: Rare-earth elements and examples of their uses

Rare-earth element	Uses
Scandium	Aerospace components, aluminium alloys
Yttrium	Lasers, TV and computer displays, microwave filters
Lanthanum	Oil refining, hybrid-car batteries, camera lenses
Cerium	Catalytic converters, oil refining, glass-lens production
Praseodymium	Aircraft engines, carbon arc lights
Neodymium	Computer hard drives, cell phones, high-power magnets
Promethium	Portable x-ray machines, nuclear batteries
Samarium	High-power magnets, ethanol, PCB cleansers
Europium	TV and computer displays, lasers, optical electronics
Gadolinium	Cancer therapy, MRI contrast agent
Terbium	Solid-state electronics, sonar systems
Dysprosium	Lasers, nuclear-reactor control rods, high-power magnets
Holmium	High-power magnets, lasers
Erbium	Fibre optics, nuclear-reactor control rods
Thulium	X-ray machines, superconductors
Ytterbium	Portable x-ray machines, lasers
Lutetium	Chemical processing, LED lightbulbs

Source: www.scientificamerican.com/article/dont-panic-about-rare-earth-elements

NEITHER RARE NOR EARTHY

Rare-earth elements – often referred to simply as 'rare earths' – are neither rare nor earth elements. The name dates from the 18th and 19th centuries, with most rare earth discovered in the 19th century, except for yttrium, lutetium and promethium (Voncken 2016, p. 4).

Why are 'rare earths' called *rare*? Because, in the 19th century, only one deposit of rare-earth elements was known: in a quarry near the town of Ytterby in Sweden. And so they were thought to be rare. Adunka and Orna (2018, p. 17) note:

> When Johan Gadolin (1760-1852) took up the challenge of examining a small sample of a strange mineral found in the feldspar mine near the little Swedish village of Ytterby in 1788, little did he realise that he would set in motion a search that would last for over a century.

Why are 'rare earths' called *earth* elements? Because most rare-earth elements were first extracted as oxides. And in French (a major scientific language in the 19th century), an oxide of an element was known as the "terre" of that element, meaning "earth". Also in German, another major scientific language at that time, an oxide of an element was called the "Erde" (earth) of that element (Voncken 2016, p. 4).

Despite their names, rare-earth elements aren't truly rare geologically; and many rare earth *metals* are quite common. Even the two least abundant, thulium and lutetium, are nearly 200 times as abundant as gold (National Research Council 2008, p. 133).

Although rare-earth elements are relatively abundant in the Earth's crust, the discovered minable concentrations are less common than for most other ores (U.S. Geological Survey 2019). They are seldom found in sufficient amounts to be economically extracted, meaning that they are expensive to mine and process.

USEFUL

The first commercial use of rare-earth elements was probably the invention of Auer-Light and Auermetal used for lighter flints; both products were discovered and merchandised by Austrian chemist Carl Auer von Welsbach around 1900 (Zepf 2016, p. 6).

Today, as illustrated in Figure 1, rare-earth elements play a critical role in many sophisticated technologies in the automotive, renewable and defence sectors, and contribute to the increased efficiency and performance of products.

For example, yttrium is broadly used in fluorescent lamps, plasma display panels, energy efficient lighting, optical glasses and batteries, as well as for high-tech applications, such as lasers, superconductors, nuclear reactors and electronic components for missile defence systems (Favot and Massarutto 2019).

FIRST THE US, THEN CHINA

Until the mid-1990s, the US dominated production of rare-earth elements. The Mountain Pass Mine in California's high desert supplied most of the world's demand for rare earths. Production from the Mountain Pass mine began in 1964 and remained the main source of light rare earths in the West until the mid-1990s (Voncken 2016, p. 108).[1]

Then China moved in. In 1992, Deng Xiaoping, the late Chinese leader, reportedly declared: "There is oil in the Middle East; there is rare earth in China" (Krugman 2010).

Von Gosen et al. (2017) argue that China has been the leading producer of rare earths for decades, and since the late 1990s has accounted for more than 90% of global production. *The Economist* magazine (2019) notes that by the early 2000s China accounted for almost all of the world's production.

1 Rare earth elements have been found in New Zealand but not in mineable quantities. Rare earth geochemical concentrations and minerals are associated with igneous rocks in Nelson, Westland, Fiordland and Stewart Island (Christie and Barker 2013).

The Mountain Pass mine in California was closed in 2002. China accounted for 80% of all rare earth minerals imported by the US between 2014 and 2017 (U.S. Geological Survey 2019, p. 132). This is why rare earths now figure in the trade war between these two countries.

Mountain Pass mine in California

Photograph: David Becker/Reuters
Source: www.theguardian.com/business/2019/may/29/us-china-trade-what-are-rare-earth-metals-and-whats-the-dispute

THE US WANTS TO BE A PLAYER AGAIN

In 2017, President Donald Trump signed an executive order instructing US federal agencies to ensure the availability of critical minerals.[2] Rare-earth elements are considered critical to the US's economic and national security. In May 2018, the US Department of the Interior published a list of 35 critical minerals,[3] including rare earths.

Also in 2018, Mountain Pass resumed mining and concentrating rare earth ores. The concentrate is currently shipped to China for refining. But Mountain Pass is tooling up for refining on-site and claim they'll be fully self-sufficient from Chinese refiners by 2020 (Maloney 2019).

Australia's Lynas Corporation, a major producer of rare earth minerals outside China, signed a memorandum of understanding with Texas-based Blue Line Corp to set up a rare earths separation facility in the US.[4] In the raw materials part of the Societal Challenge 5 of Horizon 2020, the European Commission identified criticality of raw materials along with addressing the entire raw materials value chain.[5]

Rare-earth elements are considered as strategic resources. No matter what the future brings in terms of new technologies, the importance of rare earths cannot be under-estimated.

QUESTIONS TO CONSIDER

1. What are rare-earth elements, and why are they important? Why are they called *rare*, and why *earth* elements?
2. Should China control the export of its rare natural resources?
3. Will future supply of rare-earth elements be able to meet future demand? Will there be enough rare-earth elements to continue today's high-tech lifestyle?
4. Is there any environmental conundrum associated with rare-earth elements?

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2 www.whitehouse.gov/presidential-actions/presidential-executive-order-federal-strategy-ensure-secure-reliable-supplies-critical-minerals
3 Aluminum (bauxite), antimony, arsenic, barite, beryllium, bismuth, cesium, chromium, cobalt, fluorspar, gallium, germanium, graphite (natural), hafnium, helium, indium, lithium, magnesium, manganese, niobium, platinum group metals, potash, the rare-earth elements group, rhenium, rubidium, scandium, strontium, tantalum, tellurium, tin, titanium, tungsten, uranium, vanadium and zirconium. (www.federalregister.gov/documents/2018/05/18/2018-10667/final-list-of-critical-minerals-2018)
4 www.reuters.com/article/us-lynas-corp-jv-us-idUSKCN1SP0SX
5 www.universiteitleiden.nl/en/research/research-projects/science/cmlrare-earth-supply-chain-and-industrial-ecosystem-a-material-flow-assessment-of-european-union