TRUE TREASURES

Magalie is standing on the sidewalk waiting for her friend when her smartphone vibrates. Instinctively, she reaches for her iPhone, taps the screen and answers the call. Like billions of people around the world, she is oblivious to the fact that the features of this powerful device, which can sit comfortably in the palm of her hand, wouldn't be possible without the wonder materials inside them.

BY PIERRE LORTIE

FILADENDRON

Steve Jobs liked to say that the touch screen that propelled the iPhone's commercial success "works like magic." This is made possible by a transparent layer of indium tin oxide that acts as a conductor between the finger and the phone. To obtain audible sounds from speakers and ear buds and power the phone's vibration function, tiny, light high-power neodymium magnets are required. They sometimes also contain smaller amounts of other rare earth elements (REEs or rare earths), namely dysprosium and praseodymium. Rare earth metals (or REMs) are also used to produce bright colours on the screen; europium emits high-intensity red light, terbium emits green light, while cerium is used to polish the screen glass during manufacturing. No wonder the Japanese consider rare earth elements to be the "seeds of technology."

A GIFT OF NATURE

Rare earth elements are a group of 17 chemically similar metallic elements – the lanthanides – plus scandium and yttrium that are found in the earth's crust.[1] The lanthanides are elements spanning atomic numbers 57 to 71 (Table 1, p. 24).

Vital to many technologies that define our modern way of life, rare earths are transforming the world thanks to their unique magnetic, luminescent and electrochemical properties, and their resistance to corrosion and high temperatures. REEs help reduce the weight, energy consumption and emissions of many technologies, or else make them faster, stronger, lighter, more durable and efficient, with greater thermal stability. They are the reason why our electronic devices are getting smaller, thinner, faster, more functional and more powerful. The proliferation of smartphones, tablets and computers with slick screens is what makes the digital platform technologies of Google, Amazon, Netflix, Alibaba and their industry siblings work.

The growing dependence of advanced economies on rare earths, and the fact that China supplies more than 80 percent of the global rare earths market and produces around 90 percent of the world's rare earth magnets, raises serious concerns that their industries could be disrupted. Furthermore, national security could be threatened by the imposition of caps on exports and curtailed production of rare earths or of products that use them.[2] This was highlighted in August 2018 when the U.S. Congress included a provision in the John S. McCain National

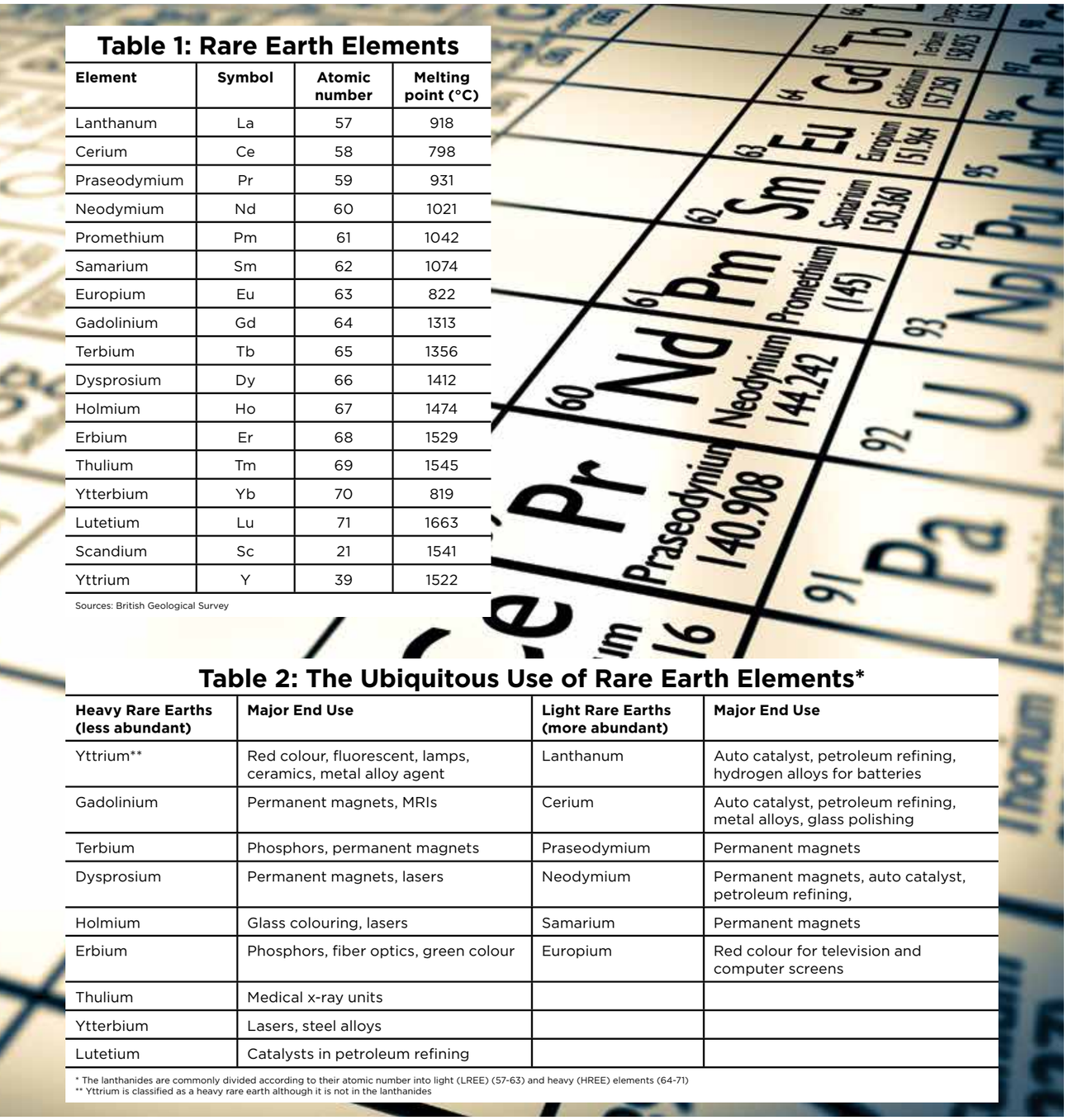

Table 1: Rare Earth Elements

Element	Symbol	Atomic number	Melting point (°C)
Lanthanum	La	57	918
Cerium	Ce	58	798
Praseodymium	Pr	59	931
Neodymium	Nd	60	1021
Promethium	Pm	61	1042
Samarium	Sm	62	1074
Europium	Eu	63	822
Gadolinium	Gd	64	1313
Terbium	Tb	65	1356
Dysprosium	Dy	66	1412
Holmium	Ho	67	1474
Erbium	Er	68	1529
Thulium	Tm	69	1545
Ytterbium	Yb	70	819
Lutetium	Lu	71	1663
Scandium	Sc	21	1541
Yttrium	Y	39	1522

Sources: British Geological Survey

Table 2: The Ubiquitous Use of Rare Earth Elements*

Heavy Rare Earths (less abundant)	Major End Use	Light Rare Earths (more abundant)	Major End Use
Yttrium**	Red colour, fluorescent, lamps, ceramics, metal alloy agent	Lanthanum	Auto catalyst, petroleum refining, hydrogen alloys for batteries
Gadolinium	Permanent magnets, MRIs	Cerium	Auto catalyst, petroleum refining, metal alloys, glass polishing
Terbium	Phosphors, permanent magnets	Praseodymium	Permanent magnets
Dysprosium	Permanent magnets, lasers	Neodymium	Permanent magnets, auto catalyst, petroleum refining,
Holmium	Glass colouring, lasers	Samarium	Permanent magnets
Erbium	Phosphors, fiber optics, green colour	Europium	Red colour for television and computer screens
Thulium	Medical x-ray units		
Ytterbium	Lasers, steel alloys		
Lutetium	Catalysts in petroleum refining		

* The lanthanides are commonly divided according to their atomic number into light (LREE) (57-63) and heavy (HREE) elements (64-71)
** Yttrium is classified as a heavy rare earth although it is not in the lanthanides

Defense Authorization Act that expressly prevents the U.S. military from purchasing rare earth magnets from China. Another event that illustrates the critical importance of rare earths and their compounds for advanced economies occurred in September 2018, when they were removed from the list of Chinese imports on which the Trump administration planned to impose tariffs – one of the very few items about which it had second thoughts.

FROM "GREEN" TO "GREENER" TECHNOLOGIES

Rare earths are vital to the technologies that define modern economies. The magnetic elements used to produce the strongest magnets are the main market driver as they are necessary for both small and powerful applications.

Examples of small applications include smartphones, hearing aids, cameras, mini- and micro-motors for medical and diagnostic instruments, gauges in cars and other vehicles. Because these devices are so small, only rare earth magnets can be used.

At the other end of the spectrum, rare earth magnets are used in the more powerful wind turbines, where they reduce the size and weight of the generators by up to 30 percent compared to other designs. Leading manufacturers have taken advantage of the unique properties of these magnets to produce direct-drive wind mills that allow electricity to be generated at slower wind speeds.

Rare earth magnet demand is also driven by the growing popularity of electric vehicles. Their attractiveness stems from the fact that using them significantly reduces the overall weight and volume of the power system for a given output torque, resulting in higher torque density, very quiet operation and limited maintenance requirements. The power system can also recover more kinetic energy during braking, resulting in a vehicle with a smaller and lighter battery and a range increase of up to 15 percent.

In another application for earth magnets, the strength and homogeneity of their magnetic field makes "open" magnetic resonance imaging (MRI) possible, thereby eliminating traditional "closed" cylindrical MRI, a claustrophobic experience for radiology patients.

SHORTAGES ON THE HORIZON

The long-term availability of critical rare earth elements in sufficient quantities to meet growing demand is a major concern. Despite its dominant position as a supplier, China's reserves are estimated at about 35 percent of the world's exploitable reserves, meaning that country is rapidly depleting its economically accessible rare earth reserves. Already, it has begun importing some rare earth oxides for which its domestic production is now insufficient. The partial acquisition of the former Molycorp mine in the United States by Shenghe Resources was motivated by its need to import ore to process in its Chinese facilities.

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Concerns about supply stability are accentuated by China's policy of retaining about 70 percent of its rare earth production for domestic use and taking advantage of its abundant resources and strong processing capacity to establish important and globally competitive industries. For example, over 40 percent of wind power installations in China are of the more efficient rare earth magnet type. By comparison, less than 1 percent of wind power generators in North America use permanent magnets, with Europe having a slightly higher percentage. The smartphone industry is another example: in the third quarter of 2018, Chinese companies accounted for more than 43 percent of the 355.2 million smartphones shipped worldwide.

AN OPPORTUNITY FOR CANADA

The Canadian government considers REEs to be "critical to Canada's economy" and stated that we are "poised to capitalize on extracting the mineral." For its part, the House of Commons observed that Canada is "endowed with world-class rare earths deposits" that represent about "40 percent of the world's known REE reserves" and that the "geology is rich in the heavy rare earth elements, those that are forecasted to be in deficit in the near future." [3] This is a very important point. The relative abundance of rare earth elements varies considerably. The chemically more incompatible light rare earth elements are more abundant than the elements with larger atomic numbers. Because of their thermal stability and magnetic properties, the elements in burgeoning demand are the less abundant heavy rare earth elements; hence, they tend to be significantly more valuable.

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Nothing beats seeing for yourself. I flew to Kuujjuaq (Québec) for meetings with Inuit leaders of the Kativik regional government, and then to Lac Brisson to visit the B Zone site of the Strange Lake Peralkaline Complex, the largest deposit identified in the Parliamentary Committee Report.

This deposit owned by Torngat Metals, a Canadian junior mining company, is located north of the 55th parallel on the Québec-Labrador border. All around, the landscape is dotted with stunted trees and ground covers that cling perilously to the granite terrain.

Knowing that a few metres underground lies a deposit that Gareth Hatch, a world-renowned expert in rare earths has described as "one of the largest and richest potential heavy rare earths (HREO) deposits in the world" and that similar large rare earth deposits exists in its vicinity, one is left in awe by the enormous economic resources that lie dormant and undeveloped here.

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AN ENCOURAGING PRECEDENT

Until the late 1990s, diamond mining in Canada was virtually non-existent. Most people considered it a fantasy that Canada could become a major producer of natural gem-quality diamonds. Yet, since 2006, Canada has been the world's third largest producer of natural diamonds. The six large-scale diamond mines operate to the highest human rights and environmental standards in the world, designed to preserve the surrounding lands and aquatic habitats. Their stones are sought-after by consumers worldwide who value diamonds produced by mines that are environmentally conscious and conflict-free. The mines are also an important source of employment and income for the people living in the remote northern communities where they are located.

Let's be honest, diamond gems are a luxury item while rare earth elements are essential for sustainable growth. Why should Canada continue to leave its important rare earth resources in the ground, and not mine, refine and process ore according to rigorous and scientifically established eco-friendly standards, thereby providing Canadian downstream companies that develop and manufacture high-tech and green technology applications with access to high-purity rare earth oxides and metals at an affordable price? ▪

[1] Promothium (61) only appears in traces as it does not have long-lived stable isotopes and, therefore, has no economic value.
[2] Australia's Lynas Corporation is the only major rare earth producer outside China; its processing plant is in Malaysia.
[3] Canada House of Commons, The Rare Earth Elements Industry in Canada – Summary of Evidence, Standing Committee on Natural Resources, June 2014.