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Global rare earth element resources and challenges for production

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The rare earth elements (REE) have been the headline of the critical metals agenda since the 'rare earth crisis' of 2009, when China restricted export quotas, resulting in a significant REE price spike. The REE (the lanthanides and yttrium) are widely used in a range of modern technology and green energy applications. They are particularly important in high-strength magnets used in wind turbines, hard disks and electric cars, and in phosphors for lighting technology. The most 'critical' REE include Nd, Dy and Pr which are used in magnets, and Eu, Y and Tb for phosphors.

Currently, almost all of the world's primary supply of REE (>90%) comes from China. The majority of the world's light rare earth elements (LREE: La-Sm) are sourced from the giant Bayan Obo deposit and a number of other Chinese hard-rock mines. Relatively small amounts of LREE are also produced from Mt Weld in Australia, Lovozero in Russia, and from placer deposits in India and Malaysia. The Mountain Pass mine in the USA, which reopened in 2012, was subsequently shut down in 2015 as REE prices fell. The heavy rare earth elements (HREE: Eu-Lu and Y) are almost entirely produced from ion adsorption clay deposits in southern China. The limited number of REE mines in operation does not reflect global REE resources. In fact, potential REE deposits are known worldwide, and understanding of REE metallogenesis is improving rapidly. A recent review of REE deposits under exploration has estimated global resources of rare earth oxides at 619 million tonnes [1], enough to meet demand until at least 2100, and many deposits remain to be explored. However, several barriers to production make development of REE deposits outside China challenging.

One of these issues is the rare earth balance problem [2]. Most known natural REE deposits are strongly enriched in the LREE. In order to meet demand for the most critical REE, excessive amounts of LREE, especially Ce, have to be produced. Ongoing research aims to address this by finding new uses for the LREE, or by identifying primary and secondary resources enriched in the critical REE. In addition, every REE deposit is different in mineralogy, texture and grain size; individual beneficiation protocols have to be developed and this requires intensive minerals processing research. Over 200 REE minerals are known, and additionally the REE can substitute into a range of other minerals. As many as 50 of these could represent potential ore minerals but only three (bastnäsite, monazite and xenotime) are currently exploited on a commercial scale. Research projects such as EURARE (EU-funded, FP7) are now developing processing methods for new ore minerals in specific deposits. Once the ore minerals have been concentrated, separation of the individual REE presents a further challenge for which there are only a few processing facilities outside China. Ion adsorption type deposits have the advantage of needing no physical beneficiation, but there is much more to learn about these in order to locate and exploit resources outside of China.

Environmental and socio-economic impacts also need to be addressed. Whilst the REE are thought to have low toxicity, some REE minerals such as monazite are enriched in the radioactive elements Th and U, which can be a major issue. There is increasing interest in potential ore minerals that are low in Th and U but relatively enriched in the critical REE, such as eudialyte. However, some of these minerals are likely to require high energy usage and strong acids to extract the REE. Investors are likely to favour projects that have high contents of the most critical REE but low radioactivity, have a proven processing path, and can be exploited at relatively low cost. There is also a need to identify the most sustainable potential sources of the REE, and the NERC-funded SoS RARE project is investigating responsible sourcing.

References:

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