A detailed assessment of global rare earth resources: Opportunities and challenges

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The rare earth elements (REE) are indispensable to infrastructure, technology, and lifestyles across the world, leading to increasing demand for these elements. The current global Rare Earth Oxides (REO) market is dominated by Chinese production, which peaked in 2006 at 133,000 tonnes REO per year and accounted for 97.1% of global production; it maintains this position. Some primary REE consumers (e.g., the United States, European Union, Japan) are seeking more secure and economic supplies of these and other critical elements. Although the REE consist of 17 individual metals (15 lanthanides plus scandium and yttrium) that are hosted by numerous types of mineralization, the relatively modest scale of the global REE mining sector limits our knowledge of REE mineral resources and mineralizing systems compared to common metals such as copper and iron.

In order to quantitatively analyze the mineralogy, ore grades and resources of current and potential global REE resources, we compiled an extensive resource data set of individual REE projects. This compilation yields a minimum global contained REO resource of 613 Mt REO contained in 49,558 Mt of mineral resources at an average grade of 1.15% REO split over 243 projects, with a further 503 REE occurrences that do not currently have resources. These resources include 169 (out of 243) resources published using various statutory mining codes (e.g., JORC, NI43-101, SAMREC), and the use of either 2013 or the most recently available data means that this compilation represents a robust minimum geological estimate.

There are ~84.3 Mt REO hosted within tailings (Steenkampskraal, Bayan Obo, Mary Kathleen) and ~13.9 Mt REO within monazite from heavy mineral sand projects, illustrating the potential for REO production from sources other than traditional hard rock mining. Our assessment indicates that ~43% of global REO resources are hosted by carbonatite deposits, and bastnäsite, monazite, and xenotime are the three most significant minerals, accounting for >90% of our total REO resource estimate.

Our data also confirm that current REE resources are dominated by the light REE, with an average light REO (LREO; La–Gd) to heavy REO (Tb–Lu and Y oxides) ratio of 1:0.17. At 2011 global production of 110 kt REO and assuming 5% annual growth, our estimated resources can sustain production until 2125, although the obvious concern is the LREO/HREO split; for example, our database contains estimated Dy resources of ~1.95 Mt Dy₂O₃, which, at a 9% annual growth, would only sustain production until 2061. The inequity of individual REEs, especially HREE, will be one of the primary long term challenges of global REE supply chain. Our database also indicates that REE deposits can contain up to ~163 ppm Th and ~30 ppm U, meaning that the production of
radioactive waste associated with REE extraction and refining is a crucial factor that needs to be assessed by the global REE industry.