Rare earth resources: criticality to diversity

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Rare earth elements (REE) have been favourites of geochemists and mineralogists for many years. Their fractionation in trace quantities has helped decipher many geological processes. REE minerals with complex compositions still challenge the best analysts. But the names of the REE reached even senior industrialists and politicians around the World when in 2010, China reduced its export quota of REE and put them at the top of the critical metals lists. REE are used, albeit often in small quantites, in just about all digital and low energy technologies.

Critical metals are economically important, difficult to substitute in many uses, and potentially at high risk of supply disruption [1]. REE fit the definition perfectly because in 2010, 97% were sourced from just one country, China. By 2014, mines at Mountain Pass, USA, and Mount Weld, Australia have opened and the figure has reduced to 86% [2] but still the Chinese dominance holds.

Perhaps geochemists are pleased when their favourite element is given the glamourous designation of 'critical'. The crtical metals agenda has been helpful in stimulating a wider renaissance in mineral deposits research. However, no one in industry wants to rely on materials with uncertain supply. Substitution and vertical integration from mine to manufacturer are both being tried but what is really needed is diversity of supply to take REE off the critical list.

So where will the diversity come from? There is plenty of choice. Carbonatite related deposits are the main source of light REE (La-Nd), large alkaline rock complexes have higher proportions of the more sought after heavy REE (Sm-Lu), and the race is certainly 'on' to find an economic source of easily leachable REE to match the ion adsoprtion clays in southern China that supply almost all of the World's heavy REE at the moment. There are also various opportunities for by-products, e.g. from apatite or bauxite deposits. All the possibilities have varying economic and environmental characteristics.

What can geological scientists do to help? It is not just exploration geology that is important. The real sticking point in many projects is the metallurgy; getting the minerals out of the rock, and the REE out of the minerals and separated from each other. Geometalluirgy is a buzzword for critical metals.

[1] Gunn, G, editor 2014 *Critical Metals Handbook*, Wiley, 439 pp. [2] U.S. Geological Survey, 2013, *Mineral commodity summaries 2013,* U.S. Geological Survey, 198 pp.