The rare earth elements: critical metals for the 21st century

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The rare earth elements (REE) are widely studied by petrologists and mineralogists, as valuable petrogenetic tools. But they are also vital raw materials for a wide range of modern technology; in particular, Nd is an essential component of NdFeB permanent magnets that are widely used in wind turbines and in the motors of electric cars. Other uses of the REE include catalysts, phosphors for lighting, ceramics, and in specialist glass. Despite their diverse use in many industrial sectors and consumer products, almost all of the world's production of the REE comes from a group of mines in China. Since 2010, this concentration of supply has led to the REE being considered as critical metals, and has driven substantial exploration and research; but few new mines have successfully begun production.

The REE are found throughout the Earth's crust but the highest concentrations are typically found in association with alkaline igneous rocks and carbonatites, or in magmatic-hydrothermal deposits. They can also be concentrated by low-temperature processes, in heavy mineral sands and in deposits formed by lateritic weathering of REE enriched protoliths. Deposits of the REE are characterised by exceptionally wide-ranging and varied mineralogy, with over 50 minerals being considered as potential REE ore minerals, although only a small proportion of those have been exploited commercially. This complex mineralogy has significant implications for the mining and processing of REE ores, and represents one of the key challenges that must be overcome to enable new REE mines to succeed.

This talk will provide an overview of currently-known REE deposits, summarise some recent and ongoing research carried out on their geology and mineralogy, and discuss the implications for successful mining of these deposits to meet global demand for the REE. This research has been carried out by a large team of collaborators across three major projects: EURARE, funded by the European Union's Framework Programme 7; SoS RARE, funded by the UK's Natural Environment Research Council; and HiTech AlkCarb, funded by the European Union's Horizon 2020 Research and Innovation Programme.