

Interaction of alkaline magmatism and carbonatites: a recipe for REE enrichment?

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The rare earth elements (REE) are critical metals that have been the subject of considerable recent research. In the published literature, REE deposits are typically divided into classes, which commonly include 'alkaline igneous rocks' and 'carbonatites' [1]. However, our recent work, carried out as part of the EURARE and HiTech AlkCarb projects, suggests that many deposits of the REE and other critical metals may be formed where late-stage carbonatites and associated fluids interact with alkaline igneous rocks. A key question is whether these carbonatites are formed by liquid immiscibility from the host alkaline magmas, or whether they are introduced from other sources.

A classic example of a mineral deposit formed in this way is at Ivigtut in Greenland, where late-stage F and CO₂ rich fluids interacted with alkali granitic melts to form a cryolite (Na₃AlF₆) deposit, with associated metasomatism and REE mobilisation. Isotopic evidence indicates that these late-stage fluids may have been carbonatite-derived [2].

Our more recent work indicates that REE enrichment in many alkaline igneous complexes may be generated by a similar mechanism. In the alkaline igneous province of NW Scotland, late-stage metasomatism by CO₂-rich fluids has generated metasomatised veins with TREO up to 2 wt% [3]. Similar features are observed in the Ditrau Alkaline Igneous Complex in Romania, where REE mineralisation is represented by monazite- and carbonate-rich veins cutting syenitic host rocks [4]; and at the Kizilcaoren REE deposit in Turkey. This talk will provide an overview of the formation of REE mineralisation in this type of magmatic-hydrothermal system and consider future research questions.

[1] Weng et al. (2015) *Economic Geology* **110**, 1925-1952

[2] Goodenough et al. (2000) *Lithos* **51**, 205-221. [3] Walters

et al. (2013) *Contrib Mineral Petrol* **166**, 1177-1202. [4] Shaw et al., this volume

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