

Weathering and supergene enrichment in carbonatite-hosted REE deposits.

MARTIN SMITH¹, MARTIN YAN-HE LI² AND SAM BROOM-FENDLEY³

¹University of Brighton

²Imperial College

³University of Exeter

Carbonatites are the dominant source of REE. However, two of the highest-grade carbonatite-hosted REE deposits (Tomtor, Russia, and Mount Weld, Australia) are in deeply weathered carbonatite. Weathered carbonatite offers the potential for major supergene enrichment of REE, lower energy cost for mining and beneficial element fractionations between the REE and actinides, and within the REE.

The Sokli carbonatite is part of the Devonian Kola alkaline province, and consists of a vertical carbonatite pipe, ~2km in diameter, surrounded by a halo of metasomatically altered ultramafic rocks and fenite. Bedrock REE mineralisation is hosted by late stage REE-Sr-Ba rich dolomite carbonatite (O'Brien and Hyvönen, 2015). The deposit is capped by ~100m of carbonate-poor laterite. Lithologies include friable laterite including crandallite minerals and pyrochlore, bands of cemented phosphate rock dominantly composed of carbonate-fluorapatite and goethite, and clay-rich laterite formed of phlogopite altered to vermiculite. Bulk rock analyses indicate enrichments in the REE of 10 to 100x compared to bedrock. There is little fractionation in the REE relative to bedrock, which could indicate residual enrichment of bedrock REE minerals (Fig. 1). However, sequential extraction and electron microprobe analyses indicate element fractionation between minerals, including the development of positive and negative Ce anomalies. The mineralogy includes residual monazite-(Ce), but also widespread development of secondary monazite (with significant Ca and S contents), rhabdophane and florencite, alongside secondary REE-poor apatite, and the incorporation of the REE into oxides and weathering derived silicates. The dominant mineralising processes are therefore dissolution and re-precipitation of REE minerals alongside residual enrichment. Preliminary U-Pb dating of secondary apatite indicates the dominant weathering period was Miocene, and mineralisation can hence be related to warm paleoclimate. Textural observations indicate comparable processes at sites including Tomtor and Dong Pao (Vietnam). Further work will focus on the structural transformation of REE mineralogy during dissolution-reprecipitation, inter-mineral element fractionation, and the conditions of weathering.

O'Brien, H., Hyvönen, E. (2015) Chapter 4.2 - The Sokli Carbonatite Complex. In: Mineral Deposits of Finland, (Maier, W.D., Lahtinen, R., O'Brien H.). Elsevier, pp.305-325.

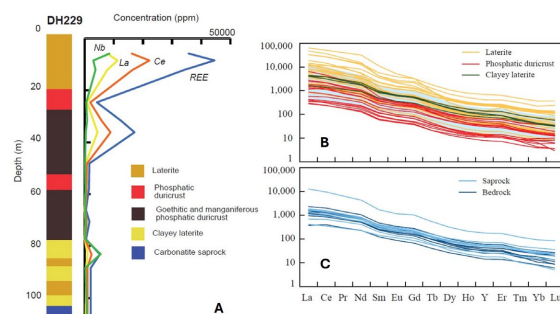


Figure 1: (a) Typical laterite profile, (b) Chondrite normalised REE concentrations in laterite, compared to (c) Bedrock carbonatite.