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Rare earth mineralisation in the Cnoc nan Cuilean intrusion of the Loch Loyal Syenite Complex, northern Scotland

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Due to growing global concerns about security of rare earth element (REE) supply, there is considerable interest in identifying new deposits and in understanding the processes responsible for their formation. Ongoing studies by BGS on potential indigenous resources have focused on the Caledonian alkaline intrusive complexes of north-west Scotland. The highest values of total rare earth oxide (TREO) have been found in the Cnoc nan Cuilean intrusion of the Loch Loyal Complex in Sutherland.

The Loch Loyal Syenite Complex comprises three intrusions: Ben Loyal, Beinn Stumanadh and Cnoc nan Cuilean. The Cnoc nan Cuilean intrusion, which covers an area of about 3 km2, can be subdivided into two zones: a Mixed Syenite Zone (MSZ) and a later Massive Leucosyenite Zone (MLZ). Evidence from field mapping and 3D-modelling suggests that the melasyenites were passively emplaced to form a lopolith concordant with the Moine and Lewisian country rocks. A later episode of leucosyenitic magmatism caused mixing and mingling with the melasyenite forming the MSZ. Continued intrusion of leucosyenite melts then formed the MLZ [1].

The melasyenites are enriched in TREO relative to the leucosyenites with average values of 3800 ppm and 1400 ppm respectively. The highest contents, up to 20 000 ppm TREO, are found in narrow biotite-magnetite-rich veins identified in a single stream section near the eastern margin of the intrusion. All lithologies are light rare earth element (LREE) dominated with high concentrations of Ba and Sr and low levels of Nb and Ta. Various REE-bearing minerals are present but allanite is dominant, being present in all major magmatic lithologies and the biotite-magnetite veins. Three generations of allanite have been identified: a late-magmatic phase rimming apatite; allanite micro veinlets cross-cutting the syenite; and a third phase only observed in the biotite-magnetite veins. TREO concentrations of the different allanite generations are similar, averaging 22%. The vein-hosted allanite has undergone alteration, locally leading to a net REE enrichment of up to 50% TREO. Geochemical and mineralogical studies are continuing, but a preliminary genetic model involves crystallisation of a REE-enriched melasyenite magma followed by later remobilisation and upgrading of REE within biotite-magnetite veins. This model may be a basis for continuing exploration in Scotland or in similar settings elsewhere.

References

[1] Hughes H.S.R. (2011) The geology and rare earth element metallogenesis of the Cnoc nan Cuilean intrusion, Loch Loyal Complex, NW Scotland. Unpublished MSc thesis, Camborne School of Mines, University of Exeter.