Mechanisms for concentrating critical metals in granite complexes: insight from the Mourne Mountains, Northern Ireland

Moore, K.R.[1], Lusty, P.[2] and Moles N.R.[3]

[1]Camborne School of Mines, University of Exeter, Penryn Campus, Cornwall, TR10 9EZ. k.moore@exeter.ac.uk
[2]British Geological Survey, Nicker Hill, Keyworth, Nottingham NG12 5GG.
[3]School of Environment and Technology, University of Brighton, Moulsecoomb, Brighton, BN2 4GJ.

The critical metals are the raw materials required for emerging technologies. Their production is concentrated in a small number of countries, resulting in a high risk of supply disruption [1]. The overall objective of this project was to utilise and enhance the Tellus data set for the Mourne Mountains so that the potential for polymetallic critical metal-bearing mineralisation could be investigated. We used a multidisciplinary approach that combined deep soil and stream sediment geochemical data from the Tellus Survey with mineral data from a new QEMSCAN® investigation of 55 heavy mineral concentrates (HMCs) from large volume stream sediment samples [2] and eight bedrock locations. For both sample types, the QEMSCAN® generated a statistical analysis of grain-size, mineral abundance and mineral associations. Additional higher resolution element and chemical mapping was used to place the critical metal host minerals into their petrogenetic context. The Mourne Mountains provides a natural laboratory to investigate how economic concentrations of the critical metals can develop in granite complexes. Specifically, we identified four main geochemical patterns in the Tellus data and determined their mineralogical source.

1. Thorium, rare earth element (REE) and niobium enrichment is associated with G1 and G2 granites. Critical metals were concentrated during eutectic crystallisation of F- and volatile-rich residual magmas in the roof zone of the granite intrusions.
2. Arsenic, tin, indium, REE and yttrium enrichment is associated with hydrothermal/metasomatic mineralisation. Critical metals were concentrated in minerals by the reaction of arsenic-rich fluids with the granite host rock. Comparison with the first geochemical pattern suggests that the arsenic-rich fluids have a magmatic source.
3. The processes controlling manganese and cerium enrichment remain enigmatic. Critical metals were precipitated in small cavities in the granite by post-magmatic fluids moving through the rock. The principal control on the development of these enrichments is difficult to determine due to their isolated and scattered occurrence.
4. REE and a number of other elements (e.g. U, Th, Sr, V) have anomalous concentrations along tectonic lineaments. Critical metals were concentrated by episodic fluids along post-magmatic faults. The mineralogy of the stream sediment HMCs suggests that this type of mineralisation is complex and cannot be adequately explained by the composition of the bedrock samples that we have examined.

The abundance of coarse-grained cassiterite and the occasional occurrence of coarser-grained monazite in the HMCs from some stream sediments suggest that there are additional mineralised localities that remain to be located.

In summary, research in the Mourne Mountains can enhance our understanding of the processes that concentrate critical metals and thus improve our ability to predict where new sources may occur

References:

[1] European Commission (EC). 2010. Critical Raw Materials for the EU. Report of the ad-hoc working group on defining critical raw materials.

[2] Moles N R et al. (2014) MDSG presentation, Oxford.