Stream Sediment Geochemistry as a Geological Mapping Tool: Critical Metal Mineralisation in the English Lake District

Adam Eskdale, PhD in Department of Earth Sciences Royal Holloway University of London

Rationale for Study

Energy critical elements (ECE) are elements deemed essential for the development of modern technologies critical to our society, with particular emphasis on those in the sustainable energy sector. Understanding regional geological variation is critical to facilitate successful mineral exploration campaigns for these elements, especially in areas of the world where visible rock surfaces are difficult to see at the surface e.g., due to high topography, excess of vegetation, and man-made developments.

Within this remit, stream sediment geochemistry is an incredibly useful tool to help geologists understand the rock within the surrounding area of the drainage catchment. As the local rocks are eroded by local streams, the water transports particles of the rock and deposits them on the riverbed further downstream. These particles have a piece of the original source-rock chemistry, and therefore are incredibly important to help geologists conduct mapping.

My PhD research is focused on characterising cobalt-bearing mineral (ore) across the English Lake District, with specific goals to define a model for how these ores form. This is part of a wider research initiative to understand how primary cobalt-bearing deposits form, facilitating future mineral exploration for these styles of mineral system. I have been using the G-BASE stream sediment geochemical database developed by the British Geological Survey to understand broader geochemistry and rock types across the region, and identify possible, previously unrecorded As-Co-Cu-Fe-Ni ore enrichment at scale. Although currently a purely theoretical model, with the financial support of the 2022 RHUL Travel Award this model is currently being tested using in-field data.

Fieldwork and Laboratory Analysis

Lake District, UK: 22/07/2022 – 29/07/2022

To test the model's success, a fieldwork campaign was conducted, travelling to 'enriched' areas identified from the stream sediment data modelling. In total, 6 different sites were visited: the mining area of Coniston, Seathwaite, Tilberthwaite, and Shap along with two sites within the Black Combe and Devoke Water areas. Myself, my supervisor, and another Earth Sciences colleague stayed locally in Ambleside, travelling each day to a different site with the Earth Sciences departmental vehicle (see Fig. 1, A). At each site we collected samples from the local host rock we could see (Fig. 1, C), any mineralisation of metals (Fig. 1, D), and from spoil heaps outside old mining adits (Fig. 1, B). Sampling was conducted whilst complying with regulations for Sites of Special Scientific Interest (SSSI). After a week of mapping and sampling, we returned to RHUL Earth Sciences department for further work. All fieldwork costs (accommodation, vehicle rental, vehicle fuel) were supported by the 2022 RHUL Travel Award and the Earth Sciences Kirsty Brown Memorial Fund.

Figure 1: (A) RHUL Earth Sciences departmental vehicle used on the trip; (B) spoil heaps outside an old mining adit near Seathwaite; (C) in-situ veins cutting through host rock; (D) mineralised veining within shale host rock.

Following the fieldwork phase, any samples we collected were screened for analysis using more quantitative methods. Representative samples for any mineralisation at each site, and for the local host rock were chosen and then crushed using the Earth Sciences Rock Crushing Lab. Crushing the rocks into a fine powder creates a more homogenous mixture of material, ideal to use for generating our own geochemical data for comparison with the G-BASE model values (Fig. 2, A).

Following the crushing step, the powders were then dried in a furnace at 1100^{o}C, weighed (Fig. 2, B), and melted into molten material (Fig. 2, C) before ‘casting’ them into fusion beads (glass discs) which can be put into an XRF machine to generate our geochemical data (Fig. 2, D). Currently I am still in the process of preparing all of the samples using this method, with the first batch of fusion beads already in the XRF machine ready to start collecting data.

Figure 2: (A) Crushed rock sample from Seathwaite; (B) weighing stage of the process, putting sample into platinum crucibles; (C) melting of sample within the crucibles into a molten glass; (D) pressed molten glass onto Al-disc, creating the final fusion bead.

Preliminary Conclusions

As not all of our samples are yet prepared for analysis, full conclusions cannot be made. However, the data we have generated so far is indicative of a relatively successful model. Our data have identified the local host rocks in these areas to be a combination of shale-based and volcanic-based lithologies, concurrent with established geological maps of the sites. We will continue to generate all our data and then compare the results with the average values from the G-BASE modelling tool, before also identifying any metal mineralisation in the samples found. This will define the true success of the G-BASE stream sediment data as both a geological mapping and ore-metal identification tool.