Application of indicator mineral chemistry to the exploration for IOCG deposits in central Zambia

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Project Highlights:

- Opportunity to work with Ivanhoe Mines on an active exploration targeting program in Zambia
- Develop new exploration tools for IOCG mineral systems in Zambia
- Contribute to understanding of the complex mineral system of global IOCGs

Overview:

The Mumbwa region in central Zambia (Fig. 1) is recognised as one of the world's IOCG provinces, and has been subject to exploration since it was discovered as part of the 'Big Concession' in the 1950s. Mineralisation is related to syenitic intrusions that are part of the latter stages of the Hook Granite event at 570-520 Ma (Milani et al., 2019); a mostly felsic A-type granite event, with some associated syenites and mafics, formed during the peak of the Lufillian Orogeny (Milani et al., 2015). This places the Zambian IOCGs within a unique time window with almost all other IOCG provinces being Precambrian in age (e.g. Cloncurry, Queensland; Stuart Shelf, South Australlia; Carajas, Brazil), or Mesozoic (e.g. Candelaria-Punta del Cobre, Chile).

Indicator mineral studies have developed significantly in recent years in a number of mineral systems as a tool for exploration targeting and early fertility assessments. They technique can be applied to hard rock samples, whereby common accessory minerals can record in situ evidence of key processes of the mineral system like volatile exsolution, and therefore can give an indication of prospectivity (e.g. zircon in porphyries; Pizarro et al., 2020; and apatite in porphyries; Stonadge et al., 2023).

Additionally, indicator minerals can be used in exploration in overburden/soil sampling programs, with the chemistry of the minerals helping to identify fertile, altered and barren systems. The UoL has expertise in both of these applications with work on apatite in porphyries (Stonadge et al., 2023) and magnetite in overburden in Zambia around the Munali intrusion (Ward et al., 2018).

Due to the range of intrusions related to the Hook Granite, an effective indicator mineral approach can significantly aid exploration for IOCGs in the region by identifying key minerals in the intrusive rocks with characteristic geochemical signatures. By constructing a database of mineral chemistry from both mineralised and barren systems across the region, this can be transformed into a predictive tool during early-stage soil sampling and drilling of new targets.

Figure 1: Fieldwork in Central Zambia in the Mumbwa IOCG province

Methodology:

- Desk study to collate all available reports, data, papers and previous work on prospects across the region.
- Fieldwork to (1) sample existing cores; and (2) obtain soil samples from selected prospects/deposits
- Mineral chemistry by Laser Ablation ICP-MS on magnetite, apatite, rutile, and/or other key minerals across the prospects: (1) baseline characterisation of the chemistry of these minerals in the hard rock, and then (2) a comparison of overburden material from selected site (e.g. as procedure used in Ward et al 2018)
- Development of an indicator mineral framework for the use in exploration targeting in Zambia.

Possible Timeline

Year 1: Desk Study followed by initial field season to sample cores and soils on priority 1 targets. Initial labwork characterising petrology of the igneous, alteration and ore minerals

Year 2: Bulk of the analytical work identifying a range of geochemical characteristics of indicator minerals. This will largely be from LA-ICP-MS analysis. Second field season to collect follow up samples from Priority 1 targets and sampling of Priority 2 targets. International conference presentation.

Year 3: Development of the framework for identifying key minerals and the geochemical indicators of metal fertility. International conference presentation.

Training and skills:

You will work closely with Ivanhoe Mines in Zambia and other industry partners to develop a deep understanding of the application of scientific research in the context of the mineral exploration business. During at least one of the field seasons, you will be offered the opportunity to gain valuable industry experience on one or more of the exploration projects that are related to the PhD.

TARGET researchers will participate in a minimum of 40 days training over the 3.5 years of study composed of:

- an annual one-week workshop dedicated to their year group, and tailored to that cohort's needs in terms of skills development – *for the first three years of their study*;
- an annual all-TARGET workshop with cross-year interactions, advanced training and opportunities to specialise in particular areas – *all years of study*;
- a number of one-day workshops;
- additional online events and in-person workshops attached to relevant conferences.

Partners and collaboration (including CASE):

You will work closely with Ivanhoe Mines in Zambia and other industry partners to develop a deep understanding of the application of scientific research in the context of the mineral exploration business. This PhD will run in parallel with a large collaborative project investigating the metallogeny of central Zambia.

During at least one of the field seasons, you will be offered the opportunity to gain valuable industry experience on one or more of the exploration projects that are related to the PhD.

Further reading:

Milani, L., et al., 2015. A-type magmatism in a syn-collisional setting: The case of the Pan-African Hook Batholith in Central Zambia. Lithos 216–217, 48–72.

Milani, L., et al., 2019. Geology and mineralization of the Cu-rich Mumbwa district, a potential IOCG-type system at the eastern margin of the Pan-African Hook batholith, Zambia. J. Afr. Earth Sci. 158, 103513.

Pizarro, H., et al., 2020. Porphyry indicator zircons (PIZs): Application to exploration of porphyry copper deposits. Ore Geol. Rev. 126, 103771.

Stonadge, G., et al., 2023. The volatile record of volcanic apatite and its implications for the formation of porphyry copper deposits. Geology 51, 1158–1162.

Ward, L.A., et al., 2018. The use of magnetite as a geochemical indicator in the exploration for magmatic Ni-Cu-PGE sulfide deposits: A case study from Munali, Zambia. J. Geochem. Explor. 188, 172–184

Further details:

Please contact the lead supervisor david.holwell@le.ac.uk for further information.

Please visit https://target.le.ac.uk/ for additional details on how to apply.