The role of mafic rocks as a structural trap and metal source for Copperbelt mineralisation at Mumbezhi, NW Zambia

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Project Highlights:

- Opportunity to work with Prospect Resources on an active exploration program in Zambia
- Develop practical criteria for exploration targeting
- Contribute to the highly topical debate on the timing of Copperbelt mineralisation

Overview:

The Central African Copperbelt is the most globally endowed sediment-hosted Cu and Co basin discovered to date. It is located within a Neoproterozoic rift basin (from ~880 Ma) along the southern margin of the Congo Craton, with mineralisation hosted in Katangan Group clastic, carbonate and evaporitic sediments that sit on basement highs, or 'domes' in the central and northwestern part of Zambia. The sediments were intruded by a suite of mafic rocks around 750 Ma and subject to deformation during basin inversion during the Pan African/Lufilian orogeny at around 550-520 Ma.

The timing of mineralisation and source of metals has proven to be highly debated over recent years (e.g. (Hitzman and Broughton, 2017; Sillitoe et al., 2017). Whilst some models invoke a syn-genetic origin for the mineralisation (i.e. before the mafics were intruded), many recent geochronological studies have placed mineralisation (or at least some stages thereof) during the Pan African (i.e. after the mafics were intruded). Whilst it is widely accepted that basal redbed sediments are the major source of metals in most basins with sediment-hosted base metal mineralisation, it is generally thought that other sources are required in the Copperbelt to account for the vast resources present (e.g. Hitzman et al., 2010).

Mafic rocks have inherently high contents of base metals compared to most crustal rocks (including redbeds) and so offer a potential enriched source of metals to any basinal system, providing there can be efficient leaching of the metals. Recent work at Leicester has demonstrated that mafic rocks in many parts of the Copperbelt are significantly leached of Cu and Co and they are thus a contributor to the overall metal budget. However, it is not yet constrained as to how significant they are and how proximal mafic source rocks need to be to large deposits, and the role of mafics also depends on their timing relative to the major mineralisation events and fluid flow. If this is post-mafic emplacement, then the mafics are a key part of the mineral system and need to be addressed as such.

Furthermore, mafic rocks play a potentially crucial role as a structural control on mineralisation. The rheological contrast between rigid mafic bodies and the softer metasedimentary rocks means that during deformation, fluid flow and mineralisation can be focussed in pressure shadow areas adjacent to mafic bodies. This has never been thoroughly tested in the Copperbelt, although evidence on a centimetre scale of Cu precipitation in pressure shadows exists (Twite et al., 2020).

This project aims to address these outstanding research questions by investigating the relationship of mafic bodies to Cu mineralisation at Prospect Resources' Mumbezhi project area in NW Province, Zambia. Recent drilling has delineated a significant resource (107 Mt @ 0.5 % Cu) with further exploration targets. The orebodies appear to be spatially associated with mafic bodies in apparent structural traps, and therefore offer the perfect opportunity to (Aim 1) investigate the role of the mafics in contributing metals to the mineralisation; (Aim 2) ascertain the timing of mineralisation relative to mafic emplacement/deformation; and (Aim 3) determine the structural controls on ore deposition adjacent to mafic bodies.

Figure 1: Leicester researchers drill core logging at the Mumbezhi field camp, NW Province, Zambia

Methodology:

- Fieldwork to sample and undertake structural analysis of cores, work with 3D models from drillcore databases and undertake mapping.
- Mineralogical (quantitative SEM mapping) and geochemical (bulk rock XRF) analysis to determine the levels of base metal leaching and alteration of mafic rocks to address Aim 1.
- Geochronology via U-Pb techniques on zircon of mafic rocks, (this will be done through a NERC Environmental Isotope Facilities (NEIF) grant application that the student will lead) plus other techniques on mineralisation-related phases such as molybdenum, biotite to address Aim 2.
- 3D modelling of structural setting using Micromine or similar software to address Aim 3.

Possible Timeline

Year 1: Desk Study followed by initial field season to integrate with field team, sample cores and familiarise with 3D structure. Initial labwork characterising petrology of the igneous, alteration and ore minerals.

Year 2: NEIF grant application in October. Bulk of the analytical work using SEM and geochemistry at Leicester, plus geochronology at BGS later in the year. Second field season to collect follow up samples from. International conference presentation.

Year 3: Further geochronology work and synthesising of data to generate a number of constraints regarding mafic rocks that can be applied to practical exploration tools. International conference presentation. Knowledge exchange workshop in Zambia.

Training and skills:

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 Prospect Resources in Zambia to develop a deep understanding of the application of scientific research in the context of the mineral exploration business. Leicester and Prospect have a good working relationship established, already collaborating on two Masters projects (Fig. 1) that will form valuable context for this PhD. 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.

The geochronological work will be done at the NERC Isotope Geosciences Laboratory at the British Geological Survey in Nottinghamshire, following an application for use of these facilities through the NEIF grant system. The student will then work with isotope geoscientists and geochronologists and receive training in radiogenic isotopic analysis.

Further reading:

Hitzman, M.W., and Broughton, D.W., 2017, Discussion: "Age of the Zambian Copperbelt" by Sillitoe et al. (2017) Mineralium Deposita: Mineralium Deposita, v. 52, no. 8, p. 1273–1275.
Hitzman, M.W., Selley, D., and Bull, S., 2010, Formation of sedimentary rock-hosted stratiform copper deposits through Earth history: Economic Geology, v. 105, no. 3, p. 627–639.
Sillitoe, R.H., Perelló, J., Creaser, R.A., Wilton, J., Wilson, A.J., and Dawborn, T., 2017, Age of the Zambian Copperbelt: Mineralium Deposita, v. 52, no. 8, p. 1245–1268.
Twite, F., Nex, P., and Kinnaird, J., 2020, Strain fringes and strain shadows at Kamoa (DRC), implications for copper mineralisation: Ore Geology Reviews, v. 122, p. 103536.

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.