Understanding the controls on critical metal contents of orogenic gold deposits: a case study in the Filabusi Greenstone Belt, Zimbabwe

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Project Highlights:

- At least 4 months of fieldwork in Zimbabwe
- Work with an exploration company to help develop sustainable mineral resources
- Gain advanced skills in a variety of mineralogical, geochemical and structural geology techniques to study mineralisation

Overview:

The Filabusi belt, Zimbabwe, is an Archean granite-greenstone belt that contains orogenic gold deposits, some of which are associated with significant enrichment in a variety of sought-after critical metals, including tungsten, molybdenum and bismuth. Tungsten is particularly abundant in some areas as scheelite ($CaWO_4$) yet, when viewed globally, tungsten is rarely mined from Precambrian rocks, suggesting that Filabusi is unusual. The critical metal abundance varies spatially across the belt but the reason for this is not clear. Understanding what causes these anomalous critical metal enrichments and how they vary spatially will a). facilitate exploration for deposits where these critical metals could be co-produced from gold operations, and b). provide added dimensions to understand what controls the localisation of the gold mineralisation for exploration targeting. For example, scheelite has different controls on solubility compared to gold and if they are precipitated together this narrows down the possible conditions. In addition, scheelite can provide a wealth of information about the mineralising fluids since REE and other trace elements are easily substituted in the structure making it amenable to source tracing and Rb-Sr and Sm-Nd dating.

Variations in the contents of critical metals in different gold deposits could relate to fluid source – it is interesting that some tungsten-rich deposits appear to be spatially related to granitic intrusions. Alternatively, differences in trapping mechanisms for metals between deposits may be important, due perhaps to host rock composition, structural controls, or emplacement depth and timing.

In this project you will work together with CASE partner Kavango Resources Plc to characterise and understand the variations in critical metal content of gold mineralisation across the belt to produce a large-scale mineralisation model. Detailed work will be carried out on Kavango licences and other licences where Kavango can arrange access. There has been little geological research in Zimbabwe since the 1990s, making this an area fruitful for research employing modern ideas such as a minerals systems approach. Mining accounts for over 70% of Zimbabwe's much needed export earnings and it is estimated that for every direct job in the gold mining sector another eight jobs are created elsewhere in the economy. This project will help develop a more sustainable mineral supply by facilitating the co-production of critical metals from gold deposits.

Figure 1: Typical examples of mineralisation in the Filabusi belt: a. high grade gold bearing structure, b., c. sheared vein showing tungsten as scheelite which fluoresces under UV light (c.).

Methodology:

- Desk study to populate a GIS for the belt incorporating all relevant literature data and new data developed within this project.
- Fieldwork to map key localities and log drillcore for mineralisation, host lithology, hydrothermal alteration, structures, and age relationships and to collect samples from outcrop, mined material and drillcore.
- Analysis of structures from remote sensing, drone imagery, field mapping, drillcore logging and thin sections to determine the structural controls on mineralization at scales from the greenstone belt to the microscopic.
- Optical mineralogical and textural analysis of samples augmented by µ-XRF scanning of cut faces.
- Mineralogical and microtextural analysis of polished thin sections using transmitted and reflected light petrography.
- SEM analysis of mineral chemistry and microstructure.
- Analysis of geochemical data to understand characteristics, correlations and spatial variations within the mineralisation.
- Fluid inclusion microthermometry on selected samples to determine fluid density, temperature and chemistry.
- Stable isotope (S, O, C, H) and radiogenic isotope (Sm-Nd, Rb-Sr, U-Pb) analysis of selected samples to trace fluid source(s) and to provide radiometric dating of key events (*subject to successful application for funding at NERC National Environmental Isotope Facility).

Possible Timeline

Year 1: Initial orientation fieldwork and sample collection, literature review and GIS construction, training in structural techniques, sample petrography and analysis, initial fluid inclusion work, data interpretation, poster at national conference, second phase of fieldwork and sample collection

Year 2: Continue sample analysis and fluid inclusion work, data interpretation, submit initial paper, application to NEIF for isotope work, present at national conference, commence isotope work, 3rd fieldwork, poster at international conference.

Year 3: Complete petrography and analysis, complete isotope work, interpret complete datasets, presentation at international conference, submit papers on findings, write thesis.

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.

You will become proficient in field mapping, core logging and measurement and analysis of structural data. You will develop skills in the use of analytical equipment, especially SEM, automated-SEM and µ-XRF to obtain mineral chemistry and microtextural information and the use of a microthermometry heating-freezing stage for fluid inclusion analysis. GIS training will be supported by Kavango. You will take courses in structural geology and GIS, focussed on mineral resources. These skills are highly attractive to both industrial and academic employers for the green transition. You will join a thriving community of mineral resource researchers in the Centre for Sustainable Resource Extraction.

Partners and collaboration (including CASE):

Kavango Resources is London registered and has an office in Bulawayo and a field camp near Filabusi. They have licences on three areas in the Filabusi belt and through a subsidiary are producing gold in one of them. They currently support two Leicester MGeol student projects and it is anticipated that further MGeol students will work with the researcher on related sub-projects.

As a CASE partner Kavango will: co-supervise the project, host the student for a minimum of 4 months total for fieldwork in Zimbabwe, provide access to company datasets and licence areas, enable sample collection from field and drill core and cover sample shipment to the UK, fund additional laboratory work, provide field assistants, transport and accommodation during fieldwork and cover flights to and from the UK.

Blenkinsop at Cardiff will provide training in advanced structural techniques, such as remote sensing and drone data interpretation, field measurements and mapping, taking measurements from oriented core, and microstructures, followed by training in data processing and analysis of structural data. Tom will enable comparison of the Filabusi occurrences with other areas of Zimbabwe through his comprehensive knowledge of orogenic gold in Zimbabwe. The student will visit Cardiff University to undertake training in these skills.

Further reading:

Baglow, N. (1998). The geology of the Filabusi Greenstone Belt and surrounding granitic terrane. Zimbabwe Geological Survey, Bulletin 91, 263 pp.

Blenkinsop, T., Oliver, N., Dirks, P., Nugus, M., Tripp, G., & Sanislav, I. (2020). Structural geology applied to the evaluation of hydrothermal gold deposits. In *Reviews in Economic Geology v.21* (pp. 1–23). https://doi.org/10.5382/rev.21.01

Blenkinsop, T. O. M., Doyle, M., & Nugus, M. (2015). A unified approach to measuring structures in orientated drill core. In *Richards, F. L., Richardson, N. J., Rippington, S. J.,Wilson,R.W.&Bond, C. E. (eds) Industrial Structural Geology: Principles, Techniques and Integration. Geological Society, London, Special Publications, 421, http://dx.doi.org/10.1144/SP421.1*. https://doi.org/10.1144/SP421.1

Centre for Sustainable Resource Extraction, University of Leicester https://le.ac.uk/csre

Darbyshire, D.P.F., Pitfield P.E.J., & Campbell, S.D.G. (1996). Late Archean and Early Proterozoic gold-tungsten mineralisation in the Zimbabwe Archean craton: Rb-Sr and Sm-Nd isotope constraints. *Geology*, 24, 19-22.

Kavango Resources https://www.kavangoresources.com/projects/zimbabwe/why-zimbabwe

Oberthür, T., Blenkinsop, T.G., Hein, U.F., Höppner. M., Höhndorf, A. & Weiser, T.W. (2000). Gold mineralisation in the Mazowe area, Harare-Bindura-Shamva greenstone belt, Zimbabwe: II. Genetic relations deduced from mineralogical, fluid inclusion and stable isotope studies, and the Sm-Nd isotopic composition of scheelites. *Mineralium Deposita*, 35, 138-156.

Zimbabwe https://en.wikipedia.org/wiki/Zimbabwe

Further details:

To discuss the project please contact Prof Gawen Jenkin: grtj1@le.ac.uk

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