Constraining Ore Forming Processes at the Redmoor Cu-W-Sn Deposit, Cornwall

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Project Highlights:

- Granite-related Cu-W -Sn polymetallic mineralisation.
- Crystal-scale stable isotope and trace element geochemistry.
- Critical Mineral Resources in the UK.

Overview (including 1 high quality image or figure):

Granite-related Sn-W and polymetallic mineral systems are globally important sources of critical minerals. Tin is the main Pb-free solder in electronics and tungsten is used in a wide array of industrial applications for its hardness and high melting temperature. These systems also include economic concentrations of Cu; key for delivering the green transition. While these mineral systems are undoubtedly magmatic-hydrothermal, the degree to which mineralisation processes and even metal enrichments are reliant on interaction with external fluids is poorly established (Lehmann, 2021). This project will apply geochronology as well as crystal-scale trace element and stable isotope (B, O, H, and transition metals) geochemical analyses of ore and gangue phases from the Redmoor W-Sn-Cu deposit in Cornwall to constrain the hydrothermal evolution of the deposit and address these uncertainties.

Figure 1: Strong copper and tungsten mineralisation in diamond drill core from Redmoor.

Redmoor is a globally significant source of critical minerals hosted in Tavy Formation metasedimentary rocks east of the Bodmin Moor pluton. The CASE partner, Cornwall Resources, have carried out 14,000 m of diamond drilling and an inferred mineral resource of 11.7 Mt of ore at 1.17 % Sn equivalent, including economic W and Cu and enrichments in Pb-Zn-Bi-Ag. As such the deposit represents a strategically important critical mineral asset for the UK as set out in the Critical Minerals Strategy. To date, the paragenesis of the deposit lacks structural and geochronological constraints and it remains unclear what fluid processes are responsible for the deposition of key economic elements.

This project will aim to answer the following questions:

1) What is the mineral and fluid paragenetic history of the Redmoor deposit and can magmatic or fluid events be constrained in a structural framework?
2) What are the principal fluid and metal sources and magmatic-hydrothermal processes that generate polymetallic ore bodies such as Redmoor? What role, if any, do external fluids play in mineralisation?
3) Over what time scale did the hydrothermal system at Redmoor develop?

To address these questions the student will examine the stable isotope and trace element geochemistry of key ore and alteration phases and date key ore and gangue phases.

Methodology:

The paragenesis of the deposit will be established via diamond drill core logging and petrographic analysis of samples selected during field visits to Redmoor. Stable isotope and trace element data from ore and alteration phases will be acquired using a combination of Secondary Ion Mass Spectroscopy (SIMS) and LA-MC-ICP-MS. This will require preparatory textural and mineral chemical mapping using the SEM-EDS facilities at Cardiff University. Ore fluid temperature and chemistry will be determined using fluid inclusion microthermometry at Cardiff and Laser Raman at UCL. The student will model the hydrothermal system using stable isotopic and P-T-x constraints derived from the above techniques. There will be opportunities for the successful candidate to refine or develop the methodological approach during the project, in particular the student can lead on developing the principle geochronological approach for the study, which may include direct Rb-Sr dating of micas and U-Pb dating of bracketing intrusive units.

Possible timeline:

Year 1: Review Sn-W and polymetallic mineralisation systems ahead of fieldwork at Redmoor while on placement with the CASE Partner, Cornwall Resources. Fieldwork will focus on establishing a clear structurally constrained paragenesis and producing a sample suite.

Year 2: Mineralogical and stable isotope analysis of key ore and gangue minerals. Fluid inclusion microthermometry and laser Raman characterisation of fluids. Training in analytical techniques.

Year 3: Data analysis, including modelling of the fluid system at Redmoor for comparison to empirical isotopic and mineral chemical data. Writing paper manuscripts and thesis and presenting results at international conferences such as the SGA and SEG conferences.

This is an outline only and the student will have the opportunity to develop the schedule for the project in discussion with the academic and industry advisors.

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.

The student will receive training in microanalytical techniques at Cardiff University, including SEM-EDS, LA-ICP-MS and MC-ICP-MS (including sample preparation) and fluid inclusion microthermometry. Dr Katie McFall will supervise training in operation and interpretation of Laser Raman at partner institution UCL. Cornwall Resources will provide training in mineral exploration techniques (core logging, structural measurements, mapping, 3D modelling and visualisation) during industrial placement, which will include fieldwork. The student will also be encouraged to attend specialist workshops and short courses associated with conferences.

Partners and collaboration (including CASE):

The student will spend a minimum of three months on placement with the CASE partner, Cornwall Resources, and will have regular interaction with industrial supervisors, Dennis Rowland and Rowan Thorne. This will be an excellent opportunity for the student to develop an open and productive working relationship with industry geologists and to develop their knowledge exchange skills.

Dr Katie McFall at UCL will take an active role in supervising the successful candidate. It is also anticipated that the student will visit UCL to make use of the analytical facilities available, including laser Raman and potentially the geochronology and thermochronology facilities.

Requirements: Applicants should ideally have a first-class degree in geology, with a broad interest in mineralogy, ore deposit geology and mineral systems.

Further reading:

Harlaux, M. et al., 2021. Fluid mixing as primary trigger for cassiterite deposition: Evidence from in situ δ18O-δ11B analysis of tourmaline from the world-class San Rafael tin (-copper) deposit, Peru. *Earth and Planetary Science Letters*, *563*, p.116889. doi: 10.1016/j.epsl.2021.116889

Lehmann, B., 2021. Formation of tin ore deposits: A reassessment. *Lithos*, *402*, p.105756. doi: 10.1016/j.lithos.2020.105756

Further details:

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

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Katie McFall: https://www.ucl.ac.uk/earth-sciences/people/academic/dr-katie-mcfall

Jens Andersen: https://dees.exeter.ac.uk/csm/people/profile/index.php?username=jcanders

Cornwall Resources Ltd. Redmoor Project: https://www.cornwallresources.com/redmoor-project