TARGET Mineral Resources

UKRI Natural Environment Research Council

Hydrothermal Processes and Metal Sources at the Odienné Cu-Au Project, Cote D'Ivoire: Insights into IOCG Mineralisation

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Co-supervisors: Professor Thomas Blenkinsop, Cardiff University; Dr Katie McFall, UCL; Mr Andrew Chubb, Awale Resources; Mr Andrew Smith, Awale Resources.

Project Highlights:

- Study the first IOCG mineral system discovered in West Africa in both the field and the laboratory.
- Exciting fieldwork opportunity in an active exploration environment and an engaging lab programme, including SEM-EDS, LA-ICP-MS, and SIMS analysis of stable isotopes and trace elements in key alteration phases.
- Opportunity to contribute to wider mineral system models for IOCG mineralisation and development of future exploration strategies.

Overview:

Iron Oxide-Copper Gold deposits represent ~5 % of global Cu resources and can also contain important reserves of critical metals (e.g., Co ± Ni, REEs, Bi-Te-Se, and U). They are also important sources of gold, making them an attractive target for explorers. Despite their importance, substantial uncertainties remain around several aspects of IOCG mineral systems, including the source of fluids and metals. Understanding the evolution of these polymetallic deposits will contribute to securing the future metal reserves required for the green energy transition.

The CASE partner, Awalé Resources, have made several high-grade Cu-Au discoveries across the Odienné licence area in the Denguèlé Region of northwestern Côte d'Ivoire. Many of these are interpreted as IOCG due to their association with oxidised, Fe-rich hydrothermal breccias and enrichments in Ag, Bi, Mo, and W. The Odienné Project is likely the first discovery of significant IOCG mineralisation in the West African Craton; a geological province well-known for its orogenic gold resources. This represents an excellent opportunity to study a significant new IOCG system and to apply and refine the IOCG model in a new geological setting.

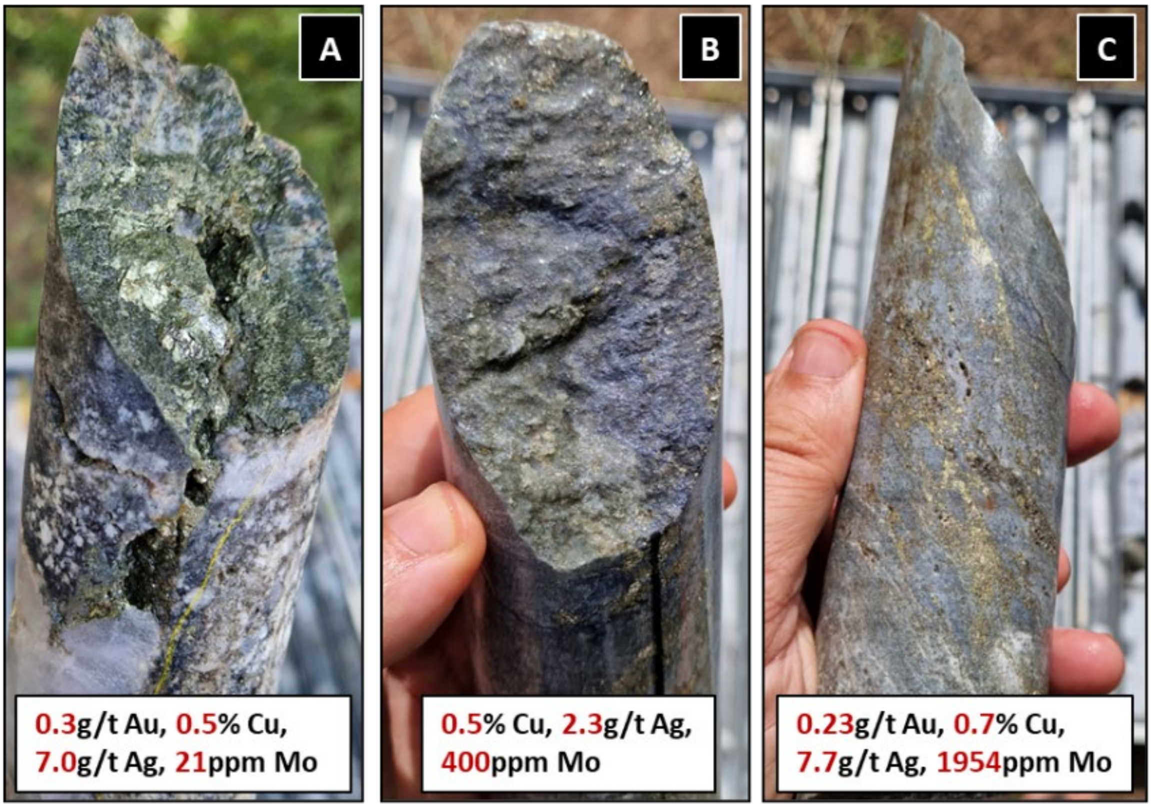

Figure 1: Examples of Cu-Au-Ag-Mo mineralisation from the Sceptre discovery at Odienné.

This project aims to constrain the hydrothermal processes responsible for Cu - Au mineralisation at Odienné and to elucidate the fluid sources and controls on metal tenors in IOCG-style deposits. To do this, the student will address the following research questions:

1. What are the primary mineralising processes controlling Cu and Au deposition on the Odienné property and what are the fluid and metal sources?
2. What controls the metal signature of an individual system (e.g. Cu-rich versus Au-rich)?
3. How do the hydrothermal systems at Odienné compare to global examples of IOCG mineralisation?

These questions will be addressed using a combination of field studies, detailed petrographic, stable isotopic, and geochemical analysis. In particular, the fluid history of the deposits will be explored using paired stable isotope (B, O, and D) and trace element geochemistry of tourmalines associated with the mineralisation at Odienné. This approach will allow modelling of fluid sources and / or processes to be linked to paragenetically equivalent metal concentrations.

Methodology:

The geology and paragenesis of the deposits will be established via diamond drill core logging and petrographic analysis of samples selected during field visits to the Odienné Project in Cote D'Ivoire. Stable isotope data (O, B, and D) from tourmaline will be acquired using Secondary Ion Mass Spectroscopy (SIMS). This will require detailed preparatory textural and mineral chemical mapping of tourmalines using the SEM-EDS facilities at Cardiff University. Trace element concentrations will be determined by LA-ICP-MS at the Element lab at Cardiff. The student will receive appropriate expert training in all relevant techniques.

Interpretation of isotopic data will require temperature and chemistry constraints from the hydrothermal ore fluids; the student will therefore undertake fluid inclusion microthermometry at Cardiff and Laser Raman at UCL to provide these constraints. There may be opportunities for the successful candidate to refine or develop the methodological approach during the project.

Possible Timeline

Year 1: Review IOCG mineral systems and the geology of the West African Craton ahead of initial fieldwork and placement with the CASE Partner, Awale Resources. Fieldwork will focus on understanding of the geology of the key study sites and producing a representative sample suite.

Year 2: Largely laboratory based. Mineralogical and stable isotope analysis of ore and gangue minerals, including tourmaline. Fluid inclusion microthermometry and laser Raman characterisation of fluids. Training in analytical techniques.

Year 3: Data analysis, including modelling of the fluid systems in the Odienné deposits for comparison to global IOCG examples. 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:

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. Awale Resources will provide training in mineral exploration techniques (core logging, structural measurements, mapping, 3D modelling and visualisation) during industrial placement, which will largely comprise fieldwork in Cote D'Ivoire. The student will also be encouraged to attend specialist workshops and short courses associated with conferences.

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):

The student will spend a minimum of three months on placement with the CASE partner, Awale Resources, and will have regular interaction with industrial supervisors, Andrew Chubb and Andrew Smith. 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. They will also develop important field skills such as core logging.

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.

Further reading:

Lambert-Smith, J. S., et al., 2020. Stable C, O, and S isotope record of magmatic-hydrothermal interactions between the Falémé Fe skarn and the Loulo Au systems in western Mali. Economic Geology, 115(7), pp. 1537-1558.

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*, pp. 116-889. doi: 10.1016/j.epsl.2021.116889

Groves, D.I., et al., 2010. Iron oxide copper-gold (IOCG) deposits through Earth history: Implications for origin, lithospheric setting, and distinction from other epigenetic iron oxide deposits. Economic Geology, 105(3), pp. 641-654.

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

Awale Resources Ltd.: https://awaleresources.ca/