General Information	
Project Title:	
Developing new models for strategic Sn-W-Ta-Li mineralization: an isotopic study from Central Africa	
Lead Institution:	University of St Andrews
Department / School / Institute	School of Earth and Environmental Sciences
CASE Partner Organisations [OPTIONAL] Leave blank if not applicable	AfriTin Mining, Johannesburg
End-user Collaborations [OPTIONAL] Leave blank if not applicable	

Project Team The first supervisor should be from the lead institution. The Second Supervisor should be from a second IAPETUS2 organisation	
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In Collaboration with Add any non-IAPETUS University collaboration partners here. [OPTIONAL] Leave blank if not applicable	
Name	
Organisation	
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Biography URL	

Project Details

The information provided here will be used to create the project advertisement online and in pdf format. The overall project description should not normally be longer than 1,200 words in total, including references. Please note that the boxes below are plain-text only, formatting & links will be stripped from the text.

Keywords Add up to 5 comma separated keywords that best describe the project.	Critical Metals; isotope geochemistry; geodynamics; Central Africa

Overview

The Great Lakes region in central Africa hosts significant, world-class deposits of the critical “3T” metals (tin, tungsten, and tantalum) as well as lithium. These deposits, found notably in Rwanda and the Democratic Republic of Congo (DRC), outcrop as vein and pegmatite-hosted granite-related mineralization types (e.g., Pohl 1994; Dewaele et al. 2011). The magmatism driving these deposits is most likely related to the ca. 1.4—1.0 Ga Kibaran Orogeny, which defines one of the world’s major global repositories of 3T+Li metals, extending south into the Namaqua terrane in South Africa and Namibia, and formed during the Mesoproterozoic assembly of Rodinia (e.g. Tack et al. 2010).

The 3T+Li are metals essential for our transition towards a low carbon economy. Constraining the nature of these mineralization types will allow the development of new metallogenic models, and new exploration tools, as well as building a modern geological framework required to promote an investment-related infrastructure to help Central African countries such as Rwanda sustainably exploit their mineral endowment. Deposits of 3T+Li are, however, unevenly distributed both in space and time, with many orogenic belts being barren with respect to these metals, leading to questions around the processes leading to their development and concentration, and their relationship to the wider tectonic framework (e.g., Romer & Kroner, 2016). Further, within the Kibaran orogenic belt there is an uneven distribution of metals, with Sn and Li usually endogranitic or pegmatite hosted, while W being exogranitic and frequently associated with hydrothermal veins cutting Palaeoproterozoic black shales, all leading to questions about the ultimate source of the metals.

Understanding why the diversity of mineralisation styles have evolved in Rwanda requires that we can interpret the mineralisation within the framework of geological events in space, time and magmatic source. Are the different mineralisation styles different expressions of the same geological event, with metallogenic affinity controlled by geochemical variations in the local source and host rock inputs? Or do they reflect different metallogenic affinities arising from different generations of magmatism and related hydrothermal activity occurring via distinct magmatic sources during different geological events?

At present the chronological framework for mineralisation is sparse and the existing (columbite-tantalite U-Pb) chronological data are complex (e.g. Dewaele et al. 2011). Older work on the broader tectonic framework of Central Africa (e.g. Cahen et al. 1984; Fernandez-Alonso et al. 1986; Fig. 1) is currently in the process of being updated by the supervisors.

The goal of the PhD project is to undertake an integrated in-depth study into Rwanda (and DRC) magmatic-hosted critical metal deposits via fieldwork, petrography, geochemistry, geochronology and tracer isotopes. The student will undertake extensive work on several case-study deposits, using modern mapping techniques to undertake detailed field mapping. They will sample appropriate examples of mineralization, magmatic intrusions and the hosting rocks and apply modern geochemical and isotopic methods to characterize the various generations of magmatism and to trace metal concentrations.

The student will combine zircon U-Pb with the new approach of cassiterite U-Pb analysis to refine and expand mineralisation timings and provide a new chronological framework for ore formation. They will then employ isotopic tracers of source within the mineralisation and associated magmatism such as zircon Lu-Hf and novel cassiterite Lu-Hf isotopes (Kendall-Langley et al., 2020), and metal tracers such as trace elements in zircon. These data will ultimately be linked to the regional tectonic architecture to derive a much more fundamental understanding of the framework and nature of the 3T mineralization, and its relationship to the hosting magmatism.

The candidate will work in partnership with ArfiTin, an AIM-listed miner, who have an active programme of exploration in the country, in tandem with the Rwanda Mines, Petroleum and Gas Board (RMB). A key aspect of the project is knowledge transfer and partnership with local Rwandan geologists.

Methodology

Fieldwork will be conducted by the PhD student during at least one visit to Rwanda and possibly the DRC, in collaboration with the Rwanda Mining Board (RMB) and AfriTin. Fieldwork will initially centre in Rwanda, ground-truthing the historically mapped granitic intrusions around the country such as the Rutongo mining district N of Kigali and the Rubavu District near Lake Kivu.

Analytical work will be carried out at both the University of St Andrews, the British Geological Survey. Both the St Andrews Isotope Geochemistry Laboratory (StAIG) and BGS are equipped with laser ablation ICP-MS facilities to undertake *in-situ* trace element and isotopic analyses of mineral phases, to date magmatic rocks through zircon U-Pb geochronology, and mineralization via a combination of *in-situ* LA-ICPMS and ID-TIMS cassiterite U-Pb at the BGS where appropriate.

With Hf concentrations up to 400 ppm reported, cassiterite Lu-Hf isotopic analyses have shown recent promise (Kendall-Langley et al., 2020). The student will build and develop this approach for wider LA-ICP-MS application by characterising suitable reference materials for *in-situ* analysis through solution-mode/ column chemistry techniques and applying this to the study areas. Results will be evaluated within the context of the magmatic Lu-Hf evolution.

Timeline - Year 1

Literature review, review historic data from Rwanda. Field season (April/May) to collect samples for analysis.

Timeline - Year 2

Laboratory training. Collect initial geochemical and isotopic data; petrographic analysis; present results at domestic conference

Timeline - Year 3

Internship in Johannesburg to build GIS geological model. Possible Field Season 2, and further analytical work including cassiterite Lu-Hf methods. Integrate dataset & prepare

Timeline - Year 3.5 (6 months only)

6 months completing thesis, writing papers

Training & Skills

The PhD student will join the Planetary Geodynamics Research Group at the University of St Andrews, and become part of a vibrant research culture in the School of Earth and Environmental Sciences, with MSc, PhD and postdocs working on a wide range of Earth Science research projects.

Full training in digital-based field mapping and sample selection will be provided, as well as in sample categorization and preparation, and geochemical and isotopic analysis. Both the St Andrews Isotope Geochemistry Laboratory (StAIG) and BGS will provide essential analytical support for this project but all School research facilities will be made available as required.

The internship will place the PhD student within the Johannesburg-based exploration department at AfriTin, where full training in GIS and other resource modelling software will be given.

The candidate will be required to travel to Rwanda to conduct fieldwork at in year 1, and also possibly in year 3. Fieldwork will be supported by AfriTin via its current exploration activities in Rwanda and by local geologists at the RMB, as well as the supervisors. The student is also expected to attend national and international conferences to disseminate research results and to spend time away from St Andrews to integrate project partners at BGS.

The student will become part of the IAPETUS DTP, which offers a multidisciplinary package of training focused around meeting the specific needs and requirements of each of our students who benefit from the combined strengths and expertise that is available across our partner organisations.

References & Further Reading

Dewale S, Henjes-Kunst F, Melcher F, Sitnikova M, Burgess R, Gedes A, Fernandez-Alonso M, De Clerq F, Muches P, Lehmann B. 2011. Late Neoproterozoic overprinting of the cassiterite and columbite-tantalite bearing pegmatites of the Gatumba area, Rwanda. *Journal of African Earth Sciences* 61, 10-26

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Fernandez-Alonso M, Lavreau J, Klerkx J. 1986. Geochemistry and geochronology of the Kibaran granites in Burundi, Central Africa: Implications for the Kibaran orogeny. *Chemical Geology* 57, 217-234

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Muchez P, Hulsbosch N, Dewaele S. 2014. Geological mapping and implications for Nb-Ta, Sn and W prospection in Rwanda. *Bulletin des Séances. Académie Royale des Sciences d'Outre-Mer* 60, 515-530

Pohl W. 1994. Metallogeny of the northeastern Kibara belt, Central Africa—Recent perspectives. *Ore Geology Reviews* 9, 105-130.

Romer RL, Kroner U 2016, Phanerozoic tin and tungsten mineralization—tectonic controls on the distribution of enriched protoliths and heat sources for crustal melting. *Gondwana Research* 31, 60-95.

Tack L, Wingate M, De Waele B, Meert J, Belousova EA, Griffin W, Tahon A, Fernandez-Alonso M. 2010. The 1375Ma “Kibaran event” in Central Africa: prominent emplacement of bimodal magmatism under extensional regime. *Precambrian Research* 180, 63-84.

Further Information

For any information on the project or the School of Earth and Environmental Sciences at St Andrews, please contact Nick Gardiner (nick.gardiner@st-andrews.ac.uk).
At this point in the form, you will be able to upload any project related images or photographs that you wish to be used online with your submission. Please upload either jpeg or png files Maximum upload size: 52.43MB All images must be owned/copyright by the uploader or suitable licensing arrangements must be in place prior to upload. IAPETUS may request proof of licensing for any commercial / copyrighted content uploaded.
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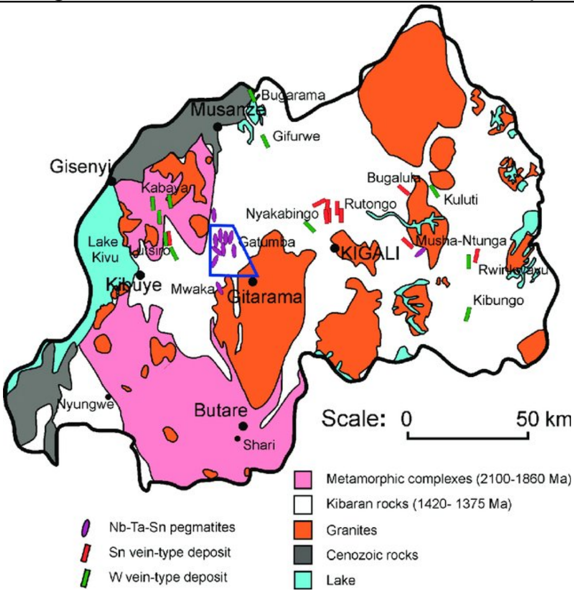

Fig 1. Simplified Geological map of Rwanda showing major granitic intrusions. From Muchez et al., 2014