Project title: Enrichment of critical elements in granites: melting process or protolith?

Project code: OU2

Host institution: The Open University

Theme: Dynamic Earth

Key words: granite, geochemistry, critical elements, mineral deposits

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Project Highlights:

- Resolve the provenance of critical elements in mineralised granites
- Field sampling of European granites and source rocks
- Training in sophisticated geochemical analysis

Overview:
Developing green technologies for the future requires certain critical elements (http://tinyurl.com/z77y4v7), including the Rare Earth Elements (REE), In, W, Nb, Ta, Sb, Ga and Be. These elements are currently produced in very few countries, raising the spectre of disruption to their supply. They are commonly hosted in Sn-W bearing granites, but little is known about which minerals carry and concentrate these elements from the crustal protolith, via metamorphism and partial melting (anatexis), to the granitic magma. This project will track these trace elements from their original source to the host granite.

A recent study proposes a critical role for both the composition of the starting materials and the melting conditions in determining whether granites are enriched in critical elements or not. Unmineralised Himalayan leucogranites represent a rare example of granites formed from a known, accessible single source: pelitic metasediments (e.g. ). This situation offers an opportunity to investigate the partitioning of critical elements by key mineral phases (e.g. feldspar, micas, tourmaline, titanite, magnetite, rutile) through metamorphism and low temperature (<750°C) anatexis by muscovite breakdown. By contrast, studies of mineralised granites suggest that critical elements may only be released into the melt as their host minerals break down at the higher temperatures of biotite dehydration melting (>750°C).

This project will exploit recent advances in laser ablation in situ analytical methods to determine element concentrations in minerals from mineralised and unmineralised granites and their corresponding source rocks. Existing samples of granites and source rocks will be supplemented by field sampling in Europe (NW Iberia, Cornwall, or Saxony). The elemental data will constrain the budgets of critical elements at the mineral species level and investigate potential enrichment processes from protolith to melt formation. The results will test a recent model that links Sn-W granite mineralisation to high-temperature anatexis of an intensely weathered protolith.

We can test the hypothesis by 1) modeling element concentrations in high-T (>750°C) melts that would theoretically be formed by biotite breakdown in Himalayan samples; 2) comparing these model results with Variscan metalliferous high-T melts to assess the role of temperature in causing mineralisation of economic proportions during granite formation.

Methodology:
The Open University holds samples of Himalayan crustal melts (granites), sub-solidus protoliths (mica schists) and in situ anatectic migmatites that are ideal for this study. Initial analysis of these curated samples will focus field sampling of contrasting, high-temperature granites and their source rocks (e.g. from NW Iberia, Cornwall, and/or Saxony) for comparison studies. Recently-developed laser ablation (LA) ICP-MS protocols will be employed for in situ analysis of critical element concentrations in key minerals, alongside bulk rock analysis by solution ICP-MS. These results will evaluate element partitioning at different peak metamorphic temperatures and during incongruent melting by muscovite breakdown. Modelling elemental concentrations in these samples during biotite breakdown (>750°C) will test the hypothesis that higher melt reaction temperatures are essential for Sn and W (and potentially other critical element) mineralisation in granitic crustal melts.

Training and skills:
The successful student will be trained in fieldwork techniques in Europe, as well as advanced petrological and geochemical analysis of igneous and metamorphic samples. In situ LA-ICP-MS analysis will be central to the project. Training in modelling techniques, including the behaviour of trace elements during melting and metamorphic phase relationships, will also be provided where appropriate.

The School of Environment, Earth and Ecosystem Sciences has a thriving postgraduate community. Online teaching opportunities via the Open University Virtual Learning Environment are available, including on the new Massive Open Online Courses (MOOCs). Our current graduate students are very active in science outreach on digital platforms (e.g. http://www.fieldworkdiaries.com/) and at local primary schools.

NERC CENTA students are required to complete 45 days training throughout their PhD including a 10 day placement. In the first year, students will be trained as a single cohort on environmental science, research methods, and core skills. Throughout the PhD, training will progress from core skills sets to master classes specific to CENTA research themes.

Partners and collaboration (including CASE):
Gabriel Gutierrez Alonso, Salamanca University.

Possible timeline:
Year 1: Induction and literature review; Petrographic and electron microprobe (EMP) analysis of existing samples at OU; Detailed LA-ICP-MS analysis of first sample batch; Evaluation of suitable sites for fieldwork;

Field season (NW Iberia, Cornwall or Saxony): Characterisation of mineralisation field relations; collection of granite and protolith samples for geochemical analysis.

Year 2: Complete analysis of first sample batch; Trace element modelling on initial results; Petrographic, EMP analysis of samples from field; Preparation and LA-ICP-MS analysis of field samples; Further trace element and pseudosection modelling; Scope potential publication topic(s) and refocus analytical programme as necessary.

Year 3: Complete remaining geochemical analyses; Finish data collation and interpretation; Refine trace element modelling; Integrate results with published data to test the factors influencing mineralisation; Develop manuscripts of papers for publication; Prepare and deliver conference presentation(s); Draft and revise thesis chapters; Revise paper manuscripts and complete thesis.

Further reading:

Further details:
You should have a strong background in, and enthusiasm for, at least two of the fields of magmatic systems, geochemistry, and metamorphic petrology. Fieldwork experience is desirable. You will join a well-established team of Earth scientists studying all aspects of geochemistry, magmatism and orogeny at the Open University (http://www.open.ac.uk/science/environment-earth-ecosystems/research/dynamic_earth/geochemistry; www.open.ac.uk/research-groups/himalaya-tibet/).

Please contact Tom Argles (tom.argles@open.ac.uk) for further information.

Applications should include:
- a cover letter outlining why the project is of interest and how their skills match those required,
- an academic CV containing contact details of three academic references
- a CENTA application form, downloadable from www.centa.org.uk/media/1202/centa-studentship-application-form.docx
- and an Open University Application form

Applications should be sent to STEM-EEES-PhD-Student-Recruitment@open.ac.uk by 5 pm on Friday 22nd June 2018