An integrated accessory mineral approach to understanding post-subduction magmas and mineralisation

Project Code: GL/18/NERC-AJM

Department: School of Geography, Geology, and the Environment

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Host: University of Leicester

CASE Partner: Zeiss

Key words: Accessory minerals, post-subduction magmas, mineral deposits, gold, E-tech elements

Start Date: September 2018

Eligibility: Home/EU candidates

Closing Date: 15th January 2018, midday

Project Highlights:
- Research that bridges the fields of igneous petrology and economic geology
- Placement with Carl Zeiss to develop new automated approaches to mineral characterisation
- Fieldwork in the central/western US Rocky Mountains to understand magmatic processes in post-subduction settings and associated mineralisation
- Develop analytical experience with a range of high precision analytical instruments at a number of UK-based facilities

Overview:
Gold, together with increasingly desirable ‘e-tech elements’ (tellurium, Te and selenium, Se) are commonly associated with alkali magmas formed in post-subduction settings. This link remains poorly understood. One suggestion is that these deposits form from hydrous magmas generated by partial melting of subduction-modified lithosphere and hydrous, sulphide-bearing cumulates in the roots of former volcanic arcs. When these fertile, hydrous residues experience a second stage of post-subduction melting, the redissolving of sulphides is thought to liberate elements such as Au, Te and Se. However, the role of cumulates and other subduction-modified sources in the formation of post-subduction magmas and their consignment of economically important elements remains largely untested.

This project will use a suite of robust accessory minerals including zircon, apatite, titanite, and magnetite to develop a petrogenetic model for post-subduction magmatism and mineralisation. The robust nature of accessory minerals means that they may often be inherited from deeper and unexposed parts of the magmatic system. They may also carry with them a cargo of less resilient minerals (such as magmatic sulphides) in the form of inclusions. Compositional zoning combined
with high precision analytical techniques also offer an exciting opportunity to develop a time-sequential record of key magmatic processes.

Cenozoic magmatism in the central and western United States was initially subduction-related but became progressively more alkali as subduction waned and a post-subduction, extensional tectonic regime developed. The most economically significant Au, Te and Se deposits are associated with the more alkali, post-subduction magmas. The textural and compositional characteristics of accessory minerals will be analysed from a range of igneous rocks that span this transition to reveal important changes in source, process and endowment of economically important elements.

**Methodology:** Volcanic and plutonic samples will be collected during a field season in the Rocky Mountains, *central and western USA*. Mineral separation and sample preparation will be carried out at the University of Leicester (UoL).

Quantitative petrographic mineral assessments will be conducted using Zeiss’ automated Mineralogic Mining software in conjunction with Mr Shaun Graham at Zeiss in Cambridge. Information will be gathered about the abundance of accessory minerals and their inclusion phases.

A suite of trace elements and isotopes will be analysed in a range of accessory minerals using a combination of high precision instruments. These will include an in-house Laser-Ablation Inductively Coupled Mass Spectrometer (LA-ICP-MS) at the UoL to analyse trace element compositions and assess the ability of accessory minerals to distinguish different crystallising environments. Further analytical time will be sought at two NERC facilities – the National Isotope Geoscience Laboratories (NIGL) and at the UK’s only Secondary Ion Mass Spectrometry (SIMS) facility at the University of Edinburgh. This work will seek to utilise Hf and O isotopes in order to assess the relative importance of mantle and crustal inputs during magma generation.

These data will be integrated to establish a rigorous and mineral-informed model for post-subduction magmatism and associated mineralisation.

**Training and skills:**
As an industrial CASE student, the successful candidate will join Zeiss for a minimum of three months during the course of this project. Specialist training will be provided in technique development and the student will gain valuable experience in the financial and business side of technique development.

The student will become proficient in the use of analytical equipment including quantitative evaluation of minerals, SEM (UoL), high-resolution mass spectrometry (UoL and NIGL) and Secondary Ion Mass Spectrometry (University of Edinburgh). This combination of state-of-the-art analytical methods to investigate novel scientific questions will provide the student with a unique set of skills that will be attractive to industrial and academic employers. They will join a thriving community of igneous and applied researchers, and work closely with members of two major NERC-funded projects (FAMOS - From Arc Magmas to Ore Systems, and TeaSe – Te and Se Cycling and Supply).

**Partners and collaboration (including CASE):**
Dr Andrew Miles investigates magmatic processes in relation to crustal evolution using the chemistry of robust accessory minerals. Drs Dave Holwell, Dan Smith and Manuel Keith are lead researchers in magmatic processes associated with mineralisation. Drs Chiara Petrone and Johan Lissenberg will advise on interpreting magmatic processes using mineral chemistry. All supervisors are partners on two NERC funded consortium projects (FAMOS and/or TeaSe) that focus on magmatic-hydrothermal processes. *Mr Shaun Graham* is an Applied Development Engineer at Carl Zeiss Microscopy with experience in automated mineralogy to improve and optimise mineral processing and performance.

**Possible timeline:**
**Year 1:** A thorough review of the latest literature will be conducted. Fieldwork and sample collection will be carried out in the western USA. Training in mineral separation and SEM imaging will be provided at the UoL and a full petrographic analysis of mineral textures will be carried out.
Trace element compositions will be analysed in multiple accessory minerals using the in-house LA-ICP-MS. An application to the EMMAC NERC facility will be made for isotope analysis. Industrial training in automated mineralogy will be carried out during a first placement with Zeiss.

Year 2: Ongoing analysis of samples at the University of Leicester and Edinburgh. Interpretation of data to be carried out. Apply for analytical time at NIGL. A second placement with Zeiss.

Year 3: Integration of data will provide a model for magma evolution and mineralisation in a post-subduction setting. Publication of papers and conference presentations, including the opportunity to present at international meetings, will be part of the schedule from year 2 onwards.

Further reading:

Further details:
For Project enquiries, contact Andrew Miles, University of Leicester, ajm131@le.ac.uk
For Admissions enquiries, contact Charlotte Langley, Programme Administrator, pgrgeol@le.ac.uk
Funding Details

NERC is part of Research Councils UK (RCUK) and therefore this funding is only available to Home/EU applicants.

The studentship is available for full-time registration and will cover all tuition fees for up to four academic years together with an annual tax-free stipend; the RCUK rate for 2017/18 is £14,999. The successful applicant will receive an RTSG (Researcher Training Support Grant) of £2,750 per annum towards e.g. travel, conferences and running costs. An additional £1,000 pa will be contributed by the CASE partner towards the RTSG. Additional costs incurred by the student visiting and working in the CASE establishment (e.g. travel and subsistence) will be covered by the CASE partner.

Entry Requirements

Applicants must have a first-class or high upper second-class honours degree (or equivalent qualification) in a relevant discipline and meet the University's English language entry requirements.

The studentship is for full-time study only, and applicants must be able to commence their studies from September 2018.

Apply Now

1. Complete the Studentship Application form
2. Prepare your supporting documents:
   - A full CV
   - Certificates and Transcripts from undergraduate and postgraduate degrees
   - English Language certificate (if applicable)
   - Two academic references
   Supporting documents not in English must be provided with a certified English translation
3. Apply online and attach your supporting documents and Studentship Application form

Important Advice for Applicants

The closing date for receipt of applications is midday on Monday 15th January 2018. Interviews will be conducted in person; Skype may be used in certain circumstances.

In the Fees and Financial Support section of the University of Leicester application, you must state that you wish to be considered for GL/18/NERC-AJM.