Building an Precambrian continent: the role of ductile shear zones

Overview

The geological mechanisms of continent formation and growth on Earth have changed through time, with a global subduction-driven mobile-lid (plate tectonic) regime having replaced a stagnant-lid (non-plate tectonic) geodynamic regime at c. 3.0–2.9 Ga in the Mesoproterozoic (Fig. 1). High-grade metamorphic and magmatic rocks within the Lewisian Complex, northwest Scotland, span this critical time period, and have undergone several episodes of subsequent deformation retrograde overprinting, complicating interpretation of the tectonic evolution of this terrain. In particular, prominent Paleoproterozoic crustal-scale ductile shear zones are thought to represent the loci of amalgamation of separate crustal blocks with distinct geological histories (e.g. Goodenough et al., 2010). However, it is unclear whether these deformation zones record large-scale horizontal motion and welding of continental masses previously separated by an ocean of indeterminate size, such as occurs at the terminal stages of the Wilson Cycle (e.g. Park and Tarney, 1987), or record intracontinental deformation where two distinct crustal blocks were subsequently accreted.

This project will involve fieldwork, structural mapping, and sample collection from several localities within and around two large ductile shear zones in the Precambrian Lewisian Complex, northwest Scotland, which will allow competing hypotheses of terrane accretion in the region to be tested. Detailed petrological and microstructural observations will be obtained at a range of scales across the Complex in order to construct a model for pre-, syn-, and post-shear terrain growth. This research will complement ongoing research aimed at determining the geological processes responsible for the growth and long-term stabilization of Archean terrains (e.g. Feisel et al., 2018), and will provide new insight into secular changes in metamorphism and tectonics throughout geological time.

Methodology

Fieldwork will involve geological mapping and collection of a variety of metamorphic and magmatic rocks from two prominent shear zones in the Lewisian Complex, northwest Scotland. Subsequent laboratory work will involve bulk-rock and mineral chemical analysis, with these data used to perform thermobarometry and petrological modelling. Isotope geochronology will be used to constrain the absolute ages and rates of metamorphism and deformation.

A student working on this project will gain experience in the following tools and techniques:

- Field work, structural mapping and identification of minerals in the field
- Optical microscopy
- X-ray fluorescence (XRF) analysis
- Scanning-electron microscopy (SEM)
- Electron probe micro-analysis (EPMA)
- Laser ablation inductively coupled mass spectrometry (LA-ICP-MS)
- Petrological modelling (e.g. software such as THERMOCALC and Perple_X)
Timeline

Year 1: Doctoral training courses, literature review, fieldwork planning, fieldwork and sample collection, sample characterisation, and laboratory training.

Years 2 and 3: Microanalytical work (XRF, SEM, EPMA), isotope geochronology (LA-ICP-MS), and petrological modelling. Data compilation and interpretation. Presentation of results at domestic and international conferences.

Year 4: Data integration, thesis completion, write papers for submission and publication in scientific journals.

Training & Skills

The successful student will join the Hard Rock research group at the University of Oxford, UK, which has a long-standing history of research excellence in metamorphism, tectonics, and investigation into early-Earth geodynamics (e.g. Piccolo et al., 2019; Palin et al., 2020). They will also have the opportunity to interact with faculty at external institutions and industry partners at annual career fairs.

The student will be trained on how to conduct a field campaign, how to prepare and characterise geological thin sections, and perform advanced petrological and geochemical analyses of igneous and metamorphic rocks. This will include hands-on work with SEM, EPMA, and LA-ICP-MS equipment in leading laboratories across the UK. Training will also be provided on how to conduct geochemical and petrological modelling, for use in performing thermobarometry and interpreting the geodynamic evolution of discrete lithological units.

The student will also be mentored on how to prepare scientific results for presentation at international conferences and how to write papers for publication in high-profile, international journals.

References & Further Reading


Further Information

Applicants are encouraged to contact the supervisory team for further information:

Richard Palin
Email: richard.palin@earth.ox.ac.uk
Website: http://users.ox.ac.uk/~jesu1061/

Mike Searle
Email: mike.searle@earth.ox.ac.uk
Website: https://www.earth.ox.ac.uk/people/searle/

Marc St-Onge
Email: marc.st-onge@canada.ca
Website: https://profiles.profiles.science.gc.ca/en/profile/professor-marc-st-onge

Nick Roberts
Email: nirob@bgs.ac.uk
Website: www.bgs.ac.uk/people/roberts-nicholas/