PROJECT TITLE: Rare earth elements in metamorphic rocks: understanding controls on the rates and length scales of chemical transport

Project Science Theme: Earth Science and Hazards
Project keywords: Metamorphism; diffusion; rare earth elements

Lead Institution: University Bristol
Lead Supervisor: Freya George, Bristol, School of Earth Sciences
Co-Supervisor: Tomas Martin, University of Bristol, School of Physics
Co-Supervisor: Stephanie Walker, University of Exeter, Department of Earth and Environmental Sciences

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Webpage: https://www.bristol.ac.uk/earthsciences/research/petrology/

Project Description

Rare earth elements (REEs) are powerful tracers of metamorphic processes: their strongly fractionating behaviour can preserve sensitive records of mineral growth, dissolution, fluid–rock interaction, and recrystallisation. REEs are also used to understand crustal evolution via geochronology and bulk geochemical studies, and their mobilisation is central to the concentration of critical metals. However, the length scales, rates, and pathways of REE transport during crustal heating—particularly along grain boundaries—remain poorly constrained. This PhD will determine how far and how fast REEs move through metamorphic rocks, and what controls that transport.

The project will combine experiments on synthetic materials with analyses of natural metamorphic rocks. Diffusion experiments in Bristol's Experimental Petrology labs, using high-pressure and high-temperature apparatus, will investigate how temperature, partitioning behaviour, and grain boundary structure influence REE transport. As the project develops, the student will select natural samples to test and extend experimental findings and will have scope to refine experimental and modelling priorities according to emerging results and their interests. Element distributions and microstructures will be characterised using electron-beam methods and LA-ICP-MS, with opportunities to apply TEM and X-ray computed tomography. Diffusion and reaction modelling will combine observations across scales.

The student will receive training in experimental, analytical, and numerical approaches. Training in data interpretation, scientific writing, and conference presentations will be complemented with external laboratory visits, workshops, and mentoring of other students. The supervisory team comprises expertise across disciplines and institutions: Freya George in Earth Sciences at Bristol, specialising in metamorphic petrology and mineral reaction processes and who has previously worked with both co-supervisors; Tomas Martin in Bristol Physics, contributing expertise in nano-scale grain-boundary characterisation; and Stephanie Walker at the University of Exeter, providing skills in trace-element mass spectrometry. These partnerships will broaden the PhD experience and create an integrated environment spanning petrology, materials science, and geochemistry.

Useful recruitment links:

For information relating to the research project please contact the lead Supervisor via: freya.george@bristol.ac.uk

Bristol NERC GW4+ DTP Prospectus:
https://www.bristol.ac.uk/study/postgraduate/research/great-western-four-doctoral-training-partnership-nerc/

How to apply to the University of Bristol:
http://www.bristol.ac.uk/study/postgraduate/apply/

The application deadline is Thursday 7 January 2027 at 2359 GMT