PROJECT TITLE: Redox controls on titanate pyrochlore: from critical mineral ores to nuclear wasteforms

Project Science Theme: Science for Environmental Solutions
Project keywords: Pyrochlore, carbonatite, actinides, redox, nuclear

Lead Institution: University Bristol
Lead Supervisor: Professor Claire Corkhill, Bristol, Earth Sciences
Co-Supervisor: Sam Broom-Fendley, University of Exeter, Cambourne School of Mines
Co-Supervisor: Richard Brooker, University of Bristol, Earth Sciences
Co-Supervisor: Dan Glymond, National Nuclear Laboratory

Project Enquiries: c.corkhill@bristol.ac.uk

Project description

The titanate mineral pyrochlore hosts U, Th and rare earth elements (REE) in carbonatite-derived critical-mineral ores. It is also a leading candidate for ceramic materials designed to safely immobilise the UK's plutonium stockpile, incorporating neutron-absorbing REE required to maintain criticality control. However, important synthesis questions remain before such materials can be deployed by the nuclear industry. In particular, we do not understand how redox conditions during crystallisation control actinide and REE incorporation, oxidation state and coordination environment. Resolving these controls is also vital to understanding REE-bearing pyrochlore formation in natural ore systems and sustainable REE recovery.

This project will use natural geological systems as analogues to determine how U, Th and REE partition into pyrochlore crystallising from carbonatitic melts as a function of oxygen fugacity, temperature and melt chemistry, linking natural critical-mineral formation with engineered nuclear wasteforms.

The Doctoral Researcher will design redox-controlled cold-seal pressure-vessel experiments, using piston-cylinder experiments where advantageous. Products will be characterised by SEM/EPMA and X-ray absorption spectroscopy, including HERFD-XANES/EXAFS at ESRF, with natural carbonatite pyrochlores providing geological validation. The researcher will select priority compositions and analogues, lead beamtime proposals, and redirect experimental priorities as results emerge.

Training is central. Brooker will provide hands-on training in high-P–T experimental petrology and redox control; Broom-Fendley in carbonatite mineralogy, critical-mineral geochemistry and natural-system interpretation; and Corkhill will train the researcher in actinide materials and synchrotron spectroscopy and mentor them in translating fundamental research into nuclear practice, through engagement with industry, radioactive-waste organisations and the UK nuclear policy community in which she is embedded.

The National Nuclear Laboratory will provide, through a CASE award, a three-month placement at Workington, giving hands-on experience of industrial titanate synthesis for plutonium immobilisation. Together, Bristol, Exeter and NNL provide integrated training spanning experimental Earth science, critical minerals, advanced spectroscopy, industrial nuclear materials and science-to-policy translation.

CASE partner:

The National Nuclear Laboratory will provide supervision, quarterly meetings, access to materials and data, provision of 3-month placement at NNL Workington (remote alternative is available if required).

Useful recruitment links:

For information relating to the research project please contact the lead Supervisor via: c.corkhill@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