

Meeting future net-zero carbon energy needs: Improved borehole sealing using compacted bentonite and silica grout

Supervisory Team

- Prof. Rebecca Lunn, University of Strathclyde
- Dr Gea Pagano, University of Strathclyde

Key Words

Energy; Geology; Geoscience; Carbon Capture and Storage; Hydrogel; Geotechnics; Hydrogeology; Borehole; Groundwater; Grout.

Eligibility

A 4-year PhD studentship is available **for UK or international applicants**. This includes payment of tuition fees and a **stipend of £20,668** for academic year 2022/23, rising each year in line with UKRI rates. Candidates must have completed a Bachelor's or Master's degree in a relevant subject area (e.g. civil engineering, environmental engineering, petroleum engineering, geology, geoscience, environmental science, chemistry, material science, physics) and have obtained a 2(1) or above. PhD funding is provided by the Engineering and Physical Sciences Research Council and Nuclear Waste Services Ltd.

Overview

This project will investigate new technologies for borehole sealing to prevent the upward leakage of fluids and gases that are stored at-depth in the ground. **Reliable borehole sealing is vital for global development of an energy industry that can meet net zero carbon by 2050** (2045 in Scotland). The UK Committee for Climate Change predicts that future energy production will include: carbon capture and storage in subsurface reservoirs (to capture CO₂ emitted from hydrogen production); nuclear power production (and hence the ability to safely dispose of nuclear wastes in the subsurface); and subsurface hydrogen storage to meet energy needs when output from renewables is low e.g. in low wind speeds. To store wastes or gases in the ground, boreholes must be drilled for site investigation and/or gas/fluid injection. These must then be sealed to stop unwanted fluid or gas leakage. One method for sealing is backfilling the hole with bentonite, a clay which swells when wet to form a tight seal. However, recent trials have shown that in weak or damaged rocks, the borehole walls can collapse before the bentonite is put in place. This PhD project will investigate the potential for bentonite to be used in conjunction with other silica-based grouting materials to provide a successful seal. The PhD will be based primarily in the laboratory. Depending on the skills and interests of the successful candidate, the research will involve: investigation of geotechnical properties; determination of chemical interactions between bentonite clay and silica hydrogels; investigation of

performance using state of the art imaging techniques such as Micro X-Ray Computer Tomography and Scanning Electron Microscopy; numerical modelling of material performance.

Methodology

The project will be largely experimental, using equipment in the University of Strathclyde's geotechnical laboratories. Silica will be injected into samples of damaged mudstone and the resulting material will be tested for shear strength, erosion resistance and unconfined compressive strength. The chemical and physical interactions between the colloidal silica and the bentonite may also be investigated to determine any long-term impacts on sealing. Investigations will make use of the University of Strathclyde's Advanced Materials Research Laboratory, which hosts equipment such as Scanning Electron Microscopy, X-Ray Diffraction facilities and Micro X-Ray Computer Tomography. The successful candidate may also have the opportunity to test their technology as part of a larger field trial to demonstrate borehole sealing methods.

Training & Skills

This project will suit a student interested in energy, geoscience, geotechnics, rock mechanics, geochemistry and/or material science using experimental techniques. You will learn basic laboratory techniques and will be trained on regularly used analytical equipment.

As a PhD student at the University of Strathclyde, you will also complete the University of Strathclyde's acclaimed Research development program, acquiring cross-disciplinary skills to broaden career prospects in various industries.

The candidate may also choose to undertake a short secondment to gain work experience at Nuclear Waste Services Ltd.

Make an Application

Candidates can apply at:

<https://www.strath.ac.uk/studywithus/postgraduateresearch/yourapplicationoffer/>

The closing date for applications is Nov 21st 2022. The PhD project can start at any time, ideally beginning as soon as possible. However, **candidates MUST be able to start before March 31st, 2023.**

Further Information

For further information on the application process, please contact: Morag.McIntosh@strath.ac.uk

For further information regarding the project please contact Prof Rebecca Lunn or Dr Gea Pagano (rebecca.lunn@strath.ac.uk arianna.pagano@strath.ac.uk)