Development of coupled processes numerical models of tracer and colloidal transport in an underground research laboratory beneath the Swiss Alps

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Summary: This project will develop new for modelling the movement of radioactive contaminants as dissolved tracers and attached to colloids. This problem is crucial to understanding how the rock around a radioactive waste repository provides a barrier contributing to the protection of the environment. The work will be in collaboration with the Swiss nuclear industry (NAGRA) as part of their international modelling team undertaking research in their underground rock laboratory at Grimsel beneath the Swiss Alps. It is also supported by ESI Ltd a leading UK consultancy

Details: The colloid and radionuclide experiment in the Grimsel Underground Research Laboratory (URL) (http://www.grimsel.com/gts-phase-v/crr/crr-introduction) involved very detailed characterization of a small shear zone intersecting a specially excavated tunnel. Following detailed characterization, radionuclide migration experiments were conducted in a dipole flow field. The first objective of the project will be to develop a two-dimensional flow model using COMSOL multi-physics to represent contaminant transport in such a hydrogeological setting. The advantage of COMSOL Multiphysics is the ability to rapidly implement and modify the equations to be solved allowing us to investigate the hydro-mechanical (H-M) couplings and how these affect permeability. The initial developments will be verified by reproducing the detailed results from the existing experimental data (made available by NAGRA). This will require the development of a detailed understanding of Pressure and Concentration monitoring data in a disturbed complex stress distribution and the low permeability environment. Modelling of non-linear flow and transport can be challenging and the work will be carried out in parallel with related studies at Imperial College who will focus on the rock mechanics of the fracture system around the tunnel. High injection pressures in a low permeability environment can create complex behaviour that is difficult to reproduce. The resulting models will be validated, working as part of the NAGRA multi-disciplinary team involved in conducting and interpreting ongoing radioactive tracer experiments as part of the next phase of experimental investigations in Switzerland. The current Colloid Formation and Migration experiment (Gaus and Smith, 2008. Modellers dataset for the Colloid Formation and Migration Project, NAGRA report NAB 08-27 and http://www.grimsel.com/gts-phase-vi/cfm-section/cfm-introduction) will test our model's ability to represent radionuclide migration in a natural flow field such as might be found in a underground geological disposal facility such as is envisaged for the disposal of radioactive waste in the UK. The tools and techniques developed here will in future help us to demonstrate our understanding of the near-field around a UK repository.

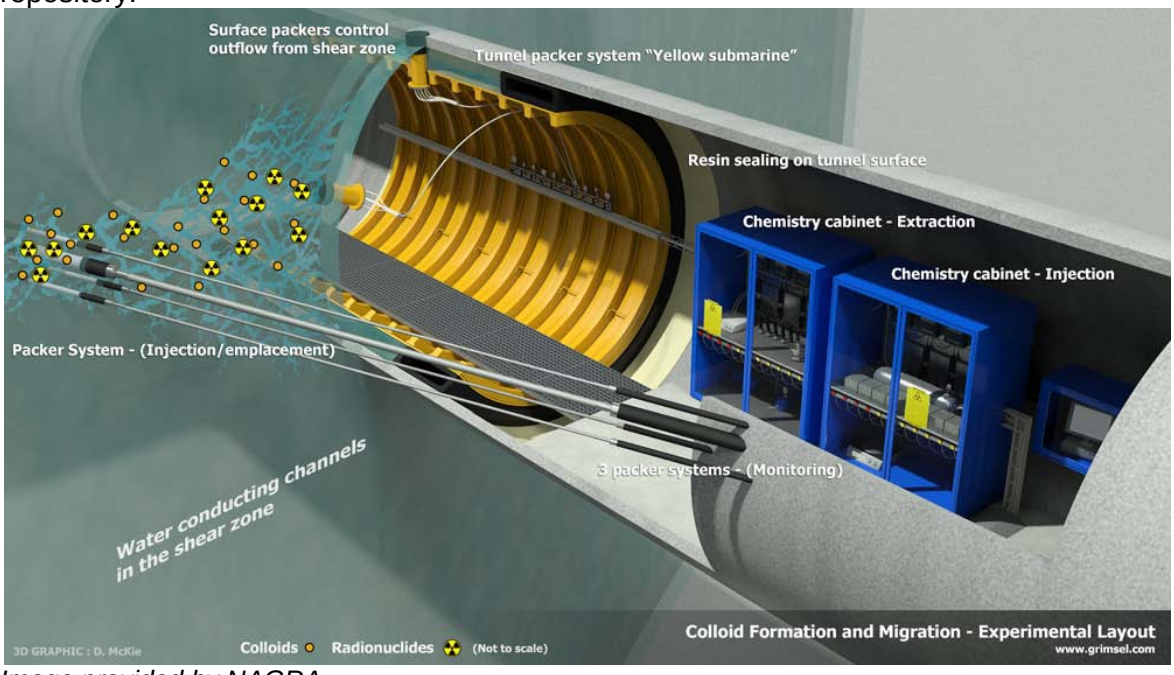

Image provided by NAGRA

Training: The student will be able to attend modules in the Birmingham Nuclear Decommissioning and Waste Management MSc and Hydrogeology MSc in, radiochemistry and modelling of contaminant transport. The student will have access to industry-leading software as practical training and a foundation of their research. The student will also receive guidance in the preparation and presentation of their research to academic, industry and policy audiences. Presentations at high-profile international conferences will be expected and in particular, attendance as a contributor to the Grimsel International Modelling Team as a NAGRA participant. CASE support is available from ESI Ltd, one of the UK's leading hydrogeological specialist consultancies, who will also provide supervision, and ensure that the work achieves maximum impact. A background in hydrogeology or related disciplines, such as mathematics or engineering is required.

Contribution: This PhD studentship contributes to work package WP5: Modelling of transport in fractures from tests performed at Grimsel of a NERC Radioactivity And The Environment (RATE) Consortium in partnership between Birmingham University, Imperial College and Leeds University. The work package focussed on transport of radioactive contaminants in the fractured rock mass around a GDF tunnel. This project is a unique opportunity for a UK doctoral researcher to be involved within the Swiss national programme and access a Underground Research Laboratory. Numerical models developed will aim to explain the detailed characterisation of the transport experiments including the influence of colloid migration effects, hydromechanical coupling and the influence of the boundary conditions at the open tunnel. Initial work will focus on the development of general transport equations that allow the non-linear coupling of flow properties to hydro-mechanical processes and colloids. The models will be tested on datasets from the completed GTS phase V CRR experiments within the fault zone. These models would then be validated against ongoing experiments in the ongoing phase VI experiments.

This PhD has confirmed funding under the NERC RATE programme. There will be an additional £1000 per annum contribution to the studentship from ESI Ltd - an industry leading SME consultancy with strong links to the University, employing about 50 professional hydrogeologists. Applicants should apply via: http://www.birmingham.ac.uk/students/courses/postgraduate/research/gees/earth-sciences.aspx where they should click on 'Apply now' and choose the option 'PhD in Department of Earth Sciences' and give the PhD title in the 'Funding details' section of the online application.