

“ the physical and chemical characteristics of the clay limit the migration of any radionuclides released from a canister after closure of the repository ”

In the Swedish disposal concept, canisters containing spent nuclear fuel will be placed in large-diameter disposal boreholes drilled into the floor of the repository tunnels. Each full canister will weigh up to 27 tonnes. The canister consists of a 50mm thick outer copper skin, which acts as a corrosion barrier in the oxygen-poor groundwater of the crystalline rock selected for disposal, and a nodular iron insert to provide strength and rigidity. The space around each canister will be filled with

mineral phases, the ultra-small dimensions of both the particles and the pores and the complex interactions which occur between the mineral surfaces, water molecules and dissolved chemical species. The physical and chemical characteristics of the clay limit the migration of any radionuclides released from a canister after closure of the repository. Because of the important pH-buffering effect of the bentonite on the porewater, this engineered barrier is often referred to as the clay buffer.

LASGIT

Large-scale gas injection test at the Äspö hard rock laboratory, Sweden

by Jon Harrington, David Birchall and Steve Horseman

pre-compacted bentonite blocks which, over time, will draw in the surrounding groundwater and swell to close up construction gaps. Once hydrated, the bentonite will act as a low permeability barrier. Many aspects of the behaviour of the bentonite (such as geotechnical, hydrodynamic and transport properties) stem from the large surface area of the

The metal canisters are expected to have a very substantial life in the repository environment. However, for the purposes of performance assessment (PA), we must consider the possible impact of groundwater penetrating one of the canisters. Under anoxic conditions, corrosion of the steel inner will lead to the formation of hydrogen gas. Radioactive decay of the waste and the radiolysis of water will produce some additional gas in the container. Depending on the gas production rate and the rate of diffusion of gas molecules in the pores of the bentonite, it is possible that gas will accumulate in the void space of the canister. Gas will enter the bentonite when the gas pressure exceeds some critical entry pressure specific to this material. Since water penetration of the canister is a prerequisite for the occurrence of hydrogen gas in the buffer, the timing of gas movement in the clay might coincide with that of radionuclide release into the buffer porewater. The possibility of an interaction between gas and radionuclide migration therefore emerges as an important issue in PA.

As part of an ongoing programme of research aimed at the development of safe disposal technologies, the Swedish waste management company



Courtesy Svensk Kärnbränslehantering AB

Surface installations at the Äspö Hard Rock Laboratory in Sweden.

SKB commissioned the BGS to undertake a series of detailed laboratory studies aimed at resolving specific issues relating to the gas migration process. It has been shown that gas moves through the clay following pressure-induced pathways. The clay tends to dilate when these pathways are formed. Both the porewater pressure and the total stress acting within the clay are strongly affected by the passage of gas. The laboratory work has highlighted a number of uncertainties, notably the sensitivity of the gas migration process to experimental boundary conditions and possible scale-dependency of the measured responses. These issues are best addressed by undertaking a large-scale gas injection test or 'Lasgit'.



Large scale gas injection test (Lasgit) 420m below ground at the Äspö Hard Rock Laboratory in Sweden. A BGS scientist stands next to a gantry crane positioned over the disposition hole.

Lasgit will be undertaken at the Äspö Hard Rock Laboratory (HRL), around 360 kilometres south of Stockholm in the municipality of Oskarshamn. The HRL consists of a network of underground tunnels, totalling over 3600 metres in length, at an average depth of around 460 metres. The underlying diorite formation is representative of the geological conditions likely to be encountered in a Swedish conceptual nuclear repository.

The Lasgit test is a full-scale demonstration project conducted in the Assembly Hall Area of the HRL at a depth of 420 metres. This is a 'mock test' which does not use any radioactive materials. A disposition hole, 8.5 metres deep and 1.8 metres in diameter, has been drilled into the gallery floor. Thirteen circular filters of varying dimensions will be located on the surface of a copper canister to provide point sources of gas which mimic canister defects. These filters will also be used to inject water during the initial hydration phase. Helium gas will be used as a safe substitute for hydrogen during gas testing. Once the pre-compacted bentonite blocks have been installed, the borehole will be capped with a conical concrete plug retained by a reinforced steel lid. The lid will be held down by rock anchors designed to withstand over 5000 tonnes of force. Additional instruments will record variations in the relative humidity of the clay, the total stress and porewater pressure at the borehole wall, the temperature, any upward displacement of the lid and the restraining forces on the rock anchors.

The state-of-the-art experimental monitoring and control systems for Lasgit are housed in the 'gas laboratory' which is a self-contained unit designed and assembled by the BGS within a modified shipping container. A customised graphical interface based on National Instruments LabVIEW™ software will enable remote control and monitoring to be undertaken by staff at the BGS Headquarters in Keyworth and will also allow the project's international partners to access data using their desktop computers.

Lasgit will provide the industry with important new information on the mechanics of gas flow in buffer bentonite. The numerical data will be used in the development and validation of process models aimed at repository performance assessment. The experiment is scheduled to run continuously over the next five years. ■

With sadness we report that, before this article could be published, Steve Horseman died suddenly while on holiday. Steve was an energetic, enthusiastic and much respected scientist, and a frequent contributor to Earthwise. He will be greatly missed by all of his friends and colleagues at the BGS.

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Layout of the Lasgit experiment showing the copper canister, the bentonite buffer, the plug and the rock anchors.

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