A STUDY OF GEOLOGICAL DISPOSAL FACILITY (GDF) AGEING PHENOMENA IN BENTONITE-17605

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ABSTRACT

Since the 1950's, the UK's nuclear activity in energy, defence and medicine has led to the accumulation of a large amount of higher activity radioactive waste (HAW). Most of nuclear waste arises in a wide variety of physical and chemical forms with different radioisotopes and loadings. Due to complexity in HAW, it is imperative that there be a rigorous management system that ensures population and environmental safety over extended periods. The concept of Deep Geological Disposal of waste in a stable geological formation is, nowadays, an internationally accepted solution as the surest and the most viable long term method for management.

Any future Geological Disposal Facility (GDF) will comprise, among other artificial and natural engineered barriers, a barrier immediately around the waste containers compounded by a sealing material. The long-term stability of a GDF will be determined by the design and construction of the engineered barriers, and the mechanical, hydraulic and geochemical interactions that may happen between the different engineered components as a result of combined processes such as the heat produced by radioactive decay and the ion water composition of the surrounding host rock. Bentonite clay has been selected as the most promising buffer and backfill material in many disposal programmes because of its swelling capacity, low permeability, plasticity and cation exchange capacity.

In the nuclear scope, bentonite testing at different scale-lengths (laboratory and field scale) has been performed and implemented in order to examine the thermo-hydro-mechanical (THM) and thermo-hydro-geochemical (THG) processes that may happen in the engineered barriers and geological settings associated with a GDF.

Two major European field scale tests have been performed to better understand bentonite performance and behaviour immediately after HAW emplacements. The **Full-Scale Engineered Barriers Experiment** (FEBEX) at the Grimsel Test Sit (Switzerland) and the **Alternative Buffer Material** (ABM) Project at the Äspö Hard Rock Laboratory (Sweden).

The Febex Experiment was a pilot project designed for 'field research' of HAW repository hosted in crystalline rock where surrogate HAW canisters were placed horizontally in drifts, surrounded by compacted blocks of bentonite, sealed by a concrete plug and maintaining a constant canister surface temperature of 100°C. After five years of operation, a partial dismantling was carried out in 2002. Heater

n°1 was dismantled and several samples were taken to investigate THMC processes occurring in the surrounding bentonite. The dismantling of the heater n°2 (after 18 years of operation) started in late 2014 and is planned to be finished at the end of 2016 (termed FEBEX-DP).

The FEBEX Project utilised bentonite from the Cortijo de Archidona deposit (Almeria, Spain). This ‘Febex’ bentonite is sourced from calcium-magnesium montmorillonite with good properties in relation to swelling capacity, permeability, adsorption capacity, and thermal conductivity.

The ABM Project is a large-scale programme that has been running since 2006. The programme is designed to study a suite of possible buffer materials and correlate the physical and chemical properties of eleven different types of bentonites to their fundamental mineralogical properties. The ABM test consists in three ‘packages’ containing a central heater tube surrounded by different pre-compacted bentonite blocks and instrumentation. Each ‘package’ was installed in separate boreholes. The target temperature for the surface of the heated tubes in contact with the bentonite was 130°C.

Both FEBEX and ABM test the bentonite was saturated with water percolating from surrounding host rock (FEBEX and ABM) and also via artificial supply systems (ABM), being the water itself acting as a long term corrosion agent.

For both experiments and emerging interest is in the interaction of bentonite with metallic components, under geological disposal conditions are not considered to be thermodynamically stable and hence arising corrosion products could interact with the buffer. These interactions depend on various factors such as the redox potential, temperature, pH, solute concentration and buffer material characteristics.

During the operational phases of the FEBEX and ABM and after its ‘closure’ a significant volume of air was found to be retained in the bentonite. Under these conditions a period of initial aerobic corrosion by the air in the bentonite barrier would have occurred followed by establishment of anaerobic corrosion would be the dominant process ongoing. The anaerobic corrosion began when the bentonite became water saturated. Under these conditions, the water acted as the major oxidant.

The present project focuses on the characterization of samples arising from the FEBEX and ABM Projects as well as performing additional independent experiments designed to complement these prior studies. Characterization will focus mainly on corrosion related alteration combined with thermal effects. Through detailed sample characterization, the intention is to achieve a greater knowledge regarding the changes to the bentonite under the experimental conditions to which it was exposed, and plausible alterations in its THM and THG properties occurring during the experiment due to blended effects of temperature, water content, engineering structural components and solutes are also to be measured.

The fulfilment of a large-scale 'in-situ' test is intricate, time-consuming and with an abundance of external variables that are not always well controlled. For this reason, the University of Bristol is performing a series of well constrained time-resolved laboratory tests which bentonite is being subjected to different possible scenarios that may happen whilst in a HAW repository. In virtue of this experiment, the UoB aims to understand the illitisation and cementation process and their effects on bentonite's safety properties.