Analysis of coupled THM phenomena in clay barriers

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ABSTRACT

Considerable progress has been made, in the past 25 years, in defining a scientific basis for the final disposition of radioactive waste. Notably, underground repository concepts under development in the EU put strong emphasis on the performance of the engineered barriers surrounding the hazardous materials, the so-called "near field", whose role in the overall disposal system is not simply to fill the space between the waste canister and the host rock but also to retard the saturation of the surrounding rock, thus minimising the release of possible radionuclides into groundwater. Accordingly, the evolution of the behaviour of the near field is a key-aspect in the evaluation of the long-term performance of the repository, which can be accomplished quite satisfactorily only investigating the phenomenon in coupled thermo-hydro-mechanical (THM) way.

The paper focuses on the analysis of clay barriers studied in the context of the FEBEX (Full-scale Engineered Barriers Experiment) experiment (and subsequent ones) at the Grimsel test site (Switzerland). The test aims at performing the behaviour under natural conditions of the Engineered Barrier System (EBS) designed by the Spanish Agency for Radioactive Waste Disposal (ENRESA), which represents the Spanish concept for the isolation of high-level radioactive waste in crystalline rock. According to this idea, the canisters enclosing the waste are placed horizontally in drifts excavated into the granite and surrounded by a clay barrier made of highly-compacted bentonite blocks. In the experiment the nuclear waste is simulated by two cylindrical heaters so that the overall problem can be numerically handled in axial-symmetry. Heating is performed at a constant temperature of 100°C, while the bentonite buffer is slowly hydrated [1, 2].

Comprehensive laboratory tests carried out in the context of the project have already allowed in the calibration of the finite element model CODE-BRIGHT [3] adopted to describe the THM behaviour of the compacted expansive clay put in place as buffer material, and the good agreement obtained so far with the experimental results are a proof of the feasibility of the EBS for safe, long-lasting geological repositories. The paper analyses in detail the more coupled THM phenomena and their impact in the long term behavior of the clay barrier system.

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