BEHAVIOUR OF A BENTONITE BARRIER IN THE LABORATORY: EXPERIMENTAL RESULTS UP TO 8 YEARS AND NUMERICAL SIMULATION

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INTRODUCTION
The conditions of the bentonite in an engineered barrier for high-level radioactive waste disposal were simulated in a series of tests. Cylindrical cells with an inner length of 60 cm and a diameter of 7 cm were constructed. Inside the cells, six blocks of FEBEX bentonite have been piled-up, giving rise to a total length similar to the thickness of the clay barrier in a repository according to the Spanish concept. To obtain the blocks, the clay with its hygroscopic water content was uniaxially compacted at a nominal dry density of 1.65 g/cm³. The bottom surface of the material was heated at 100°C and the top surface was injected with granitic water (Villar et al. 2005a). The duration of the tests was 6, 12, 24 and 92 months. The temperatures inside the clay and the water intake were measured during the tests and, at the end, the cells were dismounted and the dry density, water content and hydro-mechanical properties were measured at different positions (see the companion paper by Fernández et al. for geochemical and mineralogical complementary results).

A fully coupled Thermo-Hydro-Mechanical (THM) formulation has been adopted as a general framework to analyse these experiments. Numerical analyses have been performed using the CODE_BRIGTH (Olivella et al. 1994) program, which is a finite element code developed to handle coupled THM problems in porous media. The cells have been modelled as a boundary value problem. The geometry, initial conditions and boundary conditions have been adopted in order to reproduce as closely as possible the actual conditions of the tests. The modelling has considered the different stages of the tests, i.e., heating and hydration, cooling and dismantling (Villar et al. 2005b). The extensive experimental campaign carried out during the FEBEX project has allowed to determine and estimate the main parameters of the constitutive models related to the thermal, mechanical and hydraulic problems. This work presents the comparisons between the main recorded variables of the tests (water intake and temperature) and the model results. The main results of the postmortem analysis are also presented in this paper.

MAIN RESULTS
There is a sharp temperature gradient in the vicinity of the heater. The temperatures inside the clay during the TH treatment are a little lower as the duration of the test is longer, what is due to the increase in thermal conductivity of the clay with water content. The distribution of water content along the bentonite column in the four 60-cm long TH tests is shown in Figure 1, where it can be seen there is an important gradient even in the longer test. The injection of water provokes also in the vicinity of the hydration surface a decrease of the dry density due to the swelling of the clay, while heating gives rise to an increase of the dry density near the heater.

The high swelling capacity of the bentonite is confirmed by the deformation caused in the Teflon cell—which gave place to an overall decrease of dry density with respect to the initial one—and by the sealing of the six blocks that constituted the bentonite column in the longest test. The evolution of water intake follows the expected behaviour, that is, a clear reduction in the rate of water intake as the test goes on (Figure 2).
**Figure 1:** Final distribution of water content for tests of different duration.

**Figure 2:** Computed versus registered values of cumulative water intake and rate of water intake.

**References:**

