INTEGRATION OF THM-EXPERIMENTAL WORK AND MODELLING

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Long-term safety of the bentonite buffer relies heavily on appropriate saturation of bentonite buffer resulting evidently on adequate swelling pressure low hydraulic conductivity. After transient period after installation of buffer components the buffer swelling pressure is to remain sufficiently high regardless of e.g. the conditions during the early evolution promoting hydrothermal alteration. For these reasons it is of central importance to characterise different "underlying saturation flow regimes", USFRs, and the related time dependent fluxes in various parts of buffer in then currently prevailing conditions. The THM-processes govern the behaviour from transient to fully saturated state and occur during long periods of time from tens of years up to hundreds or even more. Therefore it is important to be able to understand the underlying processes sufficiently and to develop proper modelling techniques. This can be carried out only by integrating testing and modelling. THM-modelling has also important role in design development phase when different engineering techniques e.g. for wetting of buffer are evaluated. *This paper presents the integration of THM-experimental work and modelling carried out in Finland and elsewhere for the development of the buffer designs.*

The primary objective of this work is to provide experimental and modelling data for assessing the behaviour of bentonite buffer during saturation with respect to fulfilling the performance targets. The development of numerical methods allows to simulate the different processes which take place in materials and to understand them better. In laboratory testing, the numerical methods allow us to simulate the tests and to choose the best geometry and boundary conditions and to verify the experimental designs.

The clay barrier behaviour is complex because there are some phenomena coupled: heat flow, water flow in vapour and liquid phases and strains. Some constitutive laws approximate all these phenomena. These laws relate gradients with fluxes in transport phenomena and stresses with strains in mechanical phenomena. The parameters necessary to establish these relations are necessary to reproduce correctly the clay barrier behaviour.

This work uses CODE_BRIGHT (COupled DEformation BRIne, Gas and Heat Transport). This code was developed initially for studying multiphase flow in saline materials (Olivella *et al.* 1994) but some constitutive laws for rocks and clays have been implemented, so it is possible to simulate the clay barrier behaviour. The key aspects of the tests presented below are modelled and later compared to results.

The experimental program to provide data and reference to observed behaviour has consisted of following tests:

- Small scale laboratory tests: Provide the different parameters. Due the complexity of the processes which take place inside the samples, the numerical methods could be necessary for analyze the test results (Pintado *et al.* 2002). Although there is the theoretical possibility to have more than one parameter from one test, it is better to considerer one test for calculate one parameter and use the results to check rest of parameters. Sometimes, one test is used for one parameter but the measures allow to check other parameters.
- Large scale laboratory tests: these tests are used to reproduce in small scale the phenomena which take place in the barrier. Modelling these tests is useful to understand better the processes inside the barrier under the qualitatively point of view and it is possible to quantify other phenomena like piping or crack formation although modelling these phenomena is quite difficult.

- Large scale tests (Gens *et al.* 2009): With the parameters from the small scale laboratory tests and the validation of these parameters with the large scale laboratory tests, plus a better understanding of the phenomena, it is possible to design and simulate the large scale tests, where the conditions of the repository are reproduced. In this case, the boundary conditions play an important role because they aren´t easy to fix.

The work ongoing is the small scale laboratory tests. Some thermal, thermo-hydraulic, hydro-mechanical and thermo-hydro-mechanical test are running. The previous scoping calculations allow to have an idea about the time necessary to run the test and the order of magnitude of the variables measured. This experimental work is doing with the MX-80 (Dueck, 2004), the clay reference.

The scoping calculations allow us to know what parameters control a test. This work can be done under statistical point of view with an accurate analysis of the derivatives of the variables respect the parameters.

The results from the small and large scale laboratory tests and the large scale test provide the information necessary for simulate the repository behaviour. As it was mentioned previously, the boundary conditions are quite important because the hydration of the barrier depends on the water contribution from the host rock. The accurate knowledge of the groundwater flow will be quite important to simulate properly the clay barrier. Other boundary conditions have to be considered, like the mechanical contact between different materials (buffer, backfill and host rock) and the behaviour of special parts of the barrier, like the gaps initially filled of air, water or pellets.

The future quality control of the repository in the early stages will calibrate the model used for calculate and simulate during the design phase. There is experience in the control of a construction, like in dams, where the properly auscultation during its live is necessary to assure the security of the population.

References:

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