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Modelling of hydro-mechanical Processes associated with Gas Transport in Wyoming Bentonite

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Bentonite is a preferred sealing material for the Engineered Barrier System (EBS) of deep geological repositories for radioactive waste. The performance of the bentonite-based EBS components in terms of long-term radiological safety can be expressed in terms of so-called safety functions, namely the physical isolation of the wastes from the human environment, the confinement and retention of radionuclides in the repository near field and eventually the attenuated release of radionuclides to the environment. After repository closure, gases may be generated by the corrosion of metals or by the degradation of organic waste components, giving rise to the accumulation of a free gas phase and the build-up of gas-overpressures in the backfilled underground structures. The percolation of such a free gas phase through the saturated bentonite may impair the safety functions of the EBS.
The complexity of the coupled thermo-hydro-mechanical and –chemical (THM-C) processes associated with gas transport in bentonite gives rise to a multitude of phenomena, which seem hardly predictable by the means of existing numerical modelling tools. For this reason, a comprehensive experimental programme was initiated to characterise the phenomena and processes, associated with gas percolation through bentonite samples at the laboratory scale. The laboratory programme comprised the geo-mechanical characterisation of unsaturated bentonite samples (index tests, compaction curves, retention behaviour), bentonite hydration (swelling pressure, saturated permeability) and gas injection tests in oedometric and triaxial configurations. Complementary microstructural investigations of the as-compacted and the hydrated material were carried out to get insight in the evolution of porosity during hydration. Further studies were dedicated to the evolution of microstructure before and after gas percolation.
The acquired data bases were made available to a benchmark exercise as part of the “SKB Task Force on Engineered Barriers”, aimed at modelling gas transport in compacted bentonite. Four modelling teams participated in this modelling task, drawing on different THM codes and applying different process models for the simulation of the gas percolation phenomena for a range of test configurations and gas injection scenarios. A common feature of all modelling approaches was the use of heterogeneous distributions of pore structure to account for the localisation of gas flow. Preliminary evaluations of the modelling results reveal that the as-compacted state of the test sample and the hydration procedure have a major impact on the gas percolation through the specimen.