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Gas transport in bentonite buffer material: the effect of interface

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As a part of the thermo-hydro-mechanical behaviour of Engineering Barrier Systems (EBS), generation and migration of gases are a significant issue in the long-term performance of clay buffer. Bentonite is commonly proposed as sealing material, due to its very low permeability, swelling facility and self-sealing capacity.

This paper reviews the gas permeability of bentonite samples coming from the FEBEX (Full-scale Engineered Barriers Experiment) in situ test carried out at the Grimsel Test Site underground laboratory in Switzerland, in which the bentonite barrier was composed of highly compacted blocks. These samples were subjected to barrier conditions, i.e. thermal and hydraulic gradients for 18 years. Hydration was natural and a heater with a surface temperature of 100°C simulated the waste container. The aim of this study was to experimentally investigate the gas transport properties of the bentonite and assess the performance of the sealed interfaces between blocks. To this end, a custom-built equipment was designed. Half of the samples were drilled onsite in the middle of blocks and the other half at the contact between two blocks, so there was an interface along the core, which could be considered as a potential flow path for gas.

Gas permeability was measured in samples with initial dry densities between 1.51 and 1.64 g/cm3, and with water contents between 20 and 29%, corresponding to initial degrees of saturation between 79 and 100%. In the range of pressure tested, gas permeability decreased with confining pressure. Overall, the samples with interface taken close to the heater had higher permeability than neighboring samples drilled in the middle of a block, and its permeability decreased steeply with confining pressure, and it was necessary to apply higher confining pressure to suppress gas flow through them. However, samples from the external ring (more hydrated) with and without interface behaved similarly, their permeability being clearly lower than that of samples taken closer to the heater. The results of the tests showed that the confining pressure required to block air passages was higher for the less saturated samples.

The confining pressure reduced the size of the gas pathways. The study of pore size distribution at the end of the tests showed that the percentage of macropores decreased noticeably whereas the percentage of mesopores and micropores increased in samples that reached high confining pressures during the test.

Overall, for similar values of accessible void ratio the samples with interface had higher permeability for all the range of confining pressures applied, although the difference between the permeability of a sample with and without interface tended to be lower towards the smaller accessible void ratios, in other words, for highly-saturated samples.