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Environmental degradation of Opalinus Clay with cyclic variations in relative humidity

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Clay shales are considered as favorable host rocks for nuclear waste repositories due to their low permeability, high sorption capacity and the potential for self-sealing. However, the favorable characteristics of the rock mass may change during tunnel excavation. Excavation is accompanied by stress redistribution and the development of an excavation damage zone. Furthermore, unloading and exposure to atmospheric conditions with a lower relative humidity (RH) causes desaturation of the rock mass close to the tunnel. This leads to shrinkage and the formation of desiccation cracks. During the open drift stage, seasonal atmospheric changes, especially RH variations, may alter the rock mass and influence the long-term crack evolution.

This contribution discusses the influence of RH variation on the mechanical behavior of OPA. A series of specimens were exposed to short-term and long-term, stepwise cyclic RH variations between about 60 and 95% at constant temperature. Strains were measured using strain gauges to monitor the volumetric response during RH cycles. After each applied RH cycle, Brazilian tensile strength (BTS) tests were performed to identify whether there is a change in tensile strength due to environmental damage caused by the change in RH.

Swelling and shrinkage of the specimens accompanied by irreversible volumetric expansion was observed as a consequence of the exposure to RH cycles. However, the irreversible strain was limited to the direction normal to bedding suggesting that internal damage is restricted along the bedding planes. No significant effect of cyclic RH variations on the BTS of the specimens was observed. The strength parallel to bedding remained constant over several cycles while the strength normal to bedding shows a slightly decreasing trend after 2 cycles. Furthermore, the water retention characteristics of the specimens were not altered significantly during stepwise RH cycling as the evolution of the water content was reversible throughout the cycles. For the RH variation used, the results suggest that the long-term crack evolution around excavations in OPA is not expected to be significantly influenced by environmental degradation but dominated by other processes such as consolidation and creep.