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Coupled hydro-mechanical properties of Cobourg limestone with special reference to excavation damage zones

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Argillaceous rock formations being considered as potential host or cap rocks for the geological disposal of radioactive wastes are usually characterized by the presence of bedding planes, resulting in anisotropy of their strength and deformation properties. A laboratory experimental program was performed at the Rock Fracture Dynamics Facility at the University of Toronto to determine the coupled hydro-mechanical properties of the Cobourg limestone with special reference to its potential for damage. The program consists of triaxial tests with measurement of permeability using the pulse decay method and measurement of the seismic wave velocity at different stress levels.

The tests were carried out on specimens parallel and perpendicular to the foliation planes within a geophysical imaging cell under different stress levels up to and beyond their peak strength. The specimens are characterized by random and irregular clay pockets and discontinuous argillaceous weak layers. Permeability of the specimens was measured with the pulse decay method under different pre - and post- failure deviatoric stresses. The specimens tested parallel to foliation planes show higher triaxial compressive strengths and higher axial strains at failure in comparison to the specimens tested perpendicular to the foliation planes. The permeability (k) values measured under different stress levels for all specimens show a consistent trend. The k value decreases with the stress increase at the beginning due to the closure of pre-existing fissures and beddings. The k value then increases continuously with the increase in the stress level with highest k values obtained at the post-failure stage. The evolution of the compressional and shear-wave velocities and shear wave splitting as a function of the axial stress is compatible with preferably oriented weak planes and with the evolution of the hydro-mechanical properties of the Cobourg limestone. From the test results, it can be interpreted that at the onset of dilation, where axial and diametral strains register permanent damage, the permeability values increase and lateral seismic velocities decrease. The tested specimens will be further investigated using Micro-CT and thin section studies, which will complement the understanding of the effect of induced mechanical damage on the hydrological properties of the tested specimens. The results obtained from this experiment provide valuable independent knowledge to assess the damage induced by the excavation of repositories and shafts in sedimentary rocks and their implications on long-term safety of the geological disposal of radioactive wastes.