Geophysical Research Abstracts
Vol. 21, EGU2019-12856, 2019
EGU General Assembly 2019

Water permeability estimation of the Opalinus Clay via different methods – Insights into a comparative experimental study

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The Mesozoic shale formation Opalinus clay (OPA), deposited about 180 million years ago, serves as the potential host rock for the high-level nuclear waste disposal in Switzerland. The benefits of this geological barrier are its low permeability, high radionuclide retention and the self-sealing potential of open cracks and fissures. The first aim of this study is to compare different experimental techniques for testing the intrinsic permeability, i.e. steady-state flow, non-steady-state pulse decay method and the oscillating pore pressure method. Another goal is to determine the dependence of permeability on changes in effective mean stress as this is one of the most important factors when designing an underground storage, especially with focus on the excavation damage zone (EDZ). For this purpose, permeability experiments are conducted at varying pressure gradients and effective mean stresses.

The steady-state, pressure pulse decay and the oscillating pore pressure method are common techniques to measure permeability. All of these techniques can be applied to low permeable rocks; however, each measurement technique has specific its own drawbacks. For all methods, leak tightness of the system is one of the basic prerequisites as well as the pressure equilibration of the rock sample to the prevailing pressure conditions. However, preliminary tests indicate that the oscillating pore pressure method is less sensitive to these issues but may, as the other methods, require long experimental time in the order of days for low permeable rocks.

In this study, measurements are performed on a cylindrical plug, that has been drilled parallel to bedding from the shaly facies of OPA. The results of the different methods are evaluated with respect to their dependency on effective mean pressure and pore pressure changes. Additionally, we will outline and assess the pros and cons of each technique.