Geophysical Research Abstracts
Vol. 21, EGU2019-16832, 2019
EGU General Assembly 2019

Understanding the evolution of nuclear waste repositories by performing appropriate in-situ experiments – examples from the Mont Terri Rock Laboratory

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Understanding all processes with relevance to the whole lifetime of a final repository for high-level radioactive waste (HLW) is an extraordinary challenge, but essential for the creation of repositories worldwide and a part of licensing procedures in Germany. To this end, BGR performs various experiments in national and international underground facilities. As claystone is a potential host rock for a HLW-repository in Germany, too, BGR also performs experiments in Opalinus Clay at Mont Terri Rock Laboratory in Switzerland. BGR is one of 19 consortium partners from nine countries in the Mont Terri Project since its creation in 1996.
Experiments are performed in close collaboration and exchange between the partners in order to avoid doubling. All results and experiences are made available immediately to all partners and later to the public. The experiments cover the full evolution of a HLW-repository. BGR experiments mainly cover the early repository evolution (up to several 1000 years), comprising construction period (desaturation), canister emplacement period (temperature pulse), post-closure transient phase (temperature decrease, ongoing re-saturation), and post-closure equilibrium phase.
We focus exemplarily on some selected topics of more than 20 years of BGR's participation in the Mont Terri rock laboratory.
• After a site selection process, one of the first steps is an in-situ site characterization. BGR developed different high-resolution geophysical tools which allow a precise rock characterization with geophysical parameters, dynamic elastic moduli, characterization of Excavation Damaged/disturbed Zone (ED/dZ) features at different stages of the evolution and long-term emplacement experiment monitoring for barrier integrity assessments.
• With the extension of the rock laboratory extensive investigations have started regarding the more stable sandy facies of the Opalinus Clay. In advance of the excavation, a section of the planned gallery has been instrumented with different sensors to observe the coupled hydromechanics processes due to excavation. The measurement results will be the basis of computational simulations to determine the property values of the sandy facies.
• Hydraulic characterization is another focus of our research. Permeability measurements were performed in the near-field around an excavation, in the undisturbed rock zone, in the zone with wet-spots, and in the transition area between different geological units. Additionally, a coupled thermal-hydro-mechanical (THM) code was developed in cooperation with UFZ Leipzig to analyse coupled HM (Mine-By experiment) and THM processes (Heater Test).
• Mechanical parameters of Opalinus Clay were studied in triaxial tests in Kármán cells. Young's modulus was found to exhibit a significant dependency on the confining pressure as well as a strong anisotropy regarding value and type of functional dependency.
Despite enormous efforts of all partners involved and the hitherto obtained vast, interdisciplinary knowledge, various important technical and scientific questions remain as of yet unanswered. While undisturbed rock regions and new experimental space became quite rare, add-on excavations started in 2018. With the scheduled doubling of the Mont Terri laboratory space in late 2019, synergies will open up between research on safe options for nuclear waste repositories and new studies on further potential uses of the subsurface.