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Development of tools for studying contaminant transport in fractured rock environment: laboratory migration experiments in physical models with artificial and natural fractures

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Migration of contaminants (radionuclides, heavy metals, nanoparticles) in crystalline rock environment is driven mainly by advective processes in fractures. The main goal of our project is to develop tools for evaluation of migration and retention of potential contaminants in the rock environment. Since the naturally fractured environment is typically too complex to describe, it is common to mimic its behaviour by means of numerically simulated fracture network. The groundwork for applicable simulation of large-scale structures comes out from comprehension and verification of parameters for basic components such as a single fracture. For this reason, number of numerical simulations were performed to evaluate hydraulic and transport properties of an artificial and natural single fracture system by means of different modelling approaches. This will be presented in details in a separate conference contribution by Hokr et al.

Two granite blocks were split and reassembled to generate physical models with artificial fractures. Significant contribution to the exact model representation of the flow regime is the precise fracture topography description, derived from the method of the laser scanning. This allows the model resolution up to 100 μm for each of the two granite blocks used in the study and subsequently the identification of the preferential pathways of the contaminant spreading. Both blocks were customized for both on-line measurement of the selected parameters and sample collection for off-line measurement. This arrangement allowed us to perform series of migration experiments with different conservative (NaCl, KCl, KI, HTO) and sorbing ($\text{Pb}(\text{ClO}_4)_2$) tracers. The focus of the numerical modelling effort is to fully describe the hydraulic and transport properties of the fractured granite environment based on the data from experimental tracer tests. Pressure field distribution across the fracture and breakthrough curves at the sampled positions were used for the fracture parameters calibration and evaluation of the model overall reliability.

Several physical models with natural fractures were prepared from suitable sections of borehole cores coming from two locations in the Czech Republic (underground research center Bukov and

Mrákotín quarry). Data from transmissivity measurements and conservative tracer breakthrough curves served as initial parameters for fracture description. Specially designed experimental set-up for conducting of migration experiments with very low flow rate was applied. Moreover in collaboration with HZDR (Leipzig, Germany) the unique combination of PET – μ CT techniques was employed. Spatiotemporal images of the radioactive tracer (^{18}F) concentration during conservative transport were recorded with positron emission tomography (GeoPET), and the underlying fracture structure was characterized by μ CT-imaging. First results are proving the existence of preferential migration pathways within the studied natural fractures.

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