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Improving fracture-flow models by experimental evidence from process tomography

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Advective fluid flow transport controls the migration of radionuclides in fractured crystalline rocks. Thus, the safety assessment of deep geological repositories in crystalline rocks relies critically on fracture flow properties and the reliability of transport modelling approaches. Here, we focus on heterogeneity and complexity of transport processes, typically of limited predictability. In order to tackle this issue, we suggest experimental observations by using tomographic methods, as well as feedback with and improvement of existing transport modelling approaches. As an example, tracer propagation through fractured crystalline rock cores from the Czech Republic (Bukov URL, depth of 500 m below the surface), was studied in collaboration between HZDR (Germany) and UJV (Czech Republic). Spatiotemporal data of the tracer concentration during conservative transport are based on positron emission tomography (PET), and the underlying fracture structure was characterized by μCT-imaging. The latter yields a structural model for reactive transport modelling. The PET data sequences provide (i) the validation of existing simulation approaches, and (ii) serve as input or the parameterization of advanced simulation concepts.

First results underscore the outlined approach. In particular, the PET measurements clearly show preferential and localized pathways, a feature of the process that significantly reduces the effect of interactions at the fracture surface (and thus retention by adsorption); although repeat experiments are suggesting that the identified pathways are not constant over the experimental periods.

As a consequence of the combined experimental and simulation approach, we expect (i) advanced model concepts based on experimental insights and (ii) an improved understanding of reactive transport processes with a focus on temporal heterogeneity of preferential pathways.