ADVANCED ANALYSIS OF RN MIGRATION IN FRACTURED CRYSTALLINE ROCK

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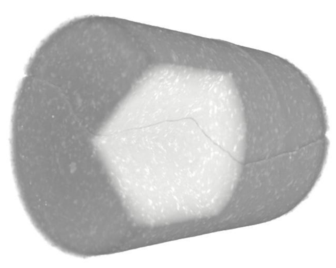
Introduction

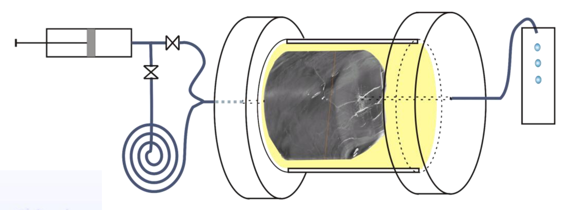
Safety assessment of deep geological repositories in crystalline rocks relies critically on (i) the identification of fracture flow properties and (ii) the reliability of transport modeling approaches. Here, we identified both heterogeneity and complexity of transport processes typically not able to be predicted using common approaches because of, e.g., surface wetting and surface heterogeneity. In order to tackle this issue, we suggest experimental observations of such processes in the laboratory by using tomographic methods, as well as feedback with and improvement of existing transport modeling approaches. As an example, tracer propagation through fractured crystalline cores from the Czech Republic, being sampled at Bukov URL at a depth of 550 m below the surface, was studied in collaboration between HZDR and UJV.

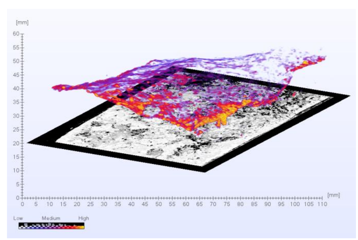
PET & µCT-imaging techniques

As an example, tracer propagation through fractured crystalline cores from the Czech Republic, being sampled at Bukov URL at a depth of 550 m below the surface, was studied in collaboration between HZDR and UJV. Before further experiments the samples had to be assembled very accurately and casted with epoxide into special column cells provided with one inlet and one outlet hole.

Spatiotemporal images of the tracer concentration during conservative transport were recorded with positron emission tomography (PET), and the underlying fracture structure was characterized by µCT-imaging. The latter yields a structural model for reactive transport modeling, whereas the PET sequences are used as experimental control of the simulations, and also are parameterized in order to develop new, experimentally-based simulation procedures.







Drill core sampling

Structural characterization of core samples using µCT. Transport experiments and flow monitoring with GeoPET technique.

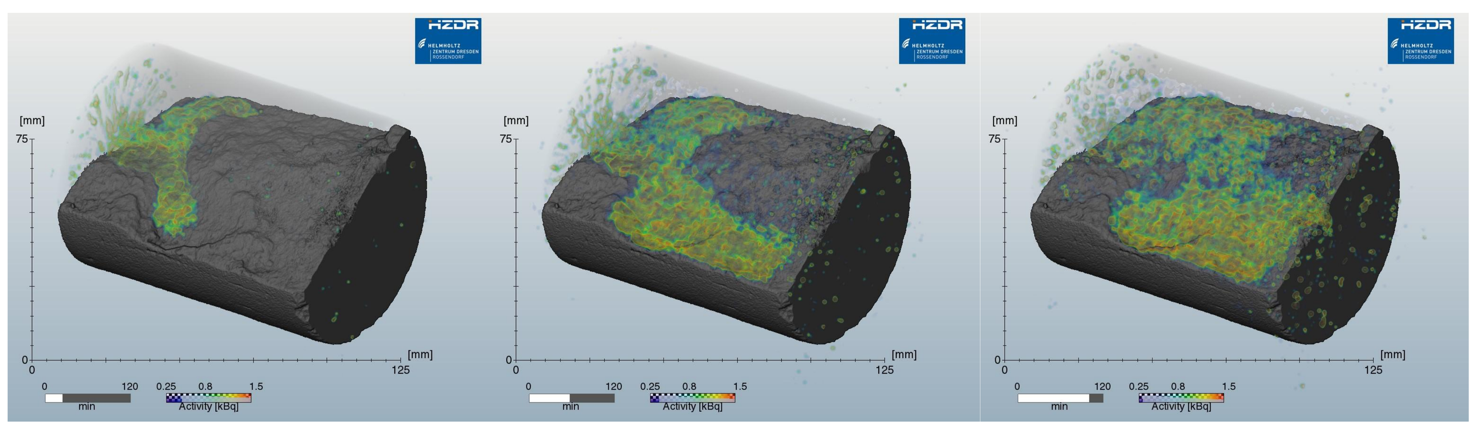
Results

First results underscore the opportunities in reactive transport analysis by using **PET-µCT techniques**. Specifically, the PET datasets clearly show the existence of **preferential pathways**, in contrast to previous assumptions about homogeneous hydrodynamics in such settings. This behavior impacts significantly the **spatial heterogeneity of chemical reactions at the fracture surface**. Thus, adsorption reactions may show specific spatial pattern. Additionally, the fluid flow pathways are **not stable over reaction time** during the repeated flow-through experiments. This result expands the complexity of reactive transport approaches at fracture surfaces still further.

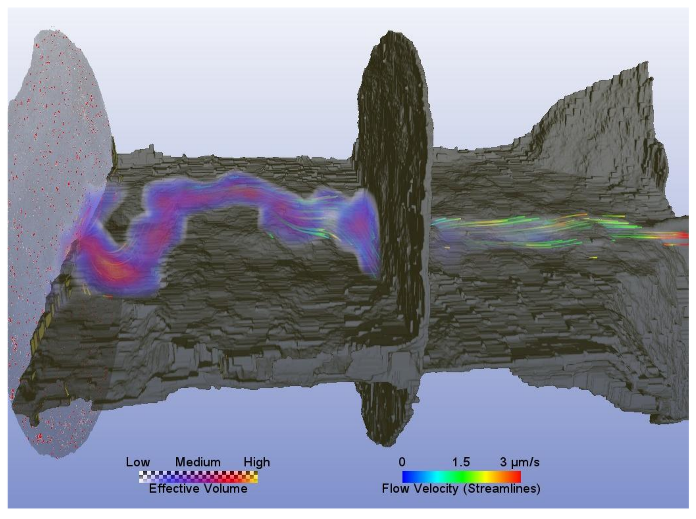
Consequently, we are focusing on (i) simplified and reliable models with experimental proof-of-concept, and, (ii) better understanding of reactive transport processes with a focus on temporal heterogeneity of preferential pathways.

Natural fracture surfaces

- Quantitative tomographic process monitoring with GeoPET (Positron Emission Tomography) in cooperation with HZDR Leipzig (DE)
- Use for column experiments with tracers



GeoPET/µCT-imaging of the tracer propagation ($^{18}F^{-}$) along the fracture, 3 frames out of 60.



- Computation of effective volume and local flow rates from PET
- RTM-simulations based on experimental transport parameterization

Parameter derivation from GeoPET-Frames (work-in-progress, example: fractured sandstone)

Future steps

Further HZDR and UJV joint experimental activities are outlined within the **WP FUTURE (Fundamental migration of radionuclides**) in the frame of the European joint program project **EURAD**, submitted in September 2018.

European Commission

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