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Taking profit from molecular sensitivity on the macro scale: application of PET for investigating transport processes in barrier material

Johannes Kulenkampff
HZDR - Institute for Resource Ecology, Reactive Transport, Leipzig, Germany (j.kulenkampff@hzdr.de)

Positron emission tomography (PET) is an ideal method for tracing smallest amounts of radiolabelled substances propagating through widely impermeable material. It provides a means for experimental crossing of scales from molecular dimensions to the macroscale in particular in tight, heterogeneous, and complex materials. Characterization of transport properties of barrier material with this method benefits from its
- extremely high sensitivity („picomolar“),
- reasonable spatial resolution (around 1 mm),
- stability (up to years),
- direct comparability with and input for geochemical modelling.
These features are accomplished with high-resolution PET scanners, actually dedicated for biomedical research, in combination with a radionuclide laboratory for producing PET-tracers. Such a facility is available at the Leipzig research site of the HZDR, where we developed and applied the GeoPET-method since about 15 years. GeoPET provides a suite of quantitative tomograms of the concentration of the propagating PET-tracer during transport processes, i.e. reactive flow and diffusion. Subsequently, such flow field data are parameterized with the aid of time-resolved-image processing methods and inverse modelling.
In order to illustrate the high potential of the method, we present examples from measurements on barrier rocks (granite, salt rock, clay), that yield spatially resolved flow and diffusion parameters on macroscopic samples.

Reference:
J. Kulenkampff, M. Gründig, A. Zakhnini and J. Lippmann-Pipke. Geoscientific process monitoring with positron emission tomography (GeoPET), Solid Earth, 7, 1217-1231, (2016).