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Quantitative observation of tracer transport with high-resolution PET

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Transport processes in natural porous media are typically heterogeneous over various scales. This heterogeneity is caused by the complexity of pore geometry and molecular processes. Heterogeneous processes, like diffusive transport, conservative advective transport, mixing and reactive transport, can be observed and quantified with quantitative tomography of tracer transport patterns. Positron Emission Tomography (PET) is by far the most sensitive method and perfectly selective for positron-emitting radiotracers, therefore it is suited as reference method for spatiotemporal tracer transport observations.
The number of such PET-applications is steadily increasing. However, many applications are afflicted by the low spatial resolution (3 – 5 mm) of the clinical scanners from cooperating nuclear medical departments. This resolution is low in relation to typical sample dimensions of 10 cm, which are restricted by the mass attenuation of the material. In contrast, our GeoPET-method applies a high-resolution scanner with a resolution of 1 mm, which is the physical limit of the method and which is more appropriate for samples of the size of soil columns or drill cores. This higher resolution is achieved at the cost of a more elaborate image reconstruction procedure, especially considering the effects of Compton scatter. The result of the quantitative image reconstruction procedure is a suite of frames of the quantitative tracer distribution with adjustable frame rates from minutes to months. The voxel size has to be considered as reference volume of the tracer concentration. This continuous variable includes contributions from structures far below the spatial resolution, as far as a detection threshold, in the pico-molar range, is exceeded.
Examples from a period of almost 10 years (Kulenkampff et al. 2008a, Kulenkampff et al. 2008b) of development and application of quantitative GeoPET-process tomography are shown. These examples include different transport processes, like conservative flow, reative transport, and diffusion (Kulenkampff et al, 2015). Such experimental data are complementary to the outcome of model simulations based upon structural μCT-images. The PET-data can be evaluated with respect to specific process parameters, like effective volume and flow velocity distribution. They can further serve as a basis for establishing intermediate-scale simulation models which directly incorporate the observed specific response functions, without requiring modeling on the pore scale at the highest possible spatial resolution.

Kulenkampff, J., Gründig, M., Richter, M., Wolf, M., Dietzel, O.: First applications of a small-animal-PET scanner for process monitoring in rocks and soils. Geophysical Research Abstracts, Vol. 10, EGU2008-A-03727, 2008a.
Kulenkampff, J., Gründig, M., Richter, M., and Enzmann, F.: Evaluation of positron emission tomography for visualisation of migration processes in geomaterials, Physics and Chemistry of the Earth, 33, 937-942, 2008b.
Kulenkampff, J., Gruendig, M., Zakhnini, A., Gerasch, R., and Lippmann-Pipke, J.: Process tomography of diffusion with PET for evaluating anisotropy and heterogeneity, Clay Minerals, accepted 2015, 2015.