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Visualisation of solute transport and determination of its transport properties in porous sintered glass

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Solute transport in porous media is important for several industrial applications, i.e.: hydrology, building stone performance and waste management. Spreading and mixing during solute transport is significantly impacted by the pore scale heterogeneity found in natural porous media, which complicates upscaling (Dentz et al., 2011). Therefore, simulations and experiments which investigate the evolution of pore scale solute concentration fields in such materials are very valuable. However, direct visualisation of these concentration fields at the micron-scale in rocks is complicated by the high spatial and time resolutions that are required. Bultreys et al. (2016) and Boone et al. (2016) present first tests on imaging solute transport in a carbonate rock using fast laboratory-based micro-CT. In this study, we extend this work by attempting to quantify micro-CT concentration fields, in order to investigate spreading and mixing under different flow conditions in porous materials with different degrees of heterogeneity.

A significant part of this work is aimed at the methodological challenge of performing in-situ micro-CT scans of solute transport with imaging times on the order of seconds. We use the EMCT scanner of UGCT (www.ugct.ugent.be), a micro-CT system specially designed for in-situ imaging, with a rotating X-ray tube and detector in a horizontal plane (Dierick et al., 2014) and investigate the quantitative correctness when imaging the concentration of a dissolved tracer salt (0 wt%, 2 wt%, 4 wt%, 6 wt%, 8 wt% and 10 wt% CsCl) in porous sintered glass at 12 seconds per scan, with a voxel size of 13 micron. The CsCl-concentration increases the X-ray attenuation coefficient of the fluid, which causes an increase in grey values observed in the reconstructed micro-CT datasets. The high temporal resolution at which the micro-CT images are taken, is inherently linked with a limited signal-to-noise ratio. Despite this drawback, the first experimental results suggest a linear relationship between the grey values of the tracer-solution in the fast scans and the tracer concentration.

Results from the presented experiments can be used to investigate flow structures at the pore scale and to validate pore scale solute transport simulations. Further development of the methodology could also lead to valuable insights in multi-phase solute transport and reactive transport.

References

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