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Characterization of interfacial convection in microfluidic systems

Carina Wismeth (1), Christina Glaubitz (1), Michael Manhart (2), Martin Elsner (1), and Thomas Baumann (1)

(1) Institute of Hydrochemistry, Chair of Analytical Chemistry and Water Chemistry, Technical University of Munich, Munich, Germany (carina.wismeth@tum.de), (2) Chair of Hydromechanics, Technical University of Munich, Munich, Germany

Mass transfer rates at interfaces in complex porous media are relevant for a broad range of natural and artificial filter systems and can have a significant influence on the transport of contaminants in subsurface environments. In a combined experimental and numerical study, we concentrate on the clarification and quantification of mass transfer processes at fluid interfaces by image analysis and processing. For this purpose, microfluidic experiments and quantitative particle tracking are closely coupled to providing single-particle access to the interfacial process as well as to flow directions and velocities of the interfacial convection. Extensive test series provide the experimental basis for quantifying and analyzing the impact of different boundary conditions on interfacial mass transfer processes. As a model for studying fluidic multiphase systems nonaqueous phase liquids (NAPL) – water – air is chosen. It was found that there is a fast-rotating convection current along an 1-octanol-water interface that shows a persistent movement in the form of a roll cell for min 99 h.

We experimentally characterized the influence of several properties of different NAPLs on the velocity of the interfacial convection. Furthermore, the impact of the wettability of the micromodel on the interfacial mass transfer and the time dependency was analyzed.

The experimental results show that interfacial convections along fluid interfaces can be quantified and clarified by visualization combined with trajectory analyses and particle tracking methods. Due to the extremely high flow velocity, it can be postulated that the mass transfer along a fluid interface is not only diffusion limited and that the recorded interfacial convection has to be taken into account for further assessments of mass transfer rates in complex multiphase systems.

Within this research project we aim at clarifying the hydrodynamics at fluid interfaces and quantifying the convective contribution on interfacial mass transfer processes to provide a generic data set with high reproducibility to foster the understanding of subsurface transport, especially in the vadose zone.