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Research Topic for Doctoral Thesis

Experimental investigations on microbially induced calcite precipitation in microfluidic porous media

Microbially induced calcium carbonate precipitation (MICP) is an engineering technology which has recently gained attention for different engineering applications, among which is the targeted sealing of leakage pathways, the solidification and stabilization of soil, and the replacement of energy-intensive portland cement by biocement in building materials. The precipitation of calcium carbonate is based on the hydrolysis of urea catalyzed by the enzyme urease. The major aim of the research is determining and quantifying pore-scale mechanisms that affect the relationship between porosity reduction (due to precipitates) and corresponding permeability reduction. MICP is one of the important focus topics in the collaborative research cluster SFB 1313 (`www.sfb1313.uni-stuttgart.de`). The SFB 1313 is now in its 2nd funding period (until end of 2025). Preliminary work in the Project C04 has been published on the experimental methods for microfluidic setups and corresponding visualization techniques [1], the investigations of mechanisms in enzyme induced calcite precipitation (EICP) [2,3], and the comparison with numerical models [3]. This work is going to be continued, while the focus is now on the inclusion of bacteria that also grow in the pore space and form a biofilm which produces urease in-situ.
As part of the SFB 1313 research team, the doctoral researcher would have to perform microfluidic experiments, supervise B.Sc. and M.Sc. students, process and archive the data, and prepare it for use in numerical simulations. Furthermore, the doctoral researcher is expected to learn how to run simulations with the Dumux software (in-house C++ code - `www.dumux.org` - [4]) to compare experimental results with numerical simulations and coordinate model comparison studies with other modeling groups in the SFB¨1313.

Literature:

1 F. Weinhardt, H. Class, S. Vahid Dastjerdi, N. Karadimitriou, D. Lee, H. Steeb: Experimental Methods and Imaging for Enzymatically Induced Calcite Precipitation in a Microfluidic Cell, *Water Resources Research*, 2021, doi: 10.1029/2020WR029361.
2 L. von Wolff, F. Weinhardt, H. Class, J. Hommel, C. Rohde: Investigation of Crytal Growth in Enzymatically Induced Calcite Precipitation by Micro-Fluidic Experimental Methods and Comparison with Mathematical Modeling, *Transport in Porous Media*, 2021 doi:10.1007/s11242-021-01560-y
3 F. Weinhardt, J. Deng, J. Hommel, S. Vahid Dastjerdi, R. Gerlach, H. Steeb, H. Class: Spatiotemporal distribution of precipitates and mineral phase transition during biomineralization affect porosity-permeability relationships, *Transport in Porous Media* doi:10.1007/s11242-022-01782-8
4 T. Koch, D. Gläser, K. Weishaupt, et al.: DuMux 3 - an open-source simulator for solving flow and transport problems in porous media with a focus on model coupling, *Computers & Mathematics with Applications* doi:10.1016/j.camwa.2020.02.012

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Start Date: 01.01.2023 (or earlier)