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High-resolution Darcy-Brinkman simulation of wormhole growth based on X-CT data.

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In 2022 a number of pre-exascale and exascale supercomputers had become available for scientists. We took the opportunity of the pilot phase of the LUMI supercomputer to perform a number of simulations of wormhole growth with an aim to use as much spatial information as possible. The goal was to investigate if properties of growing wormholes could be recovered if sufficient resolution is assured, and how porous matrix-wormhole interaction changes with CT resolution. Additionally, samples used in this study underwent experimental studies. They were scanned before and after the experiment, as well as during the dissolution. This 4D tomographic data and pressure history provided necessary input for high-res simulations as well as validation framework.

As the LUMI computer, as well as most of the newly built HPC machines, is based on GPUs we decided to use the Lattice Boltzmann code as main flow and transport solver. LBM has significant number-crunching performance thanks to its intrinsic parallelization properties which was paramount for this study. Based on an open-source, highly parallel multi-GPU TCLB solver, we design the model capable of handling Darcy - scale simulations with the initial porosity fields constructed based on X-ray microtomography images. In particular, we analyze the reactive-infiltration instabilities, which lead to the formation of dissolution fingers (wormholes), in which both the flow and reactant transport become spontaneously localized. Since dissolution fingers dramatically increase permeability of the rock, wormholing is important both for industrial applications and in hydrogeological studies. The main problem in modeling of wormholing is a multi-scale character of this process, with flow and transport near a wormhole tip strongly coupled to the macroscopic geometry of the emerging structures. The ability to perform large scale parametric and sensitivity studies of wormholing constitutes thus an important addition to experimental studies, hence the need for a high throughput simulator.

We test our numerical predictions against the data from time-lapse dissolution experiments in an aim of constructing a predictive model capable of recovering time evolution of 3D wormhole shape based on the initial X-ray tomography data.

Participation

In-Person

References

Hoefner M.L., Fogler H.S., Pore evolution and channel formation during flow and reaction in porous media. AIChE J. 34, 45–54 (1988)

Daccord G., Lenormand R., Fractal patterns from chemical dissolution. Nature 325, 41–43 (1987)

Ladd, A.J.C., Szymczak, P., 2021. Reactive Flows in Porous Media: Challenges in Theoretical and Numerical Methods. Annu. Rev. Chem. Biomol. Eng. 12, 543–571.

Silva, G., Ginzburg, I., 2016. Stokes–Brinkman–Darcy Solutions of Bimodal Porous Flow Across Periodic Array of Permeable Cylindrical Inclusions: Cell Model, Lubrication Theory and LBM/FEM Numerical Simulations.

Transp Porous Med 111, 795–825.
https://doi.org/10.1007/s11242-016-0628-8

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