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A Benchmark Study of Pore-scale Multiphase Flow in Pore-doublet: The Impacts of Hydrodynamics on Mineral Dissolution Reaction Rate

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Abstract: Multiphase flow in porous media is ubiquitous in soils, oil and gas reservoirs, geologic carbon storage and hydrogen storage systems, and batteries. In recent years, direct observation using microfluidic experiments and pore-scale numerical modeling have become increasingly important tools for studying pore-scale fluid dynamics. To further examine the precision of the experiment and evaluate the performance of numerical models in order to expand beyond experimental conditions, it is necessary to develop proper benchmark experiments.
emsp;emsp;In this work, a benchmark study is developed for gas-water two-phase flow through a pore-doublet geometry. Microfluidic experiments for a range of capillary numbers and fluid properties were performed and characterized using optical microscopy techniques. Subsequently, the experiments were numerically simulated using the interFoam and interFlow solvers in OpenFOAM, and the phase-field and level-set methods in COMSOL. The comparison enables us to systematically examine the impacts of modeling decisions (e.g., mesh resolution, model dimensionality) under a range of flow rates and wettability conditions. Finally, mineral dissolution was numerically simulated using CrunchFOAM, a solver based on OpenFOAM and coupled with the CrunchTope geochemical framework, to evaluate the subsequent impacts on geochemical reactions in two-phase systems.

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