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Benchmark for Investigating Coupled Hydro-Geochemical Processes with Gas Production

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Coupled mineral dissolution and precipitation processes with gas production are critical processes in energy subsurface systems, e.g., generating hydrogen gas during the anoxic corrosion of metallic nuclear waste canisters, during natural hydrogen degassing from serpentinized mafic rocks, and CO_2 sequestration in deep saline aquifers. However, the fate of exsolved gas within porous media remains poorly understood. The optimization of these systems relies on understanding underlying hydro-geochemical processes and a realistic system evolution description. Recent advances in multi-phase reactive transport models can predict the long-term behaviour of such systems [1, 2]. However, the challenge remains to describe the coupling between multi-phase flow, the chemical processes, and consequential changes to the transport properties of porous media (e.g., porosity, relative permeability). There is a need to develop experimental benchmarks providing a cross-scale understanding of coupled dissolution and precipitation with gas generation, test and improve implementations of reactive transport models in the description of such phenomena. In this context, we developed a 3D-reactive transport experiment on a macroscopic scale with a simplified chemistry investigating coupled dissolution of $BaCO_3$, producing CO_2, and precipitation of BaSO4. The water phase, gas production and transport were imaged by Nuclear Magnetic Resonance Imaging (MRI). SEM analysis revealed a significant pore structure modification through $BaSO_4$ precipitation in the pore space and on CO_2 bubble surfaces. Especially precipitates on the gas bubbles may influence transport properties significantly. These experiments provide a robust set of data to benchmark reactive transport models, and we currently concentrate on summarizing our results for setting up such a numerical benchmark.

[1] Ahusborde, E., Amaziane, B., de Hoop, S., El Ossmani, M., Flauraud, E., Hamon, F. P., ... & Voskov, D. (2024). A benchmark study on reactive two-phase flow in porous media: Part II-results and discussion. Computational Geosciences, 1-18.
[2] de Hoop, S., Voskov, D., Ahusborde, E., Amaziane, B., & Kern, M. (2024). A benchmark study on reactive two-phase flow in porous media: Part I-model description. Computational Geosciences, 1-15.

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References

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