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Investigating coupled mineral dissolution and precipitation processes with gas production in porous media using Magnetic Resonance Imaging

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Coupled mineral dissolution and precipitation processes with gas production are relevant processes in engineering subsurface systems, e.g., the anoxic corrosion of steel generating hydrogen gas in nuclear waste deep geological repositories or during groundwater remediation using permeable reactive barriers. 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 with a simplified chemistry monitored by time resolved Nuclear Magnetic Resonance Imaging (MRI). A Perspex reactor of 2 cm*0.5 cm*0.5 cm was filled with witherite ($BaCO_3$) sandwiched between two layers of quartz sand. An acidic solution with a low pH saturated with sulphate was injected into the reactor, driving the dissolution of $BaCO_3$, producing CO_2, and the precipitation of barite ($BaSO_4$). The water phase, gas production and transport were imaged by MRI. The effluent and differential pressure were monitored to estimate the total bulk mineral temporal evolution in the system and relative permeability, respectively. In situ measurements of pCO_2 and pH give insights on the gas production in the system. 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.