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Understanding the effect of mineral dissolution and precipitation reactions on permeability evolution using 3D printed reactive rock samples

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Mineral dissolution and precipitation reactions can alter the petrophysical properties of porous media, including porosity and permeability. However, predicting how reactions impact flow and transport in porous media is challenging. Permeability evolution is difficult to predict as it depends on the spatial distribution of reactions within the porous media which can largely vary and is not well understood. Natural rock samples are often used to observe these processes in lab experiments. However, samples are inherently heterogeneous, and experiments are non-repeatable on the same sample, which limits understanding of impacts of varying properties and parameters on reactions and permeability evolution. To resolve these limitations, 3D printed reactive porous media is explored here as a new way to examine porosity and permeability evolution due to mineral dissolution and precipitation reactions as it can represent and replicate natural rock heterogeneities. Here, 3D X-ray Computed Tomography (X-ray CT) images of sandstone pore structures are captured, segmented, and used as the basis for 3D printed sandstone pore structures. X-ray CT images of printed samples are collected and compared to real samples. 3D printed samples are then used in laboratory core-flood dissolution and precipitation experiments to discern the impacts of reactions on permeability evolution in a series of replica experiments with controlled parameter variation. Permeability evolution is inferred from monitoring the pressure differential across the sample, and time-lapsed 3D X-ray CT images are used to track the evolution of reactions and the pore structure. The outcome of this work will help to understand more precisely the changes of porosity and permeability from mineral dissolution and precipitation reactions in heterogeneous porous media.