Dynamic Imaging of Reaction at Reservoir Conditions Considering the Impact of Chemical and Physical Heterogeneities in Carbonates

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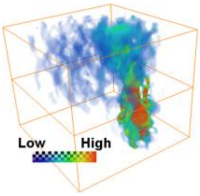

We develop a combined experimental and modelling approach to study how pore-scale dissolution occurs in different mineralogical settings represented by varying chemical and physical heterogeneity [1]. We use X-ray Microtomography (XMT) to image pore-scale in situ dissolution of carbonate rocks flooded with supercritical CO_2 ($scCO_2$) saturated brine at reservoir conditions. A Navier-Stokes flow solver was applied directly on the sequence of 3D images to calculate flow fields and the corresponding permeability changes incurred by the dissolution.

We study different mineralogical settings ranging from single to mixed mineralogy consisting of calcite and dolomite – the main idea is to vary physical (initial pore structures and associated velocity fields) and chemical heterogeneity. The mixed mineralogy cases looked at (a) composite core with a controlled spatial distribution of calcite and dolomite and (b) reservoir samples with random spatial distribution of the two minerals. It is found that varying chemical and physical heterogeneity can have a different impact on the effective reaction rates. However, mass transfer limitations cause the pore-scale effective reaction rates in all cases to be at least an order of magnitude lower than those measured in a batch experiment. The nature of dissolution can be time-dependent: evolving pore structure and velocity field heterogeneity can change the patterns from dissolution in a large number of higher-velocity channels throughout the rock volume to preferential dissolution occurring by widening of a single dominant channel. These observations have important implications on the coupled reactive transport behaviour that is normally found in natural carbonate aquifers where the effective reaction rates at the field-scale can differ by orders of magnitude from the batch reaction rates.

[1] Al-Khulaifi, Y., Lin, Q., Blunt, M. J., & Bijeljic, B. (2017). Reaction Rates in Chemically Heterogeneous Rock: Coupled Impact of Structure and Flow Properties Studied by X-ray Microtomography. **Environmental Science & Technology**.