Mixing-controlled reactive transport at the pore scale and its impact on flow field and upscaling of reactive transport

H. YOON[1*] AND T. DEWERS[1]

[1]Sandia National Laboratories, Albuquerque, NM 87123, USA (*correspondence: hyoon@sandia.gov)

Mixing-controlled pore-scale reactive transport

Dissolved CO_2 during geological CO_2 storage may react with minerals in fractured rocks or confined aquifers resulting in mineral precipitation and dissolution. Complex pore structures in reservoirs also influence flow complexities that can have a significant impact on coupled pore-scale phenomena including fluid dynamics in capillary systems, multiphase flow, and heterogeneous geochemical reactions. In this work, pore-scale experiments on transverse-mixing induced geochemical reactions in microfluidic pore networks (micromodel) are used as a basis for understanding coupled processes among hydrodynamics, transport, and reactions at the (sub) pore-scale. In particular, precipitation and dissolution dynamics affect the flow field, resulting in transient behavior of reactions. We will apply micro particle image velocimetry (μPIV) using laser scanning confocal microscopy for characterizing 3-D fluid velocities in dynamic precipitation and dissolution regimes. Pore-scale models of coupled fluid flow, reactive transport, and heterogeneous reactions are applied to account for transient 3-D experimental results of $CaCO_3$ precipitation and dissolution.

Upscaling of reaction rates

Response function of reaction rates will be constructed from pore-scale simulations which account for a range of reaction regimes characterized by the Damkohler and Peclet numbers under different pore configurations. Newly developed response functions will be used in a continuum scale model that may account for large-scale phenomena. In particular, this work is motivated by the observed CO_2 seeps from a natural analog to geologic CO_2 sequestration at Crystal Geyser, Utah where the lateral migration of CO_2 pathways was observed at a scale of ~ 100 meters over time. Implications for evaluating mineral precipitation patterns observed in natural analogues for CO_2 storage and leakage are discussed to link pore-scale processes to the field scale observations. Comparison of field observations and continuum-scale simulation results will provide mechanistic explanations of the lateral migration of CO_2 pathways.

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