

Microfluidics applications for calcium carbonate precipitation and dissolution and Sr isotopic fractionation

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Reactive flow and multicomponent transport in the subsurface environment is fundamental to understanding coupled multiphysics processes critical to various geoscience and environmental applications such as geologic carbon storage, subsurface energy recovery, and environmental fate and transport. In this work, experiments in microfluidic pore networks are used as a basis for understanding coupled processes among hydrodynamics, transport, and reactions at the (sub) pore-scale. CaCO₃ precipitation and dissolution dynamics affect the flow field, resulting in transient behavior of reactions. Pore-scale models of coupled fluid flow, reactive transport, and heterogeneous reactions are applied to account for transient experimental results of CaCO₃ precipitation and dissolution. In particular, various methods of estimating reactive surface area are evaluated using 2-D and 3-D imaging results of CaCO₃ precipitates in the microfluidics and 2-D and 3-D pore scale simulation results. Our preliminary results show that reactive transport in the microfluidic device can be quantitatively evaluated through multiscale imaging, and pore scale simulation results can account for dynamic relations between the evolution of reactive surface area, CaCO₃ phase stability, and local hydrodynamics. We run complementary batch and column experiments to address the dynamics of strontium (⁸⁶Sr/⁸⁷Sr/⁸⁸Sr) isotopic signatures during mineral dissolution-precipitation reactions, and reactive transport in single- and multi-mineral systems. A pore-scale model provides fundamental mechanistic explanations of how geochemical processes and pore-scale interfacial reactions will impact Sr isotopic fractionation.

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