



Mixing-induced dissolution in fingering reactive flow

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The evolution of porosity in carbonate reservoirs during CO₂ injection, and the wormhole formation in karst aquifers can be attributed to fast equilibrium reactions, which are characterized by large Damköhler numbers. Under these conditions the reaction rate is mixing-controlled, and can be quantified in terms of the mixing rate of the conservative components of the chemical system [De Simoni *et al.* (2005), *Water Resour. Res.*].

Here, we study the calcite dissolution during the convective-driven mixing of CO₂ in a carbonate saline aquifer. The CO₂-brine mixture is denser than the two initial fluids, leading to a Rayleigh-Bénard-type instability known as convective mixing, which greatly accelerates CO₂ dissolution. The dissolution front can display a stable or fingering shape depending on the relation of the governing forces.

We explore the feedback between fluid instabilities, porosity evolution, and permeability changes by means of numerical simulations of a CO₂ stationary layer dissolving into brine using an analogue-fluid system with a non-monotonic density-concentration curve [Neufeld *et al.* (2010), *Geophys. Res. Lett.*; Backhaus, *et al.* (2011), *Phys. Rev. Lett.*; Hidalgo *et al.* (2013), *Adv. Water Resour.*]. We derive an analytical expression for the speciation contribution to the reaction rate which is valid under a wide range of reservoir conditions (pH < 8.3). This allows us to analyze systematically the impact of conservative mixing mechanisms on the dynamics of the complex reactive flow system.

Our findings show how the developed porosity patterns depend on the fingering instabilities caused by the convective-driven dissolution of the CO₂, the movement of the receding CO₂-brine interface, and the properties of the chemical system.