

CO₂-brine solubility and the effects of salt precipitation during carbon dioxide injection through pore-scale network modeling.

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The goal of this study is to model alterations in brine saturation and permeability due to salt precipitation during the injection of supercritical carbon dioxide in deep saline aquifers for the purpose of carbon storage. Storage and sequestration of carbon dioxide in deep geologic formations represents a promising near-term solution for the reduction of atmospheric carbon emissions [1]. In this technique, carbon dioxide captured from large-scale emitters is injected at supercritical conditions into high-permeability porous rock formations, where it fills the porous space. However, a challenge remains in identifying the effects of salt precipitation during CO₂ injection, known as dry-out [2], on the solid rock matrix. Through this process, dissolution of CO₂ and brine between the two phases can lead to evaporation of brine near the injection front and the relative increase in salt concentration in the brine. If the increased brine concentration is above the solubility limit of the brine, salts could precipitate onto the rock surface, potentially blocking pores. This can reduce the injection site's permeability to CO₂ penetration, compromising the CO₂ injection process. An improved understanding and modeling of this mechanism could aid in mitigating its effects.

To study the effects of salt precipitation and pore blockage on pore-scale brine saturation and relative permeability changes in porous media, we begin with a two-phase quasi-static pore network model [3] modified to include grain distributions. We then apply a correlation to determine the mutual solubilities of CO₂ and water in chloride brines [4] to compute the water transport into the CO₂ phase near the injection site (high flow) and then model the reactive transport of carbonate and ionic species [5]. Precipitation of the salts will be described for salt concentrations above solubility limits in the brine [6]. We perform pore network simulations on a variety of geometries derived from stochastic reconstructions of porous carbonates, based on a published method [7], and compare the simulated saturation values to microfluidics experiments [8]. We also report relative permeability values over a range of salt concentrations and solid mineral types. The results of this work can be applied to develop pore-to-core upscaling of saturation- and relative permeability-porosity relationships for use in reservoir-scale continuum simulations.

References:

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