Intermediate scale testing and modeling for improving fundamental understanding of dissolution trapping in deep geologic formations

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Abstract. Geologic sequestration of carbon dioxide has gained increasing importance in recent years as way of reduction of direct emission to the atmosphere as a greenhouse gas. Reduction atmospheric loading is expected to slow down global warming and hence climate change. Goal of safe and successful sequestration in deep geologic formations is stable trapping and reduction of the risk of leakage. Trapping occurs through two mechanisms. First through capillary entrapment where the injected supercritical CO_2 as a liquid gets immobilized within the soil pores due to capillary effects. The second is through dissolution trapping where the entrapped CO_2 dissolves into the saline formation water and stays as a solute and also diffuses into low permeability zones when they exist. In the long term, trapped CO_2 will mineralize depending on the existing geochemical conditions. Basic issues related to capillary trapping have been investigated in reservoir engineering and in applications involving subsurface contamination from non-aqueous phase liquids (NAPLs). However, dissolution trapping of CO_2 has not received much attention. The goal of the research reported here is to conduct experimental and modeling investigations to improve our understanding of the dissolution of superficial CO_2 in heterogeneous formations after capillary trapping has occurred.
The experimental plan involves tests in small and intermediate scale tanks packed to represent different heterogeneous configurations. As a first test in the design of these experiments, research was conducted to select surrogate fluid combinations to be used in place of supercritical CO_2 and brine. These selected fluids were both tested in fluid/fluid mixtures and then in a test sand using a small tank to determine behavior in the porous medium. To better observe dissolution processes, the most suitable sand packing configuration was selected for the small tank. Samples taken from the tank were analyzed using Gas Chromatography to determine dissolved concentrations. Then, to determine effect of groundwater flow on dissolution, very low water velocities were simulated in the tank. A multiphysics numerical code COMSOL was used to conduct initial simulations to interpret the experimental data. The data from these small tank experiments will be used to develop models of dissolution kinetics and up-scaling experiments in intermediate scale tanks. These preliminary findings from the small tank experiments and modeling results will be presented.

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