



Implications of rock composition, brine composition and pressure/temperature conditions for CO₂ mineral trapping in deep saline aquifers

Peter Alt-Epping and Larryn W. Diamond

Rock-Water Interaction Group, Institute of Geological Sciences, University of Bern, Bern, Switzerland
(alt-epping@geo.unibe.ch, +41 31 631 4843)

The numerical simulation of the physical and chemical processes during and after the injection of CO₂ is a challenging task because of the complexity and the coupled nature of the physical/chemical phenomena. The dominant processes and the trapping mechanisms during and after the injection of supercritical CO₂ into a geological formation vary significantly over time. In the short term, the most important mechanisms of retaining CO₂ are the trapping of CO₂ under low permeability cap-rocks or sealing structures (hydrodynamic trapping) and residual trapping where CO₂ remains in the pore space at irreducible saturation. Over longer time-scales CO₂ dissolves into the brine (solubility trapping) and may then be involved in reactions with the minerals of the aquifer rock potentially leading to the precipitation of secondary carbonate minerals (mineral trapping). Mineral trapping is the safest and therefore most attractive form of sequestering CO₂ because it would immobilize CO₂ for long time scales.

Critical factors affecting the potential and efficiency of carbonate precipitation are the composition of the aquifer rock, pressure and temperature. The injection of CO₂ into a saline aquifer constitutes a perturbation of the undisturbed temperature and pressure conditions, and of the brine composition as CO₂ dissolves into the brine and generates acidity. These perturbations will induce a chemical disequilibrium between the brine and the aquifer rock and trigger mineral dissolution/precipitation reactions. These reactions in turn impact on the brine composition and therefore influence the potential, the processes and the distribution of post-injection carbonate precipitation.

Unlike the primary mineralogy of the aquifer rock, the temperature and pressure conditions at the base of the injection well can be controlled via the injection temperature and the injection rate at the wellhead. Ideally the pressure and temperature conditions in the aquifer promote mineral dissolution during injection, creating additional pore space and enhancing permeability and injectivity, and carbonate precipitation after injection when pre-injection pressure/temperature conditions are restored.

In a reactive transport study we explore in different injection scenarios favorable conditions for CO₂ mineral trapping. We are conducting simulations with the code PFLOTRAN (Hammond et al., 2010) to compare silicate and carbonate-dominated aquifer rocks in terms of their potential for post-injection carbonatization. We identify the processes, the timing and the regions of preferential carbonate precipitation. Furthermore we will explore how the injection temperature and injection rate affect mineral solubilities for different aquifer rocks and determine whether it is possible to optimize the injection temperature and the injection rate to enhance post-injection CO₂ mineral trapping.

REFERENCES

Hammond G E, Lichtner P C, Mills R T and Lu C 2010 , PFLOTRAN: Reactive Flow & Transport Code for Use on Laptops to Leadership-Class Supercomputers, in Ground Water Reactive Transport Models, Bentham Science Publishers Ltd