



Feasibility Study on the Combination of CO₂-storage and geothermal Energy Production

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It is widely accepted by the scientific community that greenhouse gases influence the world climate. Therefore, the reduction of CO₂ in the atmosphere is of paramount importance and various options for the sequestration of CO₂ have been proposed and discussed. In the project CO₂Trap, funded by the German Federal Ministry of Education and Research (BMBF under grant 03G0614A-C), we therefore develop, study and evaluate the approach to convert dissolved CO₂ into the geochemically more stable form of calcite in a reaction with calcium provided from the dissolution of anhydrite and alkalinity supplied by feldspars or fly ashes. The idea of CO₂ sequestration in deep saline aquifers itself is not new, but the costs related to it could be transformed into a benefit if combined with geothermal heat or power production.

The common arrangement of bore holes of a geothermal plant is the well doublet, consisting of one well for hot water production and one well for re-injection of the cooled and CO₂ enriched water. Anhydrite dissolves due to its retrograde solubility. This leads to a rising calcium concentration in the brine. If the pH is high enough, because of feldspar weathering or conditioning of the brine with fly ashes, calcite will precipitate and thus CO₂ is trapped as a mineral.

To assess the feasibility of this technology the following questions have to be answered:

1. Does the transfer of anhydrite into calcite work at all and what are the reaction rates?

2. What are probable alkalinity sources and how fast are they available? (see Back et al. this issue)

The transformation of anhydrite into calcite has been proven in laboratory experiments as well as by thermodynamic modelling. The reaction proceeds at pH values higher than approximately 5. First experimental results showed considerable calcite precipitation at pH values between 7 and 8. Furthermore, anhydrite dissolution kinetics are studied in laboratory experiments under boundary conditions equal to the ones in the reservoir. Experimental results indicate that the properties of the rock samples are important. These characteristics include the form of crystallisation, intrinsic impurities and crystal defects. The experiments concentrate on the influence of pH, salinity and ionic additives on the dissolution kinetics of anhydrite especially at saturation states close to thermodynamic equilibrium.

Numerical simulations are applied to investigate the whole process on multiple scales, from micro up to the reservoir scale. Focus for spatially related reactive transport simulations is to study the porosity-permeability feedback. Micro scale reactive transport simulations provide functionality in larger scale models to produce a tool for predictive reservoir management. Though first simulations show that anhydrite is not the major player from the chemical point of view, its dissolution with resulting pore space increase is important to balance pore space reduction through calcite and secondary silicate precipitation in the reservoir. Furthermore, the supply of alkalinity is of utmost importance to push the overall reaction towards the products. Buffering capacity is necessary for the transformation of anhydrite into calcite. Both options, in-situ alkalinity through plagioclase dissolution or surface water treatment using fly ashes, lead to calcite precipitation in the reservoir.