CO_2-H_2O-basalt interactions – reactive transport experiments and simulations

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Rapid CO_2 mineral trapping in basalt has been demonstrated in field[1], and in controlled laboratory experiments[2]. Although reactions are qualitatively well known, little is known about the dynamics of reacting mineral phases and the flow of CO_2-charged water in a pore network with rapidly changing geometries. Moreover, the outcome of reactive transport of CO_2 in basalt strongly depends on the kinetic/thermodynamic model used, and attempts to fit numerical models to reactive transport experiments are few.

In this study we demonstrate the extent of glass-mineral reactions, changes in porosity and permeability, and the spatial distribution of reaction products in a 1D column with progressive changes in pH and alkalinity along the flow line.

1D reactive transport simulations using PHREEQC v3 demonstrate that the balance between glass dissolution rate and choice of kinetic model for the mineral reactions strongly affect the spatial distribution of secondary phases. Assuming growth according to local equilibriumm, or a TST-type of kinetic equations, leads to rapid growth concentrated in a narrow region in the core. Using other kinetic growth models, including the slow-down of rates by non-stocihiometric solutions[3] leads to more diffuse mineralization fronts.

Preliminary laboratory experiments have demonstrated that smectites form together with calcium carbonate. Other carbonates have not been detected this far. The spatial distribution of the secondary phases and changes in the pore network geometry will be analyzed over the next months (April-May 2018), and kinetic models and parameters used in the numerical models will be tuned to fit the experiments.

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