



Modelling of fluid-rock interactions during a large-scale column experiment under reservoir conditions

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The understanding of CO₂-fluid-rock interactions is a key aspect of safe, geological storage, of CO₂. Here we compare coupled model (transport and geochemistry) results with experimental data to assess the model reliability. The study is based on a laboratory experiment conducted at high pressure and temperature. It consisted of a flow through experiment (Bateman *et al.*, 2005). A saline solution saturated with CO₂ (100 bar at 70°C) was injected into a large column filled with a synthetic mineral mixture representing a possible reservoir mineralogy.

The PHREEQC (Parkhurst and Appelo, 1999) numerical model was used with two objectives: (1) to test model ability to reproduce experimental data and (2) to determine how much detail needs to be included in the model in order to reproduce the experimental data.

The modelling did reproduce the experimental observations, and highlights the dissolution of calcite and dolomite at the column inlet, which was observed in the experiment (Bateman *et al.* 2005). The simulation suggests that aqueous silica is controlled by labradorite dissolution. Although no clearly identifiable secondary precipitates were observed, the modelling suggests that minor secondary precipitation may occur but is limited to dawsonite and to a lesser extent gibbsite. Initial modelling led to an overestimation of calcite and plagioclase dissolution, due to the uncertainties on the reactive surface area and kinetic rates for certain minerals, under the experimental conditions. Consequently, we adjusted the model by reducing the surface area (equivalent to reducing the kinetic rates) of calcite and alumino-silicate two-fold in order to obtain a better fit.

This study illustrates the important reactivity of carbonates and confirmed the ability of geochemical modelling to reproduce the mechanisms involved. Minor minerals have a small effect on the geochemistry, and a simplified mineralogical model can be used to match the experimental data. Silicates have slow dissolution kinetics under the experimental conditions, this experiment seems to be too short and the temperature too low to elucidate silicate interactions. These silicate interactions are important on the long term in reservoirs for large-scale CO₂ storage projects. Thus, for future experiments it would be useful to focus on generating silicate reactions and the accurate determination of silicates reaction rates.

The work described forms part of joint research project carried out within CO₂GEONET, the European Network of Excellence that focuses on the geological storage of CO₂.

Bateman K., Turner G., Pearce J.M., Noy D.J., Birchall D., Rochelle C.A., (2005) - Large-scale column experiment: study of CO₂, porewater, rock reactions and model test case. *Oil and Gas Science and Technology – Rev. IFP*, 60, pp.161-175.

Parkhurst D.L., Appelo C.A.J. (1999) – User's guide to PHREEQC (Version 2) – A computer program for speciation, batch-reaction, one-dimensional transport, and inverse geochemical calculations. *U.S. Geological Survey Water-Resources Investigations Report 99-4259*, 310 p.