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Using CO_2-charged seawater for carbon storage in basalts – Experimental insights

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Geological carbon storage by subsurface injection of CO_2 dissolved in freshwater has been applied for several years on industrial scales in the CarbFix project in Iceland at the Hellisheiði geothermal power plant. Release of cations from basalt dissolving in the initially slightly acidic fluid allows subsequent preciptation of stable carbonate minerals, leading to save and long-term storage of the CO_2.

To expand this method beyond locations where freshwater is readily available, such as dryer climates and offshore, work is being carried out to adapt the CarbFix method for co-injection of the CO_2 with seawater due its significantly different chemistry compared to freshwater.

We will report on laboratory experiments where CO_2-charged seawater was reacted with basaltic glass for up to 8 months to study the evolution of the fluid chemistry and solid alteration products as function of parameters such as time, pCO_2, water/rock ratio, seawater composition, and presence of seed crystals. The closed system experiments were conducted in stirred Ti reactors at 130 °C. Precise monitoring of the pressure allows to constrain the fluid CO_2 system together with alkalinity measurements. The reacted fluid was sampled *in situ* at the end of the experiments before quenching and retrieval of the solids.

The reacted seawater chemistry shows increases in the initially acidic pH to *in situ* values of around 5.7 along with increases in alkalinity, Si, and Ca, indicating basalt dissolution. Experiments run for several months show strong decreases of seawater Mg concentrations and alkalinity, which can be linked to clay precipitation. Electron microscopy shows abundant clay mineral formation on top of the dissolving basaltic glass along with minor amounts of anhydrite, which precipitates due to the increase in seawater Ca concentrations.

Thermodynamic calculations indicate that the reactive fluid is at or above saturation with respect to most carbonate minerals, including calcite, magnesite, dolomite, ankerite, and siderite, at the end of the experiments. Analyses of total inorganic carbon (TIC) in the reacted solids (rinsed, to clean off any remaining seawater), indicate small but significant amounts of carbon in samples reacted for several months. These analyses show that up to ~ 24% of the CO_2 initially present in the reactor were mineralized at 130 °C over the timespan of up to 5 months.