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Geochemical interactions between CO_2 and minerals within the Utsira caprock:

A long-term experimental study

Keith Bateman, Christopher Rochelle, Gemma Purser , Simon Kemp, Doris Wagner, and Antony Benham
British Geological Survey, Keyworth, Nottingham NG12 5GG, United Kingdom (kba@bgs.ac.uk)

During the underground storage of carbon dioxide (CO_2) in deep saline formations, the containment of CO_2 will be crucially dependent on the integrity of seals above the CO_2. These seals could be natural (e.g. a clay-rich caprock) or man-made (e.g. the engineered seals around a borehole). It is important therefore, to assess how the CO_2 might impact these seals, as this could ultimately control the longevity of CO_2 storage. We have undertaken a long-term experimental study focused on the geochemical reactions between CO_2, synthetic porewaters and caprock material from the Sleipner field.

The experiments utilised samples of disaggregated Utsira caprock, together with synthetic formation waters based upon measured compositions. The experimental conditions were representative of the *in-situ* environment (30˚C, 8 MPa). Experiments were pressurised with either nitrogen (N_2) or CO_2. The former provided a 'non reacting' reference point from which to compare the reactive CO_2 experiments.

Short-term experiments using disaggregated Utsira caprock were ran for up to 14 months. Those without CO_2 showed little or no reaction, indicating that the synthetic Utsira porewater used in the experiments was a reasonable approximation for the actual *in-situ* porewater composition. However, the experiments using high-pressure CO_2 were dominated by carbonate mineral dissolution. Dissolved Ca concentrations, showed a rapid increase within the first few weeks to about 1400 mg l^{-1}. This reflects the acidification of the synthetic porewater, with CO_2, and subsequent carbonate mineral dissolution. The fluid chemical data indicate that over two thirds of the calcite present in the mudstone caprock dissolved in the experiments, with mineralogical analyses possibly indicating even larger decreases (from 3.2-4.0% to 0.7% or less). Most of the calcite is present as shell debris in the Utsira caprock mudstone, and the observed reduction in calcite content is consistent with the dissolution of these. We found no evidence for the formation of secondary precipitates such as Ca/Mg/Fe carbonates or dawsonite.

Long duration experiments ran for up to 7 years, and these confirm the shorter-term observations. The experiments pressurised with N_2 showed little or no reaction. Reactions in experiments involving high-pressure CO_2 were dominated by carbonate mineral dissolution. Fluid chemical data from the long duration tests confirm previous findings that over two thirds of the calcite in the mudstone caprock dissolved, and dissolved Ca concentrations remained at about 1400 mg l^{-1}. No definitive evidence of other changes in mineralogy (including clay mineralogy, could be identified in either the CO_2-pressurised or N_2-pressurised experiments.

In terms of the overall impact of storing CO_2 at Sleipner, the results from these experiments show no indication of major deleterious, geochemical, reaction processes occurring with the caprock. The only process identified was some dissolution of carbonate phases when CO_2-rich fluids contact the caprock.