Geophysical Research Abstracts
Vol. 12, EGU2010-10410-1, 2010
EGU General Assembly 2010

Long-Term CO_2 Exposure Experiments – Geochemical Effects on Brine-Saturated Reservoir Sandstone

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The injection of CO_2 into deep saline aquifers is the most promising strategy for the reduction of CO_2 emissions to the atmosphere via long-term geological storage. The study is part of the CO_2SINK project conducted at Ketzin, situated 40 km west of Berlin. There, food grade CO_2 has been pumped into the Upper Triassic Stuttgart Formation since June 2008. The main objective of the experimental program is to investigate the effects of long-term CO_2 exposure on the physico-chemical properties of the reservoir rock. To achieve this goal, core samples from observation well Ktzi 202 have been saturated with synthetic brine and exposed to CO_2 in high quality steel autoclaves at simulated reservoir P-T-conditions of 5.5 MPa and 40 ˚C. The synthetic brine had a composition representative of the formation fluid (Förster et al., 2006) of 172.8 g/l NaCl, 8.0 g/l $MgCl_2 \cdot 2H_2O$, 4.8 g/l $CaCl_2 \cdot 2H_2O$ and 0.6 g/l KCl. After 15 months, the first set of CO_2-exposed samples was removed from the pressure vessels. Thin sections, XRD, SEM as well as EMP data were used to determine the mineralogical features of the reservoir rocks before and after the experiments. Additionally, NMR relaxation and MP was performed to measure poroperm and pore size distribution values of the twin samples.

The analyzed samples are fine- to medium grained, moderately well- to well sorted and weakly consolidated sandstones. Quartz and plagioclase are the major components, while K-feldspar, hematite, white & dark mica, chlorite and illite are present in minor and varying amounts. Cements are composed of analcime, dolomite and anhydrite. Some samples show mm- to cm-scale cross-beddings. The laminae comprise lighter, quartz- and feldspar-dominated layers and dark-brownish layers with notably less quartz and feldspars. The results are consistent with those of Blaschke et al. (2008).

The plagioclase composition indicates preferred dissolution of the Ca-component and a trend toward albite-rich phases or even pure albite during the experiments. Additionally, XRD data suggest anhydrite dissolution in the course of CO_2 exposure. The chemical evolution of the brine displays increasing Ca^{2+} concentrations (Wandrey et al., 2010) in line with the preferred dissolution of the anorthite component of plagioclase. SEM photomicrographs show corrosion textures on mineral surfaces of, e.g., plagioclase. The petrophysical properties of the sandstone samples also suggest slight changes. NMR and MP data indicate a slightly increased porosity and a shifting to larger pore sizes.

The physico-chemical measurements imply (i) Ca^{2+} dissolution from the rock by the fluid, and (ii) slightly increasing porosity, but decreasing permeability. However, additional evaluation is still needed to interconnect the changes suggested to occur during CO_2 exposure and to better understand CO_2-brine-rock interactions. Supplementary core samples have been removed from the pressure vessels after 21 and 24 months and will soon be analyzed. Further core fragments will remain in storage in the autoclaves for longer-term experiments.

References

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