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Mineral-microbial interaction in long term experiments with sandstones and reservoir fluids exposed to CO_2

Monika Kasina, Daria Morozova, Linda Pellizzari, and Hilke Würdemann
Helmholtz Centre Potsdam, GFZ German Research Centre for Geosciences, 14473 Potsdam, Germany

Microorganisms represent very effective geochemical catalysts, and may influence the process of the CO_2 storage significantly. The goal of this study is to characterize the interactions between minerals and microorganisms during their exposure to the CO_2 in a long term experiment in high pressure vessels to better understand the influence of biological processes on the composition of the reservoir sandstones and the long term stability of CO_2 storage. The natural gas reservoir, proposed for the CO_2 storage is characterized by high salinity (up to 420 g/l) and temperatures around 130°C, at depth of approximately 3.5 km.
Microbial community of the reservoir fluid samples was dominated by different H_2-oxidising, thiosulfate-oxidising and biocorrosive thermophilic bacteria as well as microorganisms similar to representatives from other deep environments, which have not previously been cultivated. The cells were attached to particles and were difficult to detect because of low cell numbers (Morozova et al., 2011).
For the long term experiments, the autoclaved rock core samples from the core deposit were grinded, milled to the size of 0.5 mm and incubated with fresh reservoir fluids as inoculum for indigenous microorganisms in a N_2/CH_4/H_2-atmosphere in high pressure vessels at a temperature of 80°C and pressure of 40 bars. Incubation was performed under lower temperature than in situ in order to favor the growth of the dormant microorganisms. After three months of incubation samples were exposed to high CO_2 concentrations by insufflating it into the vessels. The sampling of rock and fluid material was executed 10 and 21 months after start of the experiment.
Mineralogical analyses performed using XRD and SEM – EDS showed that main mineral components are quartz, feldspars, dolomite, anhydrite and calcite.
Chemical fluid analyses using ICP-MS and ICP-OES showed that after CO_2 exposure increasing Si^{4+} content in the fluid was noted after first sampling (ca. 25 relative %), whereas after the second sampling it decreased (to 31 relative %) in comparison to the reservoir fluid sample. This may suggest dissolution of silicate minerals at first, and secondary precipitation at second stage of experiment. In addition, immobilization of heavy metals dispersed within silicate minerals was also detected. An increase of Ca (3.2 up to 13% relative), SO_4 (up to 14 relative %) and Fe_{tot} (47 and 24% relative) were also detected after first and second sampling respectively and may suggest dissolution of cements and iron rich minerals. The concentration of organic acids increased relatively by 12.5 % and 25% after first and second sampling respectively might be an indication for metabolic activity of microorganism or an effect of mobilisation due to CO_2 exposure.
The presence of newly formed mineral phases was detected using SEM-EDS. Quartz, albite and illite precipitation is a common process in all studied samples. However only illite is considered to be of bacterial origin, nevertheless its crystallization can also occur as a consequence of inorganic diagenetic processes.
Further analyses of the microbial community composition, quantity and activity will bring a more insight into the CO_2 exposure processes.

Daria Morozova, Dagmar Kock, Martin Krüger, and Hilke Würdemann. Biogeochemical and microbial characterization of reservoir fluids from a gas field (Altmark). Geotechnologien 2011