Experimental study of mineral-microbial interaction to investigate the effects of CO_2 storage

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The influence of biological processes on the composition of reservoir sandstones the interactions between fluids and minerals are monitored during exposure to CO_2 in long-term experiments. Samples from the core deposit were incubated with fresh reservoir fluids as inoculum for indigenous microorganisms in a $N_2/CH_4/H_2$-atmosphere at a temperature of 80ºC and a pressure of 40 bars for half a year. Afterwards the samples were exposed to supercritical CO_2. Incubation was performed under lower temperature than in situ conditions to create more favourable growth conditions for microorganisms.

Analyses of the downhole fluids taken from a reservoir well using genetic fingerprinting methods (PCR SSCP and DGGE) revealed different DNA sequences indicating the presence of H_2-oxidising, biocorrosive thermophilic bacteria, thiosulfate-oxidising bacteria as well as some microorganisms similar to representatives from other deep environments, which have not been cultivated previously. Given a high temperature (120 – 127°C) and high salinity (up to 420 g/l) of fluids, the cells were difficult to detect because of very low numbers. The analysis of rock and fluid material from the long-term experiment after 11 and 31 months of incubation with CO_2 indicated the dissolution of major minerals and cements present in the sandstones, and secondary precipitation of new mineral phases such as quartz, albite, gypsum, halite, iron oxides and clay minerals. Changes in organic acid concentration and the release of organic components might indicate a metabolic activity of microorganisms or a mobilisation due to CO_2 exposure.

Slight indication of microbial activity like EPS formation was detected: Calcofluor white staining of carbohydrates indicates the presence of biofilms. We assume that changes observed in the samples until now were related mainly to CO_2 exposure and fluid-rock interaction. In the next steps, samples will be fed with H_2 to enhance microbial growth and molecular biological analyses will be used to characterise the changes in the biocenosis due to CO_2 and H_2 exposure.

What caused the rise of atmospheric O_2?

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Oxygenic photosynthesis appears to have evolved well before O_2 levels increased in the atmosphere, at around 2.4 Ga. This has led to numerous suggestions as to what may have kept O_2 suppressed and then eventually allowed it to rise. These suggestions include changes in the recycling of carbon and sulfur relative to water (or hydrogen), a switch from dominantly submarine to dominantly subaerial volcanism, gradual oxidation of the continents and a concomitant decrease in reduced metamorphic gases, a decline in deposition of banded iron-formations, a decline in nickel availability, and various proposals to increase the efficiency of photosynthesis. Several of these different mechanisms could have contributed to the rise of O_2, although not all of them are equally effective. To be considered successful, any proposed mechanism must make predictions that are consistent with the carbon isotope record in marine carbonates, which shows relatively little change with time, apart from short-lived (but occasionally spectacular) excursions. The reasons for this constancy are explored here, but are not fully resolved. In the process of making these comparisons, a self-consistent redox balance framework is developed which will hopefully prove useful to others who may work on this problem and to astronomers who may one day try to decipher spectral signatures of oxygen on Earth-like exoplanets.

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