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Analysis of biomolecules and microbial transformation products in gas field formation waters and in laboratory experiments simulating geological storage of carbon dioxide

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RECOBIO-2, part of the BMBF-Geotechnologien-funded research area on technologies for a sustainable storage of carbon dioxide in geological formations, investigates the presence of microbes in potential CO_2 storage units and the effects of microbial activity on geological CO_2 storage unit properties. Formation water was sampled form two natural gas field sites (Schneeren and Altmark; both operated by GDF SUEZ E&P Germany GmbH). Rock material was obtained from exploration drilling cores of both gas fields (GDF archives).

For both gas fields, molecular biological analysis revealed the presence of microorganisms, among which autotrophic bacteria and archaea, able to transfer CO_2 into organic carbon (Ehinger et al., 2009; Gniese et al., 2010). Formation fluids contain dissolved organic carbon in the range of 70 to 150 mg/l (occasional up to 1 g/l), dissolved inorganic carbon (several tenths mg/l in Schneeren and several hundred mg/l in Altmark gas field) and dissolved hydrogen (up to 3 μmol/l in Schneeren and up to 0.1 mmol/l in Altmark gas field). Up to 50 % of the total dissolved organic carbon was identified and qualified by single compound analysis. It comprises carbonic acids (mostly formic and acetic acid), alcohols (methanol, ethanol), methane, amino acids (free and in peptide bonds) and sugars (polysaccharides). Furthermore, formation water ethylacetate extracts contain elemental sulphur, linear and branched alkanes, dicarbonic acids and fatty acids.

To reveal possible autotrophic microbial CO_2 turnover processes, autoclave experiments at elevated pressure and temperature conditions using microbial active formation fluids, milled formation rock materials and mixed N_2-CO_2-H_2-gas phases were conducted (Muschalle et al.,). The experiments with Schneeren field site materials showed a considerable CO_2 consumption accompanied with a rise in DOC-concentrations of the fluid phase from 70 mg/l to 2.7 g/l. Carbonic acids and alcohols were present in the same proportion like in the formation waters prior to incubation. Accordingly, the content of elemental sulphur, linear alkanes and fatty acids in the ethylacetate extracts of the fluid phase increased. At some sampling dates, sugar and amino acid concentrations of several tenths mg/l were detected. After the experiments, the incubated rock material was analyzed for proteins and polysaccharides using fluorescence microscopy. Protein covers of particle surfaces developed during incubation and were visualized by DTFA staining. Associated to protein films, polysaccharide and calcium accumulations were detected using calcofluor white and calcein stains. Interestingly, no carbonates could be extracted from the incubated rock material using sequential extraction techniques. This fact strengthens the hypothesis of autotophic microbial CO_2 turnover into organic material during geological CO_2 storage.

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