Microbial activity in gas field fluids and in laboratory experiments simulating geological CO_2 storage

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Microbial activity in gas field fluids from two natural gas fields in Germany was assessed for evaluation of possible biochemical transformation of injected CO_2. 16S rDNA clone library construction revealed the presence of bacteria (*Thermoanaerobacterium* sp., *Petrotoga* sp. *Desulfotomaculum* sp.) in both gas fields and archaea (*Methanolobus, Methanoculleus*) in one gas field [1]. Gas field fluids of both fields contain free amino acids, polysaccharides, carbonic acids (formic acid, acetic acid) and alcohols (methanol, ethanol). Bio-molecules and metabolites form 25 to 50% of the total dissolved organic carbon of 2 to 10 μM. Moreover, both gas field fluids contain 0.1 to 250 μM dissolved H_2.

Laboratory experiments for simulation of geological CO_2 storage were conducted in high-pressure reactors (autoclaves) for 6 to 12 months. Gas field fluids and milled rock material from exploration drilling cores were reacted at p_{CO2}=6.5 bar, p_{H2}=3.5 bar, p_{N2}=4 bar and T=40°C. During the experiments, cell numbers of the reactor fluids rose and CO_2 and H_2 were consumed. DOC concentrations increased up to several hundred mM, while its composition remained comparable to the gas field fluid DOC. For one gas field, sulphate reduction was observed. Fatty acids, saturated hydrocarbons and elemental sulphur (in sulphate reducing systems) were detected in the sediments after the experiment. Fluorescence microscopy was used for visualisation of polysaccharides, proteins and calcium in the sediment samples. Both protein-calcium and polysaccharide-calcium associations were detected. REM-EDX analysis revealed biogenic sulphides and carbonates in sulphate reducing systems. Microbial activity at simulated CO_2 geological storage resulted in elevated concentrations of dissolved organic carbon, production of EPS and precipitation of biogenic minerals and thus might influence CO_2-storage capacities and rock physical properties of CO_2 storage units.

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Analysis and application of water-rock-CO_2 reaction using basalt to underground CO_2 sequestration

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Water-rock-CO_2 reaction attract attention in many parts of science. It consists of three following reactions:

$CO_2 + H_2O = H_2CO_3 = H^+ + HCO_3^-$ (1)
$MSiO_3 + 2CO_2 + H_2O = M^{2+} + H_4SiO_4 + 2HCO_3^-$ (2)
$M^{2+} + 2HCO_3^- = MCO_3 + CO_2 + H_2O$ (3)
where M is bivalent metal ion.

There are two steps. First, CO_2 dissolves in the water by (1) or mineral and water react CO_2 by (2). Next, bivalent metal ion and hydrogen carbonate ion generate and carbonate minerals (MCO_3) precipitate by (3).

We are applying them to the CO_2 underground sequestration and the estimate of atmospheric CO_2 concentration of Archean and formation of mineral water, and global carbon cycle in earth system. In this paper we will focus on CO_2 underground sequestration based on experimental water-basalt-CO_2 reaction and computer simulation.

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