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Hydrogen-driven microbial redox reactions in deep geosystems relevant for hydrogen storage

M. Krüger, A. Dohrmann
Bundesanstalt für Geowissenschaften und Rohstoffe (BGR), Geochemie der Rohstoffe, Hannover, Germany

In the subsurface, biotic and abiotic processes can generate and consume hydrogen. Hydrogen has a low reduction potential and is thus a highly energetic electron donor when involved in sulfate, carbon dioxide or ferric iron reduction. Although known as important drivers for the deep biosphere, the contributions of different processes to hydrogen turnover in different geosystems still are not well understood. In context with the ongoing transformation to renewable energy resources, underground H_2 storage (UHS) in deep porous or salt cavern systems came into focus. In situ microbial and geochemical reactions that consume H_2 are highly relevant topics in deep biosphere research, and also are still a major uncertainty during UHS.
Consequently, we studied the potential microbial hydrogen oxidation rates – combined with the possible production of metabolic products like H_2S, acetic acid or CH_4 - in formation fluids from natural gas fields and salt caverns, thereby considering the importance of *in situ* pressure and temperature conditions, fluid chemistry and mineral composition. In addition, more defined experiments were conducted with selected pure cultures representing important metabolic groups of deep biosphere microorganisms.
Several original formation fluids showed immediate H_2 consumption. Microorganisms oxidized hydrogen at relevant *in situ* pressure conditions (up to 100 bar) and tolerated dynamically changing pressure and temperature conditions. The microbial hydrogen oxidation rate was strongly dependent on H_2 partial pressures and the availability of e.g. sulfate as a terminal electron acceptor. Added core material also had a stimulating effect on microbial hydrogen consumption and survivability. High-throughput sequencing of 16S rRNA gene amplicons indicated hydrogen oxidation by sulfate reducing bacteria to be the presumed process in the studied porous rock reservoir fluids. In addition, hydrogen turnover by methanogenic, sulfate-reducing, acetogenic as well as iron-reducing microorganisms was investigated with defined microbial cultures.