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Experimental study of microbial effects on anhydrite and cement during hydrogen storage in salt caverns.

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Although a number of studies have been carried out, especially in recent years (e.g., Hemme and van Berk, 2018), to evaluate the chemical-physical influences of hydrogen storage in underground salt caverns, many questions still need to be answered. Because of the lack of reliable data on the effect of hydrogen on permeability and mechanical integrity in the critical lithologies, such as anhydrites, sump sediments, or the casing cements, as well as information on the kinetics of abiotic geochemical and microbial reactions in the corresponding pore fluids, predictions on the long-term behaviour of geological hydrogen storage are only possible to a limited extent. For this, knowledge about the volumetric extent and kinetics of the reactions is essential. Experimental work and microstructural analyses is required to determine the input parameters for the geochemical models on the different reaction kinetics.

We will present the first results of an experimental study demonstrating kinetics of biotic and abiotic reactions of H_2 and H_2S with anhydrite and casing cement, taking into account for instance the bacterial growth and reduction rate, the brine volume and sulfate concentration, pressure and temperature. Our objective is to visualize the known but also the unknown processes occurring, which may affect the mechanical integrity of salt cavern during hydrogen storage at various scales, by microstructural analyses. It can be assumed, that the reactions are challenging to constrain in a laboratory experiment due to slow rates, however, microstructural investigations allow the determination of the onset and development of the chemical alteration of the materials already at a relatively early stage down to the submicron pore scale.

In the first step, the sample material (anhydrite and cement) was investigated using a range of established microanalytical techniques and methods to assess the microstructure, pore space and mineralogy at high resolution and accuracy (e.g., Klaver et al., 2015, Jiang et al., 2021). Considering the low permeability, of anhydrite/polyhalite, these samples were artificially fractured before assembly in the flow cell to enlarge the surface area. The experiments are designed in a way, that they allow assessing the effect of biomass accumulation on hydraulic conductivity, as well as the bacterial sulfate reduction. After completing the investigation, microbial activity, changes in pore space due to biofilm formation, and the mineralogical changes in the solid phases were studied ex-situ using scanning electron microscopy on the sample surfaces polished with a broad ion beam under cryogenic condition (Schmatz et al., 2015, Pötschke et al., 2022). The method enables the visualization (of the onset) of the biological, chemical and structural changes in the sample material and opens up the possibility for upscaling the processes.

Participation

In-Person

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