Interactions between chemical inhibitors, scale formation, corrosion and microbes at geothermal plants

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Chemical inhibitors are used to prevent scale formation and corrosion that adversely affect the reliability and economic efficiency of geothermal plants. However, knowledge about inhibitor efficiency with respect to chemical fluid composition, temperature and fluid abundant microorganisms is required. In addition, to be sufficiently effective, inhibitors have to be stable in the geothermal plant and the near wellbore area but for ecological reasons also degradable. Since microorganisms, such als sulfate reducing bacteria (SRB), are involved in scaling and corrosion processes, the influence of the inhibitor supply on the microbial community composition should be investigated.

Thus, lab-scale experiments with fluid samples from different geothermal plants in Germany were performed. As fluids from the North German Basin, the Upper Rhine Graben and the Molasse Basin have a significantly different chemical fluid composition that leads to a region-specific formation of scales, different inhibitors were tested. In order to investigate the interactions between microbes and reservoir rock material, fluids were incubated with rock material from outcrop analogues.

First results show the degradability of the supplied inhibitors that was indicated by the production of CO_2 in the gaseous phase of the vessels. Particularly, a correlation between the CO_2 yield and the inhibitor concentration illustrated the substrate-dependent activity of microorganisms.

The influence of inhibitor supply on the microbial community composition in fluids was shown for a bypass system at a geothermal plant in the Styrian Basin. At this plant, supply of a nitrate-based inhibitor led to a reduced diversity and abundance of SRB and a higher abundance of nitrate reducing bacteria. This corresponded to a reduced content of corrosive H_2S in fluids.

3D fluid distribution in subducted slabs: new constraints on H_2O cycling

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Large amounts of H_2O are carried into trenches via subduction of the sediments, basaltic crust and uppermost mantle that make up the oceanic lithosphere. A major question is how much of this subducted H_2O is released into the overlying mantle wedge, promoting melting, and how much is carried deeper into the mantle. This depends, at least in part, on whether H_2O is able to form an interconnected network among the mineral grains that make up the rock down to very low fluid fractions. In order to achieve connectivity and allow the fluid phase to escape, a minimum amount of fluid (critical porosity) is required when dihedral angles are more than 60 degrees. We investigated the distribution of seawater in simplified sediment analogs (i.e. quartz for siliceous sediments; calcite for carbonate sediments), in natural clays (kaolinite and montmorillonite) and in bulk eclogite. Experiments were performed in a piston-cylinder apparatus at 2 GPa and 650°C. Fluid fractions ranged from ~10% to ~1% to determine the porosity at which connectivity of the seawater network is lost for each rock type.

We used synchrotron X-ray microtomographic techniques (at Argonne National Laboratory, IL) to obtain 3-D images of the pore space network in order to constrain the grain scale distribution of fluids in a subducted slab. This nondestructive 3-D imaging technique has a spatial resolution of 0.7 µm and provides quantitative information on geometrical parameters of fluid topology, such as porosity, dihedral angle distribution, fluid channel sizes and connectivity. The geometrical parameters were extracted using the VSG Avizo® software. This study lays the groundwork for determining the 3-D grain scale distribution of fluids in a range of subducted lithologies. Results from this study provide important new insights into the amount of fluid that can be transported into the deep mantle by subduction.

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