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Modeling abiotic H2 generation in the Soultz-sous-Forêts geothermal system, Rhine Graben, France

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In the last years, investigations on H2 abiotic generation has been developed in order to better understand the process of H2 generation in natural reservoirs as a clean alternative source of energy. Most of these investigations are related to modeling and laboratory experiments of mafic and ultra-mafic rocks and its serpentinization process, where the source of H2 is linked to the oxidation of Fe(II) bearing minerals and reduction of H+. In this study we use geochemical and reactive transport modeling to investigate the possibilities of abiotic H2 generation from a rich biotite granite in the basement of the Soultz-sous-Forêts geothermal site located in the Upper Rhine Graben, west of France.

The Soultz-sous-Forêts geothermal site is an Enhanced Geothermal System with a high local thermal gradient where deep wells (≈5000 m depth) were drilled penetrating the granite basement creating a heat exchanger to produce electricity. The basement is made up of a massive granite with different petrographic types, very rich in biotite and amphibole, and different grade of fractured and hydrothermal alteration that host a high salinity Na-Cl brine at temperatures up to 200˚C. Previous measurements of gases in the Soultz-sous-Forêts boreholes reported values in a range of 0.25 – 46.3% vol. of H2. These values are still not well understood and are mainly linked to reactions within the casing tube and the brine.

Our investigations indicate that the generation of abiotic H2 can be possible in the granite by hydrothermal alteration of the biotite as a source of Fe(II), which oxidizes to Fe(III) leading to the precipitation of ferric iron minerals and reduction of H+ under low redox conditions at different temperatures. Moreover, the presence of CO_2 in the system can favor the reactions and control the pH and redox conditions.