

Formation of zeolites in sandstone-brine interaction experiments under geothermal conditions

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Enhanced geothermal systems (EGS) use open hole circulation, where hot, highly saline brines react with the reservoir rocks. Sandstone formations are one of the favourable targets because of its often high matrix permeability and even higher fracture permeability. Geochemical-mineralogical reaction of the highly saline brine with the reservoir sandstone could result in a change of the permeability with high impact on the geothermal circuit.

To understand the kinetic of rock-brine reactions arkosic sandstone samples with a fresh surface, representing fracture surfaces, have been treated with two molar Na-Cl, Na-Ca-Cl, or Ca-Cl solutions in batch-type experiments at 200 °C, and ~16 bar, in time series up to 60 days duration.

Depending on the experimental solution different zeolite phases formed during the experiments. The zeolite formation consumes clay minerals from the sandstone cementation and quartz from the clasts. Alkali cations for zeolite formation are provided from the solutions. Thus, type of zeolite phases and their chemical compositions depend strongly on the fluid composition. Accordingly, analcime precipitate in the experiments with pure Na-Cl solution close to its ideal composition of $\text{NaAlSi}_2\text{O}_6 \times \text{H}_2\text{O}$. In the experiments with Na-Ca-Cl solution analcime and wairakite (ideal: $\text{CaAl}_2\text{Si}_4\text{O}_{12} \times 2 \text{H}_2\text{O}$) were formed. Here, analcime incorporates elevated amounts of Ca, and wairakite relatively high amounts of Na. In the pure Ca-Cl experiments, wairakite and epistilbite ($\text{CaAl}_2\text{Si}_6\text{O}_{16} \times 5 \text{H}_2\text{O}$) have formed on the sandstone surface. Both chemical compositions are nearly ideal.

Consequently, type and composition of zeolite phases can provide information about the temperature, pressure and fluid composition in the reservoir. Cation ratios in the zeolites give evidences of the fluid with which they have reacted. Since the reaction rate of zeolites is rather fast, changes in fluid composition will result in a rapid re-equilibration of the solids.

The reaction of the sandstone with the reservoir-like brine result in the formation of new zeolite phases, which can have a high impact on the permeability of a geothermal circuit and therefore for the live time of a geothermal installation.