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Long-term flow-through petrophysical experiments on geothermal reservoir rocks: An assessment of risk potentials during reservoir stimulation and exploitation.

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In the course of stimulation and fluid production the chemical fluid-rock equilibrium of a geothermal reservoir becomes disturbed by either temperature changes and/or an alteration of the fluid chemistry. Consequently, dissolution and precipitation reactions could be induced that result in permeability damage. In connection with the investigations at the deep geothermal doublet Groß Schönebeck (GrSk 3/90 and 4/05) complementary laboratory based research is performed. The latter addresses such effects under conditions that simulate the physical, geological, and geochemical setting at this site within the Northeast German Basin 50 km north of Berlin, Germany: an effective pressure of approximately 60 MPa, a temperature of 150°C, and Lower Permian (Rotliegend) sandstone saturated with Ca-Na-Cl type formation fluid with a high salinity (TDS) of 265 g/L. For this purpose two identical HPT-permeameters have been set up that are capable of maintaining in-situ conditions pertinent to deep geothermal systems over periods of months while in the same time allowing a variety of continuous petrophysical investigations. Specifically, the use of corrosion resistant parts enables experiments involving highly saline formation fluids. Rock permeability, electrical conductivity as well as p- and s-wave velocities can be determined and the fluid can be sampled under pressure for further chemical analysis. Continuous flow experiments, so far have been performed over a maximum of 6 months. Thus, stable

physical conditions have been maintained over periods that are significantly longer than those usually attained in conventional laboratory-based petrophysical testing. In detail, we investigated (1) the effect of long-term flow on rock permeability in connection with potential changes in fluid chemistry and saturation, (2) iron hydroxide precipitation related to oxygen-rich well water invasion during water-frac stimulation, and (3) the occurrence and consequences of baryte precipitation as a result of fluid oversaturation with respect to Ba and SO4 during reinjection of the (cooled) formation fluid. In all three substudies petrophysical experiments related to the evolution of rock permeability were complemented with microstructural investigations and a chemical fluid analysis. In this contribution, we will present an overview of the technical features of the apparatuses as well as the scientific outcome of the experiments outlined above.