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Fluid-rock interactions at near- and supercritical conditions and their effect on physical properties of high-enthalpy hydrothermal systems

Juliane Kummerow, Siegfried Raab, and Jan Schuessler

GFZ German Reserch Centre for Geosciences, 6.2 Geothermal Energy Systems, Potsdam, Germany (jule@gfz-potsdam.de)

We present new data of reactive flow experiments, which are performed in order to study the impact of mineral dissolution/ precipitation on physical properties of fluids and rocks in unconventional high-enthalpy hydrothermal systems (T > 350 °C). Hydraulic and electrical properties of rock cores from different active and exhumed geothermal areas on Iceland were measured up to supercritical conditions (T_{max} = 380 °C, p_{fluid} = 25 MPa) during long-term (2-3 weeks) flow-through experiments in an internally heated gas pressure vessel at a maximum confining pressure of 42 MPa. Various conductivity mechanisms and processes contribute to the bulk conductivity of rocks. To better distinguish between electrolytic conductance through the pore fluid, surface conductance at mineral-fluid interface, and the effect of compositional fluid alteration, in a second set of experiments the effect of fluid-rock interactions on the fluid conductivity was measured for increasing temperatures in a range of 24 – 422 °C at constant fluid pressures of 25 and 31 MPa, respectively. The flow experiments were supplemented by microstructural investigations as well as by chemical analysis of fluid samples, taken at every temperature step.
At low temperature (< 200 °C), both physical and chemical data show only slight fluid-rock interactions, whereas above 200 °C, continuously increasing Si concentrations in the fluid samples indicate a beginning mineral dissolution. This is also reflected in a decreasing formation factor, at least for electrical measurements on porous samples with high initial fluid-rock contact area. At near-critical conditions Si dissolution is going to accelerate and also Al is more intensively mobilized. Compared to measurements on pure fluids, the electrical conductivity of fluids which are in contact with reactive materials rises steeply by factor 7 within seconds, when the critical point is exceeded. This points to an extensive and spontaneous increase in rock solubility. However, above the critical temperature only temporary conductivity equilibria were reached in the order of several hours. Rather a continuous increase and decrease of fluid conductivity was observed, which may indicate a dynamic interplay of the input of new charge carriers by mineral dissolution and ion depletion due to mineral precipitation. Regarding the measurements on rock samples, for supercritical conditions we can resolve the influence of mineral precipitation in the pore space only, which is indicated by a decrease in bulk conductivity by about 40 % and in rock permeability by about 5 % after the sample was exposed to supercritical conditions for 4 hours.