EGU21-12187, updated on 27 May 2022
https://doi.org/10.5194/egusphere-egu21-12187
EGU General Assembly 2021

Long-term evolution of fracture permeability in slate as potential target reservoirs for Enhanced Geothermal Systems (EGS)

Chaojie Cheng, Johannes Herrmann, Erik Rybacki, and Harald Milsch
GFZ German Research Centre for Geosciences, Potsdam, Germany (chaojie@gfz-potsdam.de)

The long-term sustainability of fractures in Variscan metamorphic rocks will determine whether it is reasonable to utilize such formations as potential unconventional EGS reservoirs. During long lasting fluid flow within fractures, dissolution, precipitation, and chemical reactions between the fluid and the rock matrix may alter the flow pathway structure and flow properties. Within the framework of the European Union's Horizon 2020 initiative "MEET (Multi-Sites EGS Demonstration)", we performed long-term fracture permeability experiments on saw-cut slate samples from the Hahnenklee drill site, Harz Mountains, Germany, under constant pressure and temperature conditions. Two experiments were performed using deionized water as pore fluid with intermittent flow for more than one month at 10 MPa confining pressure and 1 MPa pore pressure. Three sequential investigations were performed, including (1) an initial continuous flow tests at room temperature, (2) temperature cycles between room temperature and up to 70 °C or 90 °C, and (3) measurement of the time-dependent permeability evolution at 70 °C or 90 °C. During stage (3), the effluents were sampled in time intervals of 6 days and analyzed using inductively coupled plasma optical emission spectrometry (ICP-OES). The results show that (1) sample permeability first continuously decreases, but progressively converges within about three days, (2) increasing temperature leads to an additional permeability decline that is irreversible, and (3) the time-dependent permeability reduction is much more pronounced at 90 °C in comparison to that at 70 °C. The effluents are enriched with Na, Fe, K, Ca, Si, where the Na concentration is always an order of magnitude higher than the others. Except for Si, concentrations are progressively decreasing with time. During the entire experimental period, sample permeability was reduced by approximately 90% at 90 °C and 60% at 70 °C compared to their initial values. In contrast, both samples showed a negligible permeability decline with time at room temperature after cooling. Our results demonstrate that thermally-enhanced fluid-rock interactions lead to a permanent and at least partial closure of fracture aperture, which is unfavorable for geothermal exploitation. However, the degree of permeability reduction may strongly depend on initial fracture roughness, which remains to be investigated.