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Fracture permeability evolution as a result of geochemical granite alteration in geothermal systems

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Geothermal systems in crystalline basement rocks require fractures and faults to allow economic heat production. Sufficient permeability of these flow paths is vital and affects the lifetime of such systems. As fluids are produced and reinjected, the resulting flow, fluid mixing as well as related pressure and temperature changes affect the geochemical equilibria between fluids and host rock. Disequilibria of fluids and rock then potentially drive dissolution, precipitation, or other geochemical alteration processes (e.g., illitisation). Such changes can change then mineralogical and geometrical properties of fractures, resulting in hydraulic property changes of the major flow paths of the fault zones. Cornwall in SW England hosts several granitic plutons that are the subject of current geothermal projects (United Downs Deep Geothermal Power and Eden Projects). These projects target fault zones in crystalline rock that provide pre-existing pathways for fluid flow.

To study the effects of geochemical alterations on fracture permeability in granites, we conducted a series of long-term reactive transport experiments in our unique flow-through reactor setup. Carnmenellis granite samples from central Cornwall have been collected of which small plugs (15 mm length, 10 mm width) and powders (< 125 µm grain size) were prepared. A tensile fracture was induced into the plugs to allow flow along the samples. We injected water with different fluid composition, representing different diluted to heavy brines encountered around geothermal systems, into the fractured granite plugs and pulverized gouges at 80 °C and 20 MPa confining pressure. The development of fracture and gouge permeability as well as effluent composition are analysed. CT-scans before, in-between, and after experiments are used to analyse changes in fracture and gouge structure. To complement the experiments, we model our system with GeoChemFoam [Maes and Menke, 2021], a reactive-transport modelling code that combines flow and transport calculations from OpenFOAM with geochemical calculations. The CT-scans of our samples act as basis for mesh and mineral distribution.

Participation

In-Person

References

Maes, J., and H. P. Menke (2021), GeoChemFoam: Direct Modelling of Multiphase Reactive Transport in Real Pore Geometries with Equilibrium Reactions, Transp. Porous Media, 139(2), 271-299, doi:10.1007/s11242-021-01661-8.

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