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Insights into the hydromechanical rock mass responses during in-situ rock mass stimulations

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In February 2017, a total of six in-situ hydraulic shearing (HS) experiments were conducted in the framework of the decameter scale In-situ Stimulation and Circulation (ISC) project in crystalline rocks at the Grimsel Test Site, Switzerland. During these experiments, three ductile (containing very few distinct fractures) and three brittle-ductile (containing multiple fractures) shear zones were the target for high-pressure fluid injections. The injected fluid volume was $\sim$1 m^3 per experiment. The experiment volume has an overburden of $\sim$480 m and the maximum principal stress is dipping 40° towards East with a magnitude of 13 MPa. In this contribution, we present the observations and preliminary interpretations of the hydromechanical rock mass response during the different experiments and compare them to the target shear zone type.
To monitor the hydromechanical response, six boreholes were drilled into the rock mass. Three of them are dedicated to pressure monitoring in seven intervals covering the target shear zones. In the other three boreholes, a total of sixty longitudinal Fiber-Bragg Grating strain sensors were installed. These sensors have a base length of one meter and are installed across intact rock, fractures or shear zones.
During most of the HS experiments, the near-wellbore injectivity was successfully increased to a magnitude that is similar for all experiments. The same was observed for the near-wellbore transmissivity. For both parameters, a stronger increase was observed at the ductile shear zones, where the initial parameter magnitudes were smaller. The jacking pressure was reduced during most experiments and the induced slip dislocation at the injection point was in the range of 0.5 - 1.5 mm. We observed a pressure increase up to a radial distance of $\sim$16 m from the injection well during all experiments. Further away from injection location the pressure monitoring data suggest poro-elastic effects. Pressure fronts that were expected to propagate along the target shear zone were only observed during two experiments.
The strain monitoring revealed a zone of transient variable deformation (i.e. mix of compression and extension) close to the injection location and a compressive zone further away from the injection location. The extent of the variable zone seems to depend on the target shear zone type and is larger for the ductile shear zone. During the experiments, a meter scale Poisson effect was directly measured in the rock mass. Additionally, the formation of new fractures was detected.
Our data highlight the complexity of the rock mass and fracture response during a decameter scale hydraulic stimulation and provide a basis for the development of future large scale hydromechanical-coupled numerical models of stimulation experiments.