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Direct and Microseismic Observations of Hydraulic Fracturing in Barre Granite and Opalinus Clayshale

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Hydraulic fracturing applications such as enhanced geothermal systems and unconventional hydrocarbon extraction have been shown to result in induced/triggered seismic events. In these field cases, we often have a general understanding of the stress state at the time and place of the seismic event; however, there are few instances where we have detailed measurements of the mechanisms leading to seismic activity. In this study, we present results from a laboratory investigation where we hydraulically fracture granite and opalinus clayshale specimens at two injection rates, and directly measure displacement fields at micrometer resolution along with acoustic emissions. Specifically, we cut a 1cm x 2mm notch into the center of each prismatic specimen, apply 3.5 MPa of uniaxial load, and then increase fluid pressure until a hydraulic fracture propagates. A high speed camera with a 5X macro lens is used to image the surface of the rock at the tip of the notch, resulting in a field of view of 7mm x 4.67mm. The test is also instrumented with 8 piezoceramic sensors, from which we calculate hypocenter locations and focal mechanisms.

Preliminary results show that the lower injection rates tended to result in a more complex microfracture network, due to the increased number of arrested microcracks. We also see that microcracks in granite tend to form as a series of oblique en-echelon cracks, whereas microfractures in opalinus tend to form directly along bedding plane boundaries. We also see that for the given experimental setup, irrecoverable damage begins to occur around 95% of peak fluid pressure at 0.039 mL/s in both granite and shale, while at 0.39 mL/s the damage begins to occur around 80-85% of peak fluid pressure in both granite and shale.