Investigation of the physical link between the injection induced seismicity and information from borehole logging

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Understanding of the physics behind induced seismicity is an important research topic in seismology. Geoscientists have used seismological analyses, numerical simulations, and seismostatistical analyses to investigate the processes occurring in and the behavior of reservoir rock masses upon hydraulic stimulations that frequently led to substantial induced seismicity. Knowledge of the physics related to induced seismicity associated with fluid injections is key to seismic hazard mitigation. In this study, we approach this problem unconventionally, analyzing at high spatial resolution the natural fracture and in-situ stress information inferred from borehole logging, i.e. data available prior to stimulations, while conventional seismological approaches study the waveforms of induced seismicity, which are posterior phenomena. Injection-induced seismicity is primarily caused by an increase of fluid pressure in the existing fractures, which decreases the fracture’ s shear strengths. Using pre-stimulation information, we investigate the potential of induced seismicity by evaluating the state of stress of natural fractures. Then, we try to find the link to the tendency of observed induced seismicity where we got fault plane geometry information from waveform analysis.

In this study we investigate the natural fracture and in-situ stress data sets from the Basel EGS project in Switzerland. The data originates from the lowermost 2.4 km long borehole section through the basement consisting of granitic to monzonitic rocks. The natural fractures were inferred by careful analysis of acoustic borehole logging images (Ziegler et al. 2015), the in-situ stress data was derived from borehole breakout analysis and some well-test constraint (Valley and Evans, 2009; 2015). Ziegler and Evans, (2020) discovered that the orientation of the seismically inferred faults and natural fractures are similar. Based on these findings of the link between the fault to cause induced seismicity and natural fracture from borehole logging, we investigate the physical link between those beyond the geometrical consistency. We estimated various geomechanical parameters such as shear stress, normal stress, apparent shear strength, i.e., critical pore pressure, and slip tendency. We compared the distributions of those parameters estimated from induced seismicity and natural fractures. We try to find the link between those relationships and discuss the preliminary foundings. Then, we will extend our findings to the theory proposed by the conceptual theory of b-value reduction with increasing stress (Scholtz, 1968).

Keywords: induced seismicity, borehole logging, natural fracture

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