Self-Consistency in Scaling Relations for Seismicity Induced during Hydraulic Fracture Stimulations

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Abstract

Understanding whether large and small earthquakes have the same physics is a major question in seismology and plays a role in understanding the development of discrete fracture networks associated with hydraulic fractures. S it is becoming evident, it is possible to generate larger magnitude events (M > 0) during hydraulic fracture stimulation under different circumstances, such as increasing injection rates that cause changes in local stress conditions. In order to examine the scaling relationship of larger events (M>0) and small magnitude events (M<0), microseismic data from fully integrated passive seismic monitoring programs were used. In this study we identify that even if small magnitude events are generally lower in stress release compared to those observed for the larger events; over all scales of observation the events follow a self-similar behavior. The differences for small and large magnitude events can be explained by the observed failure mechanisms where smaller events tend to be driven by shear-tensile failures of pre-existing discrete fractures (joints) whereas the larger events appear to be dominated by shear driven failure processes associated with pre-existing faults. Our investigation in failure mechanisms show that the larger-magnitude data have in general a much stronger shear component compares to the lower-magnitude data which have much smaller shear associated with them. We also notice that slip is not a dominant mechanism in lower-magnitude events.