Seismic moment evolution during hydraulic stimulations in EGS projects

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Recent results from an EGS project in Finland suggest a possibly successful physics-based approach in controlling stimulation-induced seismicity in geothermal projects. We analyzed the temporal evolution of seismicity and the growth of maximum observed moment magnitudes for a range of past and present stimulation projects. Our results show that the majority of the stimulation campaigns investigated reveal a clear linear relation between injected fluid volume, hydraulic energy and cumulative seismic moments. For most projects studied, the observations are in good agreement with existing physical models that predict a relation between injected fluid volume and maximum seismic moment of induced events. This suggest that seismicity results from a stable, pressure-controlled rupture process at least for an extended injection period. Overall evolution of seismicity is independent of tectonic stress regime and is most likely governed by reservoir specific parameters, such as the preexisting structural inventory. In contrast, there are few stimulations that reveal unbound increase in seismic moment suggesting that for these cases evolution of seismicity is mainly controlled by stress field, the size of tectonic faults and fault connectivity. Transition between the two states may occur at any time during injection, or not at all. Monitoring and traffic-light systems used during stimulations need to account for the possibility of unstable rupture propagation from the very beginning of injection by observing the entire seismicity evolution in near-real-time and at high resolution for an immediate reaction in injection strategy.