Modeling fault reactivation and induced seismicity in supercritical geothermal systems

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Abstract

Understanding the geomechanical features of supercritical geothermal systems is a great challenge that involves coupled process in the solid skeleton: changes in temperature and pore water pressure influence both the stress redistribution and porosity change, which in turn can have an effect on permeability. Such changes can be induced by operation of deep geothermal wells involving fluid production/reinjection, both during drilling, permeability enhancement or long-term operations. The current lack of experience and the extraordinary challenges posed by accessing in-situ information make numerical modeling a viable exploratory method to understand coupled processes and assess geomechanical risks.

We have performed finite element analyses including temperature, pore pressure, deformation and porosity/permeability changes of fluid extraction and reinjection in an idealized supercritical geothermal doublet. We have investigated the long-term fault stability during 25 years of reinjection/production and found that seismicity increase is dominated by rock cooling during cold fluid reinjection. The microseismicity is expected to increase its frequency by several orders of magnitude in a relatively short time (within 5 years), while the timing of greater magnitude events depends essentially on the heat diffusion characteristics of the system and the distance of major faults from the injection wellbore. In the case considered, the fault is expected to slip after roughly 10 years of operation and the slip front grows as a logarithmic function of time. While it is difficult to predict magnitudes of the largest events, our model provides precious insights on the fault stability of supercritical geothermal systems and proves to be a useful tool for safely managing site operations.