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Effect of fault architecture and permeability evolution on response to fluid injection

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Earthquakes can be induced by human activity involving fluid injection, like wastewater disposal from oil and gas production. The occurrence of such events has generated considerable public concern (Colorado, Oklahoma, Arkansas...). Injection induced seismicity is thought to be mainly due to the increase in pore pressure, which reduces the effective strength of a nearby fault, and/or due to the change in subsurface stress around faults at critical stress states and having favored orientations and properties. In this work, we employ a coupled hydro-mechanical model by considering the full poroelastic effects and not solely changes in pore pressure in a rigid host. We also consider the changes in porosity and permeability due to the changes in the local volumetric strains. Our results highlight the effects of the fault architecture (based on general description from field data) and permeability evolution on the pressure diffusion and the fault poroelastic response. We show that the existence of high permeability damage zones facilitates the pressure diffusion and, in some cases, results in a sharp increase in pore-pressure at levels much deeper than the injection wells, because these regions act as conduits for fluid pressure changes. This eventually results in higher seismicity rates, which makes predicting the correct hydro-mechanical response of faults crucial to avoid risks of high magnitude seismic events.