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# Injection-induced seismicity controlled by the pore pressure rate

Michelle Almakari, Pierre Dublanchet, and Hervé Chauris
MINES ParisTech - PSL Research University , Centre de Géosciences , Equipe Géophysique, France
(michelle.almakari@mines-paristech.fr)

Injection of fluids into underground formations reactivates preexisting faults and modifies the seismic hazard, like the 2011 Mw 5.7 in Oklahoma. Nevertheless, as observed in Soultz-sous-Forêt,injecting fluid into the subsurface may fundamentally engender aseismic slip, with later micro-earthquakes as an indirect effect. However, the physics behind induced seismicity remain poorly understood. According to some studies, injection-induced earthquakes are triggered by elevating the fluid pore pressure above a certain threshold.

We propose to model the seismicity triggered by a fluid flowing inside a heterogeneous fault producing alternatively aseismic slip and microseismicity, and to identify the main parameters controlling induced-earthquake nucleation. We present a coupled 2-D continuous quasi-dynamic rate-and-state earthquake simulator, composed of an alternation of unstable and stable (creeping areas) patches, with a 1-D fluid diffusion model along the fault segment. Our model allows taking into consideration both the weakening and strengthening behavior of the fault.

First, we show that the injection of fluids disrupts the state of the fault and leads to a sharp increase in seismicity. Our results suggest that the seismicity rate seems to be in direct correlation with the pore pressure rate, while the quasi-dynamic rupture is controlled by the evolution of the pore pressure front. We also show that induced seismicity is not bounded by a pore pressure level but rather by an injection rate threshold. This injection rate also governs the number and magnitude of the induced events, whereas a fast injection can trigger more numerous events but with lower magnitudes than a slow injection.