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# Impact of dilatant strengthening and energy dissipation on fault slip stability

**Antoine Jacquey**[1], Manolis Veveakis[2], and Ruben Juanes[1]
[1]Massachusetts Institute of Technology, Cambridge MA, USA
[2]Duke University, Durham NC, USA

The temporal and spatial distribution of fluid pressure and temperature within a fault core are key determinants of the onset and nature (seismic or aseismic) of fault slip. Laboratory and field observations indicate that transient localization of fluid pressure and temperature often go hand in hand with strain localization upon seismic rupture: as slip occurs on a fault plane, temperature increases due to dissipated energy and fluid pressure decreases due to dilatant strengthening. An accurate description of this thermo-hydro-mechanical multiphysics coupling controlling slip mechanisms is therefore essential to characterize the stability of fault slip.

Here, we present results from analytical and numerical analyses of the stability of fault slip adopting a thermo-hydro-mechanical coupling scheme together with a rate-dependent plasticity formulation. In particular, we focus on the relevance of dilatant strengthening competing with energy dissipation as driving processes for stick-slip events and aseismic slip. We analyze the multiple steady states of the system and their respective stability by means of a numerical continuation technique, and we describe the dynamic evolution of deformation, fluid pressure and temperature fields by considering an associated transient problem.

The results presented here provide insights into the stability criterion for aseismic slip and the dynamic evolution of slip instability as a function of the physical (thermal and hydraulic) properties of the fault material and the boundary conditions (tectonic stresses and off-fault fluid pressure and temperature conditions). We identify two mechanisms for periodic slip, one driven by elastic loading and the other by multiphysics oscillations. We discuss the implications of these results for characterizing the transition from stable aseismic slip to unstable seismic slip in the context of natural and induced seismicity.