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# A thermo-chemo-mechanical model to explain the velocity dependence of friction in fault gouges

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A dramatic decrease of friction has been observed in many experiments performed on synthetic or recovered fault core samples at seismic slip rates for different materials. This phenomenon has major implications to understand the creation of earthquakes in the brittle part of the lithosphere as it plays a role on the stress drop and thus the energy budget, but also on the stability of a fault. These observations have become possible thank to the development of new experimental apparatus that allows to shear the material at high velocities under high normal stresses.

In this study, we show that this behavior of the friction coefficient can be explained as a coupled multi-physical effect. We consider the fault core an infinite sheared layer and deploy thermo-chemo-mechanical couplings to account for the most important mechanisms involved in a fault zone. In particular, the increasing velocity during a seismic slip induces a temperature rise, which in turn can trigger chemical reactions that affect the shear stress of the system. The steady state of the system of equations obtained can be studied using a pseudo-arclength continuation algorithm.

The evolution of friction at steady state for a given imposed velocity is general and can account for a wide variety of chemical processes. The model fits adequately results of experiments performed on various materials encountered in fault zones such as clay, halite, carbonate and granite. This study also allows to obtain the activation energy for the temperature weakening and chemical strengthening processes and highlight the importance of thermo-chemo-mechanical couplings in the nucleation and propagation of seismic slips.