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A small-scale numerical study of fault slip mechanisms using DEM

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How do earthquakes start? What are the parameters influencing fault evolutions? What are the local parameters controlling the seismic or aseismic character of slip?

To predict the dynamic behaviour of faults, it is important to understand slip mechanisms and their source. Lab or in-situ experiments can be very helpful, but tribological experience has shown that it is complicated to install local sensors inside a mechanical contact, and that they could disturb the behaviour of the sheared medium. Even with technical improvements on lab tools, some interesting data regarding gouge kinematics and rheology remains very difficult or impossible to obtain. Numerical modelling seems to be another way of understanding physics of earthquakes.

Fault zone usually present a granular gouge, coming from the wear material of previous slips. That is why, in this study, we present a numerical model to observe the evolution and behaviours of fault gouges. We chose to focus on physics of contacts inside a granular gouge at a millimetre-scale, studying contact interactions and friction coefficient between the different bodies. In order to get access to this kind of information, we implement a 2D granular fault gouge with Discrete Element Modelling in the software MELODY (Mollon, 2016). The gouge model involves two rough surfaces representing the rock walls separated by the granular gouge.

One of the interests of this code is its ability to represent realistic non-circular grain shapes with a Fourier-Voronoï method (Mollon et al., 2012). As most of the simulations reported in the literature use circular (2D)/spherical (3D) grains, we wanted to analyse numerically the contribution of angular grains. We confirm that they lead to higher friction coefficients and different global behaviours (Mair et al., 2002), (Guo et al., 2004).

In a first model, we investigate dry contacts to spotlight the influence of inter-particular cohesion and small particles on slip behaviour and static friction. A second model is carried out to observe aseismic and seismic slips occurring within the gouge. As stability depends on the interplay between the peak of static friction and the stiffness of the surrounding medium, the model includes the stiffness of the loading apparatus on the rock walls.

The work presented here focuses on millimetre-scale phenomena, but the employed model cannot be extended to the scale of the entire fault network, for computational cost reasons. It is expected, however, that it will lead to a better understanding of local behaviours that may be injected as simplified interface laws in larger-scale simulations.