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A GRANULAR MODEL OF STICK-SLIP IN LABORATORY EARTHQUAKES

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ABSTRACT
Earthquakes are generally interpreted as frictional instabilities along solid interfaces located in the Earth lithosphere and called faults. A minimal mechanical model for such events is based on the concept of stick-slip, which necessarily involves (i) a compliant elastic medium around the interface, able to store strain energy during a loading phase, and (ii) a weakening friction law (either with slip or velocity) in the interface in order to resist motion up to a certain shear stress limit and to slide in an instable way once this threshold has been reached.

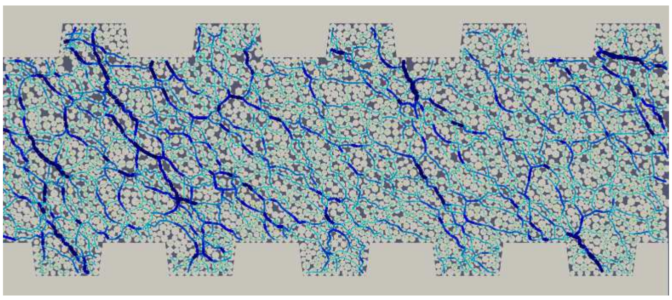

Fig.1 Conceptual granular fault with force chains

Geological evidences indicate that natural faults are systematically filled with a natural third body, called "fault gouge", which originates from the degradation and wear of the crustal rock during past sliding events. This is typically reproduced in the lab by placing well-chosen rock powders in a flat-on-flat sliding apparatus, in order to analyze the frictional stability of such interfaces [1]. In this communication, we present a simple numerical model which aims at reproducing in a conceptual way the stick-slip events observed in gouge-filled faults, both in the lab, in nature, and in similar models [2]. It is based on a granular representation of gouge (Figure 1), driven by a compliant loading system with a controlled stiffness. Grains interact through a cohesive-frictional contact model, which allows the whole interface to follow in average a Mohr-Coulomb friction law, in agreement with lab measurements.

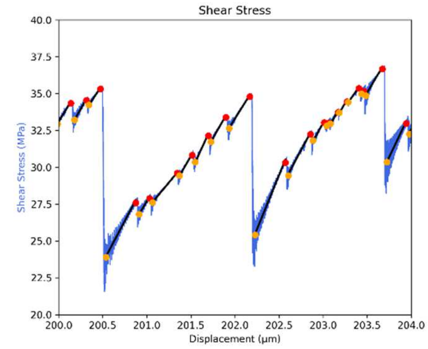

Fig.2 Typical stick-slip patterns in the frictional response

Numerical results show that a large number of stick-slip events spontaneously emerge from this simple model, and that their statistics are strongly linked to the value of the shear stiffness of the loading system. A stiffer fault tends to produce a wide distribution of events sizes (characterized by stress drops which cover several orders of magnitudes, Figure 2), while very soft faults leads to the quasi-periodic occurrence of large events with a much narrower distribution of the stress drops. Numerical results also indicate that the energy released during a given event at a given stress drop is much larger if the fault is compliant than if it is stiff, because the sliding distance associated with the stress drop is larger.

These results pave the way to a better understanding of the seismic cycle and build a new bridge between the scale of the fault granular rheology and the elastic properties of the surrounding medium.

REFERENCES
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