HOW AN EARTHQUAKE BORN? A LABORATORY PERSPECTIVE ON THE STABILITY OF FRICTIONAL SLIDING.

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ABSTRACT
Earthquakes are the most unpredictable yet destructive natural phenomena. Earthquakes are understood as frictional instabilities along a plane of weakness in the Earth crust composed of granular material (fault gouge) that is the wear product from multiple slip events. However, the lack of accessibility to earthquake faults and the complexity of physical processes has limited our ability to develop holistic models for fault zone behavior. Geophysical observations have the potential for illuminating precursors to failure for the spectrum of tectonic faulting, however we lack key laboratory data to connect these observations with predictive, physics-based models.

Laboratory experiments have put the basis for our understanding of earthquake physics. The early work of Brace and Byerlee (1966) [1] proposed stick-slip frictional sliding as a lab analog for earthquakes. Coupling these observations with the intuitions of Rabinowitcz (1956) [2] gave rise to the ‘slip weakening law’ that represent one of the most commonly used friction law to describe stick-slip motion. However, this law lacks an important ingredient: the time dependence of frictional restrengthening to allow multiple seismic cycles as observed on tectonic faults.

Rate and State friction constitutive equations (RSF) [3] represent one of the most widely framework that is used to describe frictional phenomena related to earthquakes. The fundamental concept behind this framework is that friction is governed by the deformation of nano/micro scale asperity contacts that can evolve with time and slip.

However, the empirical nature of these laws does not provide a physical framework to describe asperity contact evolution. In the laboratory we aim at bridging the gap between the micro/nano scale of asperity contact evolution with the macroscopic deformation of fault gouge and finally the km scale of tectonic faults by testing the wide range of boundary conditions for tectonic faults and .

To understand the seismic cycle and the physics of frictional instability,we couple RSF laws with elastic dislocation theory to reproduce the full spectrum of slip motion from aseismic creep, slow slip to elastodynamic stick-slip. We study the resulting microstructure of the fault zone after the experiments and find that the evolution of shear localization has a major impact in controlling frictional instabilities [4,5]. We couple mechanical data with acoustic emission and ultrasonic wave propagation to unveil the physical mechanism at the origin of unstable slip. We inform DEM [6] with specific laboratory experiments to understand what are the contact scale characteristics that can reproduce lab observation and unveil the physics of shear localization and frictional sliding.

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