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Torque controlled rotary-shear experiments reveal pseudotachilites formation-dynamics and precursor events

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Except few cases, rotary shear tests, which are designed to study dynamic friction and strengthening/weakening mechanisms in seismogenic faults, are performed by imposing, to the specimens, a slipping velocity that is pre-defined. This approach has been adopted from engineering that typically, tests man-made objects that, when functioning, spin or slide at a pre-defined velocity under a pre-defined load. On the other hand, natural earthquakes are the effect of a rupture that nucleates, propagates and arrests in the subsurface. These three phases, and the consequent emerging fault slipping velocity, are controlled by the accumulated and released energy around the seismogenic fault before, during and after the earthquake. Thus, imposing the slipping velocity in laboratory experiments might not represent the best option to uncover many aspects of earthquake nucleation and fault slipping dynamics.

Here we present some experiments performed with an innovative rotary shear apparatus that uses a clock-spring that when winded provides to the rotating sample a linearly increasing torque. Thus, the nucleation of simulated events occur spontaneously when the shear stress on the slipping surface overcomes the static friction times the normal load that is controlled by a deadweight. In addition, this method allows studying precursory seismic events resembling natural slow-slip earthquakes.

We report some preliminary results for a transparent polymer that has melting point $\sim$340 K and allows observing the slipping surface (i.e. the contact between the two samples). By coupling: i) the rotary shear apparatus, ii) a video camera recording at 60 fps and a iii) laser pointer we observed the formation and evolution of a melt film that forms in the slipping surface after a phase of "dry" stick-slip. After each seismic event the melt layer solidify forming a pseudotachilite that partially welds the slipping surfaces. We also present the mechanical data that show rupture strengthening in concomitance with the formation of the pseudotachilite. Eventually, the original and "welded" slipping surfaces stopped "fracturing" and the failure occurred between the sample and the sample-holder giving insights about fault healing-reactivation cycle. On the light of these data we will discuss the methodology and the results, including some precursory slow-slip events, draw some conclusions and provide outlook for future studies.