Stable sliding, slow and silent slip events and laboratory earthquakes across the brittle ductile transition

*Alexandre Schubnel[1], Aubry Jérôme[1], François Passelègue[2]

1. Laboratoire de Géologie, ENS, PARIS, France, 2. EPFL, Switzerland

The transition from brittle to plastic deformation corresponds to the regime where brittle fracturing and plastic flow co-exist. This transition is of fundamental importance to understand how natural faults behave differently at the bottom of the seismogenic zone, at PT conditions where the deformation regime is not fully brittle anymore.

Here, we reproduced the complete spectrum of natural faulting at laboratory scale, from stable slip to slow earthquakes and up to fast instabilities, on samples of dolostones and carbonates. Transitions from creep to slow ruptures and from slow to fast ruptures, are obtained by increasing both pressure and temperature up to conditions encountered at 3 km depth (i.e. 100 MPa confining pressure and 100 °C), which corresponds to the onset of seismicity in nature. Increasing confining pressure and temperature augments the fault elastic stiffness, which decreases the nucleation length and enhances the slip velocities during the nucleation to values allowing flash weakening and decarbonation processes.

From our experimental results, we conclude that: (i) laboratory earthquakes may nucleate on inherited fault interfaces at brittle-ductile transition conditions; (ii) in this regime where plastic deformation of the bulk and dynamic fault slip may co-exist, laboratory earthquakes are promoted when the interface is smooth, or when the loading rate is slow; (iii) stable sliding tends to produce mirror-like surface, while stick-slips is associated with matte surfaces, on which the size of the asperities grows with increasing confining pressure, (iv) slower loading rates and higher confining pressures promote the occurrence of laboratory earthquakes associated with increasing plastic deformation, while increasing initial roughness promotes stable sliding and slow stick-slip.

Keywords: slow and silent earthquakes, stick slip, brittle ductile transition

