Geophysical Research Abstracts
Vol. 21, EGU2019-11937, 2019
EGU General Assembly 2019

Exploring the mechanical effects of fluid viscosity during earthquake slip

Kathryn Hayward (1), Stephen Cox (1), Alexandre Schubnel (2), Jérôme Aubry (2), and Samson Marty (2)

(1) Australian National University, Research School of Earth Sciences, Canberra, Australia (kathryn.hayward@anu.edu.au),
(2) École Normale Supérieure, Laboratoire de Géologie, Paris, France

Seismic slip propagation is attributed to the activation of weakening mechanisms at high slip velocities, resulting from complex thermo-mechanical changes to fault surfaces. Although much research effort has been directed towards understanding the high-velocity behaviour of rocks and simulated faults, understanding of the role that fluids play in the formative stages of weakening remain an area of considerable uncertainty. We present the results of experiments undertaken on two different types of triaxial apparatus (gas and oil medium) that explore how fluid viscosity and fluid-fault interaction influence dynamic behaviour of faults during rapid slip (slip velocities up to ~1.2m/s).

Experiments have been undertaken using pre-ground fault surfaces of Fontainebleau sandstone (porosity 6-7%) in a triaxial configuration. Faults are reactivated under stress conditions comparable to upper- to mid-crustal conditions (σn < 600MPa). Pore fluids include argon, water and silicone oil at pressures ranging from 5-100MPa and viscosity spans four orders of magnitude. Complementing traditional mechanical data acquisition, we have used new technology to access high fidelity data during the micro to millisecond duration of fault slip. Techniques include the use acoustic emission sensors, strain gauges affixed adjacent to the fault surface and a custom-built laser interferometer to provide microsecond resolution of displacement during stick-slip events. Deformed samples have been microstructurally analysed using multiple techniques (FE-SEM, SEM-CL) providing insights into physical and structural changes to asperity contacts over a range of scales.

Significant findings include a dramatic reduction in the number and cumulative magnitude of acoustic emissions occurring prior to slip events where aqueous pore fluids are present and a decrease in co-seismic slip velocity with the addition of a fluid and with increasing fluid viscosity. Faults are also compared in terms of equivalent mechanical work with results showing that fluids potentially influence the partitioning of energy in the earthquake energy budget. Microstructurally the addition of pore fluids results in a significant reduction in both abrasive wear and the development of fracture damage on fault surfaces. Glass (quenched frictional melt) is observed on both dry and water-+saturated faults.

Our results show a complex interplay between pore fluid properties and the mechanical behaviour of a fault during rupture. The interaction between the fault surface and pore fluids generates rapid onset micromechanical and microstructural changes. These results have implications for understanding the dynamics of seismic rupture in porous, fluid active environments.