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Fluid-induced rupture of a fault gouge analogue in the laboratory

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An intact 14% porosity Fontainebleau sandstone was loaded tri-axially, under 100 MPa confinement and 240 MPa shear stress, in drained conditions. Pore pressure was then slowly raised and failure eventually triggered. Elastic wave velocities and permeability were monitored contemporaneously during deformation and showed important decrease prior to failure. More than 3 000 Acoustic Emissions (AE) were located, demonstrating the initiation of strain localization, followed by the formation of a large nucleation patch (˜ 1cc) from which a macroscopic fracture propagated. Nucleation speed growth evolved from <0.1 to >1mm/s, followed by unstable rupture propagation at speed comprised between 0.1-10m/s. No quiescence was observed post failure, except where rupture initially nucleated. Fast depressurization of the pore space induced secondary aftershocks on the fracture plane, probably due to a lower permeability of the faulted region. Source mechanisms of these "pore-pressure induced" aftershocks reveal that the the fractured region is being locked and compacted as the pore space is depressurized.

Two kind of pore pressure cycles were then performed on the fractured specimen at 100MPa confinement and up to failure: (1) slow pore pressurization (i.e. 0.05 MPa.s-1) and (2) fast pressurization (i.e. "flash pressurization from 5 to 80 MPa in less than two seconds). Slow pore pressurization induced stable sliding. While sliding, oscillating shear stress triggered large oscillations of the acoustic activity: from 5 to 500 AE per second for 5MPa oscillations! On the contrary, flash pressurization induced stick slip events. Complete acoustic recordings (acoustogramms) over the course of rupture enabled us to determine Omori's law exponents of 0.92 pre-failure in the intact specimen, and from 1.1 to ˜ 1.25 post failure in the varous cycles. Most of the acoustic energy was released during unstable rupture propagation and slip. However, our recorded acoustic energy does not follow the same trend as the energy released

mechanically. This last point raises the issue of acoustic - and seismic - efficiency being a function of rupture propagation, slip velocities, and perhaps even cohesion.