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Stability of fault during fluid injection

Francois Passelegue (1), Nicolas Brantut (2), and Tom Mitchell (2)

(1) The University of Manchester, SEAS, United Kingdom , (2) University College of London, Department of Earth Sciences, United Kingdom

Elevated pore pressure can lead to slip reactivation on pre-existing fractures and faults when the coulomb failure point is reached. From a static point of view, the reactivation of fault submitted to a background stress (τ0) is a function of the peak strength of the fault, i.e. the quasi-static effective friction coefficient (μeff).
In this study, we present new results about the influence of the injection rate on the stability of faults. Experiments were conducted on a saw-cut sample of westerly granite. The experimental fault was 8 cm length. Injections were conducted through a 2 mm diameter hole reaching the fault surface. Experiments were conducted at four different order magnitudes fluid pressure injection rates (from 1 MPa/minute to 1 GPa/minute), in a fault system submitted to 50 and 100 MPa confining pressure. Our results show that the peak fluid pressure leading to slip depends on injection rate. The faster the injection rate, the larger the peak fluid pressure leading to instability. Our result suggest that the stability of the fault is not only a function of the fluid pressure required to reach the failure criterion, but is mainly a function of the ratio between the length of the fault affected by fluid pressure and the total fault length. In addition, we show that the slip rate increases with the background effective stress and with the intensity of the fluid pressure pertubation, i.e. with the excess shear stress acting on the part of the fault pertubated by fluid injection. Our results suggest that crustal fault can be reactivated by fluid pressures that are locally much higher than expected from a static Coulomb stress analysis. These results could explain the “large” magnitude human-induced earthquakes recently observed in Basel (Mw 3.6, 2006) and in Oklahoma (Mw 5.6, 2016).