EGU21-5626
https://doi.org/10.5194/egusphere-egu21-5626
EGU General Assembly 2021

Dilatancy stabilises shear failure in rock

Franciscus Aben and Nicolas Brantut
University College London, Department of Earth Sciences, United Kingdom of Great Britain – England, Scotland, Wales
(f.aben@ucl.ac.uk)

Failure and fault slip in crystalline rocks is associated with dilation. When pore fluids are present and drainage is insufficient, dilation leads to pore pressure drops, which in turn lead to strengthening of the material. We conducted laboratory rock fracture experiments with direct in-situ fluid pressure measurements which demonstrate that dynamic rupture propagation and fault slip can be stabilised (i.e., become quasi-static) by such a dilatancy strengthening effect. We also observe that, for the same effective pressures but lower pore fluid pressures, the stabilisation process may be arrested when the pore fluid pressure approaches zero and vaporises, resulting in dynamic shear failure. In case of a stable rupture, we witness continued after slip after the main failure event that is the result of pore pressure recharge of the fault zone. All our observations are quantitatively explained by a simple spring-slider model combining slip-weakening behaviour, slip-induced dilation, and pore fluid diffusion. Using our data in an inverse problem, we estimate the key parameters controlling rupture stabilisation, fault dilation rate and fault zone storage. These estimates are used to make predictions for the pore pressure drop associated with faulting, and where in the crust we may expect dilatancy stabilisation or vaporisation during earthquakes. For intact rock and well consolidated faults, we expect strong dilatancy strengthening between 4 and 6 km depth regardless of ambient pore pressure, and at greater depths when the ambient pore pressure approaches lithostatic pressure. In the uppermost part of the crust (<4 km), we predict vaporisation of pore fluids that eliminates dilatancy strengthening. The depth estimates where dilatant stabilisation is most likely coincide with geothermal energy reservoirs in crystalline rock (typically between 2 and 5 km depth) and in regions where slow slip events are observed (pore pressure that approaches lithostatic pressure).