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Creeping versus locked faults: laboratory constraints compared with geodetic observations from the Longitudinal Valley Fault, Taiwan

Sabine A.M. den Hartog (1), Marion Y. Thomas (2), and Daniel R. Faulkner (3)

(1) The Lyell Centre, Heriot-Watt University, Edinburgh, UK (s.den_hartog@hw.ac.uk), (2) Department of Earth Sciences, University of Oxford, Oxford, UK (marion.thomas@earth.ox.ac.uk), (3) Rock Deformation Laboratory, School of Environmental Sciences, University of Liverpool, Liverpool, UK (faulkner@liverpool.ac.uk)

Geodetic and seismological observations have shown that the Longitudinal Valley Fault (LVF) in Taiwan is creeping at shallow depths (top ∼7 km) along its southern segment, whereas the northern part is locked. Since the LVF is bounded by the Lichi Mélange in the south, and by sedimentary and volcanoclastic formations in the north, it has been suggested that the presence of the Lichi Mélange promotes aseismic creep. However, the similarity in mineralogy of the Lichi Mélange vs. other formations questioned this interpretation. In this study, we quantify the frictional properties of the LVF by performing a series of friction experiments on samples recovered from both the creeping and locked portions of the LVF. Direct shear experiments were performed at conditions representative for ∼4 km depth, i.e. a normal stress of 100 MPa and pore fluid pressure of 40 MPa and temperature up to 170 degC using load point displacements stepped between 0.3 and 3 micron/s. Our results show distinctly different behaviour for samples from the creeping fault section, with friction coefficients being at least 24% lower than samples from the locked section and velocity-strengthening behaviour at all temperatures tested, as opposed to velocity-neutral or -weakening behaviour at the highest temperatures seen for samples from the locked section. These laboratory results show remarkable agreement with the geodetic and seismological data and suggest that mineralogy alone cannot explain the frictional behaviour of fault gouges.