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Direct shear characterisation of simulated clay-bearing gouges: a case study from the Pernicana Fault System (Mount Etna, Sicily)

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Fault stability and shear strength are strongly controlled by the mechanical and frictional properties of the rocks and gouges involved. The Pernicana Fault System (PFS) is a first order bounding fault of the unstable sector of Mount Etna volcano (Italy). The PFS is a mature fault zone and one of the most active amongst the fault systems of the eastern sliding flank, showing transition from seismic in the upper part, to aseismic behaviour in the lower part toward the Ionian Sea. The PFS is expressed intermittently at the surface as a steeply-dipping fault, but the location at depth within the sedimentary basement beneath Etna remains highly debated. The basement is complex, comprising flyschoid formations of mostly carbonate, sandstone and claystone belonging to the Appenninic-Maghrebian Chain (AMC), which lie above foreland carbonate sequences from the Hyblean Plateau (HP) belonging to the African plate. Furthermore, the south-eastern sector of Mount Etna lies on quaternary foredeep deposits of silt and clay. Recent studies have highlighted the presence of water in the system that may play a major role as a triggering mechanism of sliding. In this study, we perform triaxial tests using synthetic gouges in direct shear sliding holders to explore the frictional properties of the main lithology types (namely carbonate, sandstone and clays) identified and collected in the AMC and HP units. Samples of carbonate ($\sim$98% $CaCO_3$) and sandstone ($\sim$98% SiO_2) were manually crushed and then milled using a planetary mill, while clays (clay fraction composed by chlorite, smectite, mica, and kaolinite) were worked manually to preserve clay minerals. Powders of carbonate and sandstone were sieved and selected in a range between <180 μm and >63 μm, while natural clay were sieved to <45 μm (fine silt-clay) for the experiments. The holders, specifically designed and built for this project, allow for up to 10 mm of total displacement over a surface of 54 mm width and 98 mm length, and are equipped with pore fluid inserts for experiments in water-saturated conditions. The triaxial cell has a confining pressure capacity of 0-140 MPa and temperature capacity of 20-200°C. Here we present the results of a first set of experiments conducted at a displacement rate of 0.001 mm/s, using gouges prepared to represent the end-members of each lithology, and as mixtures of carbonate and sandstone gouges with 10%-25%-50% clays. Overall, this study aims to determine the control of pore fluids on the frictional properties of simulated gouges for the Etnean basement under representative stress conditions and to inform numerical modelling of the likely development of the PFS at depth.