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"Coseismic foliations" in gouge and cataclasite: experimental observations and consequences for interpreting the fault rock record

Steven Smith (1), James Griffiths (1), Michele Fondriest (2,3), Giulio Di Toro (2,3,4), Matteo Demurtas (2,3)

(1) Geology Department, University of Otago, Dunedin, New Zealand, (2) Dipartimento di Geoscienze, Universita degli Studi di Padova, 35131 Padova, Italy, (3) School of Earth, Atmospheric and Environmental Sciences, University of Manchester, UK, (4) Istituto Nazionale di Geofisica e Vulcanologia (INGV), Rome, Italy

Foliated gouges and cataclasites are commonly interpreted as the product of distributed (aseismic) fault creep. However, foliated fault rocks are often associated with localized slip surfaces, the latter indicating potentially unstable (seismic) behavior. One possibility is that such fault zones preserve the effects of both seismic slip and slower aseismic creep. An alternative possibility explored here is that some foliated fault rocks and localized slip surfaces develop contemporaneously during seismic slip. We studied the microstructural evolution of calcite-dolomite gouges deformed experimentally at slip velocities <1.13 m/s and for total displacements of 0.03 - 1 m, in the range expected for the average coseismic slip during earthquakes of Mw 3-7. As strain progressively localized in the gouge layers at the onset of high-velocity shearing, an initial mixed assemblage of calcite and dolomite grains evolved quickly to an organized, foliated fabric. The foliation was defined mainly by compositional layering and grain size variations that formed by cataclasis and shearing of individual foliation domains. Quantitative image analysis (e.g. grain size, strain) showed that the most significant microstructural changes in the bulk gouge occurred before and during dynamic weakening (<0.08 m displacement). Strain was localized to a bounding slip surface by the end of dynamic weakening and thus microstructural evolution in the bulk gouge ceased.

Our experiments suggest that certain types of foliated gouge and cataclasite can form by distributed brittle “flow” as strain localizes to a bounding slip surface during coseismic shearing. We will also present preliminary observations of natural calcite-dolomite foliated cataclasites from the Campo Imperatore normal fault, central Italy, which bear striking resemblance to our well-characterized experimental examples.