Coseismic origin of foliated cataclasites and preservation potential during the seismic cycle

Steven Smith[1], Matteo Demurtas[2], Elena Spagnuolo[3], Michele Fondriest[4], Giulio Di Toro[2,3,4]

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

Foliated gouges and cataclasites are most commonly interpreted as the result of aseismic faulting in the brittle upper crust. However, the occurrence of foliated cataclasites associated with possible indicators of earthquake ruptures (mirror-like slip surfaces with truncated clasts, in-situ pulverized rocks, etc.) suggests that some examples may have a coseismic origin.

Here we present the results of friction experiments and microstructural analysis performed on mixtures (50/50wt%) of calcite-dolomite gouges to ascertain the conditions of foliation formation. The gouges were sheared for 40 cm in a rotary shear apparatus (SHIVA, INGV-Rome) under constant normal stress of 17.5 MPa and slip rates of 30 µm/s to 1 m/s.

In room-humidity conditions, a striking foliated fabric was formed only at V = 1 m/s, associated with strain localization and evidence of thermal decomposition and crystal-plastic deformation in a slipping zone less than a few micrometres-thick. Instead, in water-dampened conditions, no foliation was formed at any slip rate and strain localized within an ultrafine (grain size << 1 µm) fluidized layer whose thickness decreased with increasing velocity. To investigate the preservation potential of these microstructures during the seismic cycle, we also conducted experiments that stepped from slow (30 µm/s for 10 cm slip) to high (1 m/s for 30 cm slip) velocity and vice-versa. In the 30 µm/s to 1 m/s experiment, in room-humidity conditions, characteristic microstructures of both slip velocities were preserved and the overall fabric strongly resembles that found in natural foliated cataclasites from the active Vado di Corno Fault Zone, Italian Central Apennines. In the 1 m/s to 30 µm/s experiment, performed under water-dampened conditions, evenly spaced gouge injection veins departing from the localized slip surface formed during the 30 µm/s slip event.

Our experiments suggest that foliations defined by compositional banding and/or grain size variations in gouge and cataclasite can form during coseismic sliding ($V \geq 1$ m/s) in dry conditions and that foliation is likely to be preserved during the seismic cycle. Recognition of such foliated cataclasites in the geological record would provide a marker of seismic rupture and also a window in to the mechanics of strain localization in brittle fault rocks.