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Slip surfaces associated with seismic faults and gravitational slope deformations in carbonate-built rocks

Luca Del Rio (1), Giulio Di Toro (1), Michele Fondriest (1), Marco Moro (2), Michele Saroli (3), Stefano Gori (2), Emanuela Falcucci (2), and Elena Spagnuolo (2)

(1) University of Padua, Padua, Italy (luca.delrio@studenti.unipd.it), (2) Istituto Nazionale di Geofisica e Vulcanologia (INGV), Rome, Italy), (3) University of Cassino, Cassino, Italy

Carbonate-built rocks of the Central Italian Apennines are systematically cut by active sharp slip surfaces bounding less than few cm-thick slipping zones surrounded by cm to hundreds meter-thick damage zones. Recent paleo-seismological, geological and geomorphological observations pointed out that the principal slipping zones (PSZs) may accommodate either large landslides (Deep-Seated Gravitational Slope Deformation. DGSD) and seismic or aseismic crustal scale fault deformation (normal tectonic faults, NF). Clearly, the distinction between DGSD and NF structures based on field and microstructural observations and the individuation of the processes forming the PSZs is of outstanding relevance in geological hazard studies. Currently, most of the sharp slip surfaces exposed in the Italian Central Apennines are mapped as active normal faults, even if the different geomorphological and surrounding secondary fault/fracture networks, would suggest a different behavior of such structures.
Depending on the associated geological process (i.e. DGSD vs. NF), the slip surfaces and associated slipping zones reach different depths along dip (100-1000 meters for DGSD, 10-12 km for NF), and are formed and active over a different range of temperatures (0-30 °C for DGSD vs. 0-100°C for NF), pressures (< 20 MPa for DGSD, 0 to 200 MPa for NF) and slip rates (usually < 10-3 m/s for DGSD, up to ∼1 m/s for NF). Such large differences in loading conditions should result in the formation of distinctive secondary fault/fracture networks in the damage zones recognizable at the outcrop scale and in peculiar microstructures in the slipping zones. For this reason, this study aims at identifying the geological structures and deformation mechanisms associated to both DSGD and NF by (1) conducting extensive field surveys, (2) investigating in the laboratory the origin of the different slipping zones under controlled deformation conditions and (3) performing microstructural studies on natural and experimental PSZs.

The microstructures of the PSZs will be investigated by optical and scanning electron microscopy, X-ray diffraction, micro-Raman spectroscopy, Electron Microprobe analyses, and cathodoluminescence. The microstructures of the natural PSZs and wall rocks will be compared with those produced under controlled deformation conditions (normal stress, presence of fluids, slip rate) on carbonate rocks with the rotary shear (SHIVA - Slow to HIgh Velocity Apparatus) installed at the Istituto Nazionale di Geofisica e Vulcanologia in Rome.

Preliminary microstructural analyses of end-member cases (i.e. shallow and small DSGD cutting Quaternary deposits vs. large NF producing > Mw 6.5 earthquakes) and intermediate cases (i.e. NF reactivated as DGSD) have shown neat differences in the deformation style and microstructural maturity of the PSZs. These results show how the characterization of the microstructures in PSZs from scarps hosted in carbonate rocks could represent a powerful tool to discriminate seismic faulting from DGSDs and provide new grounds for the mapping of active faults in Italy and in other seismically active worldwide.