Mechanism of formation of slip surfaces in carbonate-built rocks: seismic faulting vs. deep-seated gravitational slope deformation

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Many carbonate-built reliefs of the Italian central Apennines are cut by sup-planar bedrock scarps with sharp slip surfaces. The scarps are associated to surface displacements caused by (1) active seismogenic faults (SF), (2) deep-seated gravitational slope deformations (DGSD), (3) gravity-tectonic phenomena and (4) faults considered as inactive (on the basis of the available literature) and now exposed at the surface. Given the different origin of the scarps (e.g., DGSD vs. SF), the individuation of the processes responsible for the formation of the slip surfaces is of outstanding relevance in geological hazard studies.

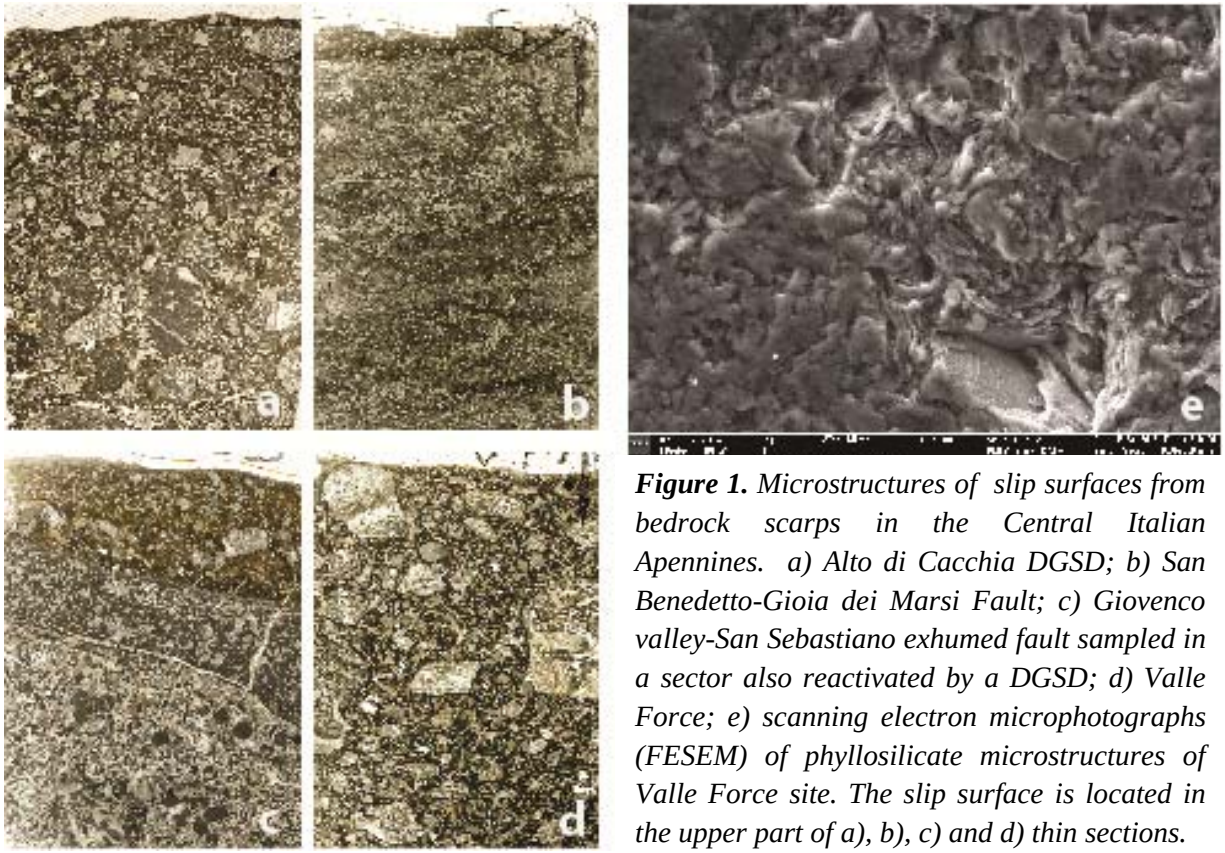

Figure 1. *Microstructures of slip surfaces from bedrock scarps in the Central Italian Apennines. a) Alto di Cacchia DGSD; b) San Benedetto-Gioia dei Marsi Fault; c) Giovenco valley-San Sebastiano exhumed fault sampled in a sector also reactivated by a DGSD; d) Valle Force; e) scanning electron microphotographs (FESEM) of phyllosilicate microstructures of Valle Force site. The slip surface is located in the upper part of a), b), c) and d) thin sections.*

Depending on the mechanism of formation (e.g., DGSD vs. SF), the scarps have slip surfaces that reach different depths along dip (10-1000 metres for DGSD, 10-12 km for SF) which formed over a different range of temperatures (0-30 °C for DGSD vs. 0-100°C for SF), pressures (< 20 MPa km for DGSD, 0 to 100 MPa for SF) and slip rates (< 10^{-3} m/s for DGSD, ca. 1 m/s for SF). Such different ambient and deformation conditions should result in distinctive microstructures in the slip surfaces and wall rocks of DGSD and faults. However, some scarps and their associated slip surfaces and microstructures might have been exploited by both seismic faults and DGSD.

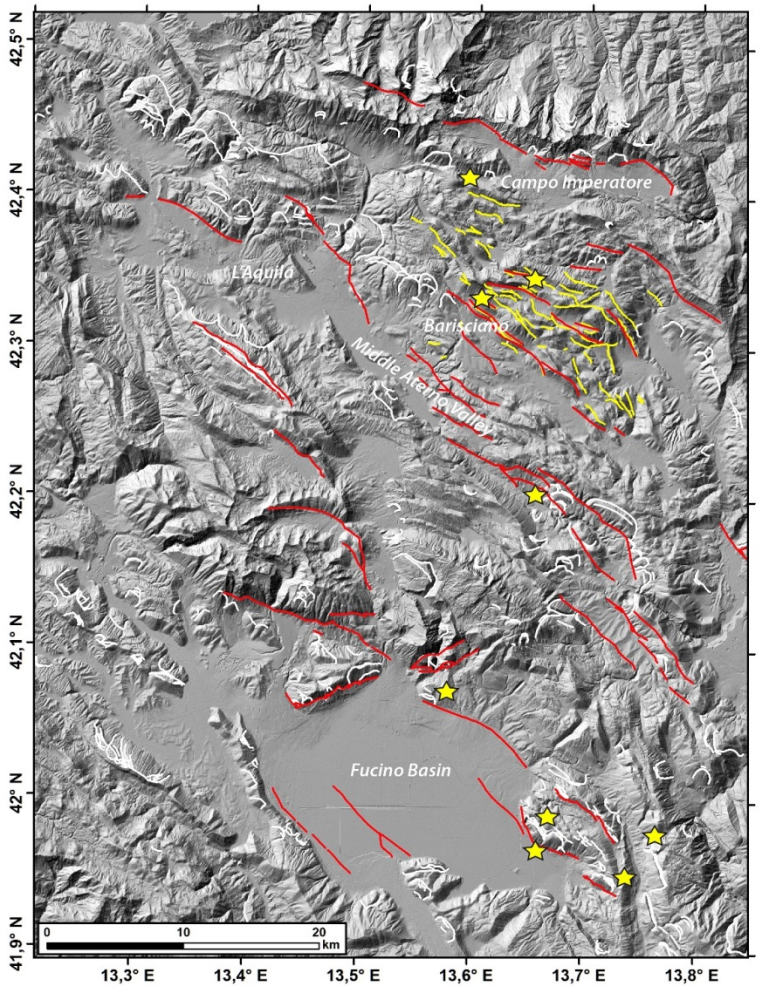

Figure 2. *Map of the active faults (red lines), DGSD (white lines) and the fault planes bordering small depressions (yellow lines). Yellow stars represent the current sampling sites of slip surfaces.*

The PhD student will carry on field and microstructural analysis on several case studies of slip surfaces and their wall rocks from faults and DGSD located in the Italian central Apennines (Figs 1 and 2). In these will include at least the following:

i) for active seismogenic faults (microstructures associated to seismic faulting): San Benedetto-Gioia dei Marsi Fault, Assergi Fault, Middle Aterno valley Fault (Galadini & Galli, 1999; Falcucci et al., 2015);

ii) for non-active seismogenic faults (microstructures associated to old seismic faulting): Fiamignano and Giovenco valley-San Sebastiano;

iii) for faults bordering small depressions (microstructures associated to gravity-tectonic phenomena): faults in the western flank of the Gran Sasso massif and the Campo Imperatore plain (Piano Presuta, Valle Force and Piano Buto);

iv) for DSGD: slip surfaces from Serrone-Colle Cerese, Mt. Ocre, Celano-Aielli (Moro et al., 2012; Albano et al., 2015).

The microstructures of the slip surfaces will be investigated with optical and scanning electron microscope (SEM) and micro-Raman spectroscopy at University of Padua, with Field Emission Scanning Electron Microscope (FESEM) and Electron Microprobe Analyzer (EMPA) at High Pressure High Temperature laboratory of Rome INGV, and at the Laboratory of Scanning Electron Microscopy and Ultra/High Resolution Microanalysis (CERTEMA - Grosseto).

The microstructures found in the natural slip surfaces and wall rocks will be compared with the microstructures produced under controlled deformation conditions (normal stress, presence of fluids, slip rate) on cohesive and non-cohesive carbonate rocks with the rotary shear (SHIVA - Slow to HIgh Velocity Apparatus) in the last years at INGV-Rome. New experiments will be carried out with both SHIVA and the ROtary Shear Apparatus (ROSA) installed at the UNIPD-DG in case of incompleteness of the available microstructural database. The comparison between the experimental products obtained under known deformation conditions (temperature, pressure, slip, slip velocity, presence of fluids, etc.) and the natural slip surfaces will allow the PhD student to identify the mechanism of formation of the scarps found in nature.

The systematic characterization of the microstructures of the slip surfaces from scarps hosted in carbonate rocks is expected to be a powerful tool to discriminate between the seismic faulting vs. DGSD origin of structures. Clearly, the proposed field, microstructural and experimental study, integrated with the Quaternary geology, paleoseismology and geomorphology analysis, may also yield novel information about the ongoing tectonic activity, the geometric and kinematic characterization of active fault systems and on the DGSD hazard and risk assessment in Central Italy. Lastly, the results of this PhD project will provide new grounds for the mapping of active faults in Italy and worldwide.

The above activities will force the PhD student (advised by the supervisors) to develop a collaborative network during the entire duration of the project, as the activities will be performed at UNIPD-DG and INGV-Rome. Thanks to this approach, we anticipate the following results:

- formation of a young researcher with ability to exploit field and microstructural/microanalytical methods (also for industrial applications), with strong background on earthquake geology;
- the individuation of the loading conditions, geological and other physical parameters resulting in the formation of slip surfaces by seismic faulting or gravitational processes (DGSD), with relevant implications for seismic hazard studies in Italy and worldwide;
- the submission to international peer-reviewed journals of two or three manuscripts regarding the mechanism of formation of slip surfaces in carbonate rocks under different deformation conditions.

References

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