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Architectural and microstructural characterization of a seismogenic normal fault in dolostones (Central Apennines, Italy)

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Fault zones cutting carbonate sequences represent significant seismogenic sources worldwide (e.g. L'Aquila 2009, MW 6.1). Though seismological and geophysical techniques (double differences method, trapped waves, etc.) allow us to investigate down to the decametric scale the structure of active fault zones, further geological field surveys and microstructural studies of exhumed seismogenic fault zones are required to support interpretation of geophysical data, quantify the geometry of fault zones and identify the fault processes active during the seismic cycle.

Here we describe the architecture (i.e. fault geometry and fault rock distribution) of the well-exposed footwall-block of the Campo Imperatore Fault Zone (CIFZ) by means of remote sensed analyses, field surveys, mineralogical (XRD, micro-Raman spectroscopy) and microstructural (FE-SEM, optical microscope cathodoluminescence) investigations. The CIFZ dips 58° towards N210 and its strike mimics that of the arcuate Gran Sasso Thrust Belt (Central Apennines). The CIFZ was exhumed from 2-3 km depth and accommodated a normal throw of ∼2 km starting from the Early-Pleistocene. In the studied area, the CIFZ puts in contact the Holocene deposits at the hangingwall with dolomitized Jurassic carbonate platform successions (Calcare Massiccio) at the footwall. From remote sensed analyses, structural lineaments both inside and outside the CIFZ have a typical NW-SE Apenninic strike, which is parallel to the local trend of the Gran Sasso Thrust.

Based on the density of the fracture/fault network and the type of fault zone rocks, we distinguished four main structural domains within the ∼300 m thick CIFZ footwall-block, which include (i) a well-cemented (white in color) cataclastic zone (up to ∼40 m thick) at the contact with the Holocene deposits, (ii) a well-cemented (brown to grey in color) breccia zone (up to ∼15 m thick), (iii) an high strain damage zone (fracture spacing < 2-3 cm), and (iv) a low strain damage zone (fracture spacing > 10 cm). Other than by the main boundary normal fault, slip was accommodated in the cataclastic zone by minor sub-parallel synthetic and antithetic normal faults and by few tear strike-slip fault; the rest of the footwall shows progressively less pervasive damage down to the background intensity of deformation. High strain domains include (1) pervasively fragmented dolostones with radial fractures (evidence of in-situ shattering), (2) shiny (mirror-like) fault surfaces truncating dolostone clasts, (3) mm-thick ultra-cataclastic layers with lobate and cuspate boundaries, (4) mixed calcite-dolomite "foliated cataclasites". The above microstructures can be associated with seismic faulting. Fluids infiltration during deformation is attested by the occurrence of multiple generations of carbonate-filled veins, often exploited as minor faults with a mylonite-like fabric (e.g. presence of micrometer in size euhedral calcite grains).

The attitude of the studied segment of the CIFZ, the thickness of the footwall block and the kinematics of the minor faults compares well with the hypocentral and focal mechanisms distribution typical of the earthquake sequences in the Apennines. In particular, the CIFZ can be considered as an exhumed analogue of the normal fault system that caused the L'Aquila 2009 seismic sequence.