ARCHITECTURE AND FAULT ROCKS OF THE SEISMOGENIC
MONTE MARINE FAULT ZONE (CENTRAL APENNES, ITALY)

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The Central Apennines of Italy are characterized by a unique seismotectonic framework formed by a complex array of active seismogenic faults responsible for Mw≤7 seismic sequences (e.g., L’Aquila Mw 6.2, 2009; Amatrice Mw 6.6, 2016). Because of these seismic sequences, many seismological, geological and experimental studies have been performed to investigate earthquakes nucleation and propagation and to constrain fault zone frictional properties during the seismic cycle (Collettini et al., 2017; De Paola et al., 2011; Di Toro et al., 2011; Nielsen et al., 2017). Nevertheless, detailed field mapping and quantitative fault zone rock characterization (e.g. Demurtas et al., 2016) are still lacking for the majority of the seismogenic faults affecting the Central Apennines. Structural architecture and fault rock distribution in active faults is a fundamental information for understanding the formation and evolution of faults, strain partitioning during the seismic cycle and the factors controlling the propagation and arrest of seismic ruptures. Accordingly, additional work on this subject is of paramount importance.

In this contribution, we present the results of a field and laboratory studies of the seismogenic Monte Marine Fault Zone (MMFZ), which outcrops along the Aterno Valley near L’Aquila town, in the Central Apennines. The fault zone cuts through the Jurassic Calcare Massiccio Fm. and the Corniola Fm. and has a very old and complex seismotectonic history. The Monte Marine fault, which consists of a ~14 km long active segment (Galli et al., 2011) was activated during the 1703 destructive earthquake that caused hundreds of fatalities along the Aterno Valley and in the near town of L’Aquila. Thanks to the trench excavations performed by Galli et al. (2011) and Moro et al. (2016), it was possible to verify the occurrence of further seismic surface ruptures during historical times along the fault and map the main fault trace in the Quaternary deposits near the villages of Pizzoli and Arischia.

To study the along-strike fault zone architecture and related fault rock properties, twelve key-sectors were mapped at 1:500 scale and two detailed geological cross sections were constructed in the Barete and Pizzoli areas. Near Barete, the master slip surface is very smooth and quasi-planar and crops out discontinuously with an average attitude of N204°/65° (dip dir/ dip). In this site, the fault core is about 5 m thick. Based on grain size and shape distributions (obtained combining field observations and laboratory analyses), the following three cataclastic facies were identified (Fig. 1): Facies 1 is localized along the master slip surface and has grains with diameter < 63 µm with sub-rounded shapes; Facies 2 consists of a coarser cataclasite with grains between 63 µm and 2 mm; Facies 3 is a coarse breccia with sub-angular, cm to dm-scale grains. The facies 2 and 3 are also cut by secondary synthetic and antithetic normal faults, some of them showing ultra-comminuted cataclasites localized along mm-thick slip zones. Additionally, in places Facies 2 hosts carbonate-cemented concretionary bodies, suggesting sin- to post-kinematic meteoric fluid circulation.

Between Pizzoli and Arischia, the structural architecture of the fault is more complex than in the Barete area because the fault zone width increases due to the presence of an overlapping zone characterized by E-W trending, breaching oblique-slip faults. In this sector, we found evidences of NE-SW strike-slip faults and NW-SE trending reverse faults, which are systematically cross-cut by the extensional faults. Reverse faults are likely inherited from the Apenninic compressional tectonics (with a 20-30°N tectonic transport direction) and were partially reactivated during the extensional phase.

In this complex sector, the fault core is about 30 m thick and consists of ultracataclasites localized along major fault surfaces (Facies1), coarser cataclasites (Facies2) and coarse loose
breccias (Facies 3) with cm-wide grains. Facies 3 is transitional to the damage zone and encompasses significant volumes of damaged rock exposed up to several hundreds of meters from the main fault. Due to internal heterogeneities, the loose fault breccia was further subdivided into 3 sub-facies as follow: 1) Facies 3a consists of a coherent/uncoherent loose mosaic breccia formed by elongate cm-grains; 2) Facies 3b corresponds to localized deformation along minor fault planes with associated cataclasites and ultracataclasites; and 3) Facies 3c is composed by m-wide blocks (lithons) often bounded by minor faults and characterized by decimetric-spaced fractures (Fig. 1).

Fig. 1 - (A) View of the Monte Marine fault zone from the village of Teora and detail on Facies 1, Facies 2 and Facies 3 observed in the field; (B) Sub-classification of Facies 3 in Facies 3a, 3b and 3c.
The spatial distribution of the fault rocks documented in this study suggests that the largest volumes of loose breccias are located in the overstep sector, where the two major fault strands overlap and where also secondary extensional structures overprint compressive features. Here, the increased structural complexity provides favourable conditions for cataclasite and loose breccia development, thus highlighting the fundamental role of inherited faults and structural complexity in developing anomalous amount of fault rocks along active fault segments. The spatial distribution and the quantitative analysis (e.g. grain size and shape distributions) of cataclastic facies may unravel the deformational processes (seismic vs aseismic) controlling the evolution of active fault zones developed in carbonate platforms.

References