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Field and microstructural investigations of an exhumed fault zone in dolostones (Southern Alps, Italy)

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In many seismically active areas in Europe (e.g. central Apennines and southern Alps of Italy; Greece) destructive earthquakes both nucleate within and propagate through thick upper crustal sedimentary sequences dominated by carbonate rocks (limestones and dolostones). Field and microstructural investigations of fault zones and fault rocks in carbonates represent a fundamental step in characterizing seismogenic fault zone structure and understanding the physico-chemical processes active during the seismic cycle. This study deals with the macro- to micro-scale description of an exhumed, sub-vertical strike-slip fault in dolostones, including mineralogical analyses of fault rock materials using energy dispersive X-ray spectroscopy and X-ray powder diffraction analysis.

The studied fault is part of the NW-SE striking Schio-Vicenza Fault System (a main lineament of the Italian Southern Alps) and is well exposed within a large quarry (Borcola Pass, Trento). Geological constraints indicate that the depth and temperature during faulting were c.1.6-1.7 km and c.50°C. The fault zone consists of a > 80 m thick damage zone surrounding a 2-3 m thick fault core that contains a series of fault rock lenses bounded by sharp, 5-6 cm thick, principal slipping zones. The damage zone is cut by three systems of sub-vertical secondary faults with average spacing between 0.2 to 0.5 m striking N-S, E-W and NW-SE. Cross-cutting relationships with basaltic dykes of Paleogene age, combined with aerial photography and field structural data, indicate that (1) N-S and E-W striking faults reactivate inherited (Jurassic to Paleogene) regional-scale joint and fault systems while, (2) NW-SE oriented faults are newly-formed sinistral strike-slip faults. Both the reactivation of inherited joints and faults, and the formation of new faults, is coeval (post-Paleogene onward) with slip activity along the studied fault and the Schio-Vicenza line. The highly cohesive fault core is made of cement-supported dolomitic cataclasites and dolomite-filled veins. These features record repeated fracturing and sealing events. A detailed analysis of one of the principal slipping zones in the fault core distinguishes two texturally-distinct slipping zones ("A" and "B"), separated themselves by a knife-sharp slip surface. Slipping zone "A" (< 4 mm thick) is white in colour and consists of sub-rounded dolomite grains < 2.5 mm in diameter suspended in a dolomitic cement. Slipping zone "B" (5-6 cm thick) is greyish in colour and consists of dolomite grains dispersed in dolomitic cement. Image analysis reveals that slipping zone "A" contains few fragments < 200 μm in diameter, and has a higher 2-dimensional fractal dimension (D = 3) than slipping zone "B" (D = 1.8). These data suggest that while grain fragmentation models (e.g. constrained comminution) can account for the clast size distribution found in slipping zone "B", other physico-chemical processes such as localized layer fluidization by (coseismic) pressurized fluids may be responsible for the unusual textural characteristics found in slipping zone "A".