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Microstructural investigations on carbonate fault core rocks in active extensional fault zones from the central Apennines (Italy)

Silvia Cortinovis, Fabrizio Balsamo, and Fabrizio Storti

NEXT - Natural and Experimental Tectonics Research Group, Department of Chemistry, Life Sciences, and Environmental Sustainability, University of Parma, Italy

The study of the microstructural and petrophysical evolution of cataclasites and gouges has a fundamental impact on both hydraulic and frictional properties of fault zones. In the last decades, growing attention has been payed to the characterization of carbonate fault core rocks due to the nucleation and propagation of coseismic ruptures in carbonate successions (e.g., Umbria-Marche 1997, L'Aquila 2009, Amatrice 2016 earthquakes in Central Apennines, Italy). Among several physical parameters, grain size and shape in fault core rocks are expected to control the way of sliding along the slip surfaces in active fault zones, thus influencing the propagation of coseismic ruptures during earthquakes. Nevertheless, the role of grain size and shape distribution evolution in controlling the weakening or strengthening behavior in seismogenic fault zones is still not fully understood also because a comprehensive database from natural fault cores is still missing. In this contribution, we present a preliminary study of seismogenic extensional fault zones in Central Apennines by combining detailed filed mapping with grain size and microstructural analysis of fault core rocks. Field mapping was aimed to describe the structural architecture of fault systems and the along-strike fault rock distribution and fracturing variations. In the laboratory we used a Malvern Mastersizer 3000 granulometer to obtain a precise grain size characterization of loose fault rocks combined with sieving for coarser size classes. In addition, we employed image analysis on thin sections to quantify the grain shape and size in cemented fault core rocks. The studied fault zones consist of an up to 5-10 m-thick fault core where most of slip is accommodated, surrounded by a tens-of-meters wide fractured damage zone. Fault core rocks consist of (1) loose to partially cemented breccias characterized by different grain size (from several cm up to mm) and variable grain shape (from very angular to sub-rounded), and (2) very fine-grained gouges (< 1 mm) localized along major and minor mirror-like slip surfaces. Damage zones mostly consist of fractured rocks and, locally, pulverized rocks. Collectively, field observations and laboratory analyses indicate that within the fault cores of the studied fault zones, grain size progressively decreases approaching the master slip surfaces. Furthermore, grain shape changes from very angular to sub-rounded clasts moving toward the master slip surfaces. These features suggest that the progressive evolution of grain size and shape distributions within fault cores may have determined the development of strain localization by the softening and cushioning effects of smaller particles in loose fault rocks.