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Fault rocks evolution and deformation processes along carbonate-bearing thrust faults

Cecilia Viti (1) and Cristiano Collettini (2,3)

(1) Siena University, Earth Science Department, Siena, Italy (vitic@unisi.it), (2) Perugia University, Earth Science Department, Perugia, Italy, (3) Istituto Nazionale di Geofisica e Vulcanologia (INGV), Roma, Italy

The integration of seismic reflection profiles with seismological data show that the strongest earthquakes in the Adriatic foreland, Northern Apennines ($5 < M < 6$) nucleate along thrust faults within carbonates. In order to understand the deformation processes responsible for the seismic behaviour we have analyzed ancient thrust faults exhumed at the Earth's surface. To do this we have studied textural and mineralogical evolution of carbonate-bearing thrust faults cropping out in the Umbria-Marche Apennines of Italy. The fault rocks belong to regional thrust faults with displacement of several kilometers and fault rock exhumation in the range 1-4 km. Our studies, based on optical, scanning and transmission electron microscopy data, show that the fault zone structure and evolution are controlled by the nature of the protolith and related deformation processes. In massive limestones, most of the deformation is concentrated along a sharp, single fault plane; here, the fault rock is a cataclasite within a carbonate cement. In layered and in marly limestones, the deformation is initially characterized by dissolution and precipitation processes, with the development of stylolites and calcite-rich veins, producing the typical SCC' fabric. With increasing deformation, calcite veins are re-worked by plastic processes, as documented by twinning. Dissolution processes favor the concentration of poorly-crystalline phyllosilicates along C and S surfaces. The development of sub-parallel phyllosilicate horizons along the fault zone allows slipping processes to occur over the entire shear zone, by frictional sliding along the phyllosilicate (001) planes. Our data suggest a mixed mode fault slip behaviour where creep, induced by dissolution and precipitation processes, and stable sliding along phyllosilicates interact with fluid-assisted fractures and slip localization along principal slip planes.