Geophysical Research Abstracts
Vol. 16, EGU2014-11075, 2014
EGU General Assembly 2014

Structural architecture and palaeofluid evolution of low-angle extensional fault systems cutting through carbonate rocks within the brittle crust. The case study of the Tellaro Detachment, Northern Apennines (Italy).

Luca Clemenzi (1), Fabrizio Storti (1), Fabrizio Balsamo (1), Giancarlo Molli (2), Rob Ellam (3), Philippe Muchez (4), and Rudy Swennen (4)

(1) NEXT - Natural and Experimental Tectonics Research Group - Department of Physic and Earth Sciences “Macedonio Melloni”, University of Parma, I-43124 Parma, Italy, (2) Department of Earth Sciences, University of Pisa, Via S. Maria, 53, I-56126 Pisa, Italy, (3) SUERC, Rankine Avenue, Scottish Enterprise Technology Park, East Kilbride, G75 0QF, Scotland, UK, (4) Department of Earth and Environmental Sciences, KU Leuven, Celestijnenlaan 200E, B-3001 Heverlee, Belgium

The Tellaro Detachment is an exhumed low-angle extensional fault zone exposed in the internal portion of the Northern Apennines thrust wedge. It developed at shallow structural levels within the brittle crust, and mainly affected the carbonate-dominated Late Triassic to early Early Miocene non-metamorphic Tuscan succession.

The three-dimensional geometry of the Tellaro Detachment has been investigated through detailed structural mapping and restoration of the superimposed deformations, while appropriate exposure allowed for accurate damage zone characterization. Pressure-depth conditions and palaeofluid evolution of the fault system have been studied through microstructural, mineralogical, petrographic, fluid inclusion and stable isotope analysis of fault rocks and fault-related dolomite and calcite veins.

Abundant fluid circulation characterized the fault zone, with development of metric- to decametric-scale dolomitic bodies, abundant pressure solution, and veining. Dolomitic bodies are discordant to bedding and typically overly the main low-angle fault segments; they are brecciated and crosscut by the subsidiary high-angle faults. Dolomite veins are only observed in dolomitic host rocks. They are generally oriented perpendicular to the tectonic transport direction and formed at about 175°C and 5.2 km depth. Stable isotope signature and elevated salinity suggest precipitation from a rock-buffered fluid. Syntectonic calcite veins with variable orientations are well developed in the fault damage zones, and characterized by multiple generations of infillings. Crosscutting relationships between differently oriented veins are not systematic in damage zones and the different calcite generations do not have any preferred orientations. Furthermore, short and irregularly shaped veins characterize the footwall damage zone in the proximity of the major low-angle fault segments. Fluid inclusion microthermometry indicates that different veins formed at different temperature-depth conditions, with individual values ranging from 90 to 165°C and from 2.2 to 4.8 km depth. Fluid mixing processes within the fault zone are suggested by: i) the presence of low- and high-salinity water in fluid inclusions homogenizing at the same temperatures; ii) broad variability in stable (oxygen and carbon) and strontium isotopic compositions. Finally, late tectonic calcite veins with variable orientations reopen/crosscut all the previous structures. They formed at low temperature (<70°C) from a low-salinity fluid of meteoric origin.

These results indicate that the long-lasting activity of the Tellaro Detachment was associated with fluid circulation in the damage zones and precipitation of dolomite and calcite infillings at gradually decreasing depths and temperatures. Initial incipient faulting was characterized by circulation of rock-buffered local fluids in a “closed system” environment. Subsequently, the propagation of the fault system, and the associated damage zone permeability increase, favored mixing of different fluids in an “open system” environment. Finally, when the fault system was almost completely exhumed and became inactive, meteoric fluids dominated the post-tectonic shallow circulation system ($\sim < 1.5$ km). Footwall fluid overpressures due to self-sealing of the major fault zones favored shear localization along the misoriented low-angle principal slip zones, and contributed to: i) the precipitation of calcite infillings in differently oriented veins in damage zones, ii) hydrofracturing processes in the immediate proximity of the principal slip zones themselves.

In conclusion, the Tellaro Detachment was active within the brittle crust from $\sim$ 5 to 2 km depth, during the progressive exhumation of the western sector of the Northern Apennines thrust wedge. It was characterized

by: i) contemporaneous activity of low-angle master fault segments and high-angle subsidiary faults; ii) elevated fluid pressures and low differential stress conditions. Our contribution testifies that the combined conduit-barrier architecture of low-angle extensional fault zones can influence fluid circulation in the brittle crust in different ways. Damage zone permeability favors mixing of fluids of different origin. Impermeable fault cores can constitute efficient hydraulic barriers promoting fluid compartmentalization and footwall overpressures, which can favor slip on severely misoriented fault zones.