Evolution of segments of the central-northern Apennine wedge through structural, geochemical, and geochronological constraints in fault zones

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1) Research objectives

General objective

This research aims at constraining the space-time (4D) orogenetic (compressional) and post-orogenetic (extensional) evolution of segments from the internal to the axial sector of the central-northern Apenninic wedge, with specific reference to fluid-fault interactions. This goal will be reached through geometric, kinematic and dynamic reconstructions, microstructural, geochemical analyses (stable and clumped isotopes, REE, and trace elements), analysis of fluid inclusions, U-Pb and K-Ar dating of syn-tectonic mineralizations and fault gouge along fault zones.

Specific objective

For five selected structures, the analyses will allow a better understanding of the formation of mineralizations during the seismic cycle, with specific reference to co-seismic structures. Isotopic analyses (He, C, O, and clumped isotopes) and analysis of fluid inclusions on mineralizations of fault zones will constrain temperature and origin of fluids involved in tectonic processes and thus shed light on fluid- rock interaction. Radiometric datings (U-Pb on syn-tectonic calcite mineralizations and K-Ar on syn-kinematic clay minerals) will constrain the timing of activity of faults.

2) State of the Art

The tectonic evolution of the central-northern Apennine wedge is characterized by a progressive migration of orogenic (compressive) and post-orogenetic (extensional) deformations toward E-NE. The time propagation of orogenetic and post-orogenic deformations toward the foreland is currently constrained only by stratigraphic data, which don't provide high resolution. In fact, studies conducted on the central-northern portion of the orogenic wedge suggest that the time gap between thrusting and crustal extension is 2-4 Ma long and the longevity of these tectonic phases (in each portion of the chain) is comprised between 1 and 4 Ma ca. [1, 2, 4]. The uncertainty of such temporal data resides in the low resolution of stratigraphic and biostratigraphic data for Cenozoic deposits of the Apennine chain (in particular continental deposits filling extensional basins).

In a local scale perspective, fault zones are characterized by the occurrence both of mineralization in different syn-tectonic structures (e.g. breccias, veins, slickenfibers) and of syn-kinematic clay minerals (e.g. illite in fault gouge), which testify to the presence and activity of fluids in tectonic processes [6]. Recent studies have demonstrated that it is possible to constrain activity (and recurrence) of seismic faults by absolute U-Pb dating on syn-tectonic calcite and K-Ar dating on syn-kinematic clay minerals [3, 7, 8]. Furthermore, by associating isotopic analyses (He, Sr, C, O, and clumped isotopes) on the same mineralizations, it is possible to infer the origin of the fluids and constrain fluid-rock interaction. This information, coupled with the analysis of the stress field and geochemical constrains, is a key factor in tectonic reconstructions both at local and regional scales [5, 9]. In this context, the focus of my proposal is on structural, microstructural and geochemical studies of syn-tectonic and syn-kinematic mineralizations in five fault zones of the central-northern Apennines. In particular, it is proposed to study reverse faults cut by younger extensional faults (or extensionally-inverted thrusts) arranged from the Tyrrhenian coast to the axial sector of the chain (where extensional tectonic is actually active). In this way, I aim at obtaining, for the first time, radiometric time constraints on the tectonic evolution of segments of the Apenninic wedge in the last 30-35 Ma, with particular focus on to the propagation of crustal extension and on time interval between compression and extension.

References

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