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Structural architecture and paleofluid evolution of the Tellaro detachment fault (Northern Apennines, Italy)

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In the Punta Bianca promontory, the Northern Apennines thrust wedge is thinned by low-angle extensional shear zones offsetting the tectonic contacts between the previously stacked nappes. Among those shear zones, the best exposed one is the Tellaro detachment, outcropping along the Tyrrhenian shoreline between Lerici and Tellaro villages, in eastern Liguria. This detachment mainly affects the unmetamorphic succession of the Tuscan Nappe, locally reducing the pristine kilometer thick succession down to few tens of meters. Locally, the Late Cretaceous shales of the Scaglia Formation are tectonically juxtaposed on the Upper Triassic limestones of the La Spezia Formation. The interposed formations are preserved as anastomosed, metric- to decametric-scale shear lenses. Near the Lerici village, the low-angle detachment fault cross-cuts the folded tectonic contact between the Upper Triassic basal limestones and cataclasites of the Tuscan Nappe, and the underlying quartzites of the Verrucano Formation.

The structural architecture of the Tellaro detachment is mainly characterized by nearly horizontal anastomosed fault segments with metric-scale corrugations, on which listric subsidiary extensional faults sole down. Metric- to decametric-scale breccia bodies are frequently associated with the main low-angle fault zones and are typically cross-cut by the subsidiary faults. Syntectonic veins and tectonic stylolites are abundant in the damage zones. Detailed structural mapping of the exposed deformation structures allowed to describe the three-dimensional architecture of the extensional fault system, and of the calcite vein network in particular, and to determine its tectonic transport direction, which is toward NE with local values ranging from N010E to N080E.

Paleofluid evolution through the Tellaro detachment has been studied through combined structural, petrographic, and geochemical analysis of fault breccias and syntectonic veins. Different fluid generations are present, with consistent chronological relationships. Stable isotope analysis (δ^{18}O and δ^{13}C) of the various vein generations is used to constrain the fluid origin, the fluid-rock interactions and the dolomitization reactions. Early deformation is associated with widespread dolomitization in the fault damage zone; dolomite isotopic signature is in the range $-7.5‰ < \delta^{18}$O V-PDB $< -1.7‰$ and $+0.8‰ < \delta^{13}$C $< +4.1‰$. Both dolomitic bodies and undolomitized limestone in the damage zones underwent brecciation, cementation, extensional faulting and multiple calcite veining events. Calcite veins of different generations are characterized by different contents in Fe and Mn. Their isotopic signature is scattered over a wide range ($-15.5‰ < \delta^{18}$O V-PDB $< -2.9‰$ and $+0.3‰ < \delta^{13}$C $< +3.1‰$), with younger generations trending toward the less depleted δ^{18}O values. The last fluid phase, overprinting all the previous structures, is represented by meteoric calcite veins with a quite clustered isotopic signature ($-7.7‰ < \delta^{18}$O V-PDB $< -4.7‰$ and $+0.5‰ < \delta^{13}$C $< +2.2‰$). Host rock isotopic signature, in the whole area, is in the range $-6.1‰ < \delta^{18}$O V-PDB $< -3.1‰$ and $+1.4‰ < \delta^{13}$C $<$ +3.3 ‰.