

Relationship between paleo-fluids and active extensional fault systems: new perspectives to explore crustal deformation processes

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During fault activity, the fluid ascendance and circulation over time might be documented by analysing the fault-related veins and coated slickensides. The vein infill often contains fluid inclusions (FI), which small droplets of the mineralising paleo-fluid (gas and liquid) trapped inside single crystals. FI's are excellent tracers to assess the fluid origin, temperature, pressure of homogenization and the extent of fluid-rock interactions. In this study, we focus on the southern Apennines fold-and-thrust belt (Italy), which is currently downfaulted by high-angle extensional faults including both slip-parallel and comb veins. There, we investigate the faults exposed in the Contursi hydrothermal basin area, which is characterized by a high seismicity ($M_w < 4$ in 10 the last years), and lies very close ($< 20\text{km}$) to the epicentral area of the $M_w 6.9$ 1980 earthquake. The Contursi low-enthalpy hydrothermal system (water temperature $< 50^\circ\text{C}$) is associated to the outgassing of deep sourced volatiles.

This study is based on a multidisciplinary approach that combines field structural analysis of the faulted outcrops with microstructural, stable isotopes (Carbon and Oxygen), trace elements, and both noble gases and $\delta D_{\text{H}_2\text{O}}$ in FI of the calcite veins sampled along single fault zones. The results show that the paleo-fluids were characterized by a low-salinity, and derived either from depths of $3 \sim 4 \text{ km}$ or ca. $8 \sim 10 \text{ km}$. Moreover, the noble gases in FIs show a prevalent crustal component added to a mantle one (up to 20%). In fact, the highest $^3\text{He}/^4\text{He}$ value (1.38Ra) in FI's fits well with those of the current gas emissions (1.41Ra). However, we also observe a variability of He isotopic signature in the FI (0.20-1.38Ra), which can be interpreted as due to early trapping processes (e.g., paleo-earthquakes). We conclude that the current outgassing of deep fluids could be associated to a long-lasting crustal deformation, posing the basis for future works aimed at better understating the role of fluids in active fault and consequently in the activities of geochemical monitoring of active seismic areas such as the site selection as well as to interpret the long data series.