



New insights into the assessment of mantle component in the paleo fluids that circulated along seismically active extensional faults, Irpinia Region, Italy

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The analysis of fault-related mineralization and, particularly, in the Fluid Inclusions (FIs) entrapped in synkinematic minerals are key to assess the origin and modalities of fluid circulation through fault zones. The results of these analyses, compared with those focusing on the present-day fluids, are crucial to better understanding the processes regulating both paleo and modern fluid degassing from Earth's interior with seismicity and crustal deformation. In particular, the focus is on the role that deep fluids might have on crustal deformation over time, and hence on the processes of earthquakes nucleation and rupture propagation. In this study, we investigate the FIs of the fault-related calcite veins documented within fault-related samples collected from the Contursi hydrothermal basin of the Irpinia Region, a tectonically active area of the southern Italy characterized by fluid degassing and seismicity. The Irpinia Region was affected in 1980 by the catastrophic Mw 6.9 earthquakes, whose epicentral area was located between 1 and 5 km away from the Contursi village. There, the Contursi hydrothermal basin is characterized by a groundwater temperature $\leq 47^\circ\text{C}$, and the outgassing of deep-sourced CO_2 coupled with mantle-derived He.

The new data gathered from the study samples show presence of low salinity paleofluids ($\cong 0.5$ wt. % NaCl_{eq}), and two families of FIs homogenization temperatures, respectively in between $100 - 130^\circ\text{C}$ and another one at higher temperature ($> 200^\circ\text{C}$). Assuming a geothermal gradient of $\sim 30^\circ\text{C}/\text{km}$, we conclude that the paleofluids precipitated at depths respectively of ca. 3 ~ 4 km, and ca. 8 ~ 10 km. Noble gases in FIs show a wide range of R/Ra values (0.09 – 1.38 Ra) and taking the SCLM component as reference (6.1 Ra value) the FIs are characterized by a predominant crustal contribution and a mantle contribution (up to 20%) with a local atmospheric-derived fluids. The highest He isotopic ratio measured in FIs (1.38Ra) fits well with the values that characterize the current high-flux CO_2 gas emission recorded in the study area (1.41 Ra). Such a similarity is interpreted as due to a ratio of crust-to-mantle He that remained approximately constant over time in the study area. The isotopic variability in FIs could be due to early trapping processes and, potentially, to paleo earthquakes associated to extensional faulting which ruptured the subsurface impermeable horizon provided by the tectonic mélange, and eventually allowed the ascendance of deep-warm fluids. The high transmissibility pathway of the ascending fluids is still active in the area, as suggested by the results of soil gas measurement, thus indicating that the current outgassing of mantle derived fluids could be associated to a long-lasting crustal process.

Amoroso et al., 2017 (Geophysical Research Letters)

Buttitta et al., 2023 (Science of the Total Environment)

Schirripa Spagnolo et al., 2024 (Earth and Planetary Science Letters)

Zummo et al., 2024 (Geochemistry, Geophysics, Geosystems)

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