Comb-veins as a marker for crustal-scale fluid circulation: insight from geochronological (U-Th dating), geochemical, and field to microstructural analyses along the seismogenic Val Roveto Fault (central Apennines, Italy)

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Comb-veins are mineral-filled fractures oriented perpendicular to fault surfaces, with their intersection with the fault surface generating lineations that are perpendicular to the downdip slip direction. Despite the large occurrence along normal faults within seismogenic extensional tectonic settings (i.e. Greece, Turkey, Italy), their origin, geochemical signature, and kinematics are still poorly constrained. Here we present the first multidisciplinary study, combining field to microscale observations (optical microscope and cathodoluminescence) with geochemical-geochronological analyses (U-Th dating, stable-clumped isotopes, Strontium isotopes, whole-rock geochemistry, and fluid inclusions), on calcite-filled comb-veins cutting through the principal surface of the seismogenic Val Roveto Fault in the central Apennines, Italy. We show that comb-veins precipitated in Late Pleistocene time (between 300 ky and 140 ky) below the present-day outcrop level at a maximum depth of \(\geq350\) m and temperatures between 32 and 64°C from deep-seated fluids modified by reactions with crustal rocks and with a mantle contribution (up to \(\geq39\)%). The observed geochemical signature and temperatures are not compatible which those of cold meteoric water and/or shallow groundwater (maximum temperature of 12 °C) circulating within shallow aquifers (\(\leq 500\) m depth) in the study region. Therefore, we propose that deep-seated crust/mantle-derived warm fluids were squeezed upward during earthquakes and were hence responsible for calcite precipitation at shallow depths in co-seismic comb fractures. As comb-veins are rather common, particularly along seismogenic normal faults, we suggest that further studies...
are necessary to test whether these veins are often of co-seismic origin. If so, they may become a unique and irreplaceable tool to unravel the seismic history and crustal-scale fluid circulation of active faults.