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Low-temperature (U-Th)/He thermochronometry applied to an active hydrothermal system: The example of the Têt fault (Eastern Pyrénées, France)

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In the Eastern Pyrénées, the Têt Neogene normal fault system localizes 29 hot springs (from 29°C to 73°C) distributed along the footwall damage zone of the main fault. Numerical models and geochemical analysis of this hydrothermal system (Taillefer et al., 2017) suggest the presence of a strong along-fault subsurface temperature anomaly governed by topography-driven meteoric-fluid upflow through the fault damage zone (advection). The study area, which was thoroughly inspected to study the local erosion rate with different methods (cosmogenic dating, regional thermochronometry, cross section restoration, geomorphology) is therefore a relevant place to use thermochonometry to estimate a local geothermal gradient and the influence of hydrothermal processes on the resetting and dispersion of (U-Th)/He ages.
Around the main hot spring cluster with temperature up to 73°C, (U-Th)/He ages were determined and confronted to regional and local tectonic and erosion rates. Far from the fault zone, AHe ages are consistent with the regional Miocene exhumation pattern (Maurel et al., 2003). Close to the fault, very low (U-Th)/He apatite ages down to about 1 Ma (mean value of 3.6 Ma) are inconsistent with the local erosion rate, implying a strong recent thermal anomaly (>90°C/km) into the fault damage zone (<500 m of the fault). In the fault zone itself, two samples display a large age dispersion that could be induced by the presence of microstructural traps and fluid inclusions in apatite, related to shearing and hydrothermal activity. Our study suggests that apatite with abnormal young (U-Th)/He ages (younger than 5 Ma in our study) near fault zones can be reset by hydrothermal activity and should therefore be interpreted with caution in such settings. We also show that thermochronometry can be used as a new tool for geothermal exploration to estimate recent thermal anomaly.