EGU24-15293
EGU General Assembly 2024
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Carbonate U-Pb geochronology as a tool to unravel complex fault evolution: an example from the central Southern Alps (Italy)

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Faults and related fractures have been studied for decades due to their potential in providing insights into past and present crustal deformation processes, climate evolution, seismology, and hydrology among others. Carbonates are very common syn-tectonic minerals that occur along fault planes or in fault-related fractures forming slickenfibres and veins (Roberts and Holdsworth, 2022). The ability of carbonates to incorporate uranium during their precipitation allows the application of in-situ carbonate U-Pb radioisotopic dating via LA-ICP-MS (Roberts et al., 2020). The integration of this method with the more conventional petrography and biostratigraphy holds strong potential in resolving the timing of brittle structure development. A robust pre-dating screening protocol using a multi-disciplinary approach, including structural, microstructural, petrographic, and isotopic characterization has been implemented to link carbonate precipitation event to fault kinematics.

This approach has been applied to the central Southern Alps (Northern Italy), where Early Jurassic rift-related faults are preserved despite their later involvement in the Alpine orogeny. Fieldwork and sampling focused on the Amora Fault (Bergamo, Italy), a rift-related N-S normal fault of the Jurassic Lombardian basin. Structural and paleostress analysis led to the identification of several mesoscopic N-S trending normal faults and veins both in the hanging wall and footwall of the Amora Fault, indicating an E-W extension. The fault is cross-cut by middle Eocene E-W trending magmatic bodies, which, in turn, are cross-cut by Alpine thrust faults. The Amora Fault and related minor faults also show strike-slip reactivation related to N-S Alpine compression.

Sampling focused on the Norian to Lower Jurassic succession in the hangingwall and footwall of the main fault plane, where carbonate syn-tectonic veins and slickenfibres are present. Structural analysis allowed relating the structures to either the rifting or the Alpine reactivation.

Microstructural and petrographic analyses assisted by cathodoluminescence on 21 samples revealed the occurrence of several carbonate phases. Elemental analyses (Ca, Mg, Fe, Sr) and O-C stable isotope analyses confirmed the circulation of different fluids. U-Pb dating on the carbonate phases provided four age clusters, each connected to a tectonic phase: (1) Early to Middle Jurassic carbonates precipitated in rift-related structures from a fluid with a $\delta^{13}C$ buffered by the host-rock.

(2) Early Cretaceous carbonates possibly related to the late stage of rifting activity. (3) Late Cretaceous carbonates precipitated from a meteoric fluid during the early stages of the Alpine orogeny. (4) Oligo-Miocene carbonates connected to the strike-slip reactivation of rift-related normal faults.

The integration of field-based and stratigraphic observations with carbonate geochemistry and geochronology allowed the recognition of a complex reactivation history for the Amora Fault.

References

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