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Temporal evolution of the Cap Creus shear zones (Eastern Pyrenees, Spain): new insights from in situ $^{87}Rb/^{87}Sr$ dating.

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Localized ductile shear zone systems play a key role in controlling the rheology of the lithosphere, influencing fluid circulation, magma emplacement, and, on a larger-scale, the development of rifts and the evolution of orogenic belts. Nevertheless, dating shear zones presents challenges in terms of the variety of processes occurring under different pressure-temperature-fluid (P-T-f) conditions, along with the coexistence of pre- and syn-kinematic minerals. In addition, shear zones are frequently reactivated during distinct orogenic cycles and their polyphase nature makes it difficult to distinguish and date deformation events. Recent technical advances have led to the development of in-situ $^{87}Rb/^{87}Sr$ dating using LA-ICP-MS/MS, which notably provides access to contextual information in micas, ubiquitous minerals that are easily deformed and sensitive to dissolution/recrystallization processes.

The world-class shear zone network of the Cap de Creus (Eastern Pyrenees, Spain) is a reference system for structural studies. However, the timing of the activation and reactivation of these shear zones is still debated, preventing the definition of reproducible geodynamic models. The shear zones are observed in a basement that recorded a polycyclic geodynamical evolution with subsequently Variscan orogeny, Tethys margin formation and Pyrenean collision. Recent geochronological data record tectonic events spanning the Carboniferous to the Eocene. However, the significance of the obtained ages remains debated, preventing the development of a well-constrained tectonic model.

This study provides new information on the geochronology of the Cap de Creus shear zones by applying $^{87}Rb/^{87}Sr$ dating in muscovite, supported by Th-U/Pb dating in monazites, both *in situ* and *in context*. The geochronometers were contextualized using an integrated approach combining petrological, structural, microstructural and geochemical analyses. This approach permits selecting the most reliable deformation markers from among the mineral chronometers in order to link the geochronological results to the microstructures. Rb/Sr isochron ages in muscovite and Th-U/Pb ages in monazite reveal two coherent age groups in the Permian and the Eocene. Microstructural studies reveal that the two generations of muscovite grains are associated with two phases of quartz plastic deformation and dynamic recrystallization, indicating a ductile reactivation of the Cap de Creus shear zone network under fluid-rich conditions during the Pyrenean orogeny.