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Time-strain evolution of shear zones from petrographically constrained Rb-Sr analysis

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Shear zones are complex high-strain structures that participate in many geological processes such as earthquakes, magma emplacement, fluid flow and mineralization. This array of processes enhance great difficulty in establishing the timing of shear zones due to multiple overprint and fluid-assisted processes (e.g., recrystallization). Although accessory minerals may record the thermal response to mylonitization on isotopic systems, but depending on the closure temperature, it can fail to track the time of low- to medium temperature fabric realignment. New analytical methods allowing high spatial resolution analysis within distinct microstructures offers the potential to better understand the strain evolution of shear zones. Here we explore the timing of mica fish development within mid-crustal shear zones using electron backscatter diffraction and *in situ* Rb–Sr geochronology via laser ablation triple quadrupole ICP-MS. Mica fish Rb–Sr dates from mid-crustal shear zones are indistinguishable from primary igneous crystallization and/or early regional metamorphic events dissociated with mylonitization. These results indicate that mica fish have maintained a primary to weakly reset isotopic composition yet display microstructural evidence of mechanical (kink and folds) and low-strain crystal-plastic deformation. As the Rb–Sr dates from mica fish are indistinguishable from the primary ages, they cannot be unambiguously linked to mylonitization. Conversely, fine-grained mica texturally associated with higher strain shear bands and strain shadows displaying microstructural evidence of recrystallization yields distinctly younger dates. Primary mica grains behaved as rigid porphyroclasts during subsequent medium-grade mylonitization, leading to the development of a fish geometry whilst maintaining near pristine Rb–Sr isotopic systematics. However, recrystallized fine-grained mica in shear bands and strain shadows were isotopically reset during medium-grade mylonitization, establishing a direct age for this deformation. These results highlight the potential for significant diachronicity in mylonitic fabrics, demonstrating the need to establish a link between texture and isotopic signature to accurately reconstruct deformation histories.