

Deformation-induced Rb-Sr age resetting mechanisms revealed by micrometer-scale LA-ICP-MS/MS age mapping

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In this study we apply our recently-developed technique to generate sub-10 μm -resolved Rb–Sr age maps [1] to investigate age resetting mechanisms in naturally-deformed muscovite. We utilize cm-sized muscovite from metapegmatites that intruded their host rocks at ~ 480 Ma (Erbendorf–Vohenstrauß Zone, SE Germany). A subsequent Devonian (~ 380 Ma) event at temperatures exceeding 600°C —above the assumed closure temperature of the Rb–Sr system—induced variable ductile shearing. The heterogeneous strain distribution resulted in strongly foliated zones alongside domains that preserved their magmatic texture. In the latter, muscovite appears as undeformed mica “books,” whereas in the foliated zones, it forms lozenge-shaped porphyroclasts (mica fish).

Within individual muscovite grains, ages from 480 to 380 Ma are recorded. The ~ 480 Ma magmatic age is preserved in over 80% of the intracrystalline volume. Complete age resetting to ~ 380 Ma is restricted to areas of neo-/recrystallization along grain boundaries and micro-shear bands. However, partial intracrystalline age resetting to ~ 400 Ma is also observed in regions without evident neo-/recrystallization.

This intracrystalline age-reset is associated with crystallographically controlled element transport parallel to (001) planes. In deformed muscovite, gradual ^{87}Sr -loss is observed along cleavage-parallel bands that simultaneously exhibit Rb enrichment. These bands are distinct at the scale of the employed spot size ($4\text{--}8\ \mu\text{m}$) and can sometimes even extend across the entire length of cm-sized crystals. The concurrent enrichment of B and Cs alongside Rb – both considered highly fluid mobile – suggests that grain boundary fluids serve as reservoirs for elemental transport. Notably, this mechanism persists despite the absence of a suitable adjacent donor/acceptor mineral for elemental exchange (e.g. feldspar), as these elemental patterns also exist along quartz–mica grain boundaries. In non-deformed muscovite the age reset is less pervasive compared to deformed muscovite and largely governed by diffusive loss of radiogenic ^{87}Sr along (001) planes with only limited transport of Rb.

We propose that, in addition to neo-/recrystallization, fluid-mediated diffusion governs age reset in relic muscovite. The latter is particularly effective in deformed mica. Here, Rb/Sr exchange is enhanced locally, likely due to dislocations and stacking faults induced by plastic deformation.

[1] Kutzschbach, M., & Glodny, J. (2024), *JAAS*, <https://doi.org/10.1039/D3JA00297G>