In situ Rb-Sr dating of fault and fracture zone minerals resolving multi-stage deformation history

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Direct dating of minerals precipitated from crustal fluids in fault and fracture zones is essential to constrain the timing of distinct physical and geochemical processes therein, such as brittle and ductile deformation, ore deposition, fluid flow and ancient subsurface microbial activity. Absolute ages of these processes can be substantially difficult to obtain, especially in faults featuring multiple reactivation events where fine-grained vein generations and discrete mineral growth zones are not easily separated from each other or their wall-rock. Here we apply the newly developed *in situ* Rb-Sr dating method by reaction cell LA-ICP-MS/MS [1, 2] to acquire absolute geochronological data with detailed spatial (50 µm) resolution, high analytical precision and textural control of reactivated veins and faults in Palaeoproterozoic granitoids, SE Sweden. This novel technique enables dating of samples not suitable for separation and pre-treatment procedures required for conventional Rb-Sr and Ar methods.

Analysis of polished rock and mineral sections comprising (1) hydrothermal mineralizations, (2) low-temperature veins, (3) ductile shear zones and (4) authigenic crystals in brittle fractures reveals the occurrence of six precipitation events. Palaeo- and Mesoproterozoic orogenic activity instigated both ductile and brittle deformation as well as hydrothermal veins, while Palaeozoic fault reactivation and low-temperature veining corresponds to far-field Caledonian-related tectonism.

Preparation includes detailed characterization of mineral paragenesis targeting one of the Rb-rich phases muscovite, biotite, adularia and illite, accompanied by Sr-abundant phases such as calcite, fluorite, albite and/or epidote. The study demonstrates that the methodology yields accurate ages of a wide range of common secondary fault-related mineral assemblages formed under diverse thermal and geochemical conditions.

[1] Zack & Hogmalm (2016), *Chem. Geol.* **437**, 120-133. [2] Hogmalm et al. (2017), *JAAS*. **32**, 305-313.