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Promises and pitfalls of MS/MS-based Rb/Sr dating of mica from pegmatites

MR. THOMAS ZACK, HELGE VINJE BIRGERHEIM AND DELIA RÖSEL

University of Gothenburg

The growing interest in understanding mineral systems that host critical raw materials has put a spotlight on accurately dating pegmatites. This is particularly important for exploring pegmatite-related lithium deposits, where establishing a robust geologic framework- such as their relationship to regional stress fields, magmatic events, or high-grade metamorphism- is essential. Notably, even petrographically similar pegmatites occurring within a few kilometers can differ in age by several hundred million years. Consequently, rapid and reliable campaign-style dating of pegmatites is becoming increasingly desirable.

A major limitation is the lack of an analytical protocol that enables straightforward and reproducible dating of pegmatites. The geochronologic gold standard, U–Pb zircon dating, is often ineffective: zircon is typically absent in pegmatites, and when present, it is frequently metamict due to extreme U and Th enrichment. Alternative chronometers such as U–Pb monazite or columbite can perform better, but suitable crystals are often scarce.

In-situ Rb–Sr dating of micas by LA–ICP–MS/MS represents a promising alternative. Micas are ubiquitous in pegmatites, and recent method developments- including the establishment of a pegmatite-derived secondary muscovite standard (Högsbo muscovite; Rösel & Zack, 2022)- have significantly advanced the technique. However, dating Li-rich micas introduces new challenges. One challenge is to delineate the robustness of such micas. In principle, muscovite (di-octahedral mica) is a more robust time-keeper than biotite (tri-octahedral mica). However, if Li-rich micas such as polylithionite (tri-octahedral mica) follow such simple relationships is an open question.

A second challenge arises from the extreme Rb enrichment in many Li-rich micas, commonly reaching several wt%. These concentrations exceed those of available reference materials by an order of magnitude and complicate data acquisition, as laser parameters- such as spot size- must be reduced to avoid detector overload, making analyses of the available standards less precise. Examples will be shown from Li-rich pegmatites from around the world, with a particular focus on classic Swedish deposits.