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Unusual K/Rb and Li-Rb-Cs trends in muscovite and feldspars indicate multi-stage anatectic origin for pegmatites in the Wekusko Lake pegmatite field, central Manitoba, Canada

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The formation of pegmatites is traditionally attributed to either extreme magmatic differentiation from granitic intrusions or anatectic melting of crustal rocks. The multi-stage melting model provides an alternative mechanism for pegmatite formation, where episodic anatexis generates progressively evolved melts capable of lithium enrichment.

Distinguishing between these origins requires integrating geochemical, geochronological, and regional geological constraints. This study investigates the Wekusko Lake pegmatite field in central Manitoba, which hosts barren to lithium-mineralized pegmatite dykes with multiple emplacement ages but lacks coeval granitic intrusions, suggesting an anatectic rather than a magmatic differentiation origin.

Whole-rock geochemistry indicates geochemical evolution trends from barren to spodumene-bearing pegmatites, but muscovite and feldspar compositions in some pegmatite bodies deviate from expected magmatic evolution. Muscovite in spodumene-bearing pegmatites exhibits slightly elevated K/Rb ratios but unexpectedly lower Li-Rb-Cs values compared to typical lithium-mineralized pegmatites described in the literature and at least one barren pegmatite from Wekusko Lake, contradicting typical fractionation trends. Feldspars show an even stronger deviation, further supporting a model where these pegmatites did not evolve from a progressively differentiating parental pluton. Instead, these trends point to source heterogeneity and/or element partitioning modifiers, such as water-fluxed melting affecting initial melt chemistry or post-crystallization metasomatic processes.

The multiple pegmatite emplacement ages suggest episodic multi-stage crustal melting, consistent with an anatectic pegmatite field rather than a single magmatic differentiation event. The absence of coeval granites reinforces this interpretation, as pluton-derived pegmatites would be expected to have a geochemically and temporally linked parental body. The unexpected K/Rb and Li-Rb-Cs systematics in feldspars and muscovite provide new geochemical indicators for recognizing anatectic pegmatites and distinguishing them from fractionated granitic pegmatites.

These findings emphasize the importance of mineral-scale geochemical studies in unraveling pegmatite origins, particularly in regions without an obvious granitic source. Understanding source melting in pegmatite formation is crucial for lithium exploration, expanding potential pegmatite-hosting terranes beyond typical pluton-related settings. Geochemical deviations in muscovite and feldspars could serve as exploration tools for identifying fertile pegmatites in anatectic terranes, improving lithium resource targeting, while future research will refine geochemical criteria to better distinguish pegmatites formed by fractional crystallization from those generated by anatexis.