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Emplacement Mechanisms of Rare Element Pegmatites, Separation Lake Greenstone Belt, Northwest Superior Province

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The rare element pegmatites of the Superior Province host a variety of critical metals (Li, Cs, Rb, Be, Ta, Nb, Ga, Tl, and Ge) essential for developing sustainable technologies. The prevailing theory regarding the Li-bearing pegmatites of the Separation Lake greenstone belt is that the dikes intruded in one event at ~2640 Ma and were pervasively overprinted by a ductile shear fabric. However, recent investigations suggest that these rocks intruded over a ~50 Ma period (ca. 2649–2601 Ma) and that the fabric is related to emplacement processes. In the current study, a variety of analytical methods such as electron backscattered diffraction (EBSD), in situ U-Pb geochronology, LA-ICP-MS, and micro-XRF scans are used to correlate the mechanisms and timing of pegmatite emplacement within the tectonic framework of the western Superior Province. Our new data show that S-type granitic magmatism in the greenstone belt had commenced by ca. 2690 Ma and that quartz and feldspar in granite bodies that share an orientation with the rare element pegmatites were deformed and recrystallized during regional deformational events. Quartz and plagioclase crystallographic axes within the domains of the Li-bearing dikes that have attributes most suggestive of deformation show very little rotation from their primary orientations (<5° misorientation) and lack a crystallographic preferred orientation, supporting the interpretation that these features were generated during dike emplacement. Micro-XRF scans of polished slabs of the rare element pegmatites show Ca enrichment at the country rock interface that decreases towards the centre of the dike and may reflect diffusion of elements from the country rock into the pegmatite. In our model, emplacement of the pegmatites operated under a mechanism similar to fluidization, in which metasomatism coincident with melt emplacement allowed for localized deformation to be imparted on the country rocks upon intrusion.