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Structural Controls on the Emplacement and Mineralization of Lithium-Bearing Pegmatites

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Lithium-rich pegmatites are an important subset of LCT-type pegmatites, which host economic concentrations of the Li ore minerals spodumene and petalite. Significant work has focused on understanding the source enrichment processes required to form Li-enriched melts, leading to the development of two formation models: low-degree partial melting, and high-degree fractional crystallization. However, recent work has shown that neither, in their simple sense, is able to enrich a melt sufficiently to form economic lithium concentrations. In addition, the focus on petrogenesis subverts the importance of geologic structures on the spatial distribution of pegmatites, especially as pegmatites are known to travel significant distances from their source. To work towards a mineral system model for hard-rock Li deposits, the structural context needs to be better constrained.

We present a case study on the Archean Zulu pegmatite field (ZPF) in Zimbabwe. Based on field and petrographic observations, we propose pegmatites of the ZPF are emplaced along an active Riedel-type shear zone. We find the most voluminous pegmatites (G1) are emplaced parallel to R, with subordinate pegmatites (G2) along both R' and X structures. Additionally, G2 pegmatites retain a predominantly magmatic, petalite-dominated mineralogy, suggesting a rapid and contracted cooling history. In contrast, G1 pegmatites retain structural signatures of significant reworking during sinistral shearing, coinciding with extensive albitisation and conversion of petalite to spodumene-quartz intergrowths (SQUI). We propose that G1 pegmatites experienced a protracted cooling history due to emplacement parallel to an active shear zone, which promoted the formation of SQUI.

This result shows that pegmatites with different orientations have significantly different mineralogy and volume, despite being emplaced at the same time. We propose that exploration in pegmatite fields should focus on constraining the major structures along which pegmatites are emplaced, as this will aid in defining which orientations are more favourable targets for further work.