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Melting of fluorine-rich biotite as a mechanism for generating lithium-rich granites

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Granites derived from anatexis of metasedimentary rocks, particularly via biotite-dehydration melt reactions, are important lithium (Li) sources. Petrogenetic models for lithium granites depend on mineral-melt lithium partitioning. While published partition coefficients ($D_{Li}^{mineral/melt}$) vary by over an order of magnitude, static values are commonly used. Here we integrate thermodynamic modelling with relevant published $D_{Li}^{mineral/melt}$ ranges, including a newly-developed dynamic composition- and temperature-dependent $D_{Li}^{biotite/melt}$ [1] to quantify enrichment of lithium in silicate melt during partial melting and fractional crystallisation [2]. Using the lithium-rich Cornubian granite batholith (UK), we demonstrate the sensitivity of model results to $D_{Li}^{mineral/melt}$ choices for modally-dominant lithium-poor phases (e.g. quartz), as well as phases traditionally thought to dominate lithium budgets (e.g. biotite). While economic lithium enrichment can result from extreme fractionation with selective $D_{Li}^{mineral/melt}$, we suggest that dehydration melting of fluorinated biotite is a more viable petrogenetic model [2], as these type of biotite exhibit the highest $D_{Li}^{biotite/melt}$ [1] and thus retain lithium in the source until their destabilisation. The fluorinated biotite model reconciles the common observations of fluorite in lithium granites and their late-orogenic occurrence, as the requisite thermal conditions are most readily achieved during the waning stages of orogenesis [3]. Melting of fluorine- and lithium-rich biotite further provides a mechanism for extensive fractionation, owing to the depolymerising effect of fluorine.

[1] Beard *et al.* (2026), *EarthArXiv,* doi.org/10.31223/x5s47k.

[2] Morris *et al.* (in press), *Nature Communications Earth & Environment.*

[3] Copley & Weller (2025), *Geophysical Research Letters* 52, e2025GL118054.