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Lithium isotopes and the quest for resources: Retrospective and prospective

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Although granitic pegmatites were among the first materials analyzed in the "modern era" of Li isotope study (i.e., since the late 1980s), studies of Li mineralization have lagged somewhat behind applications in other areas. Some of the problems inherent in dealing with granitic pegmatites and similar rocks include: representativeness of whole rocks versus individual minerals; separating magmatic from hydrothermal processes, including potential overprinting by late fluids; and the uncertainty of many fractionation factors. The two key areas of study are in assessing Li sources and on understanding mineralization processes (internal evolution and relationships among deposits). The former pursuit is challenged by the range of Li isotopic compositions of rocks in the upper crust, generally making unambiguous assignment of source materials impossible. The latter considerations hold promise, though complex petrogeneses make all but very targeted studies prone to equivocal results.

With a large per-amu mass difference, $^{7}Li/^{6}Li$ ratios have tantalized as a geochemical tool to better understand many processes, including formation of large-scale magmatic [1,2] and sedimentary [3] deposits of Li. During crystallization, Li isotope fractionation relates to bonding environment, with ^{7}Li preferred in environments of low coordination (short bonds). This may change in the presence of magmatic or hydrothermal fluids where coordination of Li in various compounds may differ, possibly reflected in distinctive $^{7}Li/^{6}Li$. Previous work by Teng et al. on the Black Hills granite-pegmatite system suggested a relationship through progressive fractionation of a parent melt, with isotopically heavy late stage fluids as predicted by theory [4]. New research of granitic mineralizations and pegmatites from the North China Craton, the Bohemian Massif, and elsewhere points to homogenization of $^{7}Li/^{6}Li$ ratios from the original Li isotope diversity of input materials, which may indicate systematic behavior of Li during ore-forming processes.

[1] Magna et al. (2016), *Geology* 44, 655-658. [2] Li et al. (2024), *Int. Geol. Rev.* 66, 2960–2982. [3] Álvarez-Amado et al. (2022), *J. Geochem. Exploration* 241, 107062. [4] Teng et al. (2006), *Am. Min.* 91, 1488-1898.