Lithium and Nd isotopic constraints on the origin of Li-poor pegmatite with implications for Li mineralization

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Origin of pegmatite has been increasingly attracting international attention due to its genetic link with rare-metal mineralization (e.g., Li, Be, Nb, Ta). We report combined Nd and Li isotopic data (and trace elemental data as well) for the Li-poor pegmatite (barren) from the Qinghe pegmatite field of the Altai orogen (NW China), which, along with compiled data of global Li-rich pegmatite (with spodumene mineralization), was used to investigate the origin of pegmatite-forming magma and how source characteristics control the Li mineralization. The Qinghe pegmatites show significantly varied initial Nd isotopic compositions ($\varepsilon_{Nd}(t)$ = -4.3~-1.7), which overlap the surrounding mica schists (-6.5 ~ -1.5), but lower than the granites (-2 ~ +2.9) of the orogen. These data, together with the low REE (3.3~41 ppm) and absence of biotite in the pegmatites, suggest they were not derived from extreme differentiation of a parent granite as traditionally thought, but from low degrees of partial melting of the schists involving muscovite dehydration melting. The melting occurred under relatively low temperatures (amphibolite facies), below that required for the break-down of biotite and most REE-rich accessory phases, due probably to the combined effects of fluxing components (B, F, H_2O, alkalis). The Qinghe pegmatites are characterized by heavy Li (δ^7Li = 4.1~14.5‰) and low Li abundance (3.6~50 ppm), which contrast to that of local schist (δ^7Li = +0.9~+3.0‰, Li = 24~123 ppm) and granite (δ^7Li = +0.9~+3.0‰, Li = 24-70 ppm), and also to that of global Li-rich pegmatites (δ^7Li = -1.0~+10‰, Li >500 ppm). Modelling study indicates that (1) the heavy Li signature of the Qinghe pegmatite is due to significant Li isotopic fractionation during the low T partial melting of schists, not by magma differentiation as advocated by many others, and (2) Li-poor pegmatites always have heavy Li signature compared with Li-rich pegmatites due to the abundance of biotite in the source, and the formation of Li-rich pegmatite with Li mineralization is attributable to the dominance of muscovite (over biotite). This study is of significance to understanding the origin of pegmatite, the Li isotopic behavior during low-T crustal anatexis, and spodumene-mineralization conditions.