

Muscovite as tracer for the evolution of spodumene-bearing LCT-pegmatites

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Muscovite is an indicator mineral helping to elucidate the evolution of pegmatites and evaluate their economic potential for lithium. However, the ability of muscovite to record late-stage hydrothermal alteration of spodumene remains poorly constrained.

In the unzoned Bald Hill pegmatite, hosted by Archean metasediments, muscovite is present as cm-sized flakes associated with spodumene and albite as well as fine-grained aggregates pseudomorphically replacing spodumene. Two generations of muscovite were identified based on SEM observations, PXRD refinements, and EPMA as well as LA-ICP-MS analyses. Primary Rb-rich muscovite (1.19 wt.% Rb₂O) belongs to the 2M₁ polytype with near-stoichiometric composition. It contains K₂O (9.83 wt.%), Fe₂O₃ (1.02 wt.%), MgO (0.02 wt.%), F (0.2 wt.%) and is characterized by ratios of K/Rb (6.52), K/Cs (147), and trace element concentrations of Li, Cs, Nb and Ta of 611, 549, 167, and 56 ppm, respectively. The chemical composition of secondary 1Md muscovite varies in wide ranges: K₂O (5.38-8.56 wt.%), Fe₂O₃ (1.20-1.61 wt.%), MgO (2.06-3.61 wt.%), F (0.1-0.2 wt.%), and is distinct from primary muscovite by having higher K/Rb (37.71-51.45) and K/Cs (132.63-155.83) ratios, higher Li (1502-3272 ppm) as well as lower Rb (1004-1903 ppm), Cs (365-462 ppm), Nb (4.3-8.5 ppm), and Ta (0.9-1.2 ppm) concentrations.

Low K/Rb and K/Cs ratios as well as low Li of primary muscovite indicate that the pegmatite has formed from a highly fractionated melt, where Li was preferentially incorporated into spodumene rather than muscovite. In secondary muscovite higher K/Rb ratios and low Rb reflect the replacement (sericitization) of spodumene via coupled-dissolution and re-precipitation reactions, with K provided by the breakdown of K-feldspar. Sequestration of Li liberated from spodumene is shown by higher Li concentrations of secondary muscovite and elevated contents of Mg and Fe imply precipitation from an aqueous fluid that has interacted with the Mg-rich country rock. Occurrence of 1Md muscovite provides maximum P-T conditions of the hydrothermal alteration at <250 °C and 2 kbar water pressure. The element signature and structure of muscovite from Bald Hill give key indicators for the geochemical behavior and secondary zones of enrichment of lithium in pegmatites during late-stage