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The control of biotite/melt partitioning on the lithium budget of crustal magmas

CHARLES D BEARD[1], VINCENT VAN HINSBERG[2], JOHN STIX[2], DR. MADELEINE C S HUMPHREYS[3], OWEN M WELLER[4], CAROLINE R SODERMAN[4] AND JEAN H. BÉDARD[5]

[1]Utrecht University
[2]McGill University
[3]Durham University
[4]University of Cambridge
[5]Geological Survey of Canada

Of the major rock-forming minerals in alkaline and calc-alkaline magmatic suites globally, biotite contains the highest concentration of lithium and fluorine. The control of biotite on the behaviour of minor- and trace-elements, in particular Li and F, and its impact on metal enrichment, however, is not well understood. Published values for $D_{Li}^{biotite/melt}$ vary by over two orders of magnitude and span incompatible to compatible behaviour, complicating petrogenetic modelling of Li budgets in crustal magmas [1].

We used experiments [2] to quantify that control in sodic (per)alkaline H_2O saturated magmas with variable F content at 650–800ºC, 200 MPa total pressure and log fO_2 ~ ΔFMQ +1. Our results, alongside a literature compilation that covers a range of *P-T-X* applicable for mafic to evolved peralkaline syenite to peraluminous granite systems at upper-mantle to crustal pressures were used to constrain empirical models that describe: (1) F–OH exchange between the silicate melt and the biotite W-site; and (2) the partitioning of 1+ cations Li–Cs between silicate melt and the biotite A- and M-sites. The models use the major-element composition of biotite and melt, pressure and temperature as input. Lithium partition coefficients cover the range 0.24–33 and are lowest in F-poor biotite formed at high temperature from peraluminous silicate melt. Residual enrichment of lithium should therefore be most efficient during crystallisation of high Al/Si magmas, a finding consistent with the association between peraluminous granites and lithium-caesium-tantalum pegmatites. The biotite-melt $Kd_{F/OH}$ exchange coefficients are 1.2–51, with minima for Al-rich, Mg-poor biotite. Where $Kd_{F/OH}$ values are high, crystallisation of even small amounts of biotite will strip fluorine from the melt.

Our partitioning models can be applied to biotite from natural systems to determine the composition of their source melt, or may be integrated with phase equilibrium models to predict the metal budgets of mafic to evolved igneous systems at upper-mantle to crustal pressures [e.g., 1].

[1] Morris et al. (in press) Melting of fluorine-rich biotite as a mechanism for generating lithium-rich granites, Nature Communications Earth & Environment

[2] Beard et al. (2026) Biotite/melt trace-element, lithium, and F-OH partitioning in silicate magmas. Preprint: