5.2.26

Trace element partition coefficients for mica and a variety of mantle-derived melts and fluids

T.H. GREEN AND J. ADAM

ARC National Key Centre for the Geochemical Evolution and Metallogeny of the Continents (GEMOC), Macquarie University, NSW 2109, Australia (Trevor.Green@mq.edu.au; john_adam@bigpond.com)

Partition coefficients (Ds) for up to 38 trace elements for phlogopitic mica at 2-3 GPa, 1025-1160 °C have been determined for 3 different mantle-derived melts (basanite, lamproite and carbonatite). Partitioning for mica/lamproite differs from the other 2 compositions. Thus Cs, Ba and V are mildly incompatible, Rb compatible and Cr strongly compatible in mica from lamproite, whereas for mica from carbonatite and basanite Cs, Ba and V are compatible and Rb and Cr are strongly compatible. REE and HFSE are incompatible for mica from all 3 compositions. Additional data, obtained for mica/basanite pairs only, shows that Ni is strongly compatible, Co and Tl moderately compatible, Zn, Ga and Ge moderately incompatible and U and Th strongly incompatible. The contrast in partitioning behaviour for mica from lamproite compared with mica from basanite and carbonatite is largely controlled by crystal chemical features (especially Al^{IV}, which is low in mica from lamproite). Thus choice of Ds in geochemical modeling of mantle melting or crystal fractionation processes involving phlogopitic mica must take into account the composition of the mica. Melt structural differences between carbonatitic and silica-undersaturated silicate melts do not appear to significantly affect mica/melt Ds. Comparing the Ds for phlogopite/basanite pairs with those for dioctahedral phengite/aqueous fluid pairs [1,2] shows similar behaviour except for Cs, which does not partition into phengite. Thus Cs/Rb and Cs/Ba ratios may provide discriminants for the micas involved.

References

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5.2.31

Melt inclusions studies in Continental Flood Basalts

A.J.R. KENT

Department of Geosciences, Oregon State University, Corvallis, OR 97330, USA. (adam.kent@geo.oregonstate.edu)

Attempts to unravel the complex array of processes involved in generation, transport and eruption of CFB magmas have much to gain from the study of melt inclusions. This potential is still largely untapped, but existing work provides important insights into mantle melting and sources, melt column aggregation, crust and lithospheric contamination, and melt differentiation. Melt inclusions also offer the means to assess pre-contamination melt compositions and pre-degassing volatile abundances, even where bulk lava compositions show that significant contamination and/or degassing may have occurred.

Studies of melt inclusions in Oligocene CFB from Yemen provide a case in point[1]. Inclusions in olivine and clinopyroxene phenocrysts from lavas that are mafic, but have trace element and isotopic signatures indicative of contamination, show large variations in trace element indices such as K/Nb, Ba/Th and Ba/Nb that are consistent with a diversity of primary melt and assimilant compositions. Highly contaminated melts in primitive phenocrysts (up to Fo_{90}) require considerable crustal assimilation at the earliest stages of melt fractionation and at high mass ratios of assimilated to fractionated material ($\geq$ 5-10) – consistent with energetically-constrained models of crustal contamination. Models where hot, mafic, and perhaps turbulent magmas assimilate pre-heated wallrocks at the margins of larger magma chambers are most consistent with these observations.

Variations in trace element indices that are insensitive to assimilation but fractionated by progressive mantle melting (e.g. Sm/Yb, Zr/Y) are also preserved in inclusion compositions, even where these are highly contaminated. This suggests that final aggregation of the mantle melting column did not occur until after melts entered the base of the continental crust and assimilated crustal material – placing a novel constraint on the nature of the melt transport systems involved.

Melt inclusions can also preserve pre-eruptive H, S and Cl contents – making them an ideal means to monitor the flux of these important volatiles from mantle to the crust and atmosphere. Melt inclusions from both contaminated and uncontaminated Yemen lavas have high S and Cl contents – up to 0.3 and 0.1 wt% respectively, suggesting a significant S and Cl flux from the mantle accompanied CFB volcanism.

References

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