On the formation of subalkaline arc magmas: Source and primary melt characteristics inferred from xenoliths and experiments

A. BÉNARD[1], O. NEBEL[2], P. VASILYEV[1], R. J. ARCULUS[1], D. A. IONOV[3] AND G. M. YAXLEY[1]

[1]Research School of Earth Sciences, The Australian National University, Canberra, Australia

[2]Monash University, Melbourne, Australia

[3]Géosciences Montpellier, University Montpellier 2, France [antoine.benard@anu.edu.au]

Various models can explain the formation of subalkaline andesitic arc magmas with compositions that most closely resemble that of the bulk continental crust. Backed up by large but sometimes conflicting sets of high-pressure experiments, andesite genesis models can be classified into four main types: (i) fractionation of basalt; (ii) partial melting of subducted mafic slab lithologies; (iii) partial melting of hydrous mantle; and (iv), mixing of basalt with dacite/rhyolite. However, excluding (iv), these models are sometimes difficult to reconcile with geophysical data and inferences concerning the nature of the mantle wedge, and are typically not constrained with direct evidence from sub-arc mantle rocks.

Here we present new petrological and geochemical data for refractory mantle wedge-derived peridotite xenoliths in active arcs, and on primitive melts trapped within these rocks in veins and melt inclusions. The residual mantle samples record a restricted pressure-temperature range of formation and bear a typical 'arc signature', which is not found in other tectonic settings. Silica-rich picrites and boninites are ubiquitously found in association with these xenoliths.

We also present results from melting models and complementary high-pressure hydrous experiments in piston cylinder apparatus targeting the physical conditions experienced by the xenoliths. This approach allows us to constrain the roles of source petrology and volatiles in the genesis of primary arc melts and residual arc mantle.

We construct a model in which the silica-rich nature of a major fraction of primary arc melts derives from the nature of arc mantle sources, generated where the melting reaction involves production of olivine at the expense of orthopyroxene. These sources can form during the interaction of refractory mantle with slab-derived agents through porous flow. The silica content of primary arc melts is a major factor controlling liquid lines of evolution towards andesitic composition and that of the upper continental crust.