Indicators of craton-edge mantle processes in phenocrystic olivines of eastern Australian basaltic rocks

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Cenozoic basaltic volcanism in eastern Australia has been related to north-south plume tracks that pass approximately parallel to the edge of thick (>160km) Proterozoic lithosphere where it passes into thinner continental lithosphere (<110km) towards the east [1]. This raises the possibility that old lower lithosphere may be involved in the generation of melts close to the shelf in the lithosphere base. Minor and trace elements in olivine have been shown to have potential as indicators of the source assemblages of basaltic melts, with particular trace element concentrations or ratios indicating source assemblages other than peridotite, including pyroxenite, mica and continental crust.

The Buckland Volcanic Province in Queensland is the most southerly locality on the Cosgrove Plume track before a stretch of >1,600 km free of volcanic rocks other than leucitites. Here, analyses of olivines in basanites and alkali basalts are combined with whole-rock compositions (WR) to elucidate mineral assemblages in the mantle source. Sc/Zr and Al/Mn in olivine xenocrysts indicate that the main source contributor is spinel- rather than garnet peridotite. High modal pyroxene is indicated by high Zn/Fe, Fe/Mn and Ni in olivines, and high Ti/Sc suggests high modal clinopyroxene. Residual phlogopite in the source of basanites is indicated by low WR K/Nb, and apatite controls high WR P_2O_5, and low Rb/Sr (≥0.015) and Sr/La (≥13). The source assemblages for basanite can be summarised as apatite-phlogopite-olivine-cpx-opx and for alkali basalts as amphibole-olivine-opx-cpx±phlogopite±apatite. These mineralogical characteristics bear many parallels with apatite- and amphibole-rich xenoliths from eastern Australia [2], and with clinopyroxene-enrichment in spinel peridotites in Victoria [3]. These parallels are consistent with a source for Buckland eruptives consisting of peridotite that has interacted with a carbonate-rich melt whose origin may be in the deeper lithosphere of the craton edge. The basanite melts originate slightly deeper than the alkali basalts, explaining the phlogopite in their source.

[1] Davies R et al. (2015) Nature 525, 511-514
[2] Wass SY (1979) in The Mantle Sample: inclusions in kimberlites and other volcanics, AGU Washington, 366-373
[3] Yaxley, G. et al (1991) Earth Planet Sci Lett 107. 305-317