Trace elements in olivine from diamondiferous lamproites: Proxies for magma origin and cratonic mantle lithosphere evolution

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Lamproites from the Dharwar and Bastar cratons in India contain phenocrysts, macrocrysts, and microcrysts of olivine set in a groundmass dominated by diopside and phlogopite, with minor spinel, perovskite, apatite, barite and K-richterite. Based on microtextures and compositions, three distinct populations of olivine are recognised: (i) olivine-I which comprises Mg-rich olivine macrocrysts (Fo89–93) that are interpreted as xenocrysts derived from disaggregated mantle peridotites; (ii) olivine-II includes Fe-rich olivine macrocrysts (Fo82–89) that are products of metasomatism of lithospheric mantle wall-rocks by precursor lamproite melts; and (iii) olivine-III comprises phenocrysts and overgrowth rims (Fo83–92), which are of magmatic origin.

The Mn and Al systematics of olivine-I indicate an origin from more diverse mantle lithologies beneath the Dharwar compared to the Bastar craton. Equilibration temperatures calculated using the Al-in-olivine thermometer for xenocrysts indicate a hotter geotherm at 1100 Ma beneath the Dharwar craton (41–43 mW/m^2) compared to the Bastar craton at 65 Ma (38–41 mW/m^2). The extent of Ca–Ti enrichment in olivine-II indicates a higher degree of melt-related metasomatism of the Dharwar SCLM compared to the Bastar lithospheric root. Forsterite contents of olivine-III show a correlation with the groundmass mineralogy testifying to crystallization from lamproite melt. Modelling indicates relatively Fe-rich parental melts for the Dharwar lamproites compared to those from the Bastar craton. The Ni/Mg and Mn/Fe systematics of magmatic olivines indicate derivation of the lamproite melts from mantle sources with a higher proportion of phlogopite and/or lower proportion of orthopyroxene beneath the Dharwar craton when compared with the Bastar craton. Comparisons of olivine trace element systematics from diamondiferous magmatic rocks provide a powerful tool for reconstructing the thermal and compositional evolution of cratonic mantle lithosphere including preconditioning of source regions to the economically important volatile-rich ultramafic magmas such as lamproites and certain types of kimberlite [1].

[1] Shaikh et al. (2019), Lithos 324-325, 501–518.