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Magmatic and xenocrystic olivine constraints on Jericho kimberlite magma evolution

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Olivines are a major constituent of kimberlites and therefore potentially carry important information on the evolution of the kimberlite magma. In this study, 86 olivine grains from the Jericho kimberlite in the Slave Craton, Canada were analyzed for major and trace elements. Based on crystal habit and chemical composition, we differentiated two groups, namely a “mantle group” and a “melt group”. The large majority (80 vol %) of olivine studied here belongs to the “mantle group”. Olivines in this group are xenocrystic and similar in composition to olivine from Jericho spinel-garnet peridotite, indicating that they are derived from the shallow (< 145 km) lithospheric mantle layer. A small subset (3 vol %) of these xenocrysts are enriched in temperature-dependent trace elements (Na, Ca, Al, Cr, V, Sc) and depleted in incompatible trace elements (Y, Zr, Nb, Ti, P) compared to the rest of the xenocrysts, suggesting they are sourced from residues after partially-melting. The “melt group” (20 vol % of all olivines) consists of two distinct populations with variable Ni content, indicative of origins from evolving melts. One melt group population has similar low-Mg# (< 90) to olivine from Jericho pyroxenites and megacrysts, which geothermobarometry calculations place at a depth of ca 145 km. The composition of these pyroxenite-megacryst olivines can be reproduced by Rayleigh fractionation of experimental melts derived from carbonated, near-solidus conditions. The other “melt group” population shows a large variation in Ni content at near-constant Mg# (90.5) and represents kimberlite melt crystallization products. Their compositions can be reproduced by a two-stage model involving a reduced, ultramafic “proto-kimberlite” melt evolving by Rayleigh fractionation, transitioning to a kimberlite melt with the onset of orthopyroxene assimilation at ca 145 km. These modelling results suggest a change in the properties and composition of the Jericho kimberlite magma at the interface between the shallow and deep lithospheric mantle layers. This could be explained by carbonate assimilation at around 145 km depth, followed by rapid ascent through the shallow lithospheric mantle layer.