A diamondiferous Palaeoproterozoic mantle root beneath the Sask Craton (Western Canada)

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Primary diamond deposits are typically restricted to the stable Archean cores of continents, an association known as Clifford's rule. Archean to Palaeoproterozoic crustal ages (3.3 - 2.1 Ga) have been reported for the Sask Craton, a small terrane in Western Canada, which hosts the diamondiferous Cretaceous Fort à la Corne (FALC) Kimberlite Field. Yet the craton is enclosed by the Palaeoproterozoic (1.9 - 1.8 Ga) Trans Hudson Orogen (THO). In this study we evaluate the age and geochemistry (major, trace, and platinum group elements data, as well as Re-Os isotope systematics) of the lithospheric mantle root beneath the Sask Craton to assess the timing of craton formation and the potential role played by the THO in its evolution.

The lithospheric mantle root is dominated by lherzolite with average olivine Mg# of 91.5, which is more fertile than observed in other cratons. Garnets from concentrate further highlight the rarity of harzburgite in the lithospheric mantle. Single clinopyroxene thermobarometry provides temperature-pressure constraints for the garnet-bearing lithospheric mantle (840 to 1250 °C and 2.7 to 5.5 GPa), indicative of a cool geotherm (38 mW/m^2) and a large diamond window of ~100 km thickness (from ~120-220 km depth). Most of the studied xenoliths show evidence for melt metasomatism in their trace and major element compositions, while retaining platinum group element patterns expected for melt residues. $^{187}Os/^{188}Os$ compositions span a broad range from 0.1109 to 0.1507, corresponding to Re-depletion (T_{RD}) ages between 2.4 to 0.3 Ga, with a main mode in the Palaeoproterozoic (2.4 to 1.7 Ga).

With the absence of Archean ages, the main depletion and stabilisation of the Sask Craton occurred in the Palaeoproterozoic, closely associated with the Wilson cycle of the THO. From a diamond exploration perspective this indicates that major diamond deposits can be found on cratons that were stabilised in the Palaeoproterozoic.