Diamond formation beneath the Sask Craton – Insights from diamondiferous microxenoliths

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The "Sask Craton" is a terrane with Archean crustal ages enclosed in the Paleoproterozoic (~1.8 Ga) Trans Hudson Orogen. In the absence of Archean lithospheric mantle beneath the Sask Craton, the diamondiferous kimberlites at Fort à la Corne (FALC) represent unconventional diamond deposits. Here we study diamondiferous microxenoliths from FALC (eclogitic n=23; lherzolitic n=1), including the first known occurrence of a diamond vein. SIMS $\delta^{13}C$, $\delta^{15}N$ and N concentration data from the FALC diamonds are used to evaluate the nature of post-Archean CHO fluids ascending through the lithospheric mantle beneath the Sask Craton.

Nitrogen-based time-averaged (2 Ga) mantle residence temperatures range from 1050 to 1370°C, with modes at ~1100 and ~1300°C. Carbon isotopic compositions range from –29.2 to –3.0‰, with three discrete clusters about –21.5‰, –16.4‰ (dominated by the diamond vein), and –4.6‰. Within each of these clusters, the typical range of $\delta^{13}C$ values of ~3‰ is accompanied by large variations in $\delta^{15}N$ and N-abundances, i.e., –5.6‰ to +9.4‰ and 0.1 to 1435 at. ppm, respectively.

The observed $\delta^{13}C$-$\delta^{15}N$-N variations cannot be explained by Rayleigh fractionation during precipitation of diamond in a fluid limited environment. Rather, the large compositional variations in N-chemistry, as well as the bimodal temperature distribution suggest a complex diamond formation history involving multiple generations of fluids with distinctly different $\delta^{13}C$-N compositions. Positive $\delta^{15}N$ and extremely negative $\delta^{13}C$ values are commonly attributed to fluids derived from recycled crustal material, consistent with the eclogitic paragenesis of the host xenoliths. The population with high $T_{Nitrogen}$ (mode ~1300 °C) resided at temperatures that exceed the hydrous solidus of metabasalt and, consequently, their diamond forming medium had to be either reducing (methane dominated CHO fluid) or a melt.