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Sr-Nd-Pb isotopes of fluids in fibrous diamond record two-stage modification of the Canadian continental root

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High-density fluid (HDF) micro-inclusions in diamonds represent deep carbon- and water-rich fluids involved in geodynamic processes that modify Earth's sub-continental lithospheric mantle (SCLM) over time. However, determining the isotopic composition and age of these HDFs thus far remained an analytical challenge. Here we report coupled major and trace element and Sr-Nd-Pb isotope compositions of silicic to low-Mg carbonatitic HDFs in a suite of fibrous diamonds from Canada to determine the sources and evolution of such fluids and constrain the geodynamic context.

The diamonds were sampled using the 'diamonds-in-water' laser ablation technique (Weiss et al., 2022) for combined trace element by ICPMS and isotopic composition by TIMS using 10^{13} Ohm amplifier technology. Sr, Nd and Pb isotope compositions correlate amongst themselves and with trace element ratios, but do not show systematic variation with major elements that reflect the fluid type. The Sr and Nd vary between a bulk silicate Earth (eNd = 0; $^{87}Sr/^{86}Sr$ = 0.7046) and an enriched component (eNd = -17; $^{87}Sr/^{86}Sr$ = 0.7134) and correlate negatively with Sm/Nd and La/Nb. Sr isotopes correlate positively with $^{208}Pb/^{204}Pb$ and $^{206}Pb/^{204}Pb$ (17.5 – 18.2) overlapping cratonic xenoliths values, however $^{207}Pb/^{204}Pb$ are relatively high (15.53 – 15.68). Limited published Sr-Nd (±Pb) isotope data of HDFs from Botswana and Congo (Klein-BenDavid et al., 2010; 2014) extend toward more extreme values.

The relationships between isotopes and trace element compositions indicate the involvement of two distinct sources within the continental lithosphere: one with a primitive isotopic compositions and another with unradiogenic Nd and radiogenic Sr and Pb isotope ratios. Nd T_{DM} model ages indicate the old enrichment to be of a minimum Paleo-Proterozoic age (1.8 Ga). We suggest that the old enrichment event reflects fluid addition by subduction of oceanic lithosphere below the Canadian continental root most probably in the Paleo-Proterozoic (e.g., Wopmay collisional event). A subsequent younger event, possibly related to kimberlite eruption, introduced HDFs with a more primitive BSE signature that mix with the old metasomatized SCLM and crystallise the diamonds.

Weiss et al., (2022) JAAS 37, 1431-1441

Klein-BenDavid et al., (2010) EPSL 289, 123-133

Klein-BenDavid et al., (2014) GCA 125, 146-169