Metasomatic growth of eclogitic diamonds from decoupled volatile sources

SMART, K. A.[12], O'BRIEN, H.[3], CARTIGNY, P.[4], TAPPE, S.[15], KLEMME, S.[2] AND HARRIS, C.[6]

[1]University of the Witwatersrand, Johannesburg, South Africa; katie.smart2@wits.ac.za
[2]Westfälische Wilhelms-Universität, Münster, Germany
[3]Geological Survey of Finland, Espoo, Finland
[4]Institut de Physique du Globe de Paris, Paris, France
[5]De Beers Group Exploration, Johannesburg, South Africa
[6]University of Cape Town, Cape Town, South Africa

Diamonds are sensitive probes of mantle metasomatism, where diamond isotopic and impurity compositions allow constraints to be placed on the movement of volatile-bearing fluids/melts between both different mantle domains (e.g. convecting asthenosphere and lithospheric mantle), and Earth's crust and mantle. The metasomatic formation of diamonds can additionally record lithospheric modification events and provide assessments of the volatile inventory present in migrating mantle metasomatic fluids/melts. Here we present a case study of diamond-forming metasomatism in the Karelian mantle lithosphere, from a suite of diamond xenocrysts and several diamondiferous eclogite xenoliths from the Lahtojoki kimberlite (Finland).

Xenocrystic and xenolith-derived diamonds show remarkably consistent and overlapping $\delta^{13}C$ values between –3 and -7‰ (n = 67; st. dev. < 1‰), and N contents between 100 and 1830 atomic ppm. We interpret the close similarity of the two populations to indicate a common origin. The diamond $\delta^{13}C$ values clearly indicate a mantle carbon source, whereas the elevated N contents require an enriched source possibly derived from K-rich metasomatized cratonic mantle or subducted crustal material (e.g. the eclogitic xenoliths). The eclogite xenoliths have characteristics (Eu anomalies, elevated Al_2O_3 contents) that suggest crustal protoliths, but initial garnet $\delta^{18}O$ results overlap with mantle values.

If the diamonds have mantle carbon but separate nitrogen sources, then the volatile components involved in the diamond formation are decoupled. P-T calculations for the xenoliths show eclogite residence near the base of the Karelian lithospheric mantle, such that the eclogites would be susceptible to interaction with ascending asthenosphere-derived C-bearing fluids/melts. Metasomatism of the eclogitic cratonic mantle by such fluids/melts may have facilitated precipitation of diamond where nitrogen is scavenged from host mantle lithosphere, ultimately producing diamonds with a mixed volatile heritage.