Helium isotopes reveals what carbon and nitrogen cannot, a mantle component for strongly ^{13}C-depleted diamond

SAMI MIKHAIL[1], JAMES C. CROSBY[1,2,*], FINLAY M. STUART[2]., LUIGIA DI NICOLA[2]., FEARGUS A.J. ABERNETHY[3]

[1]The School of Earth and Environmental Sciences, University of St. Andrews, UK

[2]Isotope Geosciences Unit, Scottish Universities Environmental Research Centre, UK

[3]Department of Physical Sciences, The Open University, UK

[*]Present Address, Department of Earth Science, University of Cambridge, UK

The origin of the diamond-forming fluids are routinely addressed with the stable isotopes of carbon and nitrogen, where average $\delta^{13}C$ and $\delta^{15}N$ values are -5 ± 3‰ and -5 ± 4‰, respectively. Because these values differ from crustal sources the application of C-N stable isotopes are applied as tracers of recycled crustal volatiles into the mantle. Additionally, fluid inclusions in fast-growing diamonds provides a unique opportunity to further examine the origin of diamond-forming fluids using noble gas geochemistry. Here we combine C-N isotopes, N concentrations from the diamond with He isotopes released from trapped fluids by *in vacuo* crushing of mg-sized polycrystalline diamonds. The samples examined are dominantly eclogitic to websteritic abd originate from Southern Africa. $\delta^{13}C$ values range from -4.3 to -22.2 ‰ and $\delta^{15}N$ values from -4.9 to +23.2 ‰. These data require a significant contribution of material that is ^{13}C-depleted and ^{15}N-enriched relative to mantle, akin to altered oceanic crust or deep ocean sediments. $^{3}He/^{4}He$ ratios range from typical mantle values (8.5 R_a) to those dominated by radiogenic He (< 0.1 R_a). These new data show $^{3}He/^{4}He$ correlates with ^{3}He concentration, suggesting that the low $^{3}He/^{4}He$ are, at least in part, the result of ingrowth of radiogenic ^{4}He in He-poor diamonds after their formation.

^{13}C-depleted and ^{15}N-enriched diamonds dominate the population studied here. This indicates that subducted altered oceanic crust is essential for diamondite-formation within the SCLM beneath southern Africa. However, the fluids trapped in the low $\delta^{13}C$ diamondites (< -15 ‰) have $^{3}He/^{4}He$ ratios that indicate an origin in the convective upper asthenospheric mantle. Ergo, helium reveals what carbon and nitrogen cannot. When the carbon and nitrogen stable isotope data show strong evidence for crustal sources for diamond-formation, helium isotopes reveal an unambiguos mantle component hidden within strongly ^{13}C-depleted diamond.