A nitrogen isotope fractionation factor between diamond and fluid derived from detailed SIMS analysis of an eclogitic diamond

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Nitrogen is a common trace element in diamond, and it has the potential to help our understanding of nitrogen storage and cycling in the mantle. However, significant knowledge gaps remain in the understanding of nitrogen sources and N-isotope fractionation between diamond and its parental fluid. We have undertaken detailed intracrystalline carbon and nitrogen isotope analysis of a large, complexly-zoned diamond (using secondary ion mass spectrometry) to examine the magnitude of nitrogen isotope fractionation between diamond and its parental fluid. The diamond is from an eclogite xenolith recovered from the Jericho kimberlite of the Slave Craton in the northwestern Canadian Shield. The diamond (JDE-25), which had previously been examined for intracrystalline variations in C-isotopic composition and N-abundances, contains one zone that grew from a single, large pulse of fluid and other oscillatory zones that grew from repeated smaller fluid pulses [1].

Combined C- and N-isotope and N-abundance measurements (n = 54 each) were made across four growth zones ($\delta^{13}C$ = –5.9 to –2.3‰; $\delta^{15}N$ = –7.1 to +5.4‰; [N] = 104 to 5420 ppm). Data across a zone of continuous growth ($\delta^{13}C$ = –3.9 to –2.9‰; $\delta^{15}N$ = –7.1 to +1.3‰; [N] = 1175 to 5420 ppm; n = 25 each) can be modelled as equilibrium growth in a fractionating, fluid-limited system. Utilizing a Rayleigh distillation model to explain the isotopic shifts across this zone, we have calculated a nitrogen isotope fractionation factor of –4.0 ± 1.2‰ (at 1100°C; 2σ) between diamond and its parental fluid ($\Delta N_{diamond-fluid}$). Overall, the stable isotope profiles suggest that each of the four growth zones crystallized from fluids with distinct C- and N-isotope signatures, and that these fluid phases experienced high degrees of progressive isotopic fractionation during diamond growth.

[1] Smart *et al* (2011) *GCA* **75**:6027-6047.