Diamond growth in the lithospheric mantle: New SIMS and Raman evidence from Zimbabwe diamonds

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Mixed-habit diamonds from the eastern Zimbabwe craton have octahedral sectors enriched in nitrogen, and cuboid sectors with hydrogen-containing defects (as VN_3H; [1]). The high nitrogen and hydrogen content, and mixed crystallographic state of these diamonds provide the opportunity to evaluate C-N-H bearing fluids and diamond growth mechanisms in the lithospheric keel.

Octahedral sectors are free of any inclusions. Cuboid sectors in these diamonds trap CH_4-rich fluid inclusions (Raman peaks at 2917 cm^{-1}) associated with graphite; and also have $\delta^{13}C$ and N content co-variations suggestive of Rayleigh fractionation from oxidised source fluids.

SIMS traverses for $\delta^{13}C$-$\delta^{15}N$ in the suite support a mixing trend from more CH_4-rich sources to later rim growth from more CO_3-/CO_2-rich sources. Calculated diamond source fluid compositions are between $\delta^{15}N$ +4 and + 8 ‰ (using $\Delta^{15}N_{diam\text{-}fluid}$ of -4.9 ‰; not redox dependent; [2]), requiring that both CH_4-rich and CO_3-/CO_2-rich fluids have a recycled metasedimentary component as could occur with subduction of eclogite.

Subduction fluids in equilibrium with an eclogitic bulk composition will be H_2O-rich and contain CO_2, CH_4 and $CH_3CH_2COO^-$ [3]. When such a fluid cools down, either isobarically, or through upwards percolation, it loses carbon solubility leading to diamond precipitation [4]. The lithosphere has a limited ability to act as either a source or sink of O_2 [4], and thus diamond precipitation by cooling can occur without carbon reduction or oxidation. Precipitation of diamond from mixed C-H-O fluids could proceed according to: $CO_2 + CH_4 \Leftrightarrow 2C + 2H_2O$ [5]. This model can reconcile trapped reduced CH_4 inclusions with oxidised growth suggested by the $\delta^{13}C$-N data.

[1] Goss et al., 2014. *Journal of Physics: Condensed Matter*, **26**, 145801 [2] Petts et al., 2015. *Chemical Geology*, submitted [3] Sverjensky et al., 2014. *Nature Geoscience*, **7**, 909-913 [4] Luth and Stachel, 2014. *Contributions to Mineralogy and Petrology*, **168**, 1083. [5] Deines, 1980. *Geochimica et Cosmochimia Acta*, **44**, 943-961.