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

KAREN V. SMIT1*, STEVEN B. SHIREY2, ANDREW STEELE3, RICHARD A. STERN4 AND WUYI WANG1

1GIA, New York, NY, USA *ksmit@gia.edu.  
2DTM, Carnegie Institution for Science, Washington, DC, USA.  
3GL, Carnegie Institution for Science, Washington, DC, USA.  
4CCIM, University of Alberta, Edmonton, AB, Canada.

Mixed-habit diamonds from the eastern Zimbabwe craton have octahedral sectors enriched in nitrogen, and cuboid sectors with hydrogen-containing defects (as VN3H; [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 CH4-rich fluid inclusions (Raman peaks at 2917 cm−1) associated with graphite; and also have δ13C and N content co-variations suggestive of Rayleigh fractionation from oxidised source fluids.

SIMS traverses for δ13C-δ15N in the suite support a mixing trend from more CH4-rich sources to later rim growth from more CO3-/CO2-rich sources. Calculated diamond source fluid compositions are between δ15N +4 and +8 ‰ (using ∆15Nfluid of −4.9 ‰; not redox dependent; [2]), requiring that both CH4-rich and CO3-/CO2-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 H2O-rich and contain CO2, CH4 and CH3CH2COO− [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 O2 [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: CO2+ CH4 ⇌ 2C + 2H2O [5]. This model can reconcile trapped reduced CH4 inclusions with oxidised growth suggested by the δ13C-N data.