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Diamond growth from C-H-N-O recycled fluids in the Zimbabwe lithosphere: evidence from CH₄ micro-inclusions and $\delta^{13}\text{C}$ - $\delta^{15}\text{N}$ -N content in Marange mixed-habit diamonds

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Abstract

Mixed-habit (octahedral + cuboid) diamonds from the Marange alluvial deposits in the eastern Zimbabwe craton have high nitrogen and hydrogen content that provides an opportunity to evaluate diamond growth mechanisms and C-N-H-O bearing fluids in the lithospheric keel. Light grey cuboid sectors with hydrogen-containing defects, trap abundant dispersed CH₄ inclusions (Raman peaks at 2917 cm⁻¹) associated with graphite (Raman peaks at 1580 cm⁻¹). Clear octahedral sectors are richer in nitrogen and free of any such inclusions. Core to rim co-variations of $\delta^{13}\text{C}$ - $\delta^{15}\text{N}$ and N content can be explained by a mixing trend between earlier fluids that are CH₄-rich and later fluids that are more CO₃- or CO₂-rich. Marange diamonds have limited overall $\delta^{13}\text{C}$ variation, but do show fractionation during growth towards higher $\delta^{13}\text{C}$ values. This trend can be explained by diamond precipitation from mixed CH₄ and CO₂ fluids, where isotopic fractionation occurs as the amount of fluid wanes. Calculated $\delta^{15}\text{N}$ values for diamond source fluids evolving in this manner are between +2.3 and +6.4 ‰. These N isotopic compositions require CH₄-rich and CO₃-/CO₂-rich 'end-member' fluids to have a recycled metasedimentary component perhaps introduced with subduction of eclogite.

Keywords: methane, diamond, non-redox growth, $\delta^{13}\text{C}$, $\delta^{15}\text{N}$, cratonic lithosphere, Zimbabwe

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