3D TEXTURAL AND GEOCHEMICAL ANALYSES ON CARBONADO DIAMOND: INSIGHTS FROM PORES AND THE MINERALS WITHIN THEM

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ABSTRACT

Carbonado is an enigmatic variety of polycrystalline diamond found only in placer deposits in Brazil and the Central African Republic, with unknown primary origin. These highly porous dark nodules possess a narrow range of isotopically light carbon ($\delta^{13}C$ -31 to -24 ‰), a primarily crustal inclusion suite unusually enriched in REEs and actinides filling the pore spaces, a loosely constrained crystallization age between 2.6 and 3.8 Ga, and other atypical features which have led to a variety of formation theories, from extra-solar to deep mantle. Unravelling the circumstances responsible for the diamond material and inclusion suite may provide evidence of not-yet-understood mantle processes and/or geochemical reservoirs.

This study is the first multi-sample 3D textural analysis on carbonado using high resolution X-ray CT. We document a variety of textures in both pore structure and mineralogy within pores. All samples feature a foliation with a mild preferred orientation. We observe the same fabric in a framesite diamond, a less porous polycrystalline diamond found in kimberlites and thought to crystallize shortly before eruption. The similarity in fabrics suggests a similar process could have formed both. Additionally, spatial coherence in pore fillings in some specimens suggests that secondary minerals formed from *in-situ* breakdown of primary inclusion phases. This, combined with the presence of euhedral cavities and pseudomorphs, supports the hypothesis that the raw material comprising the secondary minerals within carbonado is largely primary.

Step-leaching and ICP analysis on three African and two Brazilian samples revealed that not only is the modern-day inclusion suite highly enriched in REE (average ΣREE = 23 wt. %), but the REE and trace element patterns match those of melts derived from low degree (< 1 %) partial melting of primitive mantle (*i.e.* kimberlite and carbonatite), suggesting a link between carbonado and such melts. At the same time, $\delta^{13}C$ in kimberlites and carbonatites are much higher than in carbonado diamond.

Our textural and chemical results support the origin of both carbonado and its pore-filling material in a mantle environment. The origin of light carbon in the mantle before 2.6 Ga remains unknown, but subduction of organic material is a possible mechanism.

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