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The complex histories of Earth's deep carbon reservoirs as told by some unusual diamonds: Polycrystalline Diamond Aggregates and alluvial diamonds from Eastern Australian orogens

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Diamonds are a major carbon reservoir in the Earth's mantle. Studying the structure, and composition of diamonds and their inclusions can reveal much information about the deep carbon cycle across space and time. We present here results on two unusual types of diamond: fine-grained polycrystalline diamond aggregates from South Africa and alluvial monocrystalline diamonds from eastern Australia.

Polycrystalline diamond aggregates can comprise up to 20% of diamonds in some Group I kimberlites. They often contain peridotitic, eclogitic and/or websteritic minerals as accessory phases. The composition of their silicate intergrowths combined with carbon and nitrogen isotope data of these diamonds tells a multi-facetted story of rapid formation by fluid-rock interactions, remobilization and storage at the base of cratonic roots or the thermal boundary layer (Jacob et al., 2025). Electron Backscatter Diffraction analysis, which provides quantitative crystal orientation data, echoes the geochemical heterogeneity of these rocks and constrains their deformation history during residence in the Earth's mantle.

Alluvial diamonds from New South Wales, eastern Australia, occur in the convergent-margin setting of the Tasmanide orogens, overlying Paleozoic and Mesozoic rocks. While the source of these diamonds remains enigmatic, they have interesting features that set them apart from many other diamond suites globally. They are strongly resorbed (>50%) and have unusual surface features, are difficult to polish due to their complex internal deformation structures and have unusually heavy carbon isotope compositions of -0.9 to +2.9 ‰ (Davies et al., 2003). They have a calc-silicate inclusion suite containing grossular-rich garnet, diopsidic clinopyroxene, titanite, calcite, coesite, corundum and molybdenite. We explore the origin and geologic history of these diamonds, and their potential relation to the geodynamic evolution of eastern Australia, using new geochemical data and results from Electron Backscatter Diffraction analysis.

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