Insights into diamond formation from polycrystalline diamond aggregates

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Polycrystalline diamond aggregates (diamondites) are produced by rapid crystal nucleation caused by extreme carbon supersaturation in mantle fluids. They may form episodically and under variable chemical conditions, providing snapshots of diamond formation in the Earth's mantle. Diamondites, thus, represent an extreme end member of diamond formation mechanisms, while forming via the same processes and ingredients as the gem-sized diamonds.

We present results on a large suite of diamondites from the Venetia mine (South Africa), comprising a complete characterisation of the diamonds and their silicate inclusions and intergrowths. The highlighted characteristic of this sample suite is its heterogeneity in all aspects, from affiliated silicate to diamond composition and texture of the diamond aggregates. The diamond grains in the samples are intergrown with silicates (garnets, clinopyroxenes, phlogopites) comprising a websteritic-eclogitic and a peridotitic-pyroxenitic suite of minerals. Diamonds, regardless of their affiliation based on their silicate phases, overlap in carbon and nitrogen composition and have $\delta^{13}C$ values between -28 and -8 ‰, $\delta^{15}N$ values of 0.8 to 16.3 ‰ and nitrogen contents of 4 to 2329 ppm. The entire range of carbon and nitrogen variability of the suite is also reflected in some individual samples. Cathodoluminescence imaging visualizes different zones in the samples that can be interpreted as different growth events with differing nitrogen contents and $\delta^{15}N$ decoupled from $\delta^{13}C$ values, in line with the variability of nitrogen aggregation states. Electron backscatter diffraction analyses identify an original texture of randomly intergrown diamond grains that is partly changed by deformation and newly grown smaller diamond grains. The large overall variability suggesting episodic formation of diamondite with nitrogen from crustal sources.