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Microdiamonds and their mineral inclusions in a Tonian alkali basaltic intrusion in the North China Craton (NCC)

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Diamonds are commonly found in kimberlites, ultrahigh pressure metamorphic rocks, ophiolites, and impact craters. Here we report an unusual occurrence of microdiamonds in an alkali basalt intrusive (930–890 Ma) named Chulan from the south-east North China Craton (NCC). These diamonds are mainly cubic and rhombic dodecahedral in habit with diameters of 0.2 to 0.6 mm. Triangular and six-sided pits and resorbed textures are observed on the surfaces of diamonds. Many opaque spherules, flocculence and euhedral inclusions, and semi-opaque spherules-like inclusions are noticed under the microscope. The analyzed diamonds show light $\delta^{13}C$ values ranging from −18.6 to −21.1‰. We have conducted micro-Raman spectroscopy, Fourier transform infrared spectroscopy (FTIR), scanning electron microscopy (SEM), focused ion beam (FIB), and transmission electron microscope (TEM) methods to analyze these mineral inclusions.

The Raman spectral analyses confirm the presence of coesite, magnetite, hematite, ilmenite, and graphite as inclusions in diamonds. FTIR results suggest that these microdiamonds are Ib-type with nitrogen contents of 193-388 ppm (median 303 ppm). FIB-TEM study verified the existence of coesite, magnetite and ilmenite as inclusions supporting the Raman analytical results. It's noteworthy that the coesite are closely associated with Fe-Ni alloy (fcc structure). Such mineral assemblages are most likely sourced from a basaltic protolith within a reduced deep mantle as indicated by HPHT experiments. Moreover, several humite-group minerals (water-bearing) are also characterized by TEM analysis within magnetite grains that embed in microdiamond. Thus, we have excluded the possibility of anthropogenic contamination origin of these microdiamonds for their unique mineral assemblage. A series of high-pressure mineral inclusions are also characterized in further TEM work. Based on the negative carbon isotope values of micro-diamonds, the existence of humite-group mineral inclusions that are water-bearing, and basaltic mineral assemblages, we have concluded that the origin of the microdiamonds recovered from an Early Neoproterozoic alkali basaltic intrusion in the NCC was closely associated with ancient subduction, recycling, and convection processes in a deep, reduced mantle environment.