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In-situ C and N isotope data of the extraterrestrial, carbonaceous "Hypatia" stone and the ureilite diamond conundrum

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A small (30g) carbonaceous, diamond-bearing stone named "Hypatia", found in 1996 by Aly Barakat in the Libyan Desert Glass area of southwest Egypt, has been shown, based on Ar isotopes, to be of extraterrestrial origin[1,2]. It is unique in being silicate-free[3]. Diamonds are up to ~300 nm in size and are thought to be shock-related[1]. SIMS analyses of C (45 spots) and N (34 spots) over a 0.3×1 mm area revealed homogeneity of δ^{13}C at -3.4‰[2] and variable δ^{15}N ranging from +4 to -112 with N concentrations between 4 and 480 µg/g with a weak correlation (r=-0.41) between δ^{15}N and concentration. δ^{15}N values are between those of bimodal N releases (+20 and -120‰) found in stepwise heating[2], with the dominant (high temperature) light N component considered to be hosted in the diamonds. Our SIMS δ^{15}N results (spot size 20 µm) thus reflect variable mixtures of diamonds and their disordered carbon matrix.

The C and step-heating N isotope characteristics of Hypatia are remarkably similar to those of the carbonaceous matter in ureilites[4-6], where it has been argued that diamonds have a separate source rather than being shock products of their carbonaceous matrix[5]. Based on the spatially homogeneous C isotope data from Hypatia, we suggest that its diamonds were locally formed by shock, whereby the N isotope difference reflects atomic N being preferentially incorporated in diamond as it forms, compared to N_2 or compound-bound N. Modelling of reactions between N species in interstellar space predicts atomic N should have a δ^{15}N value ca. 100‰ below that of N_2 and compounds[7], and to be adsorbed onto dust grains[8]. Accordingly, it is not necessary to postulate distinct carbon sources for diamond and other carbon in ureilites.

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