

NanoSIMS Isotopic Imaging of Volatile-rich Clasts from Achondritic Kapoeta Meteorite.

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Introduction: Volatile-rich carbonaceous chondrite xenoliths (C-rich clasts), mainly composed of fine-grained material, have been commonly found in various groups of meteorites, reflecting vigorous collisional and mixing processes occurring in the early solar system [1]. It is, however, still unclear whether these C-rich clasts share the same parent bodies with carbonaceous chondrites and how and when they were added into the parent bodies of their current hosts. To better understand the origin of C-rich clasts and their linkage to carbonaceous chondrites, we identified 13 C-rich clasts (50–100 μm in size) in the howardite Kapoeta meteorite and acquired C, N, O, and H isotope images with NanoSIMS (reported previously [2,3]). Our NanoSIMS scanning ion images revealed the existence of presolar grains and isotopically anomalous organic matter (OM) in these carbonaceous xenoliths. The abundances and isotopic compositions of the identified presolar grains and OM further confirm their linkage to CI- and CM-like materials as suggested by previous petrologic studies [1].

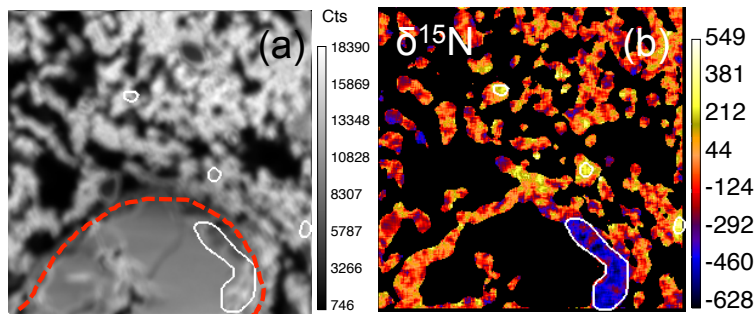


Fig. 1. SE (left) and NanoSIMS N isotope (right) images of one $10 \times 10 \mu\text{m}$ area in clast 024-011.

Results: We identified two C-poor, N-rich particles with $^{14}\text{N}/^{15}\text{N}$ ratios (439 ± 8 and 424 ± 19 , 1σ error) similar to the Sun's N isotopic composition (440 ± 5) [4]. While one of the ^{15}N -poor particles sits along the rim of an iron sulfide grain, the other particle sits along a $\sim 5 \mu\text{m}$ magnetite grain (highlighted by the red dashed line in Fig. 1).

In comparison to the surrounding micron-sized OM particles with normal and ^{15}N -rich compositions (highlighted by white circles in Fig. 1), the ^{15}N -poor region in Fig. 1 shows much lowered C contents. The enhanced $^{14}\text{N}/^{15}\text{N}$ isotope and lowered C/N elemental ratios are statistically significant according to the corresponding absolute σ plots. Both particles had normal C isotope ratios. To our knowledge, such association of isotopically anomalous N-rich phases with host minerals has never been found in any of the primitive carbonaceous chondrites, which could hint at the different formation environments of C-rich clasts with respect to carbonaceous chondrites.

Discussion & Conclusions: Previous studies showed that insoluble OM particles in primitive meteorites exhibit a wide range of N isotope ratios varying from the Sun's composition to large ^{15}N enrichments, e.g., [5,6]. In addition, it has been proposed that meteoritic insoluble OM could have been formed in the early solar system by Fischer-Tropsch reaction, during which Fe-rich minerals can act as catalysts [7]. Thus, if the two particles are organic, the Fischer-Tropsch reaction could provide an explanation to the association of these two particles with Fe-rich minerals and their N isotope ratios. Both particles, however, show C/CN ratios an order of magnitude lower than those of the surrounding OM particles. Because the formation of CN molecules requires the presence of both C and N, the inferred C/N ratios for these two particles based on C/CN are likely upper limits because of their low C contents. Therefore, it seems very unlikely that these two particles are organic. On the other hand, if they are inorganic, their ^{15}N -poor isotopic signatures seem to be quite puzzling. This is because in primitive meteorites such ^{15}N -poor isotopic signatures have only been observed in osbornite (TiN) in CAIs [9] other than insoluble OM. In contrast, meteoritic magnetite and some of the iron sulfides are known to have formed by aqueous alteration on meteorite parent bodies [8]. Therefore, if the association of the two particles with their host minerals is not a coincidence, they are likely to have formed as a result of aqueous processing of the host minerals. Thus, it remains a puzzle how these particles preserved the protosolar N isotopic signature while forming on the rim of aqueously formed mineral phases. We will carry out Auger nanoprobe and TEM analyses to characterize the compositions of the two particles to better understand their correlated morphological and isotopic signatures, which could yield important information on the evolution of N isotope ratios in the early Solar System.

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