ISOTOPIC STUDIES OF PRESOLAR GRAPHITE GRAINS FROM THE MURCHISON METEORITE.

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Introduction: Primitive meteorites contain presolar grains that condensed in the outflows of late-type stars and the ejecta of supernova explosions [1]. Presolar graphite grains were discovered because they carry the isotopically anomalous noble gas component Ne-E(L) [2]. These grains have a range of densities [3] and their isotopic composition depends on density [4, 5]. They also have different surface morphologies [5], which are reflected in the internal structure of the grains [6]. We embarked on a new study of graphite grains from the three density fractions KFA1 (2.05–2.10 g/cm^3), KFB1 (2.10–2.15 g/cm^3), and KFC1 (2.15–2.20 g/cm^3) from the Murchison carbonaceous meteorite [3]. This effort includes SEM studies of their morphology, Raman and TEM analysis of their crystalline structure, and NanoSIMS analysis of their isotopic composition. One of the goals is to see whether the isotopic composition of grains, which gives information about their stellar sources, is correlated with morphology and internal structure, and to determine whether formation conditions in different stellar environments lead to differences in grain morphology and internal structure. Here we report the results of isotopic measurements of C, N, O. Additional results will be reported at the conference.

Experimental: The graphite grains of this study were deposited from liquid suspension onto gold foils on standard SEM mounts. Secondary electron images in a JEOL 840A SEM were obtained to locate grains larger than 3 µm. Detailed high-resolution SEM images were taken with a PHI 700 Auger Nanoprobe to determines the grains' morphology. These large grains were analyzed with a Raman microprobe. Subsequently, we measured isotopic ratios of C, O, N, Si, and Mg with the Cameca NanoSIMS 50. The isotopic analyses were carried out in three independent steps, negative secondary ions of ^{12}C, ^{13}C, ^{28}Si, ^{29}Si, and ^{30}Si, and of ^{16}O, ^{18}O, ^{12}C^{14}N, ^{12}C^{15}N, and ^{28}Si were collected simultaneously by bombarding the sample with a Cs$^+$ beam, positive secondary ions of ^{12}C, ^{24}Mg, ^{25}Mg, ^{26}Mg, and ^{27}Al produced with an O$^-$ primary beam.

Results: We analyzed 29 KFA1, 52 KFB1, and 44 KFC1 grains >3µm. Based on the Auger Nanoprobe images we divided the grains into three morphological classes [5]: "cauliflowers", dense aggregates of small scales (Fig. 1a), "onions", grains with smooth or shell-like platy surfaces (Fig. 1c), and "caulionions", with intermediate morphologies (Fig. 1b). Figure 2 shows the distribution of these morphology classes among the three density fractions. Onions are dominant in the high-density fraction KFC1, cauliflowers are mostly found in the low-density fraction KFA1, whereas caulionions are present in all three fractions.

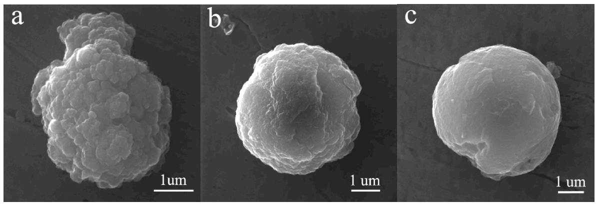

Fig. 1. SEM images of three Murchison grains displaying different morphologies: (a) cauliflower-type, (b) caulionion-type, (c) onion-type.

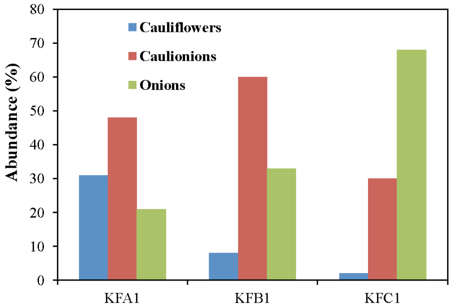

Fig. 2. Abundances of different grain morphologies among different density fractions.

We present the ^{12}C/^{13}C ratios of the KFA1, KFB1, and KFC1 grains in histograms (Fig. 3). The C isotopic ratios in all fractions vary over a large range, from 5 to 3132, compared to the solar ratio of 89. As has been noted before, the distribution of C-isotopic ratios depends on density. Most of the low-density KFA1 grains have ^{12}C/^{13}C < solar, whereas most KFB1 and KFC1 grains have ^{12}C/^{13}C > solar. All fractions have grains with ^{12}C/^{13}C ratios around 10.

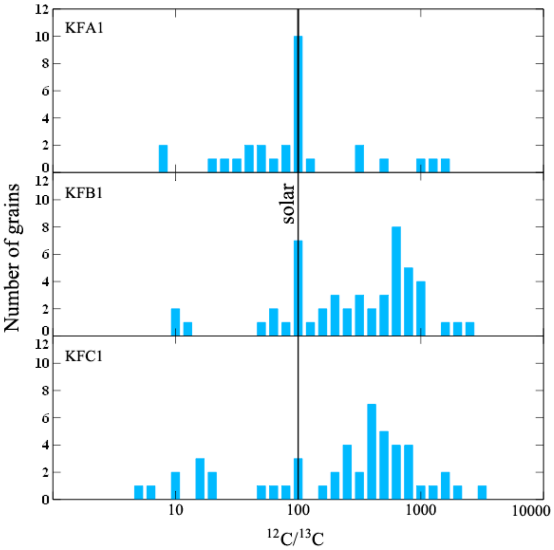

Fig. 3. Histograms of ^{12}C/^{13}C ratios in graphite grains of different density fractions.

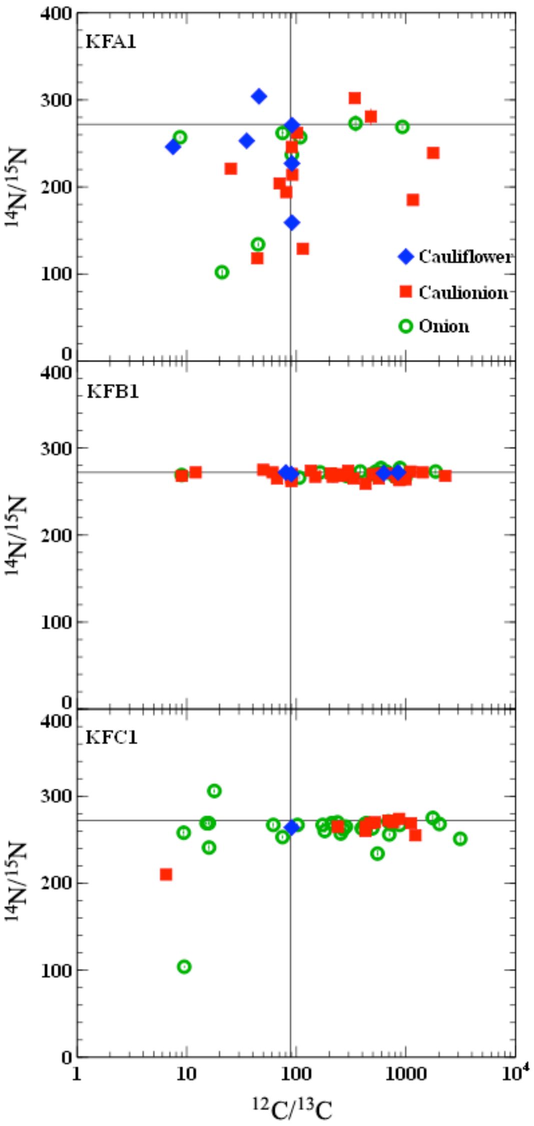

Fig. 4. Plots of N vs C isotopic ratios in graphite grains of different density fractions.

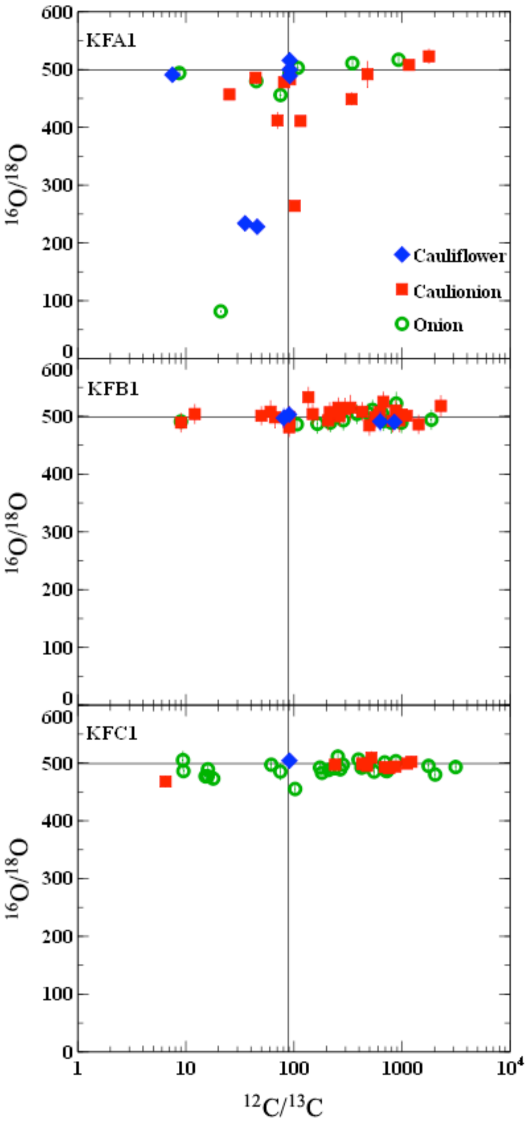

Fig. 5. Plots of O vs C isotopic ratios in graphite grains of different density fractions.

Among the density fractions, KFA1 grains have excesses in ^{15}N and ^{18}O, whereas grains of the higher-density fractions have close-to-normal N and O ratios (Figs. 4 and 5). This has been attributed to isotopic exchange with normal N and O, however preferential exchange in the tighter structure of high-density grains is difficult to understand. Low-density grains have higher N and O contents than high-density grains, and contamination might be a more likely explanation. On the other hand, we note that a few onion-type grains have large N and O anomalies. This topic needs more work. It is also interesting that the N and O isotopic ratios of KFC1 grains are more anomalous than those of KFB1 grains.

The ^{15}N and ^{18}O excesses in KFA1 grains indicate an origin in massive stars, most like Type II supernovae. Previous finding of ^{44}Ti [7] and ^{41}Ca [8] in low-density grains confirms a SNII origin. High-density grains mainly seem to come from low-metallicity AGB stars [9]. Such stars are predicted to have high ^{12}C/^{13}C and C/O ratios, which leads to the preferential condensation of graphite over SiC. Given these origins, supernovae seem to produce grains of all morphologies, whereas AGB stars produce preferentially onions and caulionions.

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