OXYGEN ISOTOPIC COMPOSITION OF PRESOLAR GRAPHITE GRAINS FROM MURCHISON FRACTION KFB1.

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Introduction: Presolar graphite grains, the carrier of Ne-E(L) [1], from Murchison (CM2) and Orgueil (CI) have been extensively studied [2, 3]. Graphite grains show a range of density (1.6 – 2.2 g/cm^3). Many low-density graphite grains originated from supernovae (SNe), while the majority of high-density graphite grains formed asymptotic giant branch (AGB) stars with low-metallicity [2, 3].

There are four graphite-rich density fractions from Murchison: KE3 (1.65 – 1.72 g/cm^3), 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) [4, 5]. Of presolar graphite grains, high-density graphite grains give us an unique opportunity to probe low-metallicity AGB stars. Silicon carbide grains of type Z also formed in low-metallicity AGB stars but the metalliciy of their parent stars is estimated to be a third of the solar metallicity [6]. The metallicity of parent stars of high-density graphite grains can go down ~15% of the solar metallicity. Therefore, these graphite grains can be examined to probe the Galactic chemical evolution of various elements.

We analyzed O isotopic ratios of KFC1 grains to grain a better insight into the evolution of O in the Galaxy [7]. In a continuing effort, we analyzed C, N and O isotopic ratios of graphite grains from KFB1.

Experimental: KFB1 grains on a gold foil were examined for their locations and grain sizes using a scanning electron microscope JEOL JSM-840A at Washington University in St. Louis. Carbon and N isotopic ratios of 56 grains were analyzed using the NanoSIMS 50 at Washington University: $^{12}C^-$, $^{13}C^-$, $^{12}C^{14}N^-$, and $^{12}C^{15}N^-$ were simultaneously collected. Synthetic SiC grains were used as standard for C, and N isotopes.

Subsequently, O isotopic ratios were analyzed using the CAMECA IMS-1280 (WiscSIMS) at The University of Wisconsin-Madison. A focused beam of 5pA was used for the analysis, and $^{16}O^-$, $^{17}O^-$ and $^{18}O^-$ were detected with electron multipliers. Terrestrial organic matter containing ~2wt.% of O (WI-STD-64, UWMA1) was used as standard. The errors of the data reported here are 2σ.

Results and Discussion: Carbon and N isotopic ratios of the KFB1 grains agree with the previous studies [2, 8], showing that most of the grains have $^{12}C/^{13}C$ ratios higher than solar, and that their $^{14}N/^{15}N$ ratios are close to that of air (272) with a few exception (Fig. 1).

Grains KFB1h-251, KFB1h-441, and KFB1h-553 show pronounced ^{18}O excesses and modest ^{17}O excesses [($\delta^{18}O = 950 \pm 35$ ‰, $\delta^{17}O = 101 \pm 31$ ‰), (4303 ± 79 ‰, 50 ± 12 ‰), (261 ± 12 ‰, 74 ± 10 ‰), respectively]. ^{18}O excesses are expected in the He/C zone of supernovae [9]. These three grains show a signature of SN origin. KFB1h-441 and KFB1h-553 also show ^{15}N excesses ($^{14}N/^{15}N = 146.5 \pm 3.1$, and 219.2 ± 5.1), another signature of SN grains.

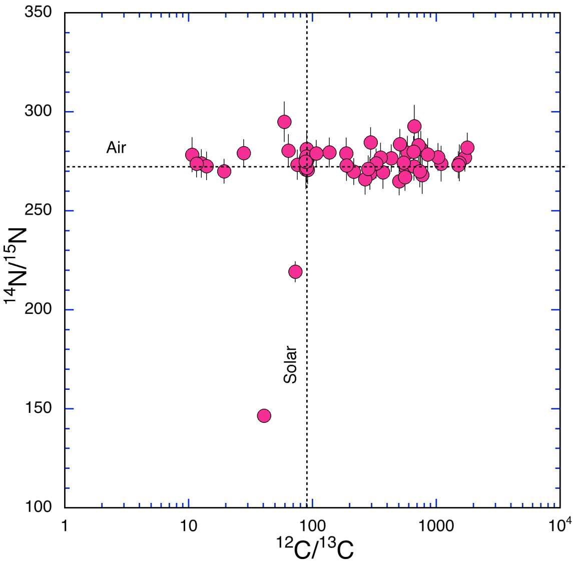

Fig. 1. Nitrogen and C isotopic ratios of KFB1 grains.

δ^{18}O and δ^{17}O of the KFB1 grains are positive and the data points seem to be on a line when we exclude these 3 SN grains, (Fig. 2a). The slope of the line is 0.65 thus they are not on a mass-dependent fractionation line.

Their O isotopic distribution is different from that of the grains from KFC1 [7]. The KFC1 grains, except two SN grains, plot around 40 ~ 80 ‰ for δ^{18}O and 10 ~ 60 ‰ for δ^{17}O (Fig. 2b). The average values (excluding the two SN grains) are $\delta^{18}O = 55 \pm 12$ ‰ and $\delta^{17}O = 38 \pm 16$ ‰.

KFB1 and KFC1 grains show similar C isotopic distributions: grains with $^{12}C/^{13}C$ ratios higher than solar (89) are dominant. Common stellar sources of KFB1 and KFC1 grains of high $^{12}C/^{13}C$ ratios (≥ 100) are considered to be low-mass (1.5 – 3M_{sun}) low-metallicity ($Z = 3 \times 10^{-3}$ up to 6×10^{-3}, $Z_{solar} = 2 \times 10^{-2}$) AGB stars [2]. As discussed in Amari et al. [7], it is predicted that δ^{18}O values in the envelope of AGB stars remain negative up to half a solar metallicity, while δ^{17}O values become positive at $Z = 6 \times 10^{-3}$ (3.89×10^{-4}) [2]. Thus, we expect negative δ^{18}O and negative/positive δ^{17}O values in the original O isotopic composition in these grains. All KFB1 grains show positive δ^{18}O and δ^{17}O, and this is not what is expected from AGB stars.

Hoppe et al. [8] proposed partial equilibrium of indigenous O and N in graphite grains to explain close-to-solar O and N isotopic ratios in graphite grains. However, the equilibrium with normal O cannot explain the observed O isotopic composition: if the indigenous O is partially equilibrated with solar O, the δ^{18}O of the grains should still be negative.

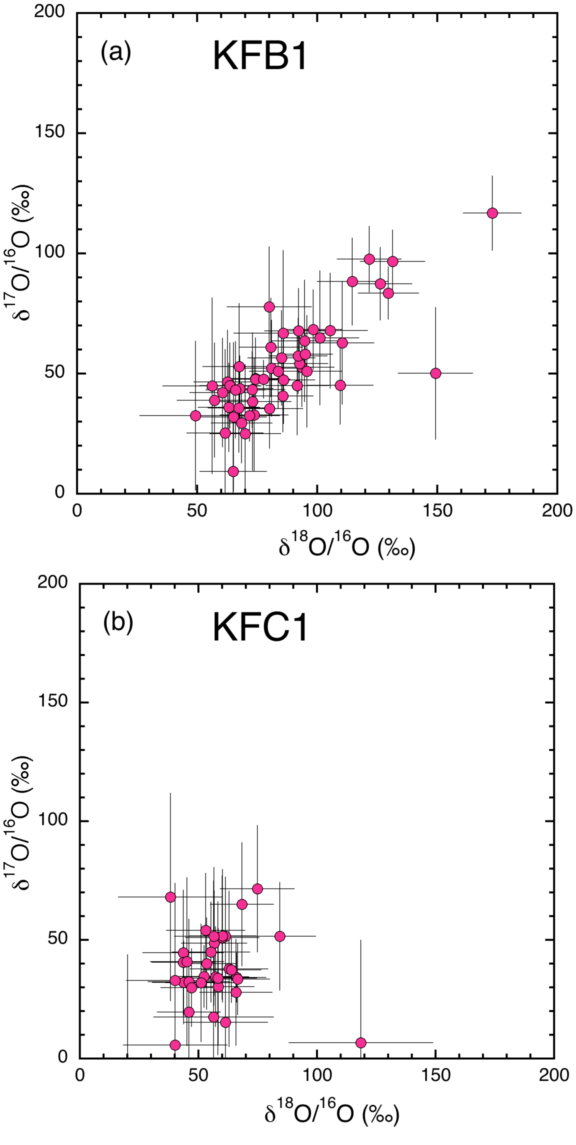

Fig. 2. Oxygen isotopes in (a) KFB1 grains and (b) KFC1 grains.

If aqueous alteration in the Murchison parent body changed the O in the KFB1 and KFC1 grains, those grains should have been affected in the same manner. Thus, it is puzzling that the O isotopic distributions of the KFB1 and KFC1 grains are different in spite of the fact that they share the same type of stellar sources (low-metallicity AGB stars) and the same parent body.

References:

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