PRESOLAR GRAPHITE AND ITS NOBLE GASES.

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Introduction: An isotopically anomalous Ne component, Ne-E(L), was first observed in primitive meteorites by Black and Pepin in 1969 [1] and served as a beacon during a long quest for what we now call presolar grains [see 2]. The ^{22}Ne dominating Ne-E(L) had long been attributed the decay of ^{22}Na and novae were considered to be a source of ^{22}Na. A noble gas study of four graphite-rich fractions with a range of density (1.6–2.2g/cm^{3}) extracted from the Murchison meteorite [3] has shown that Ne-E(L) consists of Ne-G, Ne predicted for the He-shell of asymptotic giant branch (AGB) stars [3], and Ne-R, radiogenic ^{22}Ne from the decay of ^{22}Na. Even more interesting, Kr-S, inferred s-process Kr, of the three lower-density fractions (KE1, KFA1 and KFB1: 1.6–2.15g/cm^{3}) is completely different from that of the highest-density fraction (KFC1: 2.15–2.20g/cm^{3}). The latter, having high ^{86}Kr/^{82}Kr (4.8), is attributed to low-metallicity (Z~0.003; solar $Z_{\odot}$=0.02) AGB stars. The former, showing low ^{86}Kr/^{82}Kr (~0), is considered to originate from high-metallicity (Z>0.02) AGB stars, with a possible contribution from massive stars.

Isotopic analyses of single graphite grains by ion probe SIMS have revealed isotopic features that depend on density [4, 5]. Grains with ^{12}C/^{13}C ratios higher than the solar ratio are more abundant in the high-density fractions. On the other hand, grains from supernovae, which are characterized by ^{18}O excesses, high ^{26}Al/^{27}Al ratios (up to 0.1) and Si isotopic anomalies (mostly ^{28}Si excesses), are found in the low-density fractions. As part of our continuing investigation of presolar graphite in the Murchison meteorite, we measured C and O isotopic ratios of 174 grains from fraction KFB1 (2.10–2.15g/cm^{3}) using the NanoSIMS.

Results and discussion: ^{12}C/^{13}C ratios of all the analyzed KFB1 grains range from 4.5 to 1531, while those of grains with ^{18}O excesses are confined in a narrow range of 37–183 (Fig. 1). Amari et al. [6] have argued, on the basis of a comparison between KE3 (1.65–1.72g/cm3) and KFA1 (2.05–2.10g/cm^{3}) grains, that there is a systematic difference between ^{18}O-rich grains with 20 < ^{12}C/^{13}C < 200 and those with ^{12}C/^{13}C > 200. The latter exhibit larger ^{18}O excesses and higher ^{26}Al/^{27}Al ratios (>0.01) and are found in the lowest-density fraction KE3, but not in KFA1. In this study, KFB1 is also devoid of ^{18}O-rich grains with ^{12}C/^{13}C > 200. Of 50 grains with 20 < ^{12}C/^{13}C < 200, we found ten ^{18}O-rich grains. In the highest density fraction KFC1, in contrast to all the other lower-density fractions, we have not observed any ^{18}O-rich grains: of 73 KFC1 grains that were analyzed, no grain showed ^{18}O excess.

Features which are common to the three lower-density fractions are the presence of ^{18}O-rich grains with 20 < ^{12}C/^{13}C < 200 and of Kr-S with ^{86}Kr/^{82}Kr ~ 0. ^{22}Ne-rich grains in KE3 are found only among those with 20 < ^{12}C/^{13}C < 200 and 7 out of 8 gas-rich grains have ^{18}O excesses [7], indicating that they originated from supernovae. Thus, the ^{22}Ne in these grains is either Ne-R or Ne-G, in either case from supernovae.

Bulk noble gas analysis has shown that KFB1 contains the Kr-S with very low ^{86}Kr/^{82}Kr (~0), as does the lowest-density fraction KE3. Thus, we expect that KE3 and KFB1 have the same Ne-G, because Kr-S and Ne-G should originate from the same stellar source. Most ^{22}Ne-rich grains in KE3 are also ^{18}O-rich and have 20 < ^{12}C/^{13}C < 200. In KFB1, ^{18}O-rich grains are observed only with 20 < ^{12}C/^{13}C < 200. Consequently, one may expect that ^{22}Ne-rich grains from KFB1 are found only in the range 20 <^{12}C/^{13}C < 200. However, Nichols et al. [7] found that gas-rich KFB1 grains have a much larger C isotopic range: four ^{22}Ne-rich have 20 < ^{12}C/^{13}C < 200 and seven ^{22}Ne-rich grains have ^{12}C/^{13}C > 200. The origin of the ^{22}Ne-rich grains with high ^{12}C/^{13}C (>200) is puzzling. We cannot totally exclude the possibility that the ^{22}Ne in these grains is Ne-R. However, the two grains with evidence for the initial presence of ^{22}Na (shown in Fig. 2) have low and not high ^{12}C/^{13}C ratios. It is also unlikely that the Ne-G in grains with high ^{12}C/^{13}C is from high-metallicity AGB stars: ^{12}C/^{13}C ratios predicted for the envelope of solar-metallicity $5M_{\odot}$ stars ranges only up to 120 (Gallino, private communication).

In contrast, the two ^{22}Ne-rich KFC1 grains with high ^{12}C/^{13}C ratios (>solar) are consistent with a low-metallicity AGB star origin of Kr-S in KFC1: ^{12}C/^{13}C in the envelope of AGB stars are predicted to be 575 ($M_{\odot}$=1.5, $Z=Z_{\odot}/6$) and 1000 ($M_{\odot}$=3, $Z=Z_{\odot}/6$) at the end of the third dredge-up (Gallino, private communication). Both KFB1 and KFC1 show populations of grains with ^{12}C/^{13}C ratios around a few hundred. In terms of their noble gas features, however, grains from these two separates are quite different.

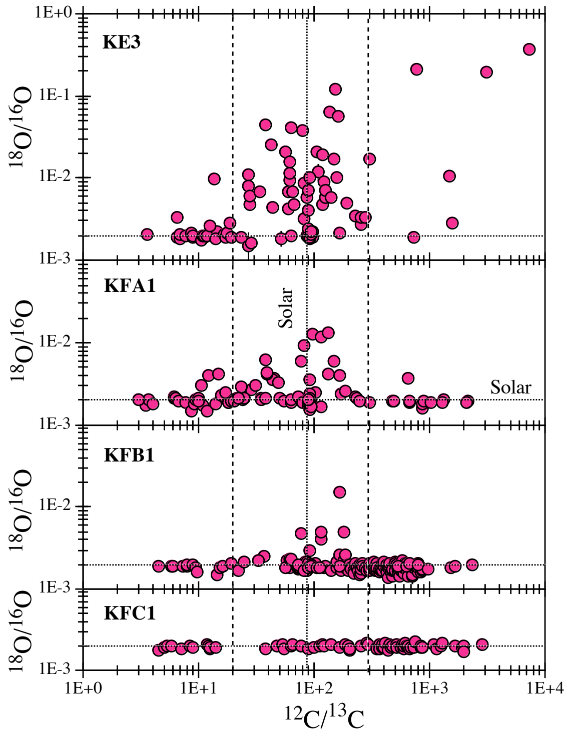

Figure 1. Oxygen-18/^{16}O and ^{12}C/^{13}C ratios of graphite grains in the four graphite fractions from Murchison. Data include this study as well as [4-6, 8, 9] and unpublished data for KFC1 grains.

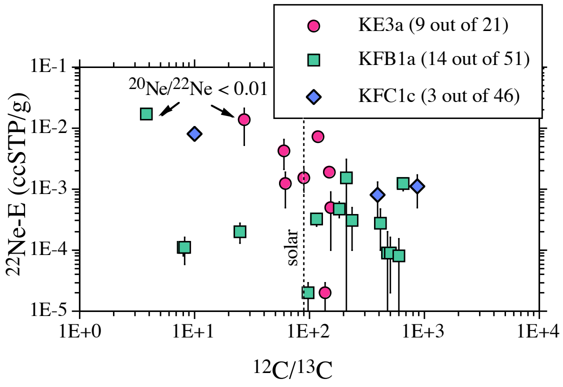

Figure 2. Results of noble gas analyses of single grains by Nichols et al. [7]. The legend gives the numbers of gas-rich grains and of analyzed grains for each separate. The two grains indicated by the arrows contain ^{22}Ne from ^{22}Na (for details see [7]).

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