COMPARISON STUDY OF PRESOLAR GRAPHITE SEPARATES KE3 AND KFA1 FROM THE MURCHISON METEORITE.

S. Amari[1], E. Zinner[1] and R. S. Lewis[2], [1]Laboratory for Space Sciences and the Physics Department, Washington University, One Brookings Dr., St. Louis, MO 63130, USA (sa@wuphys.wustl.edu, ekz@wuphys.wustl.edu), [2]Enrico Fermi Institute, University of Chicago, 5630 S. Ellis Ave., Chicago, IL 60637, USA (r-lewis@uchicago.edu).

Introduction: Graphite is the third type of presolar dust that was isolated from primitive meteorites [1]. Yet it has not been studied as extensively as SiC, which had been discovered three years earlier [2, 3]. This is because graphite is present only in very primitive meteorites and because the abundance of graphite is lower than that of SiC [4]. In addition, the separation procedure of graphite is far more complicated than that of SiC [5]. Up to date, essentially all data on graphite have been obtained from four graphite separates (KE3, KFA1, KFB1 and KFC1) with a range of density from 1.6 to 2.2g/cm^3, which were extracted from the Murchison meteorite [5]. One of the most interesting characteristics of graphite is that isotopic features depend on density. Of the graphite separates, KE3 (1.65–1.72g/cm^3) has been studied the most because graphite grains in this fraction (low-density graphite grains) have larger sizes and higher trace element concentrations than those in the other fractions. Many KE3 grains are characterized by ^{18}O excesses (^{18}O/^{16}O; up to 185 times solar), high ^{26}Al/^{27}Al ratios (up to ~0.1) and, to a lesser extent, by Si isotopic anomalies, mostly ^{28}Si excesses (up to 2 times solar) [6]. These isotopic features can be, in general, explained by a supernova origin of these grains.

Stimulated by the capabilities of a new type of ion probe, NanoSIMS, which has higher sensitivity at high mass resolution and smaller beam diameters than the CAMECA IMS-3f ion probe used in earlier grains studies [7], we have launched a detailed study of the isotopic compositions of grains from the whole suite of graphite fractions, starting with KFA1 (2.05–2.10g/cm^3) [8]. We made additional measurements on a new KFA1 mount, adding more to the database of presolar graphite. Here we will compare isotopic features of KE3 and KFA1 graphite grains and discuss their differences and similarities in the effort to probe the origin of KFA1 graphite. Data are from [6, 8, 9] as well as unpublished data obtained at Washington University.

Discussion: The C isotopic distribution of KFA1 is not markedly different from that of KE3 (Fig. 1). Grains with ^{12}C/^{13}C ratios higher than ~200 comprise about 13% and 24% of the total grains in KE3 and in KFA1, respectively. (From the total numbers of grains, grains with the normal C isotopic ratio that are shown as the spikes in the histograms are excluded.) However, KE3 and KFA1 show different characteristics in other isotopic ratios. All KE3 grains with ^{12}C/^{13}C>200 have notable ^{18}O excesses, while only one KFA1 grain (KFA1e-656) has an ^{18}O excess (^{18}O/^{16}O=3.74×10^{-3}, solar: 2×10^{-3}) (Fig. 2). It has been noticed that KE3 grains with higher ^{12}C/^{13}C ratios have higher ^{18}O/^{16}O ratios, which can be explained by mixing between different supernova layers [6]. The histograms in Fig. 3, which show all KE3 and KFA1 grains with evidence of ^{26}Al, also demonstrate a difference between grains with low and high ^{12}C/^{13}C ratios in these two separates. All KE3 grains with ^{12}C/^{13}C>200 have ^{26}Al/^{27}Al>10^{-2}, whereas only KFA1e-656 (the only KFA1 grain with an ^{18}O excess) has ^{26}Al/^{27}Al>10^{-2}. Since ^{18}O excesses and high ^{26}Al/^{27}Al ratios are believed to be signatures of a supernova origin, the lack of these features in the KFA1 graphite with high ^{12}C/^{13}C (>200) indicates a distinct origin.

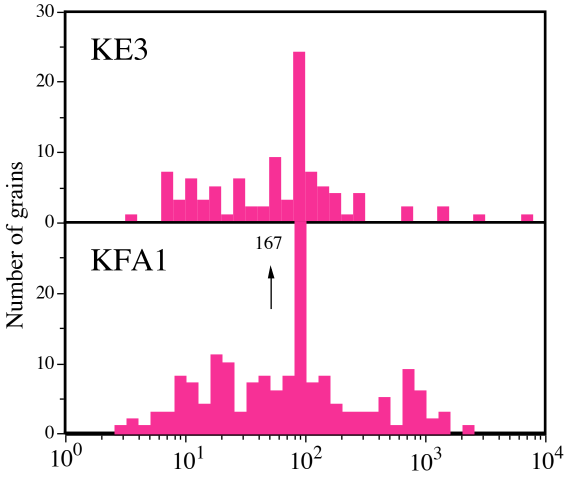

Fig. 1

Grains with ^{12}C/^{13}C ratios between 20 and 200 comprise about half (50 and 40%) of the total grains in KE3 and KFA1. Many grains from both fractions that fall into this isotopic range show the signatures of a supernova origin, ^{18}O excesses and high ^{26}Al/^{27}Al ratios. There are additional signatures for such an origin. The highest ^{44}Ca excess ever found in presolar grains (^{44}Ca/^{40}Ca = 138 times solar) due to the decay of ^{44}Ti ($T_{1/2}$=60a) has been observed in grain KFA1f-302, which has a ^{12}C/^{13}C ratio of 112±1

[10]. Another interesting fact is that the ^{12}C/^{13}C ratios of all ^{22}Ne-rich grains from KE3 are in this C isotopic range (from 27 to 153) [11].

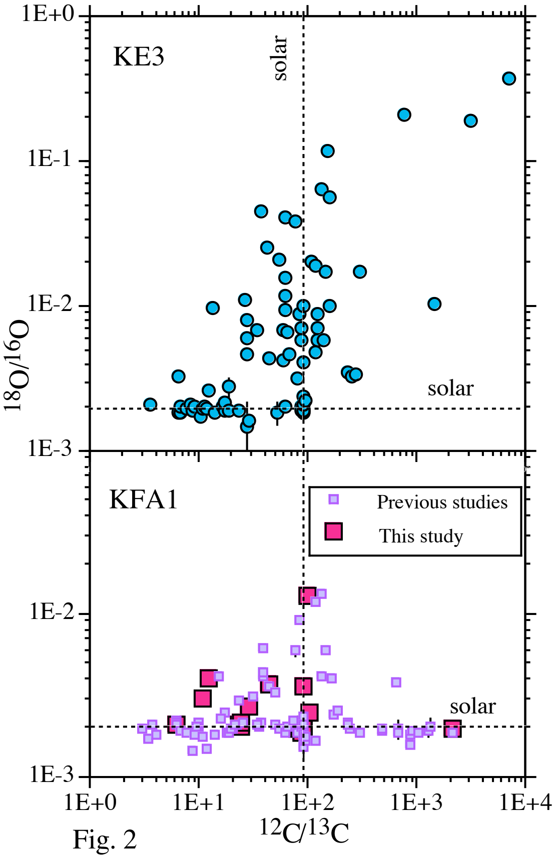

Fig. 2

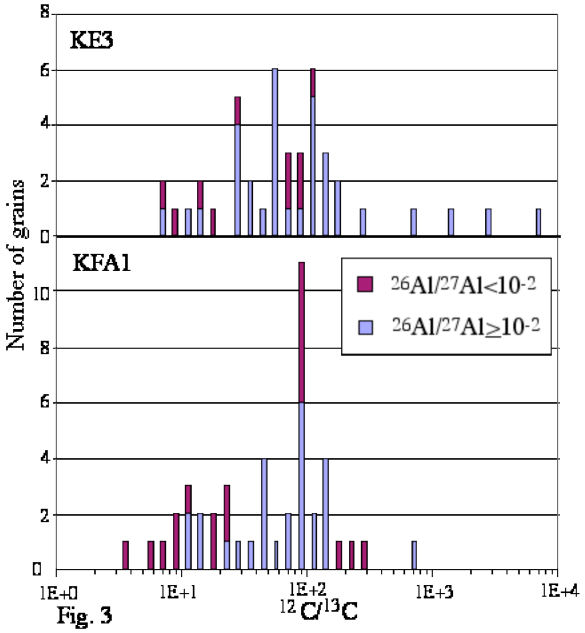

Fig. 3

Grains with ^{12}C/^{13}C <20 are enigmatic in both KE3 and KFA1. Among such 21 KE3 grains measured for their ^{18}O/^{16}O ratios, only 5 show ^{18}O excesses, of which 2 grains have ^{26}Al/^{27}Al ratios higher than 10^{-2}. Well above half of these KE3 grains do not show the supernova signature that is typical for most KE3 grains. Similarly, only a handful of KFA1 grains with ^{12}C/^{13}C <20 show ^{18}O excesses or high ^{26}Al/^{27}Al ratios. Thus, in both fractions of this C isotopic range, supernova grains are less abundant than in the 20<^{12}C/^{13}C<200 range.

A notable difference between KE3 and KFA1 grains is the distribution of ^{25}Mg excesses (Fig. 4, which shows only grains with ^{25}Mg excesses). Among grains with 20<^{12}C/^{13}C<200 KE3 grains have higher excesses, while among grains with ^{12}C/^{13}C<20 only KFA1 grains have ^{25}Mg excesses. ^{25}Mg excesses are observed only in supernova grains in KE3, but in both supernova grains and grains without any supernova signature in KFA1.

In summary, most KE3 grains with ^{12}C/^{13}C >20 are of a supernova origin, while in KFA1 supernova grains are mainly present in the C isotopic range of 20-200.

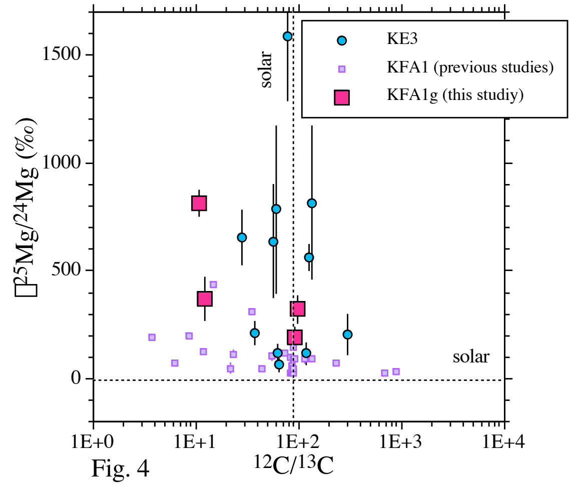

Fig. 4

References: [1] Amari S. et al. (1990) *Nature* 345, 238-240. [2] Bernatowicz T. et al. (1987) *Nature* 330, 728-730. [3] Tang M. and Anders E. (1988) *Geochim. Cosmochim.Acta* 52, 1235-1244. [4] Huss G. R. and Lewis R. S. (1995) *Geochim. Cosmochim. Acta* 59, 115-160. [5] Amari S., Lewis R. S. and Anders E. (1994) *Geochim. Cosmochim. Acta* 58, 459-470. [6] Travaglio C. et al. (1999) *Astrophys. J.* 510, 325-354. [7] Stadermann F. J., Walker R. M. and Zinner E. (1999) *Lunar Planet. Sci.* XXX, Abstract #1407. [8] Amari S. et al. (2002) *Meteorit. Planet. Sci.* 37, A11. [9] Hoppe P. et al. (1995) *Geochim. Cosmochim. Acta* 59, 4029-4056. [10] Nittler L. R. et al. (1996) *Astrophys. J.* 462, L31-L34. [11] Nichols R. H., Jr. et al. (2004) *Geochim. Cosmochim. Acta* submitted.