SEARCH FOR EXTINCT RADIOACTIVITIES IN LOW-DENSITY PRESOLAR GRAPHITE. 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@wustl.edu), [2] Enrico Fermi Institute and Chicago Center for Cosmochemistry, The University of Chicago, 5640 S. Ellis Ave., Chicago, IL 60637 USA (r-lewis@uchicago.edu).

Introduction: Presolar graphite exists only in primitive meteorites. Since the separation procedure of graphite is more complicated than that of SiC, Murchison (CM2) and Orgueil (CI) are the only two meteorites from which a substantial amount of graphite grains have been extracted [1, 2]. Of presolar graphite, low-density graphite grains (1.65-1.72 g/cm^3 for Murchison graphite and 1.67-1.92 g/cm^3 for Orgueil graphite) are characterized by ^{18}O excesses, Si isotopic anomalies as well as high inferred ^{26}Al/^{27}Al ratios (up to 0.3) [3, 4]. These isotopic signatures indicate that these grains formed in Type II supernovae. Helium and Ne analysis of single graphite grains from Murchison [5] indicates that about one-third of the grains are ^{22}Ne-rich. The ^{22}Ne is from the decay of ^{22}Na ($T_{1/2}$ = 2.6 a) that had been produced in the O/Ne zone during the hydrostatic burning and was subsequently implanted into the grains [6].

Pottasium-40 ($T_{1/2}$ = 1.27 Ga) is also produced in the O/Ne zone and decays to ^{40}Ca (88.84 %) and ^{40}Ar (11.16 %). The first ionization potential (FIP) of K (4.341 eV) is even lower than that of Na (5.139 eV). If Na was implanted, K must also have been implanted. The observed release peak of ^{40}Ar in the low density separates KE1 (1.6-2.05 g/cm^3) and KFA1 (2.05-2.10 g/cm^3) is most likely due to radiogenic ^{40}Ar [7].

Another radiogenic nucleus synthesized in the O/Ne zone is ^{60}Fe. It is mostly produced in the O/Ne zone and the O/C zone [8]. We report preliminary results of isotopic analyses undertaken to search for evidence of ^{60}Fe as well as other radiogenic nuclei.

Results and Discussion: Graphite grains from the separate KE3 (1.65-1.72 g/cm^3) [9] were deposited onto a gold foil. After documentation with the scanning electron microscope, C and Si isotopic analysis was performed with the NanoSIMS in multidetection mode followed by O and N isotopic analysis with a Cs primary beam. With an O primary beam, C as well as Fe and Ni isotopic ratios were measured in combined analysis mode, using two magnetic fields and five detectors. K and Ca were also analyzed in combined mode.

^{12}C/^{13}C ratios of the five grains analyzed range from 12 to 199, the same range as that of the ^{22}Ne-rich low-density graphite grains. Grain KE3j-571 is isotopically normal in the measured elements except C (^{12}C/^{13}C = 12). The other four grains show ^{18}O excesses. Three of them have ^{28}Si excesses and one has ^{29}Si and ^{30}Si excesses (δ^{29}Si/^{28}Si = 706 ± 42 ‰, δ^{30}Si/^{28}Si = 448 ± 45 ‰).

^{60}Ni/^{62}Ni and ^{61}Ni/^{62}Ni ratios as well as ^{57}Fe/^{56}Fe ratios of all five grains are normal within huge errors due to very low Ni counts ($^{62}Ni^+/^{12}C^+$: 6.9 × 10^{-5} – 2.7 × 10^{-3}). If ^{60}Fe and Ni in the O/Ne zone were incorporated into the grains without elemental fractionation, the δ^{60}Ni/^{62}Ni value is expected to be ~100 ‰ [8]. Since the 1σ errors of δ^{60}Ni/^{62}Ni values of the grains range from 400 to 1200 ‰, it is impossible to discern an anomaly of that magnitude. The two elements have a similar first ionization potential (Fe: 7.87 eV, Ni: 7.635 eV), thus elemental fractionation was not likely to have taken place if they were implanted as ions. However, no conclusions can be drawn on the basis of the present data.

Only Grain KE3j-941 has an excess in ^{44}Ca (δ^{44}Ca/^{40}Ca = 73 ± 12 permil). This excess is accompanied by higher δ^{42}Ca/^{40}Ca and δ^{43}Ca/^{40}Ca values (164 ± 13 permil and 452 ± 30 permil). Thus, the ^{44}Ca excess in the grain is probably due to neutron capture, not from the radioactive decay of ^{44}Ti ($T_{1/2}$ = 60 a).

Two grains with evidence of ^{41}Ca have negative δ^{30}Si/^{28}Si values [^{41}Ca/^{40}Ca: (2.46 ± 0.27) × 10^{-2}, (7.31 ± 1.66) × 10^{-3}; δ^{30}Si/^{28}Si: -422 ± 30 ‰, -404 ± 43 ‰]. When grains from previous studies are included, this trend still holds: grains with evidence of ^{41}Ca, having inferred ^{41}Ca/^{40}Ca ratios from 1.9 × 10^{-3} to 2.5 × 10^{-2}, have negative δ^{30}Si/^{28}Si values, although 3 out of seven grains have normal Si within large errors. Moreover, there is an inverse correlation between ^{41}Ca/^{40}Ca ratios and δ^{30}Si/^{28}Si values (Fig. 1). This trend is puzzling. ^{41}Ca/^{40}Ca ratios are expected to be 1 ~ 2 × 10^{-2} in the He/C, C/O, O/C, and O/Si zones, and 3 × 10^{-3} in the outer part of the Si/S zone, becoming even lower (in the range of 10^{-5} to 10^{-4}) in the inner part of the Si/S zone [8, 10]. Thus inferred ^{41}Ca/^{40}Ca ratios higher than 1 × 10^{-2} indicate that the Ca originated from the He/C to O/Si zones. However, ^{29}Si and ^{30}Si excesses are expected throughout the He/C to O/Si zones, (δ^{29}Si/^{28}Si = 4700 ‰ and δ^{30}Si/^{28}Si = 4200 ‰ in the O/Ne zone) and ^{28}Si excess is predicted only in the Si/S zone. Furthermore, in the Si/S zone, the abundances of the two elements are the highest (Figs. 2 and 3): the Ca abundance is at least 3 orders of magnitude higher than those in the He/C to O/Si zones and the Si abundance is 1 to 3 orders of magnitude higher than those in the He/C to O/Si zones. To explain the ^{28}Si excesses (or the lack of ^{29}Si and ^{30}Si excesses) and the ^{41}Ca/^{40}Ca ratios of the grains, the Si and the Ca must have originated from different zones: Si from the Si/S zone and the Ca from the outer O/Si-He/C zone. This implies that these elements were completely decoupled in the Si/S zone. Silicon and Ca counts were constant during the analyses, thus it is not likely that these elements occur in the form of subgrains in the graphite, but rather that they are uniformly distributed in the grains.

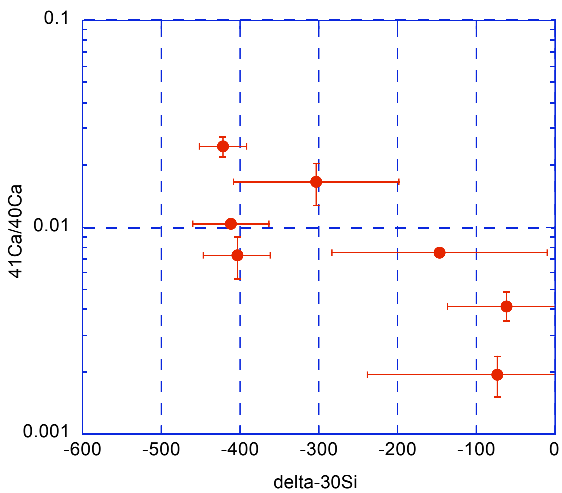
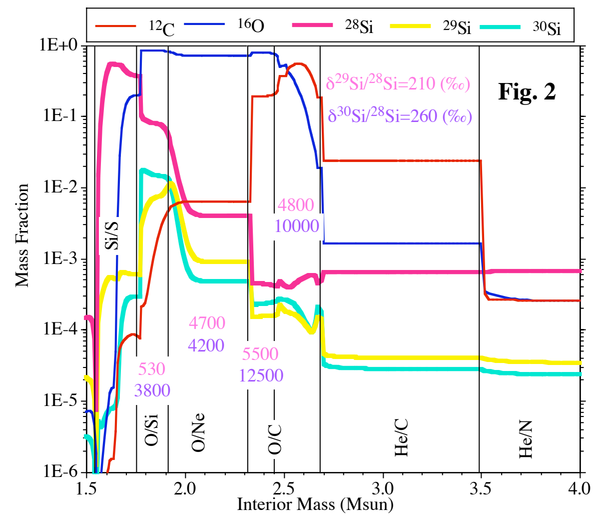
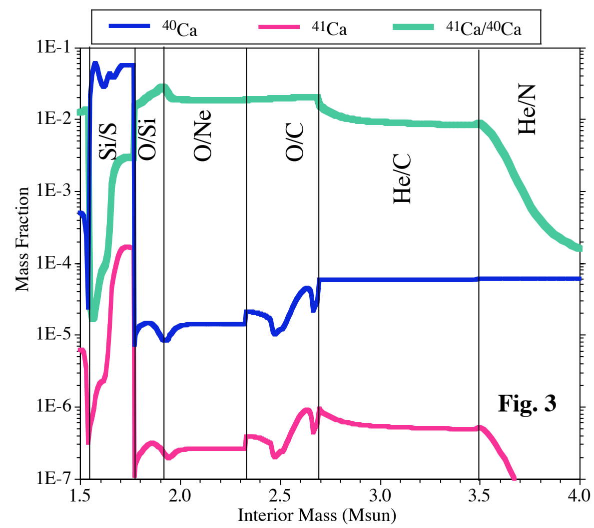


Fig. 1. Grains with evidence of radiogenic ^{41}Ca. Grains with ^{41}Ca/^{40}Ca ratios higher than 1×10^{-2} show pronounced ^{28}Si excesses, which are the signature of the Si/S zone.





Figs. 2 and 3. Yields and isotopic ratios predicted by Woosley and Weaver for a 15M$_\odot$ supernova [10].

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