Interstellar Murchison Graphite: How Many Noble Gas Components?

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Graphite is the third type of presolar interstellar grain discovered in meteorites [1], after diamonds [2] and SiC [3]. It is the carrier of Ne-E(L), nearly pure Ne^{22} in a carrier of lower density, chemical resistance to oxidation, and neon release temperature compared to presolar SiC, the carrier of Ne-E(H). The latest Murchison graphite samples, LFC1 , KE1, KFA1, KFB1, & KFC1, have [4] much higher concentrations of Ne-E(L) than previous samples, corresponding to progress in separation and purification of the carrier, ~1ppm by mass of the meteorite. Yet ion-probe analysis [1] indicates that small portions only of each of the fractions are presolar grains, a subset of the spherical compact graphitic grains >1μm in diameter. Ion probe analysis finds these grains themselves to be quite variable in isotopic composition, corresponding to different origins. Single particle laser extraction and analysis of the noble gases has found [5] that only a portion of these grains are enriched in Ne^{22}, that most of these grains are not. Finally, [4] the Ne-E(L) comes in two separate releases between 800C & 1200C, with variable proportions of these two carriers in the 5 fractions. These samples also have (1) Kr-s and Xe-s, released between 1600C & 2200C. It was suggested these might be carried at high concentration in a very refractory but minor subcomponent of these fractions.

We now suggest that the high temperature release of Kr-s & Xe-s does not require a separate carrier. A more ready explanation is that the neon is released by diffusing out of the graphite before the Kr-s & Xe-s can escape. In each sample the Ne^{22}-E/Kr^{82}-s falls monotonically over the course of the extraction (fig. 1a), consistent with diffusive separation. The trend is confounded somewhat by the presence of the 2 Ne-E(L) carriers, with their different release temperatures, but the large difference between Ne & Kr ensures the retention of the general trend for all 5 samples. Unplotted small, usually low temperature, fractions affected by large relative measurement errors, do not conform with this trend. Diffusive separation readily explains the similarity of the curves. Two carriers would work as an explanation only if each sample had the same proportion of each. Further, the Ne^{22}-E/Kr^{82}-s ratio approaches zero, not some other value characteristic of some second carrier. In addition (fig. 1b) the ratios for the totals are quite similar to those measured in SiC, something of a coincidence if the carriers are distinct. Finally (fig. 2) in the 3 cases where the Ne-E(L) is dominated by a single carrier, Murchison LFC1, KE1, & KFC1, the Xe^{132}-s/Kr^{82}-s ratio trends upwards. This is again consistent with diffusive release of the Kr ahead of the larger Xe atoms. The effect is more subdued (and lost entirely when confounded by the two Ne-E(L) carriers) due to the smaller difference Xe/Kr than Ne/Kr. Similar plots for the SiC data (not shown) do not have these trends.

We emphasize (figs. 3a & b) again [1, 3] the difference between the Ne in graphite and in SiC. Ne in SiC appears to have the theoretical Ne composition for the He burning shell in AGB stars, plus normal solar composition Ne far to the upper right and spallation Ne far to the right. The Ne in graphite appears to be AGB composition plus (nearly) pure Ne^{22}, consistent with part of the Ne-E being derived from its progenitor Na^{22}, chemically enriched over Ne during trapping in the graphite. The graphite shows no evident Ne^{21} enrichment, providing no evidence for any refractory presolar grains with long presolar irradiations & spallation target elements heavy enough (Mg, Al,...) to generate spallation Ne^{21}.

The high temperature Kr-s component, to the left of the data (figs. 4a, b) at Kr 84/82=2.40 and away from an approximately solar trapped component at 80,82,84,86 = 0.195, 1.00, 4.9, 1.53, by itself argues against a minor gas rich SiC carrier. The graphite samples, except for KFC1, have higher $(Kr^{80}/Kr^{82})_s$ and lower $(Kr^{86}/Kr^{82})_s$ ratios than any of the SiC samples, implying lower nucleosynthetic temperatures and neutron densities. Graphite sample KFC1 is just the reverse, lying on the opposite side of all of the SiC measurements. The Kr implies at least two distinct graphite populations. The Ne also implies at least two, but they are not apportioned among the 5 samples in the same manner as the first two. Hence Ne + Kr together require at least 3 distinct graphite carriers, each with a complement of Ne-E(L) as well as Kr-s & Xe-s. Hopefully, these carriers, along with all of the other grains, both solar and presolar, in these fractions will eventually be identified and characterized sufficiently that the properties can be compared in detail with proposed astronomical origins.

References. [1] S. Amari *et al.* (1990) *Nature* **345**, 238; [2] R. S. Lewis *et al.* (1987) *Nature* **326**, 160; [3] R. S. Lewis *et al.* (1990) *Nature* **348**, 293; [4] S. Amari *et al.* (1990) *LPSC* **21**, 19; [5] R. H. Nichols, Jr. *et al.* (1992) *LPSC* **23**, this volume

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