Ne-E(L) ACCOMPANIED BY $^{40}$K.
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Introduction: Presolar graphite carries Ne-E(L) [1], the component highly enriched in $^{22}$Ne. This huge excess prompted the idea that the $^{22}$Ne is from the decay of radiogenic $^{22}$Na (T$_{1/2}$ = 2.6 a) produced in novae [2]. Amari et al. [3] analyzed noble gases in the four graphite separates, KE1, KFA1, KFB1 and KFC1 with a range of density (1.6–2.2 g/cm$^3$) extracted from the Murchison meteorite [4], and concluded that the $^{22}$Ne in KE1 and KFA1 (1.6–2.05 and 2.05-2.10 g/cm$^3$) is mostly (≥ 90%) from the decay of $^{22}$Na. Low-density graphite grains (1.65–1.72 g/cm$^3$) are characterized by $^{18}$O excesses, Si isotopic anomalies (mainly in the form of $^{28}$Si excesses) and high $^{26}$Al/$^{27}$Al ratios (up to 0.1), indicating they formed in Type II supernovae [5]. From noble gas analyses of bulk samples [3] and of single grains [6] from the Murchison separates, Amari et al. [7] concluded that $^{22}$Ne in low-density grains is from $^{22}$Na produced in supernovae and is not from $^{22}$Ne that was directly implanted onto the grains. Sodium-22 is synthesized during hydrostatic burning by $^{21}$Ne(p,$\gamma$)$^{22}$Na, where $^{21}$Ne is produced by $^{20}$Ne(n,$\alpha$)$^{21}$Ne and protons are produced by $^{12}$C($^{12}$C,p)$^{23}$Na in the O/Ne zone [8].

Discussion: In the O/Ne zone, isotopes that have a similar first ionization potential as that of Na (5.203 eV) include K (4.34 eV). Potassium-40 (T$_{1/2}$ = 1.27 Ga) decays to $^{40}$Ar (11.16%) and $^{40}$Ca (88.84%). Predicted $^{22}$Na/$^{40}$K ratios are 3.40 [9] and 9.77 [8] in the O/Ne zone of 25M$_\odot$ stars with the solar metallicity. If non-radiogenic $^{40}$Ca and $^{40}$Ar are not overwhelmingly abundant and $^{40}$K was incorporated along with $^{22}$Na, elevated $^{40}$Ca and $^{40}$Ar abundances are expected in $^{22}$Ne-rich low-density grains. In graphite bulk analysis, the lighter noble gases were released in lower temperature steps than the heavier noble gases (Fig 2 in [3]), indicating noble gases were released by diffusion. In the figure below (data are from [3]), where $^{22}$Ne, $^{40}$Ar, and s-process Kr concentrations are plotted against temperatures for KE1 and KFA1, the $^{40}$Ar release peaks are observed between the $^{22}$Ne and the Kr-S release peaks. A similar release pattern is also observed in KFB1 (2.10–2.15 g/cm$^3$). Argon-40 must be from the graphite grains and is most likely from the decay of $^{40}$K.