**EVIDENCE FOR SHORT SIC LIFETIMES IN THE ISM;** C. M. O'D. Alexander, McDonnell Center for the Space Sciences, Physics Department, Washington University, One Brookings Drive, St. Louis, MO 63130 USA.

The KJ series of presolar SiC size separates isolated from the Murchison meteorite exhibit pronounced variations in the absolute abundances and isotopic compositions of their noble gases with grain size [1,2]. In the case of $^{21}$Ne, its variation in abundance with grain size appears to reflect differences in the cosmic ray exposure ages of grains, from 13Ma to 133Ma with increasing size, while they resided in the interstellar medium (ISM). These ages are significantly shorter than typical theoretical estimates of 500Ma for the residence times of refractory grains in the ISM [e.g.3] but are consistent with an observed under abundance of SiC in the ISM [4]. Another remarkable feature of the SiC noble gas data is the linear correlation between the cosmic ray exposures of the size separates and their $^{22}$Ne contents. The $^{22}$Ne is thought to have formed in the He-shell of AGB stars [5] so there is no obvious reason why it should correlate with exposure age. The observation that only about 5% of SiC grains carry essentially all the $^{4}$He and $^{22}$Ne [e.g.6] led to the suggestion that these same gas-rich grains also carry the $^{21}$Ne and that most of the meteoritic SiC has been degassed in the Solar System [2]. However, this explanation requires that the gas-rich grains be up to 1Ga old, much older than theoretical expectations, does not explain why only very old gas-rich grains survived degassing and cannot explain the variations with size of the other noble gases, including He, which do not show linear correlations with exposure age. Here an alternative model for the variation of noble gas abundances with size is outlined which is based on the premise that the measured cosmic ray exposure ages are related to the mean residence time of SiC of different sizes in the ISM.

The presolar SiC found in meteorites was probably produced by numerous stars [e.g.7] and presumably accumulated in the reservoir from which the solar system formed. If star formation in the galaxy approximates a steady state, the rate at which SiC was added to the reservoir is likely to have been, on average, constant. This being so, the 133Ma mean exposure age of the Murchison KJG fraction suggests that the reservoir had been accumulating grains of this size for at least twice this length of time.

While SiC grains reside in the reservoir they are continually bombarded by cosmic rays and their $^{21}$Ne contents rise accordingly. At the same time, grains are being continuously removed and replaced by SiC that has a zero age. Consequently, the average exposure age of the SiC in the reservoir will evolve, but given enough time both the concentration and average exposure age will reach a steady state.

In the larger grain sizes, at least, $^{4}$He and $^{22}$Ne are carried by only about 5% of the grains [6], because the stars that form gas-rich grains are relatively rare. The concentration of grains injected into the reservoir by a particular star will decay with time at rates that are approximately inversely proportional to their size. As a result, when the solar system forms the grains from this star will be depleted in the finer fractions compared to the coarser ones and the extent of the relative depletion will depend on the age of the grains. Here, then, is a means of varying the gas abundances with size and in the same direction as the exposure ages.

Changes in the $^{4}$He/$^{22}$Ne ratio with size require that a minimum of two gas-rich populations be present, here only two are assumed, and that they have different ages. At present, it is not known how the noble gases, other than spallogenic $^{21}$Ne, were trapped in the SiC but it seems likely that they were implanted by stellar winds after SiC growth was complete [1,2]. At low wind energies, implanted gas concentrations will vary as 1/r, but as the energies increase and implantation depths approach the dimensions of the smaller grains this relationship will flatten and gas concentrations could even start to increase with size. Changing the energies of the winds is thus another means of varying the gas concentrations with grain size. Finally, for the sake of simplicity it is assumed that, when it forms, SiC always has the same initial size distribution [8].

A simple mathematical model based on the ideas outlined above has been fitted to the pure s-process KJ noble gas data by solving for the ages of the two gas-rich populations, the energies (keV/amu) of the winds that irradiated them and the noble gas fluences they 'saw' (Table 1). As can be seen the fit is quite successful (Fig. 1) except, perhaps, for $^{4}$He. Using the results of the fit and assuming all stars produce the same amount of SiC one can estimate the gas abundances as a function of size in the two populations and compare these to the single grain data [e.g.6] (Fig. 2). The predicted gas concentrations of the population A grains are consistent with the less gas rich grains. The predicted gas concentrations for the population B grains are higher than observed in any grains and may, in fact, exceed the saturation levels for SiC, an effect that will have to be included in future models.

[1] Lewis R.S. et al. (1990) *Nature*, **248**, 293. [2] Lewis R.S. et al. (1993) *G.C.A.*, in press. [3] Seab C.G. (1988) In *Dust in the Universe* (eds. Bailey M.E. and Williams D.A.), pp.303. [4] Whittet D.C.B. et al. (1990) *Mon. Not. Roy. Astr. Soc.* **244**, 427. [5] Gallino R. et al. (1990) *Nature*, **248**, 298. [6] Nichols R.H. et al. (1993) *Meteoritics*, **28**, 410. [7] Alexander C.M.O'D. (1993) *G.C.A.*, **57**, 2869. [8] Little-Marenin I.R. (1986) *Ap. J.*, **307**, L15.

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**Fig. 1 Comparison of the s-process gas concentrations measured by [2] with those predicted by the fit.**

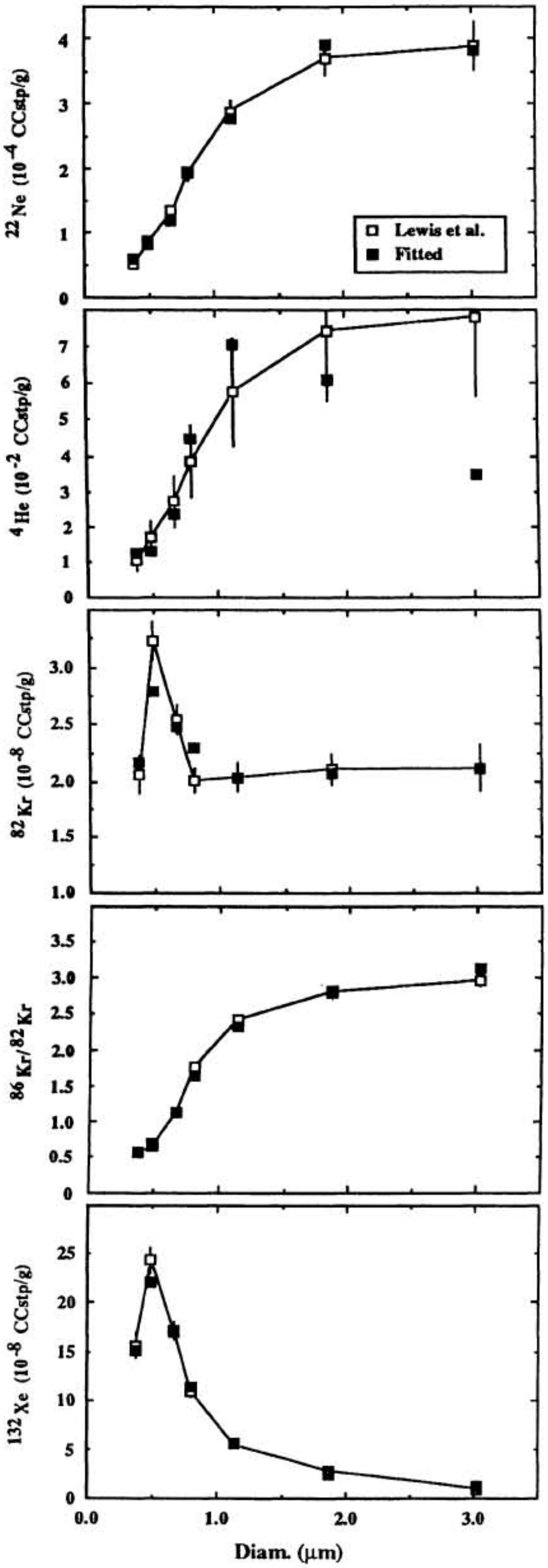


Table 1. Summary of results of the fit to the pure s-process KJ data [2]. The age is the age before the solar system formed. The isotopic ratios are the ratios in the winds. The absolute $^{22}$Ne fluences were calculated assuming all stars produce similar amounts of SiC. The wind energies include the 1 sigma in the energy distributions.

| | Pure s-process | |
|---|---|---|
| | Population A | Population B |
| Age (m.y.) | 31.1 | 84.9 |
| $^{4}$He/$^{22}$Ne | $2.1\times10^{2}$ | $1.2\times10^{2}$ |
| $^{22}$Ne (ccSTP/μm$^2$) | $5.7\times10^{-15}$ | $5.4\times10^{-13}$ |
| $^{36}$Ar/$^{22}$Ne | $1.9\times10^{-3}$ | $1.6\times10^{-3}$ |
| $^{82}$Kr/$^{22}$Ne | $3.5\times10^{-4}$ | $7.8\times10^{-5}$ |
| $^{86}$Kr/$^{82}$Kr | 0.61 | 3.4 |
| $^{132}$Xe/$^{22}$Ne | $2.8\times10^{-3}$ | $5.6\times10^{-8}$ |
| Energy (keV/amu) | $6.9\pm0.3$ | $56.6\pm31.6$ |

**Fig. 2 Comparison of the predicted gas concentrations with those measured in single grains [e.g. 6].**