NITROGEN ISOTOPIC COMPOSITIONS OF MAINSTREAM SIC GRAINS FROM CHONDRITES WITH A RANGE OF COSMIC RAY EXPOSURE AGES.

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Introduction: Extensive isotopic data on presolar SiC grains show that all meteorites sampled the same initial reservoir of presolar grains [e.g., 1-4]. While major and minor element isotopic compositions show no systematic differences between meteorite classes [4], the $^{14}N/^{15}N$ ratios of mainstream SiC grains vary between different meteorites and within a meteorite as a function of size [1-3,5,6]. Neon isotopic compositions are known to correlate with cosmic ray exposure (CRE) ages of the parent meteorite, but no such correlation has been identified in the N compositions [3,5]. The abundances and characteristics of presolar grains do, however, vary with bulk compositions of host chondrites [4,7]. Thus, it is possible that pre-accretionary nebular processing that change the bulk composition of host meteorites and the abundance patterns in their presolar grain population could also be responsible for the variations in N isotopic compositions observed in different meteorite classes.

We began testing this hypothesis by measuring C, N, and Si isotopic ratios of mainstream SiC grains from various chondrites [8]. In a continued effort, we present here additional, new isotopic data (C, N, Si) for SiC grains from Roosevelt County (RC) 075 (H3.1). We also compare our N isotopic data with that of grains from Murchison (CM2) [2] and previously unpublished data from Semarkona (LL3.0), Colony (CO3), and Qingzhen (EH3).

Experimental Methods: The RC 075 SiC-spinel separate was prepared by the method developed by [7]. A portion of this separate was dispersed on gold foil mounts and 51 SiC grains (≤ 1.5 μm in size) were identified using energy-dispersive X-ray spectroscopy with the UH JXA-8500F field-emission electron microprobe. Before putting the sample mount in the ionprobe, it was heated in an oven to ~ 700°C for 1 minute in order to oxidize organic contamination [e.g., 3]. Carbon, N, and Si isotopic measurements were carried out using the UH ims-1280 ion microprobe. A 3-5 pA Cs^+ primary beam focused to ~ 0.5 μm was rastered over 5×5 μm^2 regions and scanning isotope images were collected. Carbon and Si isotopes were measured first: C isotopes were collected in multi-collection mode followed by peak jumping to collect Si isotopes by multi-collection. The grains were subsequently measured for C and N isotopes using CN^- ions. To further minimize the effects of terrestrial contamination on the N isotopes, the sample was kept in the sample chamber between the C-Si and N measurement sequences. Isotopic ratios were calculated from regions of interest using L'image software.

The Colony isotopic data and some of the Semarkona data were measured with ASU's CAMECA ims-6f ionprobe. The remaining Semarkona and all of the Qingzhen data were measured with the imf-3f ionprobe at Caltech.

Isotopic results: Si isotopic data of the RC 075 grains indicate that most of the grains fall on the "mainstream" array (Fig.1). Two grains that appear in the bottom left and right quadrants are X and Z grains, respectively. The $^{12}C/^{13}C$ ratios of the grains are consistent with those of mainstream grains from other meteorites with a range from 20-100. One grain with $^{12}C/^{13}C$ of ~ 6 also has a $^{14}N/^{15}N$ ratio of 2349 (Fig. 2). This is an A+B grain.

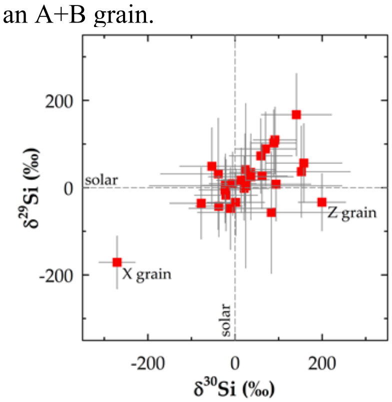

Figure 1: δ- plot of Si isotopes for SiCs from RC 075. Errors are 2σ.

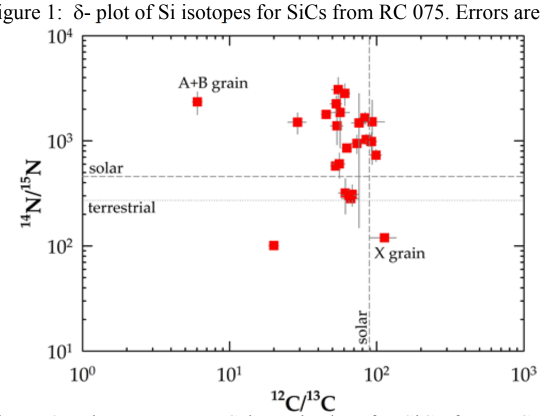

Figure 2: Nitrogen versus C isotopic data for SiCs from RC 075. Errors are 2σ.

Nitrogen data for 11 grains, out of the 32 measured, had to be discarded because high $^{12}C/^{28}Si$ ratios (> 2) indicated these grains were highly contaminated. It is imperative to exclude contaminated grains from this study because both CRE and terrestrial contamination can lower $^{14}N/^{15}N$ ratios. Most of the RC 075 SiC grains are enriched in ^{14}N relative to the solar value (Fig. 2). The average enrichment (3 times solar) is smaller than that seen in similar-sized SiC grains from Murchison (7 times solar) [2] and Bishunpur (4 times solar) [8].

Discussion: We finally have substantial N data on similar-sized grains [4] from different meteorites to facilitate comparison between the different populations. Fig. 3a shows the probability density distribution of N isotopic ratios in 316 KJE grains (≤ 1.5 µm) from Murchison (CM2) [2], 14 grains (< 2 µm) from Qingzhen (EH3), 91 grains (< 2 µm) from Bishunpur (LL3.1) [8], 27 grains (< 1 µm) from Semarkona (LL3.0), 14 grains (~ 1 µm) from Colony (CO3), and 21 grains (≤ 1.5 µm) from RC 075 (H3.1). The CRE ages for these meteorites range from 2 Ma – 24 Ma.

Standard models of low-mass AGB stars [9] and other AGB models that include Cool Bottom Processing [10] can explain the range of $^{12}C/^{13}C$ ratios and high $^{14}N/^{15}N$ ratios measured in mainstream SiC grains [e.g., 3]. However, no satisfactory explanation exists for the population of grains with low $^{14}N/^{15}N$ ratios observed in all meteorites [e.g., 3,11]. We rule out terrestrial contamination because extreme care was taken to select uncontaminated grains for this study.

The distributions of $^{14}N/^{15}N$ ratios in SiCs from the various meteorites overlap to a large extent (Figs. 3a,b). All have minimum $^{14}N/^{15}N$ ratios near the terrestrial value of 272. There are some differences in the maximum ratios observed. However, measurements of some of the grains with the highest $^{14}N/^{15}N$ ratios are very imprecise due to very low count rates for ^{15}N. Fig. 3b shows the mean and standard deviations for the nitrogen distributions as a function of CRE ages. At first glance there appears to be a weak correlation, but the distributions are not yet well-defined enough to conclude that the correlation is real.

There are also hints at differences not related to CRE age. In Fig. 3b, the mean of the Murchison data is considerably higher than that of the Colony data, although the distributions overlap. The distribution of Murchison KJE grains is also shifted to higher $^{14}N/^{15}N$ ratios relative to larger Murchison SiC grains [1,3]. But, Fig. 3a shows that ratios of $^{14}N/^{15}N > 3000$ have a low probability density in all the meteorites. In fact, the low precision of Murchison data makes its $^{14}N/^{15}N$ probability distribution essentially flat. The data for the smallest grains are very imprecise, low-count rate measurements, so the correlation of $^{14}N/^{15}N$ ratios with grain size is fairly uncertain. A deeper statistical analysis of the $^{14}N/^{15}N$ ratios in SiC grains will be required to resolve real variations in the sample.

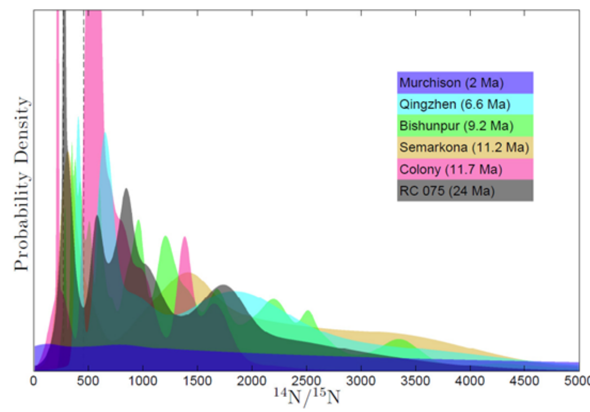

Figure 3a: The probability density distribution of N isotopic ratios in various chondrites with varying CRE ages. Each distribution is a sum of individual normal distributions with means given by the measured ratios and standard deviations given by twice the measurement errors. Dashed lines at $^{14}N/^{15}N$ ratios of 272 and 459, indicate terrestrial and solar values, respectively.

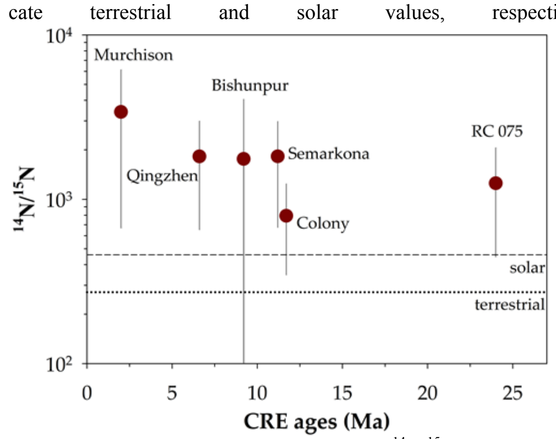

Figure 3b: Mean and standard deviations of $^{14}N/^{15}N$ ratios as a function of CRE ages.

It appears that a detailed comparison of the N data with abundances and characteristics of presolar grains within each meteorite is needed. In addition to CRE exposure and host-dependent characteristics, pre-accretionary nebular processes like, solar wind implantation could also contribute to the processes that make SiC grains ^{15}N-enriched.

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