CARBON, NITROGEN, AND SILICON ISOTOPIC RATIOS IN KJG PRESOLAR SIC GRAINS FROM MURCHISON. F. Gyngard[1], S. Amari[1], M. Jadhav[1], E. Zinner[1], and R. S. Lewis[2], Laboratory for Space Sciences and Department of Physics, Washington University, St. Louis, MO 63130, USA, fmgyngar@wustl.edu, [2]Enrico Fermi Institute, University of Chicago, Chicago, IL 60637, USA.

Introduction: SiC is the best-studied type of presolar grains [1]. Thousands of individual grains have been measured for their C and Si isotopic compositions [2-4] and many of these have been measured for additional isotopic systems, as well. Despite this wealth of data and the fact that Ti is one of the most abundant trace elements in SiC, only approximately 110 SiC grains have had their Ti isotopic compositions determined [3,5-8] and of these, most suffer from selection effects. Specifically, the Ti data for mainstream SiC, thought to have formed in the outflows of low-mass (1–3$M_\odot$) C-rich Asymptotic Giant Branch (AGB) stars [9], have not been obtained from a representative sample of the larger population as a whole. The grains analyzed have been chosen either for their high Ti concentrations [5] or their large ^{29}Si and ^{30}Si excesses [3].

Titanium in SiC is usually characterized by enrichments in the minor isotopes relative to ^{48}Ti, as evidenced by the V-shape pattern first observed by Hoppe et al [3]. This pattern is in qualitative agreement with theoretical predictions for AGB stars in which Ti is affected by s-process enrichments in the He shell [9] that are mixed into the envelope by multiple third dredge-up episodes. However, Alexander and Nittler [5] failed to see this pattern in most of their grains. It remains an outstanding question whether or not this discrepancy is a consequence of grain selection. The existing Ti data plot along correlation lines in 3-isotope plots [5,10], exhibiting a strong galactic chemical evolution (GCE) component affecting the Ti isotopes. This is further evidenced by the linear correlation seen between Ti and Si isotopic ratios for mainstream [3,5,10], Y [6], and Z grains [8]. However, the GCE of the Ti isotopes is still not well understood [11, 12].

In order to rectify the current situation and expand the existing dataset, we started an effort to measure the Si and Ti (along with the C and N) isotopic ratios in ~ 250 presolar SiC grains in the NanoSIMS at Washington University. These grains were not preferentially selected, except for their size. The NanoSIMS, with its high sensitivity, offers the advantage that Si and Ti isotopic ratios can be measured with higher precision than has been possible so far. Here we report C, N, and Si isotopic ratios of 247 presolar SiC grains from Murchison. We will obtain Ti isotopic results on these same grains in the near future.

Experimental: Energy Dispersive X-ray (EDX) analysis was performed with a JEOL 840A SEM on grains from a Murchison KJG separate (diameter 2–4.5 μm) [13] dispersed on gold foil. After identification as SiC, 247 grains of size ≥ 2.5 μm were randomly selected for isotopic measurement in the NanoSIMS, with this lower limit on grain size in place only to ensure suitably precise Ti results. Carbon and Si isotopic ratios were measured simultaneously in multidetection mode, while the N isotopes were measured in multidetection in a separate run.

Results and Discussion: Among the 247 grains analyzed, we identified 11 A+B grains (4.5%), 5 Y grains (2.4%), 6 Z grains (2%), and 225 mainstream grains (91.1%) (Figs. 1 and 2), roughly within the range of grain type abundances seen previously [3,9]. The Si isotopic ratios, expressed as δ-values, are shown in a Si 3-isotope plot in Fig 1. For clarity, the errors are not plotted, but are largely dominated by the standard deviation of measurements on standards and typically are < 5.5‰ for δ^{29}Si and < 8‰ for δ^{30}Si, yielding some of the most precise Si isotopic measurements on presolar SiC to date. Although to first order the data are similar to previous measurements on presolar SiC, two notable differences can be observed. First, there are no grains with δ^{30}Si < 0. Second, a weighted least-squares fit to the 225 mainstream grains presented here yields a line of slope 1.41 ± 0.008 and an intercept of -33.6 ± 0.5, in contrast with the previously obtained mainstream correlation line of slope ~ 1.35 and intercept ~ -18 [2,3]. The slope of 1.4 is actually more consistent with the value reported by Huss et al. [14].

Discrepancies between our measurements and the larger preexisting dataset are likely due to the fact that not many grains of this size fraction of SiC grains have previously been measured for their Si isotopic ratios. Most prior measurements of Si isotopes in SiC have been performed on either smaller grains (averaging ~ 1.14 μm) [5] or on larger grains (> 4 μm) [3] than those measured here. In a random sampling of over 200 SiC grains, statistically, we would expect to see at least a few grains with δ^{30}Si < 0. However, it could

simply be that we measured a unique population of grains, and the fact that our mainstream line is somewhat steeper and of lower intercept is a consequence of this selection. Although previous studies found little evidence for systematic deviations in Si isotopic composition as a function of grain size [4,15], our level of precision may allow us to constrain our data to an extent that subtle differences will be observable. Interestingly, 8 of 11 A+B grains plot to the left of the mainstream correlation line along a line with an intercept close to solar. This is to be expected if these grains originated from stellar sources which have not undergone s-process enhancements [6]. It remains to be seen whether high-precision Si isotopic measurements on more A+B grains will confirm this observation.

Carbon and N ratios, plotted in Fig. 2, without errors, span similar ranges for the various grain types as those found in previous studies of SiC [3]; however, a couple of exceptions are worth mentioning. We have characterized 2 Y grains based on excesses in ^{30}Si relative to the mainstream line, although their ^{12}C/^{13}C ratios (< 100) do not agree with the standard definition of Y grains having ^{12}C/^{13}C > 100 [3, 9]. One Z grain, #184, indicated in both plots, has ^{12}C/^{13}C > 100, in contrast to previous observations on most Z grains. The average ^{12}C/^{13}C ratio of the 247 grains is 55.8, in good agreement with the value of 56 seen in previous results by Nittler and Alexander [2].

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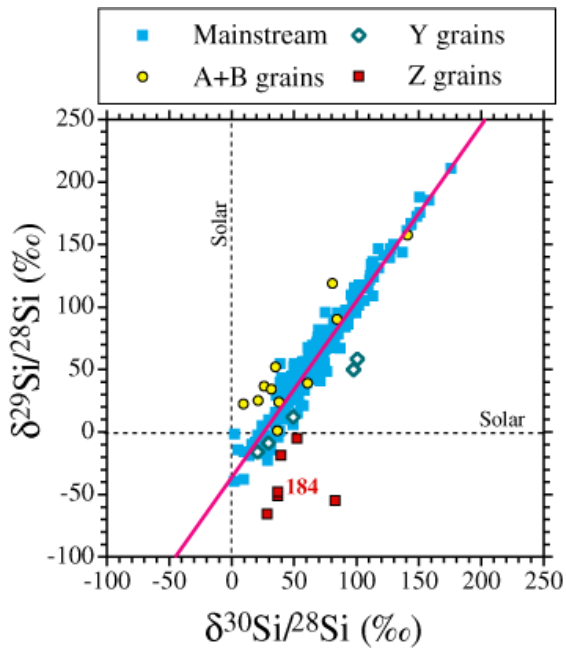

Figure 1. Silicon isotopic ratios measured in presolar SiC grains from the Murchison KJG fraction. Ratios are expressed as permil deviations from the solar ratios (δ values).

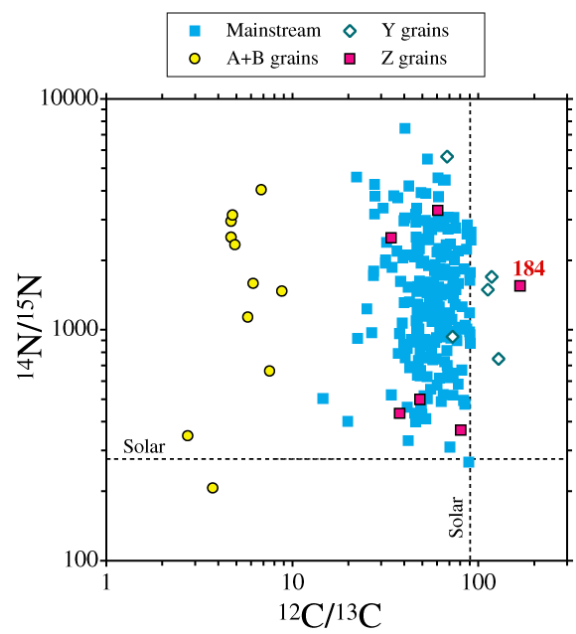

Figure 2. Carbon and N isotopic ratios measured in 247 KJG SiC grains. Note the 2 Y grains and 1 Z grain that have atypical ^{12}C/^{13}C ratios.