ANOMALOUS NITROGEN ISOTOPIC COMPOSITIONS IN THE STARDUST-RICH ANTARCTIC MICROMETEORITE T98G8: AFFINITIES TO PRIMITIVE CR CHONDRITES AND ANHYDROUS IDPs.

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Introduction: After their initial discoveries in interplanetary dust particles (IDPs) and primitive meteorites [1, 2], presolar silicates were also found in several Antarctic micrometeorites (AMMs) [3]. One micrometeorite in particular, T98G8, exhibits high abundances of silicate stardust grains and also contains several C-anomalous grains tentatively identified as SiC; notably eleven distinct presolar grains were found in a single 20 x 20 μm^2 area of this AMM [3]. Nitrogen isotopic anomalies have been associated with high presolar grain abundances in some extraterrestrial samples, including the CR chondrites and IDPs [4-7]. Here we report on C and N isotopic distributions in T98G8 and explore the relationship of this micrometeorite to other extraterrestrial materials.

Experimental and Results: We used the NanoSIMS to carry out raster ion imaging of micrometeorite T98G8, which was pressed into high purity Au for characterization. Individual areas of 10 x 10 μm^2 were mapped for C and N ($^{12}C^-$, $^{13}C^-$, $^{12}C^{14}N^-$, $^{12}C^{15}N^-$, $^{28}Si^-$) using a ~1 pA Cs$^+$ primary ion beam. Carbon and N isotopic compositions were normalized to synthetic SiC and Si_3N_4 standards, respectively.

Nitrogen isotopic anomalies in T98G8 are present both as discrete localized hotspots and as larger, more diffuse regions, as has been observed before in IDPs and CR chondrites [4, 7]. The N isotopic compositions of individual 10 x 10 μm^2 raster areas are variably enriched in ^{15}N, with $\delta^{15}N$ up to ~150 ‰. The mean $^{14}N/^{15}N$ ratio of all measured areas is 259 ± 8. Individual hotspots within these areas are ^{15}N-rich with $\delta^{15}N$ up to ~1750 ‰ (Fig. 1), but one hotspot is ^{15}N-depleted with $\delta^{15}N$ = -435 ‰. C isotopic compositions of the raster areas are normal, with a mean $^{12}C/^{13}C$ ratio of 89.9 ± 0.4. However, nine grains have anomalous C isotopic compositions (Fig. 2). Based on Si/C ion ratios and isotopic compositions, six of these grains appear to be mainstream SiC, with $^{12}C/^{13}C$ ratios between 44 and 63 and normal N isotopic compositions, and one seems to be a SiC Y grain, with a $^{12}C/^{13}C$ ratio of 181 and a $^{14}N/^{15}N$ ratio of 535 (e.g., [8]). The remaining two grains are C-rich with enrichments in ^{15}N and ^{12}C (Fig. 2), and resemble phases of likely interstellar origin found in IDPs and primitive chondrites [6, 9, 10]. Auger Nanoprobe analyses will be carried out to confirm these preliminary identifications.

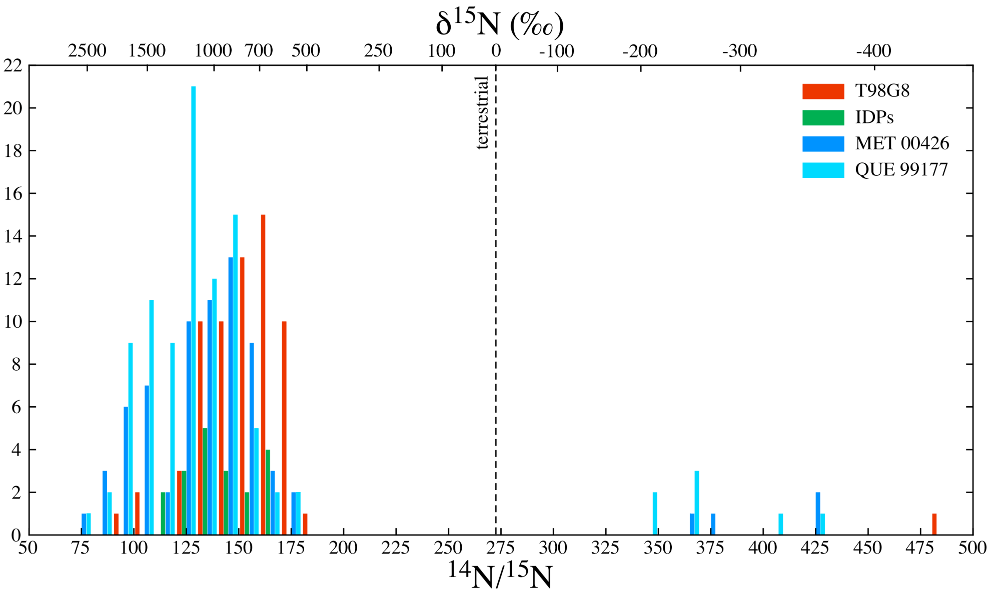

Figure 1. Distribution of N isotopic compositions (scale shows both $^{14}N/^{15}N$ ratios and $\delta^{15}N$) in isotopically anomalous hotspots of T98G8. Also shown are data for isotopically primitive IDPs [4] and two CR3 chondrites [7].

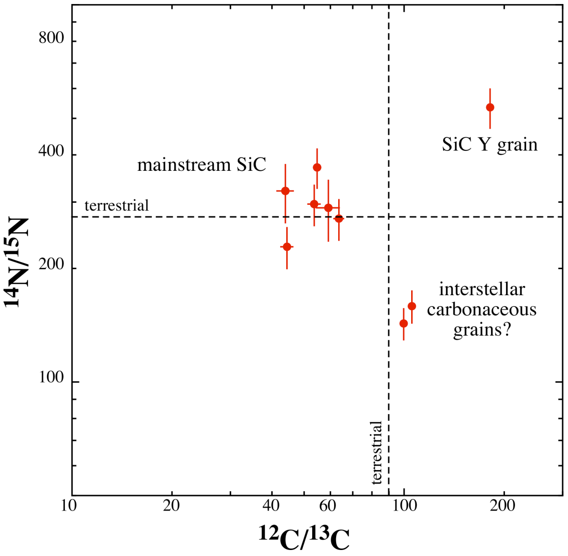

Figure 2. Carbon and N isotopic compositions of C-anomalous grains in T98G8. Errors are 1σ.

Discussion: Nitrogen isotopic anomalies are common in certain extraterrestrial materials and are typically attributed to low temperature ion-molecule reactions in cold molecular clouds [e.g., 11]. Recent theoretical work on NH_3 formation in dense molecular clouds suggests that enrichments of more than 3000 ‰ are possible at very low temperatures [12], sufficient to account for the ^{15}N enrichments observed here and in other solar system samples [4, 7, 13].

The presolar grain populations of T98G8 resemble those of other primitive extraterrestrial materials. Figure 1 shows that the distribution of isotopic compositions in N-anomalous hotspots in T98G8 is similar to that seen in isotopically primitive IDPs [4] and CR3 chondrites [7]. In addition, the abundance of O-anomalous grains in T98G8 is 170 ± 50 ppm [3], similar to matrix-normalized abundances of presolar silicate and oxide grains found in other primitive meteorites [5, 14]. We also calculate a SiC abundance of 75 ± 25 ppm for T98G8, which is consistent with an earlier determination of ~50 ppm for this AMM [3], and compares well to estimates of the SiC abundances in CR chondrites [6, 15]. T98G8 also contains two carbonaceous grains (~65 ppm abundance) whose isotopic compositions suggest an origin through ion-molecule reactions in cold molecular clouds. Such grains are rare components of IDPs, but have recently been found in high abundance in two primitive CR3 chondrites [6].

Antarctic micrometeorites are thought to originate from a variety of sources, including both asteroids and comets, although many are chemically and mineralogically similar to carbonaceous chondrites [16-18]. T98G8 consists primarily of a fine-grained assemblage of primary olivine, pyroxene and metal [3]. Unlike many other AMMs, it does not contain magnesiowüstite, a common secondary mineral that forms mainly through decomposition of phyllosilicates and carbonates upon atmospheric entry heating [19]. These magnesiowüstite-bearing AMMs are thought to originate from hydrous parent bodies [3]. On the other hand, the anhydrous mineral assemblage of T98G8 and its high presolar grain abundances suggest similarities to primitive IDPs or other anhydrous chondritic meteorites. In IDPs, presolar grains occur predominantly in an isotopically primitive subgroup, identified by the presence of anomalous N isotopic compositions [4]. Also characterized by anomalous N isotopic compositions are the CR chondrites, but many of them have experienced extensive aqueous alteration, leading to low presolar silicate abundances [20, 21]. An exception is represented by two CR3 chondrites with little evidence for secondary processing [22], which contain high abundances of O-anomalous and C-anomalous grains [5, 6]. The presence of abundant N isotopic anomalies in T98G8 suggests a possible link to these materials.

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This work was supported by NASA grant NNX07AI45G.