ELEMENTAL HETEROGENEITY IN AN ISOTOPICALLY HOMOGENEOUS SIC AGGREGATE FROM A SUPERNOVA. L. R. Nittler[1], P. Hoppe[2], and R. M. Stroud[3]. [1]Dept. of Terrestrial Magnetism, Carnegie Institution of Washington, Washington, DC 20015, lrn@dtm.ciw.edu. [2]Max-Planck-Institut für Chemie Mainz, Germany. [3]Code 6360, Naval Research Laboratory, Washington, DC 20375.

Introduction: Supernovae are believed to be important sources of dust in the Universe, but the processes of dust formation, and the amounts and types of dust formed are not well understood. Correlated structural and isotopic information on presolar grains from supernovae can help shed light on these issues. We have previously reported microsctructural and isotopic data for two SiC grains from supernovae [1]. Here we report additional NanoSIMS isotopic and elemental data for one grain indicating that it is an aggregate of isotopically homogeneous but elementally heterogeneous sub-grains.

Methods: Automatic Si and C isotopic mapping of Murchison SiC grains [2] identified ^{28}Si-rich X grains which were then targeted for Transmission Electron Microscopy (TEM) analysis. TEM sections of two grains were prepared using a focused-ion-beam (FIB) and analyzed by TEM [1]. Following TEM analysis, the TEM grid was glued to an Al stub and analyzed with the NanoSIMS 50 ion microprobe at the Max Planck Institute for Chemistry in Mainz. C, N and Si data were acquired with a 100 nm Cs^+ beam, followed by Mg-Al, Ca and Ti isotopic imaging with a ~300 nm O^- beam.

Results and Discussion: Figure 1 shows TEM bright-field images of the two analyzed grains. Grain M11B-180-7 consists of a dense packing of 10 nm crystallites with the 2H structure. Grain M11B-371-2 is a roughly Africa-shaped, porous aggregate of ~100 nm 3C crystallites. NanoSIMS measurements revealed 180-7 to be isotopically and elementally uniform, so we focus our attention on the larger grain 371-2.

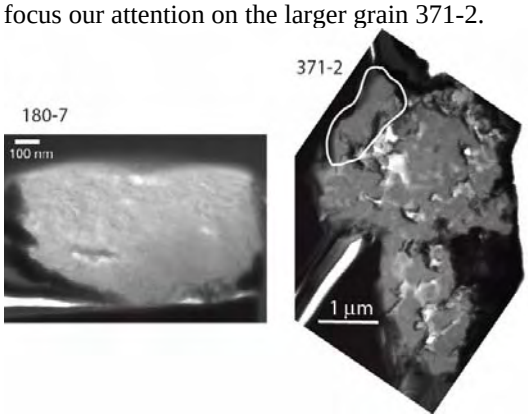

Figure 1: TEM bright-field images of two SiC X-grains (previously reported by [1]).

NanoSIMS elemental and isotopic ratio images of grain 371-2 are shown in Figure 2. Figs 2a-d reveal that all of the individual crystallites making up the aggregate are SiC (Si/C~1) and isotopically uniform in Si and C. Void spaces in the grain show isotopically normal C deposited in the TEM. Also visible are two small mainstream SiC grains ("MS" in Fig 2c) that were adjacent to the X grain on the original ion probe mount and coincidentally were included in the FIB section. Figure 2f shows that the $^{15}N/^{14}N$ ratio is highly enriched and uniform across the entire aggregate, but 2e shows that the N abundance is markedly lower in the sub-grain at upper left (indicated on both Figures 1 and 2). Al-Mg images (Fig. 2g-h) reveal the bulk of the grain to have essentially monoisotopic ^{26}Mg, with an inferred initial $^{26}Al/^{27}Al$ ratio of ~0.4, confirming our previous suggestion that the high Mg abundance observed by TEM-EDS was radiogenic [1]. Remarkably, the Al and Mg abundances of the N-depleted sub-grain are also low, though, the inferred $^{26}Al/^{27}Al$ ratio for this region is comparable to the rest of the grain. Ca and Ti isotopic images (Fig 2i-j) revealed that the anomalous sub-grain is also depleted in these elements. Count rates are too low to accurately assess isotopic homogeneity for these elements, but the grain shows a large ^{44}Ca excess indicating an initial $^{44}Ti/^{48}Ti$ ratio of ~2×10^{-3} and a ^{49}Ti excess similar to that seen for other X grains [3].

Micron-sized SiC grains from AGB stars (e.g. mainstream grains) are typically single crystals [4] as are hibonites [5] and some Al_2O_3 grains [6]. In contrast, SiC grains from supernovae appear to be largely aggregates of sub-micron crystallites [1, 7] and this is true of a supernova-derived olivine grain as well [8]. Moreover, supernova graphites are also aggregate structures, containing numerous sub-grains of carbides and metal [9]. Thus, microstructural investigations suggest that dust formation processes in supernovae are quite distinct from those in outflows from AGB stars. Although thermodynamical equilibrium likely plays a role in dust formation in both environments, the extreme radiation and shock environment in supernovae makes them much more likely laboratories for non-equilibrium dust-formation processes [10, 11].

Deneault et al. [12] proposed a model for SiC X grain formation in supernovae, in which small SiC grains condense in the O- and Si-rich inner zones and then interact with overlying gas decelerated by reverse shocks. Velocity differences lead to aggregation of

isotopically variable small grains into larger ones. The aggregate structures of the X grains analyzed here and by [7] agrees with this model, but not the observed isotopic homogeneity. The latter implies that the individual crystallites making up grain 371-2 formed from a well-mixed, isotopically homogeneous gas. However, the significantly lower (>factor of 2) minor and trace element content of one sub-grain of 371-2 suggests some heterogeneity in formation conditions prior to the aggregation of the final grain. Detailed modeling will be required to explore possible explanations for the elemental heterogeneity observed in this highly unusual grain.

References: [1] Stroud R. M., et al. (2004). *Meteoritics and Planetary Sci. (Supp.), 39,* Abstract #5039. [2] Nittler L. R. and Hoppe P. (2005). *ApJ, 631,* L89-L92. [3] Hoppe P. and Besmehn A. (2002). *ApJ, 576,* L69-72. [4] Daulton T. L., et al. (2002). *Science, 296,* 1852-1855. [5] Zega T. J., et al. (2006). *Meteoritics and Planetary Sci. (Supp.), 41,* Abstract #5375. [6] Stroud R. M., et al. (2004). *Science, 305,* 1455-1457. [7] Hynes K. M., et al. (2006). *LPS XXXVII,* Abstract #2202. [8] Messenger S., et al. (2005). *Science, 309,* 737-741. [9] Croat T. K., et al. (2005). *ApJ, 631,* 976-987. [10] Clayton D. D., et al. (2001). *ApJ, 562,* 480-493. [11] Lodders K. (2006). *ApJ, 647,* L37-L40. [12] Deneault E. A.-N., et al. (2003). *ApJ, 594,* 312-325.

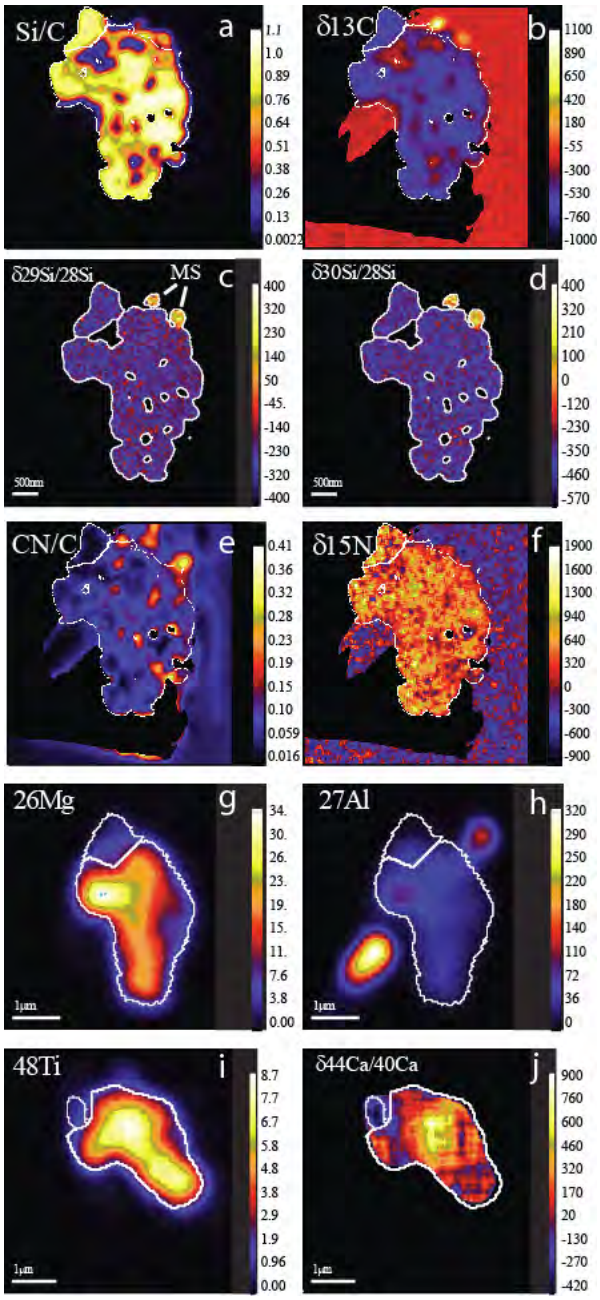

Figure 2. NanoSIMS images of X grain 371-2.