ANATOMY OF AN ISOTOPICALLY PRIMITIVE INTERPLANETARY DUST PARTICLE: COORDINATED NANOSIMS AND AUGER NANOPROBE ANALYSES. C. Floss, F. J. Stadermann, A. Mertz* and T. Bernatowicz. Laboratory for Space Sciences and Physics Dept., Washington University, St. Louis, MO 63130, USA; *current address: Dept. of Physics, Yale University, New Haven, CT 06520, USA. (floss@wustl.edu).

Introduction: Interplanetary dust particles (IDPs) are complex assemblages of primitive solar system materials that carry abundant extra-solar phases. Our recent work shows that circumstellar and interstellar phases are concentrated in a subgroup of IDPs with anomalous bulk N isotopic compositions that are isotopically primitive [1]. In order to better understand the internal structures and isotopic heterogeneities of such particles, we prepared sliced sections of several IDPs for NanoSIMS and Auger Nanoprobe analysis. Here we report the results of measurements on two samples, one of which belongs to the isotopically primitive subgroup of IDPs.

Experimental: Two IDPs, nicknamed Perse (U2121 B2) and Andric (U2108 B2), were mounted in resin and sliced with a diamond ultramicrotome, following procedures established for preparing presolar graphite grains for TEM analysis [2]. However, the slices were thicker (~200 nm) than standard TEM sections and were deposited on high purity Si wafers, which provide a stable substrate for the lengthy NanoSIMS analyses. The sections were coated with a thin (~20 Å) layer of Au to prevent charging. The NanoSIMS measurements were made in standard multi-collection imaging mode using a ~100 nm Cs^+ primary beam [e.g. 1, 3], and consisted of two series of measurements: O ($^{16}O^-$, $^{17}O^-$, $^{18}O^-$, $^{28}Si^-$, $^{24}Mg^{16}O^-$), and C and N ($^{12}C^-$, $^{13}C^-$, $^{12}C^{14}N^-$, $^{12}C^{15}N^-$, $^{28}Si^-$). Selected slices were subsequently characterized with the PHI 700 Auger Nanoprobe recently acquired by Washington University. This state-of-the-art instrument can produce elemental distribution maps on a spatial scale of tens of nanometers, which can then be correlated with isotopic data obtained from the NanoSIMS.

Presolar Silicate/Oxide Phases: Oxygen isotopes were measured in 13 slices of Perse and 14 slices of Andric in order to look for presolar silicate or oxide grains. No presolar grains were found in the 330 μm^2 area of Perse analyzed. However, five distinct presolar grains were found in four different slices of the IDP Andric. Three of the grains have ^{17}O-rich compositions consistent with a Group 1 classification (Fig. 1), whereas the other two grains are ^{18}O-rich and belong to Group 4. Although the three Group 1 grains have virtually identical oxygen isotopic compositions, based on their locations in the slices, they all appear to be distinct grains, rather than different slices of the same grain.

Portions of two of the presolar grains were still present after NanoSIMS analyses for characterization with the Auger probe. Elemental mapping and spot analyses show that, in addition to Si and O, one grain contains roughly equal amounts of Mg and Fe, whereas the other grain contains primarily Fe and S in addition to Si and O. We are currently developing analytical routines and calibrating standards for silicate mineral analyses, which will allow us to quantitatively determine the compositions of these grains. However, comparison of the (Fe+Mg)/Si ratios of these grains with preliminary data from olivine and pyroxene standards indicates that the first grain could be a pyroxene. The identification of the second grain is less certain, but the presence of Fe associated with S may indicate a GEMS particle [e.g., 4].

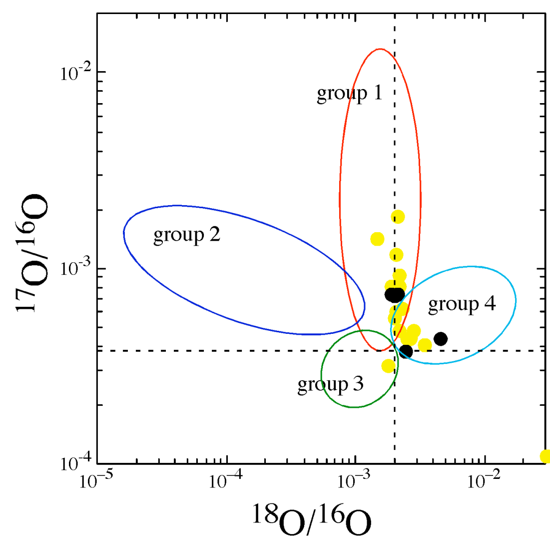

Figure 1. Oxygen three isotope graph showing presolar grains from Andric (black) and other IDPs (yellow). IDP data are from [1,5,6]; group designations are after [7].

The calculated abundance of presolar grains in Andric is ~700 ppm, about a factor of two higher than the abundance of presolar silicate grains in isotopically primitive IDPs as a group (~375 ppm [1]). The multiple presolar grains revealed by slicing of this IDP may be a common feature of isotopically primitive IDPs. The IDPs in our earlier study [1] generally did not contain many individual presolar grains. However these IDPs were pressed as single particles into Au foil and large amounts of material typically remained after O isotopic measurements which could have hosted additional undetected presolar grains. Indeed, the presence, in that study, of two IDPs with 2 and 3 presolar silicate grains, respectively, suggests that Andric is not unique.

C and N Compositions and Distributions: Carbon and N isotopes were measured in 11 slices each of Perse and Andric. All slices of Perse have normal bulk compositions for both C and N; in addition, no ^{15}N-rich hotspots were observed in this IDP. In contrast, Andric shows variable N isotopic compositions, with bulk values for individual slices exhibiting ^{15}N enrichments up to about +400 ‰ and numerous hotspots with $\delta^{15}N$ from +700 to +1000 ‰; the most ^{15}N-rich hotspot also has an anomalous C isotopic composition, with a $\delta^{13}C$ of about +125 ‰. We used the Auger Nanoprobe to map the C and N distributions in the slice containing this particular hotspot. Note that although C elemental images can also be obtained from the NanoSIMS, the same is not true for N, which is typically measured as CN^-, due to its low ionization efficiency. Thus, SIMS N maps are necessarily tied to C, whereas the Auger N map shows the distribution of this element alone. Figure 2 shows that although C and N seem to be correlated in most parts of this IDP slice, there are some exceptions (e.g., arrow). Moreover, although both C and N are present in hotspot 1, abundances are higher in other parts of the IDP with less anomalous N isotopic compositions. This is consistent with previous observations that ^{15}N enrichments are anti-correlated with CN^-/C^- ratios [1].

References: [1] Floss et al. (2006) *GCA* **70**, 2371-2399. [2] Croat et al. (2003) *GCA* **67**, 4705-4725. [3] Stadermann et al. (2005) *GCA* **69**, 177-188. [4] Keller et al. (2005) *LPS XXXVI*, #2088. [5] Messenger et al. (2003) *Science* **300**, 105-108. [6] Messenger et al. (2005) *Science* **309**, 737-741. [7] Nittler et al. (1997) *Ap. J.* **483**, 475-495.

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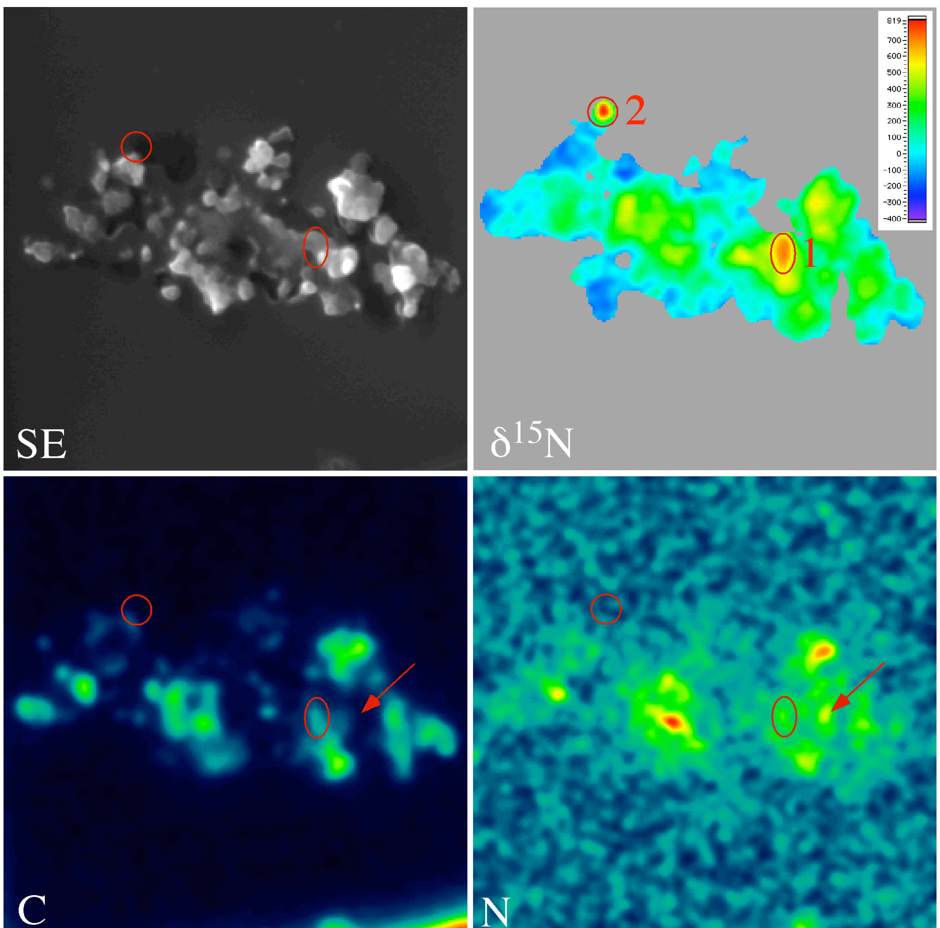

Figure 2. IDP Andric, slice 3-3, showing the locations of two ^{15}N-rich hotspots. Top: field emission secondary electron (SE) image and map of $\delta^{15}N$. Bottom: Auger C and N elemental maps. Hotspot 1 is anomalous in both C and N and is clearly visible in the elemental maps, but hotspot 2 was sputtered away prior to the Auger measurements. Arrow shows an area enriched in N, but not C. Field of view is ~5 µm across.