**ANATOMY OF AN ISOTOPICALLY PRIMITIVE IDP FROM THE 55P/TEMPEL-TUTTLE TARGETED COLLECTOR: QUANTITATIVE AUGER MEASUREMENTS OF C AND N ABUNDANCES IN N-ANOMALOUS HOTSPOTS.** C. Floss[1], F. J. Stadermann[1], A. F. Mertz[1,2] and B. Wopenka[3] [1]Laboratory for Space Sciences and Physics Dept., Washington University, St. Louis, MO 63130, USA; [2]Dept. of Physics, Yale University, New Haven, CT 06520, USA; [3]Dept. of Earth and Planetary Sciences, Washington University, St. Louis, MO 63130, USA. (Email: floss@wustl.edu)

**Introduction:** Recent work on interplanetary dust particles (IDPs) has focused on targeted collections, stratospheric dust collectors flown at specific times designed to coincide with the passage of the Earth through the dust trails of particular comets, in the hopes of collected enhanced quantities of comet dust over background extraterrestrial materials [e.g, 1]. We have carried out a study of several IDPs selected from targeted collections [2]; the particles came from collectors U2121 and L2055 which targeted the 26P/Grigg-Skjellerup comet dust trail in April 2003 [1], and from collector U2108 which was flown in November 2002 in an attempt to collect Leonid storm debris from comet 55P/Tempel-Tuttle [3]. The IDPs were mounted in resin, cut with an ultramicrotome to create multiple thick (~200 nm) slices, and mounted on Si wafers for coordinated NanoSIMS and Auger Nanoprobe analyses.

One IDP from the Tempel-Tuttle collector, U2108 B2, nicknamed Andric, is characterized by isotopically anomalous bulk N and abundant $^{15}$N-rich hotspots, as well as the presence of abundant presolar grains [2], and belongs to the isotopically primitive subgroup of IDPs defined by [4]. Although the N (and occasional C) isotopic anomalies in these IDPs generally appear to be carried by macromolecular organic matter, much work is still needed to characterize such material, and to evaluate whether all of the anomalies are hosted by the same carrier. As one step toward better understanding the nature of this material, we have been working to determine C and N sensitivity factors to be used for quantifying Auger elemental spectra of carbonaceous material. Here we report our initial results and application to N-anomalous areas from the IDP Andric.

**Experimental:** We used the PHI 700 Auger Nanoprobe to analyze four terrestrial kerogen samples with known C concentrations (64–77 wt.%) and N/C ratios that span an order of magnitude (0.002–0.021) [5]. The samples were measured according to our standard analysis procedures [6] by rastering a 10kV 0.25nA primary electron beam over areas of interest. Multiple scans of a given area are added together to obtain a single Auger spectrum, which is differentiated using a 7-point Savitsky-Golay smoothing and differentiation routine prior to peak identification and quantification. Sensitivity factors for C and N were determined by least-squares fitting of the Auger intensities to the C concentrations and N/C ratios of the kerogen standards. The same analytical procedures were then also used to obtain Auger spectra from 52 areas in slices of Andric that were previously characterized by NanoSIMS [2].

**Results:** Like other isotopically primitive IDPs [4], Andric contains discrete $^{15}$N-rich hotspots and larger, more diffuse regions that are also isotopically anomalous, but generally have lower maximum $^{15}$N enrichments. The average N isotopic compositions of individual slices range from essentially normal up to $\delta^{15}N$ = +400 ‰ (Fig. 1). $^{15}$N-rich hotspots within the slices have more $^{15}$N-rich compositions ($\delta^{15}N$= +525 – +945 ‰). Two of the hotspots also have statistically significant $^{13}$C enrichments (Fig. 1).

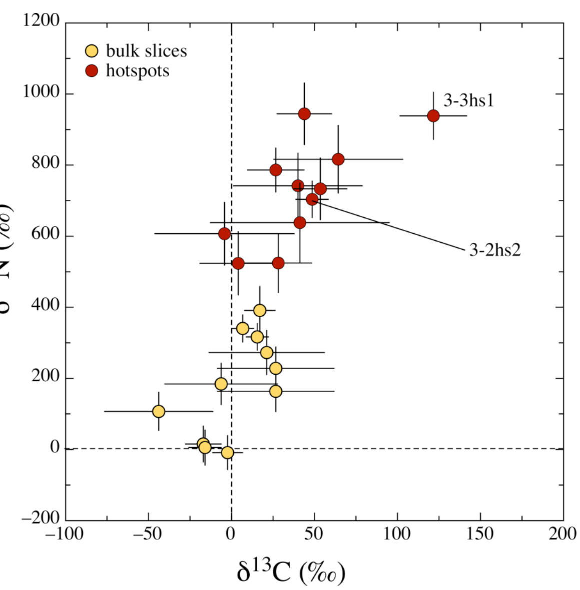


*Figure 1. C and N isotopic compositions (in permil deviations from normal) of bulk slices of Andric (yellow circles) and discrete $^{15}$N-rich hotspots within individual slices (red circles). Two hotspots with $^{13}$C enrichments are labeled. Errors are 1σ.*

We obtained Auger elemental spectra from four $^{15}$N-rich hotspots, which had not sputtered away during the NanoSIMS measurements, and from many of the other isotopically anomalous regions. All of the areas analyzed in Andric are dominated by O, Si and C; lesser amounts of Mg, Fe, S and N are also present in most regions. Abundances are variable from one region to another, with variations of a factor of five in the major elements; the compositions of the four $^{15}N$-rich hotspots fall within the ranges observed for other regions of Andric. A low Si abundance and the presence of Mg, Fe and S, in addition to C, in 3-3 hs1 suggest that this C- and N-anomalous hotspot (Fig. 1) is not SiC, but rather consists of carbonaceous matter intimately associated with silicates and sulfides.

**Discussion:** In SIMS, N isotopes are generally measured as the $CN^-$ molecule, and the $CN^-/C^-$ ratio has been used as a proxy for N abundances [e.g., 7, 8]. In our earlier work [4], we observed that IDPs with anomalous bulk N isotopic compositions tend to have lower bulk $CN^-/C^-$ ratios than IDPs with isotopically normal N, and the most N-anomalous IDPs have the lowest $CN^-/C^-$ ratios. However, it is difficult to infer directly the actual N abundance from these NanoSIMS secondary ion yields because the formation of the $CN^-$ cluster depends not only on the presence of both C and N but probably also on the exact nature of the analyzed material (e.g., matrix effects). By using Auger spectroscopy to measure C and N concentrations in discrete sub-grains, we are able to circumvent this issue of N quantification in SIMS.

The large range in C (25–85 at.%) and N (2–19 at.%) concentrations observed in Andric's isotopically anomalous regions suggests that a variety of carbonaceous components carry the N (and occasional C) isotopic anomalies observed. A similar conclusion was reached by [9] for several primitive IDPs studied from one of the Grigg-Skjellerup collectors. However, unlike these authors, who did not observe a correlation between isotopic and elemental compositions, we find that N abundances are inversely correlated with the $\delta^{15}N$ enrichments of the isotopically anomalous regions, with the most anomalous hotspots exhibiting relatively low N abundances (Fig. 2). Conversely, C abundances generally are higher in the more anomalous areas. Although there is considerable scatter, in general N abundances are also positively correlated with $CN^-/C^-$ from the NanoSIMS measurements, indicating that these ratios do indeed provide a fairly robust indication of relative N contents. Because Auger spectroscopy is a surface-sensitive technique, it is also important to note that this correlation demonstrates that the N abundances determined by our Auger Nanoprobe are not dominated by surface contaminants.

The correlations between isotopic and elemental compositions indicate that the isotopic anomalies in Andric are hosted by relatively N-poor carbonaceous matter. As N concentrations increase, the magnitudes of the anomalies decrease, suggesting that a dilution effect with isotopically normal N may be responsible. Although surface contamination during the Auger measurements does not seem to be responsible, we cannot completely rule out other forms of laboratory contamination. However, the fact that a similar correlation was observed by [4] for bulk IDPs that were prepared differently (pressed as whole particles into high purity Au rather than sliced in resin and mounted on Si wafers) suggests that this dilution is more likely to have originated either extra-terrestrially (such as during parent body or nebular alteration) or perhaps during atmospheric entry of the particles.

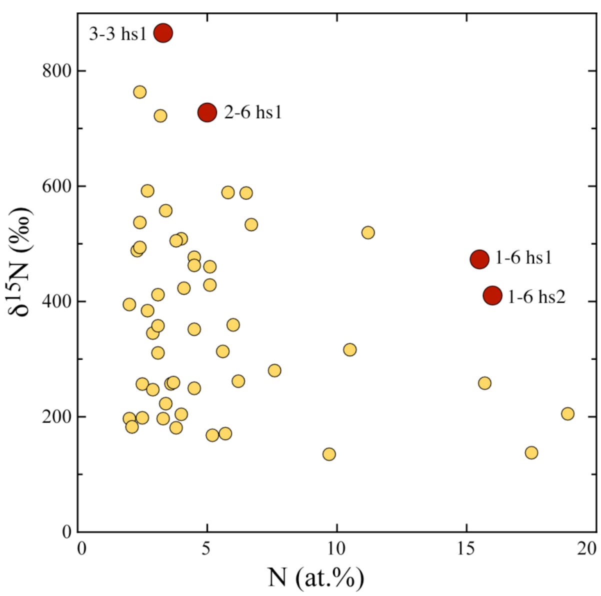


*Figure 2. Auger N abundances (at.%) vs. N isotopic compositions (in permil deviations from normal) in isotopically anomalous regions of Andric. Four $^{15}N$-rich hotspots are labeled.*

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