**THE ASSOCIATION OF $^{15}$N-ANOMALOUS MATTER WITH STARDUST IN CHONDRITES ACFER 094 AND NORTHWEST AFRICA 852.** C. Vollmer[1], J. Leitner[2], H. Busemann[3], N. Spring[3] and P. Hoppe[2]. [1]Institute for Mineralogy, University of Münster, Germany, christian.vollmer@uni-muenster.de, [2] MPI for Chemistry, Mainz, Germany, [3]School of Earth, Atmospheric and Environmental Sciences, University of Manchester, UK.

**Introduction:** Anomalous enrichments in $^{15}$N are widespread in certain carbonaceous chondrites (CCs) and interplanetary dust particles (IDPs). In CRs and CMs, $\delta^{15}$N values reach up to ~ 3200‰ in "hotspots" (as opposed to less extreme enrichments in the "bulk") [1], in IDPs up to ~1800‰ [2,3]. The largest values in any solar system sample have been measured in the CB/CH chondrite Isheyevo with $\delta^{15}$N approaching 5000‰ in hotspots [4]. The origins of these $^{15}$N anomalies still remain uncertain (see [4,5] for recent summaries). Generally, this matter is assumed to stem from the cold interstellar medium or the outer protoplanetary disk, where low temperature ion-molecule reactions could result in large fractionations [6]. Alternative scenarios for $^{15}$N enrichments are self-shielding of $N_2$ in the protoplanetary disk similar to CO, nonthermal nucleosynthesis induced by the young protosun or chemical reactions at elevated temperatures [5]. A circumstellar origin is usually excluded, because $^{15}$N-enriched stardust grains, most of which originate from novae and supernovae, usually exhibit large anomalies in C, but $^{15}$N-enriched hotspots discussed here have C isotopic compositions only around -100‰ [e.g., 3].

IDPs with $^{15}$N anomalies are also highly enriched in stardust originating from stars other than the Sun [e.g., 3]. Abundance values for stardust in IDPs are sometimes limited to these "isotopically primitive" IDPs and can reach 1.5 wt.% [3]. A supernova olivine from an IDP was also found to be embedded in $^{15}$N-rich matter [7], which supports this correlation. Certain CR chondrites with abundant $^{15}$N anomalies are also now becoming famous for their large amounts of stardust [8]. These observations apparently show that abundant $^{15}$N-rich matter is an indicator of primitiveness and excellent stardust survival.

Only recently, $^{15}$N-anomalous phases have been investigated by transmission electron microscopy (TEM) in greater detail to put further constraints on their origins [3,9,10]. Interestingly, these first TEM results indicate that the carrier phase of the $^{15}$N-anomalous signature (possibly carbonaceous) is connected to aqueously altered minerals (e.g., ferrihydrite, magnetite, carbonate, tochilinite) [3,9,10]. This observation seems to contradict the common agreement that the existence of $^{15}$N-anomalous matter is an indicator of primitiveness as explained above. It is therefore possible that the $^{15}$N-rich matter connected to stardust in IDPs is different than the matter in carbonaceous chondrites. The conclusions inferred by [5] also underline the existence of several distinct reservoirs for nitrogen anomalies.

We report here on the distribution of $^{15}$N-anomalous hotspots in the carbonaceous chondrites Acfer 094 (ungrouped) and Northwest Africa 852 (CR2) and their association with stardust grains. The aims of this study are to identify possible different carrier phases of $^{15}$N anomalies in IDPs (thought to be associated with stardust) and CCs (possibly connected to aqueous alteration). It is especially important to identify regions in CCs with high stardust abundance to prove whether these regions do also contain $^{15}$N anomalies (and vice versa). This is a very preliminary report of an ongoing study, where H-, C-, and N-isotopic measurements obtained by SIMS will be combined with FIB/TEM work on the same grains to disentangle possible formation mechanisms.

**Methods:** Procedures to locate O-rich stardust are described in [11]. In the NanoSIMS at MPI for Chemistry in Mainz, N anomalies are searched for by measuring $^{12}C^{14}N^-$ and $^{12}C^{15}N^-$ on areas previously shown to contain high amounts of "clustered" stardust [11]. Values are normalized to a N-doped SiC standard with terrestrial N isotopic composition to correct for instrumental mass fractionation. In a first setup, only N isotopes together with $^{12}C^-$, $^{16}O^-$ and $^{28}Si^-$ were measured to correlate previous stardust searches with N hotspots. In future measurements, C and H isotopes have to be determined as well. This is especially important to exclude a circumstellar origin for some of the hotspots and to test possible fractionation effects on D/H.

**Results and Discussion**: In Acfer 094, two fields with two stardust silicates, three fields with three silicates and one field with five silicates were scanned for N isotopes. The "clustering" of five stardust grains in one 100 µm$^2$ sized Acfer 094 matrix area (field "26_10") was shown to be statistically significant [11]. Similar clustering effects were also documented for IDPs [e.g., 3]. However, only two $^{15}$N-anomalous hotspots were identified within these fields: one O-shaped hotspot (~800x600 nm$^2$) in field 23_12 (two silicates) resembling a hollow nanoglobule ($\delta^{15}$N=672±41‰) and one irregular hotspot (~200x200 nm$^2$) in field 31_09 (three silicates) ($\delta^{15}$N= 345±84‰). A second search over 16 fields containing six stardust silicates (Fig. 1) revealed the presence of six $^{15}$N-enriched hotspots (range $\delta^{15}$N=412–875‰) and one $^{15}$N-depleted hotspot ($\delta^{15}N$=–238±52‰). One of these six hotspots is also shaped like a nanoglobule ($\delta^{15}N$=488±29‰). The $^{15}N$-depleted hotspot will not be discussed here, as further implications can not be inferred without additional isotopic analyses. Three of these hotspots occur within the same 100 µm$^2$ sized field ("24_09"), together with a stardust silicate and a SiC partially embedded in one hotspot (Fig. 1 and 2).

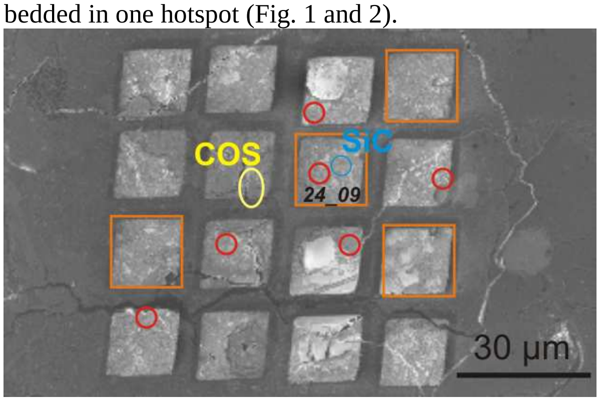


**Figure 1.** SEM image of a part of matrix region "24" in Acfer 094 [11] presputtered by NanoSIMS with unusually high abundance of primitive material. Orange squares mark fields with $^{15}N$-hotspots, red circles approximate locations of stardust silicates. COS refers to a "cosmic symplectite".

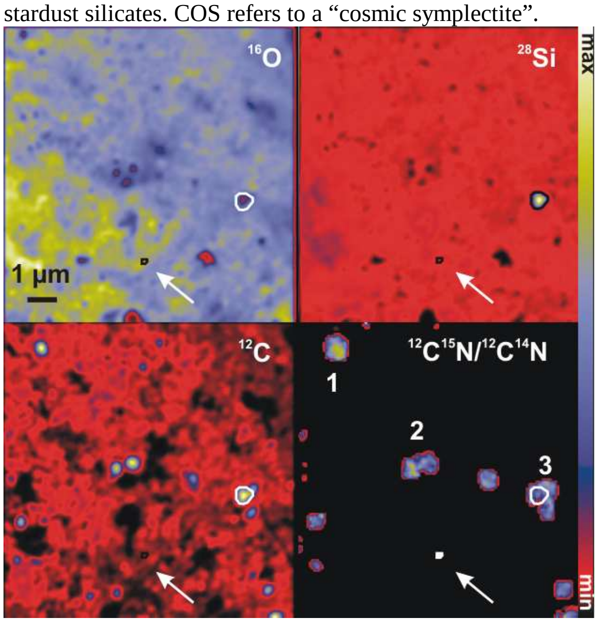


**Figure 2.** NanoSIMS ion images of matrix region 24_09. The stardust silicate reported in [11] (arrow) and a SiC grain (outlined) associated with three $^{15}N$-anomalous hotspots are marked in each image.

The abundance of stardust in the ten fields containing primitive matter (Fig. 1) is ~270 ppm, which is similar to the values reported for IDPs. This area also includes a $^{17,18}O$-enriched "cosmic symplectite" [12] assumed to have preserved pristine nebular water.

In the analyzed areas of NWA 852, stardust grains [13] and abundant N hotspots are mostly not spatially associated. The only exception is an area, where two $^{15}N$-enriched carbonaceous hotspots ($\delta^{15}N$=445±16‰ and $\delta^{15}N$=373±15‰) are closely associated with a mainstream SiC grain (Fig. 3).

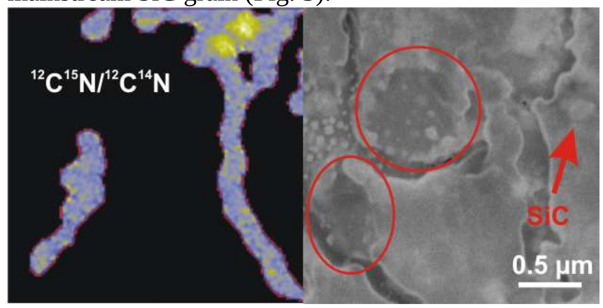


**Figure 3.** NanoSIMS ratio image and SEM micrograph of two $^{15}N$-rich hotspots in NWA 852 associated with a SiC.

**Conclusions**: The associations described here in Acfer 094 and NWA 852 are up to now statistically not significant: most stardust silicates, especially the five clustered grains in field 26_10 in Acfer 094, are *not* correlated with $^{15}N$-rich matter, i.e., occur within the same field or are in direct contact. A similar relationship as observed in IDPs therefore does not seem to exist in the two chondrites studied. However, the distribution of $^{15}N$-enriched hotspots in all chondritic materials is highly heterogeneous, and our result might simply be due to limited statistics. Above all, the overabundance of highly pristine material (stardust silicates, a SiC, $^{15}N$-hotspots and a COS) within a very limited region of only ~1000 µm$^2$ indicates that CCs like Acfer 094 also contain lithologies resembling those of the most primitive IDPs. It will then be particularly important to compare the mineralogical characteristics obtained by combined FIB/TEM work of those $^{15}N$-enriched hotspots in CCs and IDPs that are associated with stardust to the more common N-anomalous material. By these analyses it should be possible to distinguish different formation scenarios for $^{15}N$ anomalies in chondritic samples.

**References**: [1] Busemann H. et al. (2006), *Science* 312, 727. [2] Spring N. et al. (2010), *Meteorit.Planet. Sci.* 73. A5416 [3] Busemann H. et al. (2009), *EPSL.* 288, 44. [4] Briani G. et al. (2009), *PNAS* 106 (26), 10522. [5] Aléon J. (2010), *ApJ* 722, 1342. [6] Terzieva R. & Herbst E. (2000), *MNRAS* 317, 563. [7] Messenger S. et al. (2005), *Science* 309, 737. [8] Floss C. et al. (2009), *LPSC* 40, #1082. [9] Ishii H.A. et al. (2009), *LPSC* 40, #2467. [10] Bonal L. et al. (2010), *GCA* 74, 6590. [11] Vollmer C. et al. (2009), *GCA* 73, 7127. [12] Sakamoto N. et al. (2007), *Science* 317, 231. [13] Leitner J. et al. (2009), *LPSC* 40, #1512.