**TOF-SIMS ANALYSIS OF COMETARY MATTER IN STARDUST AEROGEL TRACKS.** D. Rost[1], T. Stephan[2], E. P. Vicenzi[1], E. S. Bullock[1], G. J. MacPherson[1], A. J. Westphal[3], C. J. Snead[3], G. J. Flynn[4], S. A. Sandford[5], and M. E. Zolensky[6], [1]Department of Mineral Sciences, National Museum of Natural History, Smithsonian Institution, Washington, DC 20560, USA (rostd@si.edu), [2]Institut für Planetologie, Westfälische Wilhelms-Universität Münster, Wilhelm-Klemm-Str. 10, 48149 Münster, Germany. [3]Space Sciences Laboratory, University of California at Berkeley, Berkeley, CA 94720, USA, [4]Department of Physics, SUNY Plattsburgh, Plattsburgh, NY 12901, USA, [5]Astrophysics Branch, NASA Ames Research Center, Moffett Field, CA 94035, USA, [6]Astromaterials Research and Exploration Science, NASA JSC, Houston, TX 77058, USA.

**Introduction:** The predominant fraction of particles from the coma of comet 81P/Wild 2 collected during the STARDUST mission [1–3] were captured in aerogel cells: The decelerating particles fragmented and partially disintegrated as their kinetic energy dissipated, thus forming up to millimeter long cavities (tracks) of different shapes (‘carrot’ to bulbous bifurcated). Much effort to date has been dedicated to the study of up to ~10 µm sized terminal particles and larger fragments along the track. Although these particles are chemically heterogeneous, a chondritic bulk composition for Wild 2 has been estimated after analyzing material from 23 tracks in aerogel and from residues in 7 impact craters in Al foil, the second capture material [4].

This study, however, focuses on detailed compositional examination of traces of cometary matter found in aerogel surrounding the track cavity. This work is complemented by the compositional study of extracted particle fragments [5].

**Samples:** Aerogel samples from two different tracks were analyzed: Sample C2009,~~13,~~57,0 is a keystone fragment from track 57 of cell C2009, and samples C2115,30,21,0 and C2115,34,21,0 are two ~100 µm thick slices of aerogel cut under 45° from track 21 in cell C2115 (Fig. 1). The samples were flattened on Si-wafers (Fig. 2) to facilitate the examination with ToF-SIMS.

**Methods:** Time-of-flight secondary ion mass spectrometry (ToF-SIMS) was employed using TOF-SIMS IV instruments from ION-TOF GmbH available at Smithsonian Institution and Universität Münster. Major, minor, and trace element concentrations were measured relative to Fe, with a lateral resolution of ~300 nm. A blank correction was applied to correct for the composition of the contaminated aerogel. Since the contribution of cometary material to the aerogel composition is typically only ~1%, Si concentrations could not be derived. Low voltage- and variable pressure-field emission SEM follow-up imaging was conducted in an attempt to localize individual cometary subgrains.

**Results and Discussion:** *C2009,~~13,~~57,0.* Three particles, 3–10 µm in size, are observed in the aerogel adjacent to the track. Although dominated by aerogel, the individual residual compositions are clearly distinctive, and not chondritic (Tab. 1). Particles #1 and #2 probably contain alkali feldspar and Fe sulfide, respectively. Particles #1 and #3 have a Ni/Fe ratio close to the chondritic value of 0.055.

*C2115,30,21,0 and C2115,34,21,0.* The aerogel region close to the track is intimately mixed with fine-grained material of a distinct compositional signature indicating cometary material. The average compositions as derived from each slice are very similar and close to chondritic (Fig. 3). The only significant exceptions are Ca, which is depleted by a factor of ~5, and Ni, which is enriched by a factor of ~2. Even smaller sub-samples of the sprayed, diluted cometary material, covering only 96 µm$^2$ (detail #1) or 94 µm$^2$ (detail #2), show a similar chondritic composition. Since the subsequent SEM study did not reveal individual grains at the ~0.1 µm scale (Fig. 4) we suggest that the observed diffuse cometary matter resides in grains no larger than the nanometer length scale, or is (in part) a fine condensate of impact volatilized cometary matter. Despite these observations, the cometary material is not entirely homogenous on the µm-scale and below (Fig. 5): Several Ca-rich grains are aligned along an ~10 µm long offshoot track; a Ni rich grain (<1 µm) is also seen. C2115,34,21,0 contained polycyclic aromatic hydrocarbons that seem to be indigenous to the cometary matter [6].

**Conclusion:** While the relatively big particles (>2 µm) from C2009,~~13,~~57,0 are chemically heterogeneous and non-chondritic, the ultrafine grained material from track 21, Cell C2115, has a chondritic composition on the 10 µm length scale (i.e. the ~100 µm$^2$ analyzed in detail #1 and #2) but is heterogeneous on and below the micrometer length scale, indicating individual mineral grains. It is remarkable that the cometary matter captured in the two investigated aerogel slices was found to be chondritic for a conservatively estimated total mass of only ~40 pg.

**References:** [1] Brownlee D. et al. (2006) *Science, 314*, 1711–1716. [2] Brownlee D. E. et al. (2003) *JGR, 108*, 8111. [3] Tsou P. (2003) *JGR, 108*, 8113. [4] Flynn G. F. et al. (2006) *Science, 314*, 1731–1735. [5] Stephan T. et al. (2007) *LPS XXXVIII, (this conference)*. [6] Sandford S. A. et al. (2006) *Science, 314*, 1720–1724.

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| Element | Particle #1 | Particle #2 | Particle #3 |
|---|---|---|---|
| Li | 0.017 ± 0.002 | | 0.010 ± 0.003 |
| B | 1.44 ± 0.09 | | |
| Na | 187.2 ± 0.2 | 0.0269 ± 0.0003 | 5.68 ± 0.05 |
| Mg | 55.0 ± 0.2 | 0.0042 ± 0.0002 | 8.7 ± 0.1 |
| Al | 64.5 ± 0.3 | | 1.09 ± 0.04 |
| K | 85.7 ± 0.1 | 0.00261 ± 0.00008 | 0.261 ± 0.009 |
| Ca | 26.2 ± 0.1 | 0.00015 ± 0.00003 | 0.75 ± 0.02 |
| Ti | 0.65 ± 0.08 | | 0.06 ± 0.01 |
| Cr | 0.029 ± 0.004 | | 0.23 ± 0.02 |
| Mn | | | 0.05 ± 0.01 |
| Fe | 1.00 ± 0.05 | 1.00 ± 0.01 | 1.00 ± 0.08 |
| Ni | 0.04 ± 0.03 | 0.004 ± 0.001 | 0.06 ± 0.03 |
| Ba | 0.055 ± 0.004 | | |

*Tab. 1. Atomic element ratios relative to Fe and corrected for aerogel blank for 3 particles found in C2009,13,57,0.*

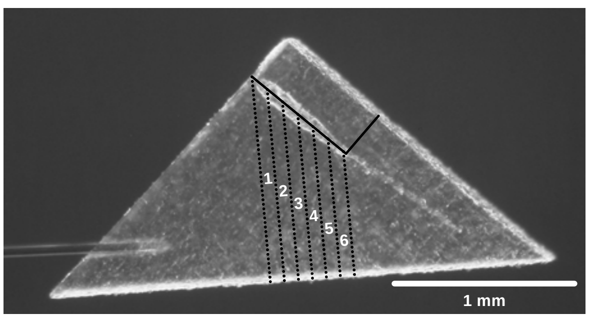


*Fig. 1. Keystone of track 21 from cell C2115. The flattened microtome slices 2 (C2115,30,21,0) and 6 (C2115,34,21,0) are shown in Fig. 2.*

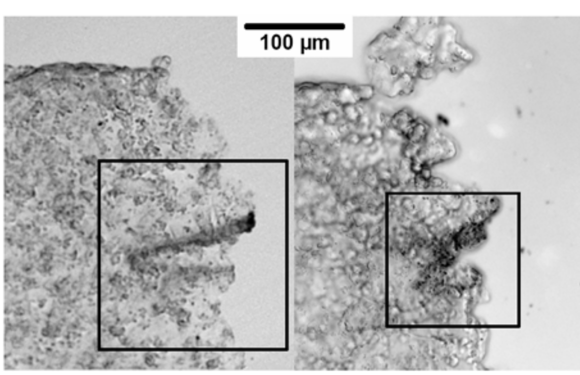


*Fig. 2. Reflected light optical microscope images of samples C2115,30,21,0 (left) and C2115,34,21,0 (right). The boxes indicate crosscut track walls containing cometary matter.*

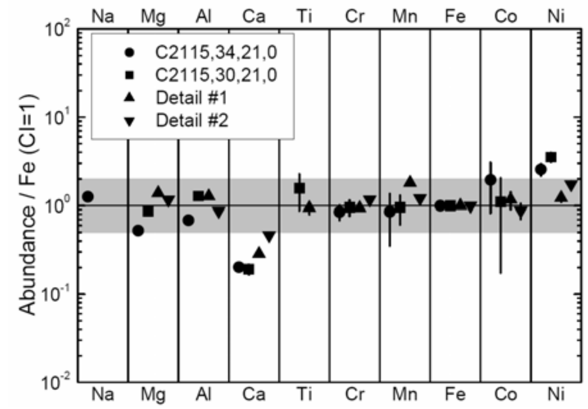


*Fig. 3. Element ratios relative to Fe and normalized to CI chondritic abundances for both track regions shown in Fig. 2, as well as from two selected detail regions from C2115,30,21,0 (Fig. 4,5 for #1). Most elements are within a factor of two (grey area) of chondritic ratios.*

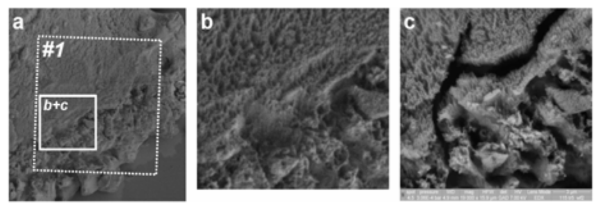


*Fig. 4. SEM images from 'detail #1' region. (a,b) low energy SE images, (c) VP SEM BSE image. Fields of view are 50×50 $\mu m^2$ (a) and 14×14 $\mu m^2$ (b,c).*

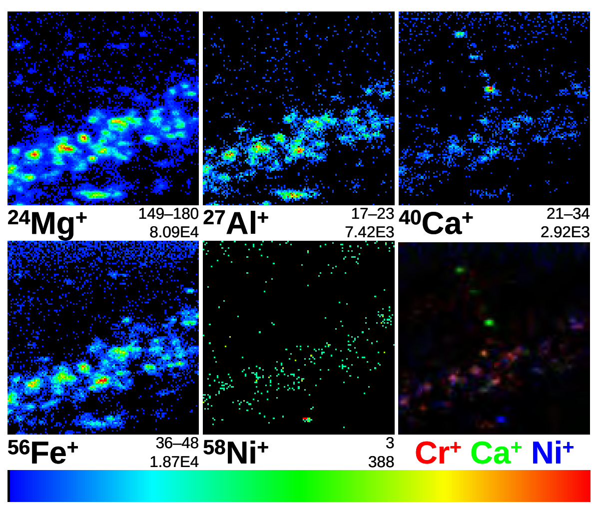


*Fig. 5. ToF-SIMS secondary ion images from 'detail #1' of C2115,30,21,0. The field of view is 35×35 $\mu m^2$. Ca-rich spots <1 µm in the upper part of the image indicate a micro-offshoot of cometary matter. The image on the lower right is a 3 color overlay of Cr (red), Ca (green), and Ni (blue) intensities.*