Evidence for Changes in 81P/Wild 2 Organic Matter Since Collection and Comparison of 81P/Wild 2 and IDP Organic Matter to Assess the Thermal Effects of Aerogel Capture . S. Wirick[1], G. J. Flynn[2], L. Keller[3], K. Nakamura Messenger[3], S. A. Sandford[4], M. E. Zolensky[3], C. Peltzer[1], C. Jacobsen[1], [1]Dept. of Physics and Astronomy, SUNY StonyBrook, NY 11794, USA,(swirick@bnl.gov), [2]Dept. of Physics, SUNY Plattsburgh, NY 12901 USA, [3]NASA Johnson Space Center, Houston, TX, 77058, USA, [4] NASA Ames Research Center, Moffett Field, CA 94035, USA,

Introduction: NASA's Stardust spacecraft collected cometary material during its passage through the dust coma of comet 81P/Wild 2 on January 2nd, 2004 and delivered this material to Earth on January 15th 2006. The first fragment we analyzed during the preliminary examination was partially vaporized by the X-ray beam. The carbonaceous material that survived was re-analysis ~2 months later and the carbon spectrum for this material had significantly changed from what we first observed.. We have observed similar changes to the carbonaceous matter in some interplanetary dust particles (IDPs).

Some of the 81P/Wild 2 organic matter volatilized upon impact with the aerogel as observed using IR spectroscopy where IR spectra were collected several mms away from sample tracks [1]. The time-temperature profile experienced by any particular 81P/Wild 2 grain during aerogel capture is not known, although Brownlee, et al. suggest that fine-grained materials, <1 micron in size, fragmented and then partially vaporized during collection, while particles much larger then 1 micron in size were captured intact [2]. Nearly all organic matter is subject to thermal alteration. To assess the heating and alteration experienced by the 81P/Wild 2 organic matter during capture we are comparing 81P/Wild2 organic matter with IDP organic matter where we have evidence of heating in the IDP [3,4].

Samples: Stardust sample CF3,0,2,4,4 was extracted from track 2, embedded in sulfur and ultramicrotome by K. Nakamura. We had only one, ~70nm thick section to analyze. This particle contained only carbon. The IDP we compare this particle to is a cluster particle, our identification number (id) L2008*F16. This particle was also a pure carbon particle, embedded in sulfur and ultramicrotomed by L. Keller. The other Stardust particle we analyzed, C2044,0,36,1,6, was an iron sulfide particle extracted, embedded in sulfur and ultramicrotomed by K. Nakamura. This particle is compared to an iron sulfide cluster IDP particle, also embedded in sulfur and ultramicrotomed by L. Keller, our id number L2009*E6.

Results: Carbon X-ray Absorption Near Edge Structure (XANES) spectra were collected using a scanning transmission X-ray microscopy (STXM) located at the X1A beamline at the NSLS, BNL, Upton, NY. Spectra were collected using a technique known as STACKS where an image is collected, the energy is changed by a small increment, then another image is collected; this was done for the energy range 280-300 eV [3]. Figure 1 shows 2 images and 2 spectra. Image and spectrum A were the first data collected from Stardust particle CF3,0,2,4,4. Image B and spectrum B were collected 2 months after the first image and spectrum. Most of the carbonaceous material ablated away during the first STACK but spectrum A is from the regions that were not destroyed by the X-ray beam. Spectrum B is also from exactly the same area 2 months later.

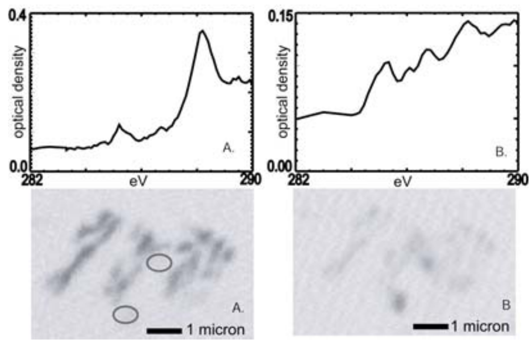

Figure 1. Fragment CF3,0,2,4,4 images and carbon spectra.

The carbon matter in L2008*F16 also changed over time but the change was on a longer time scale. Figure 2 shows both the first (A) and last (B) spectra and images collected from L2008*F16. Image and spectrum A were collected in 1999. Image and Spectrum B were collected in 2008. Data was also collected from this exact area in 2003 but no change in the carbon species was observed. Five years after this there was a significant change and the change we see in the IDP is similar to the altered carbon material in the

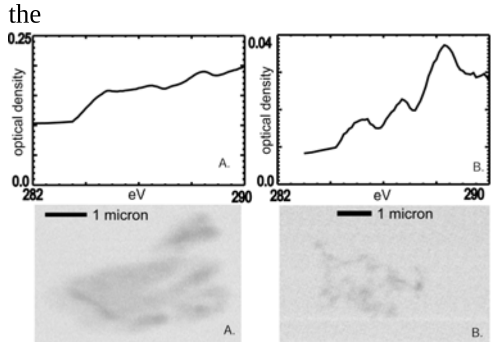

*Fig 2. IDP L2008*F16 images and spectra.*

Stardust particle. The speed of capture of the Stardust particles likely resulted in most of the organic matter being volatilized into the aerogel [1]. However some of the organic matter did survive and we saw evidence of this in a iron sulfide particle removed from track 36. Figure 3 contains STXM images (A.) of both IDP L2009*E6 (left) and Stardust particle C2044,0,36,1,6 and CLUSTER images and spectra (B.) of carbon compounds somewhere between amorphous and graphitic carbon. CLUSTER analysis is a technique we use to group similar spectra contained within a STACK data set [4]. The top dashed black spectrum is from IDP L2009*E6 and is similar to amorphous carbon in the 285-287 eV region yet contains a peak near 288.5 eV which is generally assigned to a C=O bond. The top red dotted spectrum is amorphous carbon made by burning wood and the bottom red dotted spectrum is highly ordered graphite from a natural sample [5]. The bottom solid black spectrum is from comet 81P/Wild2's iron sulfide and is almost graphitic, suggesting that this iron sulfide was heated. We know L2009*E6 was heated upon atmospheric entry to approximately 1000 degrees C due to the presence of a magnetite band on the rim of the particle [6,7]. C. in figure 3 shows both the CLUSTER images and very different spectra found in these iron sulfides. The spectra are not indicative of a heated carbon compound, i.e., they do not look like amorphous or graphitic carbon spectra. Similar spectra have been reported associated with soil micro assemblages where it is suggested that this aliphatic carbon forms a network along pore structures [8]. This close association of what we think is an aliphatic compound with the iron sulfide may explain how an aliphatic material could survive exposure to high temperatures.

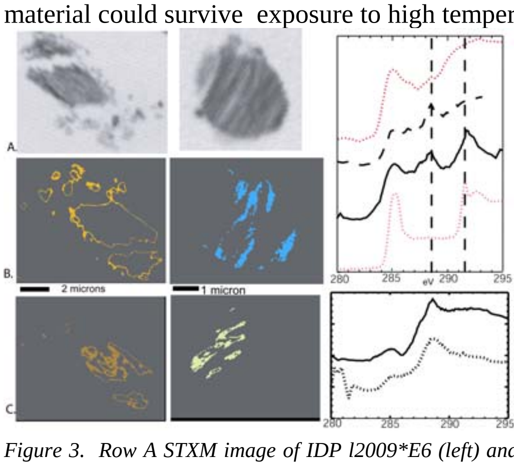

*Figure 3. Row A STXM image of IDP l2009*E6 (left) and Stardust particle C2044,0,36,1,6. Row B contains a CLUSTER image of L2009*E6 (left) and a CLUSTER image of C2044,0,36,1,6. The right top plot, the black spectra are from the CLUSTER areas, the top, red spectrum from amorphous carbon, the bottom, red spectrum from highly ordered graphite. Row C. also contains CLUSTER images and spectra from a carbon species that does not show any signs of heating.*

Discussion: We have found organic matter in both IDP L2008*F16 and Stardust particle CF3,0,2,4,4 that changes over time when exposed to our atmosphere. The particles were stored at room temperature and in the ambient atmosphere. With both L2008*F16 and CF3,0,2,4,4 most of the carbonaceous matter has ablated, sublimed or evaporated away leaving behind a spectrum we typically see in IDPs. The fact that extraterrestrial organic matter reacts with our atmosphere also suggests that IDP and cometary organics may have been important for the formation of life on early Earth.

Heating of organic compounds during the capture of 81P/Wild 2 fragments was an unavoidable reality and though it is likely most of 81P/Wild 2's organic matter volatilized upon capture, some organic matter has survived. This matter is associated with an iron sulfide from Stardust particle C2044,0,36,1,6. Some of this organic matter could be from the vaporized organic matter recondensing but there is evidence to show from a heated IDP that organic matter can survive heating by some mechanism, though what this mechanism is, is not understood at this time.

Conclusions: We have evidence that the organic matter in one Stardust particle changed with time. This particle was exposed to our atmosphere and so it is important to note that all Stardust samples should be stored under an inert atmosphere to minimize any change. It also suggests that perhaps to best understand the organic matter contained within the aerogel and associated with particles in tracks, it is important to analysis samples as soon as possible.

There is a mechanism, not understood at this time, which allows some organic matter to survive heating up to as high as 1000 ° C.

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