REFINING THE QUANTITATIVE ELEMENTAL COMPOSITION OF COMET WILD 2 DUST IN AEROGEL. H. A. Ishii[1], S. Brennan[2], J. P. Bradley[1], K. Luening[2], K. Ignatyev[2] and P. Pianetta[2], [1]Institute for Geophysics and Planetary Physics, Lawrence Livermore National Laboratory, Livermore, CA 94550, USA (hope.ishii@llnl.gov), [2]Stanford Synchrotron Radiation Laboratory, Stanford Linear Accelerator Center, Stanford, CA 94025, USA (sean.brennan@stanford.edu)

Introduction: Historically, comet dust composition measurements have been made remotely or with poor resolution and detection limits due to spaceflight limitations on instrumentation. Comet 81P/Wild 2's serendipitous orbit change to the inner solar system provided the chance for NASA's Stardust mission to collect a sample from an object originally from the cold and distant Kuiper belt and return it to Earth for in-depth analysis. Kuiper belt objects have been expected to contain primitive materials preserved since the solar system formed ~4.6 Gyr ago. The Stardust samples were subjected to intense study in the year since its January 2006 return [1], and synchrotron x-ray microprobe x-ray fluorescence (micro-SXRF) measurements have provided much information on their (non-volatile) composition and heterogeneity [2]. Measurement of bulk chemistry is of prime interest for comparison with other classes of extraterrestrial materials to understand Wild 2's place in the continuum of solar system samples. Limited sample statistics and unexpectedly heterogeneous contamination in the aerogel capture medium have proven major challenges.

We developed a dual threshold analysis approach for better distinguishing cometary material from aerogel contaminants and applied it to five Stardust impact tracks and terminal particles. Complete results from the refined composition analysis and discussions of inferred mineralogy have been submitted for publication [3]. Here, we present the dual threshold approach and demonstrate its impact on track composition.

Experimental Methods: The five Stardust impact tracks studied were extracted from a single aerogel tile, Cell 44, as keystones [4]. See Figure 1 for optical micrographs and official sample numbers. Each keystone contains a single impact track with dispersed, fine debris and a terminal particle lodged at the end. Additional details of track length, shape and deposited mass are provided in [3]. Each impact track was mapped in the hard x-ray scanning fluorescence microprobe endstation of Stanford Synchrotron Radiation Laboratory's Beam Line 6-2 with a 14 keV beam (see [2], SOM). Focused spot size was increased to 15x19 $microns^2$ with $2x10^{10}$ ph/s for efficient mapping with step size matched to spot size. Full fluorescence spectra were c collected at each map pixel with dwell time of ≥30 seconds. Total spectra for impact track and terminal particle are obtained from appropriate map pixels.

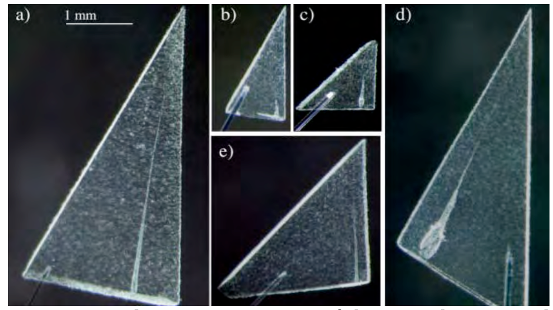

Figure 1: Optical microscope images of the 5 Stardust comet dust impact tracks in aerogel keystones analyzed by micro-SXRF: a) Track 4 (C2044,0,38), b) Track 5 (C2044,0,39), c) Track 9 (C2044,0,42), d) Track 10 (C2044,0,43) and e) Track 12 (C2044,0,52).

Isolation of Cometary Material from Background: The silica aerogel capture medium poses difficulties for in-aerogel analysis of Stardust comet dust: Si and O are major rock-forming elements, Si absorbs Mg and Al fluorescence, some of the aerogel is density graded, and non-uniform contamination by elements of interest is significant. Figure 2 illustrates the variability of Cell 44 aerogel spectra away from impact tracks.

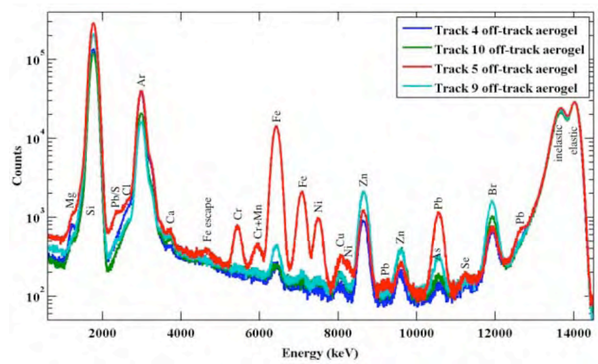

Figure 2. Aerogel background spectra obtained at multiple locations away from impact tracks in keystones from Cell 44. Spectra are plotted on a logarithmic scale. High variability in contamination is seen within a single aerogel tile. The Track 5 keystone has higher contamination levels than the other keystones.

To subtract an appropriate local aerogel background, it is desirable to isolate background pixels from cometary material pixels in the map covering the impact track. This has the advantage of limiting the dilution of the cometary spectrum by aerogel. Most micro-SXRF measurements on Stardust to date have established a single threshold level to distinguish between pixels with cometary material and aerogel alone. The Fe fluorescence signal is commonly used as an indicator of cometary material. A single threshold risks incorrect subtraction of cometary material signal inadvertently included in the background category. The resulting cometary material composition is too low by twice the mass of that material incorrectly included in the background. We remedy this by establishing upper and lower thresholds and discarding those pixels that fall in the "uncertain", in-between category, typically <1% of the total Fe mass.

Results: Figure 3 a) contains the sum spectra on a logarithmic scale for cometary material, normalized aerogel background and discarded material for Track 4. The discarded material spectrum is displayed on the same scale as the cometary spectrum to illustrate the small amount of material discarded. Figure 3 b) shows the Fe signal in the dual threshold map.

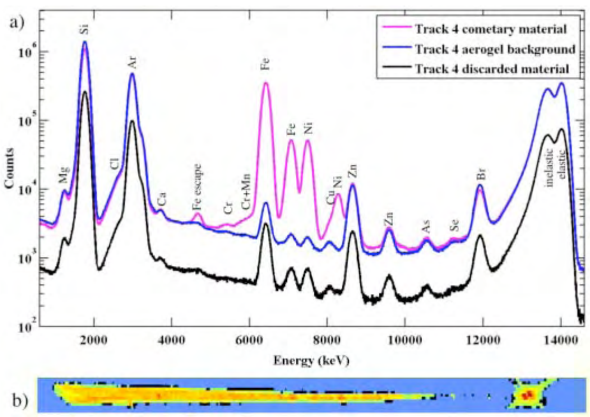

Figure 3. Results of dual threshold analysis of Stardust Track 4. a) Fluorescence spectra for cometary material (magenta), normalized aerogel background (blue) and discarded material (black) for Track 4 in its entirety. b) Fe signal in the map of Track 4 after applying dual thresholds: pixels in the blue region contain solely aerogel, pixels in the black region are discarded, and pixels in the multi-colored green, yellow, orange and red region contain cometary material with warmer colors indicating higher intensity. The spectra from these categorized pixels were summed to produce the spectra in a).

The potential impact of using a dual threshold versus a single threshold is illustrated in Table 1 where the results of both analyses for Track 12 are compared. 13% more mass is measured; Zn increases by 4x; Cu, As and K increase by 2x; and Cr and Mn increase by 1.4x. Slight variations in threshold levels have larger impact on trace and minor elements than major elements, so Fe and Ni are not significantly impacted.

A major component in Comet Wild 2 dust is known to be silicates [5], and x-ray microprobe measurements of impact tracks in aerogel cannot quantify Si, O, Mg and Al. Although most tracks contain material decorated by Fe(Ni)-sulfide beads that are readily seen by x-ray microprobe, it is critical to include all cometary material discernable, even by minor elements, for accurate future bulk composition calculations. Track 12 contains significant Cr not strongly associated with Fe. Since Fe is the element signal used to categorize pixels, those pixels were mistakenly placed in the aerogel background by single threshold analysis. In dual threshold analysis, examination of the total spectrum from discarded pixels shows high Cr relative to Fe, and high-Cr pixels were then included in the cometary material spectrum. Another example of the dual threshold analysis as a diagnostic tool revealed localized Au contamination and is described in [6].

A surprising result is Zn measurable in most impact tracks but not in any terminal particles despite improved detection limits suggesting possible gettering of Zn in track walls. A close look at sulfides as a possible culprit may be revealing.

	***single threshold* mass (g)**	***dual threshold* mass (g)**	**fractional change**
Cl	3.05E-11	5.78E-11	1.89
K	6.19E-12	1.27E-11	2.04
Ca	2.07E-13		
Cr	5.92E-12	8.51E-12	1.44
Mn	4.37E-14	6.17E-14	1.41
Fe	2.89E-10	2.98E-10	1.03
Ni	2.48E-11	2.58E-11	1.04
Cu	1.52E-13	3.10E-13	2.04
Zn	2.15E-13	8.83E-13	4.11
Ga	2.12E-14		
As	1.39E-13	2.48E-13	1.78
Se	2.09E-13	2.05E-13	0.98
total	3.57E-10	4.04E-10	1.13

Table 1. Element abundances by mass for Stardust impact Track 12 by single and dual threshold analyses. Measured masses above minimum detection limits are reported.

Conclusion: Dual threshold analysis of Stardust impact tracks and particles mapped by synchrotron x-ray microprobe in aerogel keystones provides improved composition accuracy without significant exclusion of cometary material and is potentially important for narrowing uncertainty in the bulk composition.

References: [1] Brownlee D.E. et al. (2006) *LPS XXXVII*, Abstract #2286. [2] Flynn G. J. et al. (2006) *Science, 314,* 1731-1735. [3] Ishii H. A. et al. (2007) Recovering the elemental composition of Comet Wild 2 dust in five Stardust impact tracks and terminal particles in aerogel, submitted to *Meteoritics & Planet. Sci.* [4] Westphal A. J. et al. (2004) *Meteoritics & Planet. Sci. 39,* 1375-1386. [5] Zolensky et al. (2006) *Science, 314*, 17xx-17xx. [6] Brennan S. et al. (2007) *LPS XXXVIII*, this volume.

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