TOF-SIMS ANALYSIS OF COMETARY FRAGMENTS EXTRACTED FROM A STARDUST AEROGEL TRACK. T. Stephan, University of Chicago, Department of the Geophysical Sciences, 5734 South Ellis Avenue, Chicago, IL 60637, USA (tstephan@uchicago.edu).

Introduction: Dust from comet Wild 2 was collected by the *Stardust* mission and returned to Earth in 2006 [1]. Low-density silica aerogel served as primary capture medium to facilitate gentle deceleration of cometary matter at a sampling velocity of 6.1 km/s [2]. However, the majority of the cometary matter captured by *Stardust* ended up in so-called bulbous aerogel tracks, where most of the mass collected from Wild 2 is distributed along the walls of the bulbous cavities. During deceleration, the cometary material fragmented and was thermally modified, often melted, and the cometary fragments were heavily mixed with compacted or even melted aerogel. Some dust grains, however, survived the impact more intact and can be retrieved as terminal particles from the very end of slender tracks or slender parts of tracks.

The present study is part of an ongoing effort to investigate cometary fragments extracted from various parts along *Stardust* aerogel tracks with time-of-flight secondary ion mass spectrometry (TOF-SIMS) [3–6]. Here, TOF-SIMS results for five fragments extracted from Track 77 are presented. Fragments of this track, also known as *Puki*, were investigated before [7].

Samples: Microtome sections of five fragments from Track 77 from aerogel cell C2009 were selected (Fig. 1). One sample is from the terminal particle of the track whereas the other four fragments are from the area between the bulbous part and the terminal particle. Sample numbers are C2009,20,77,1,11 for the terminal particle (TP), C2009,20,77,2,30 for fragment #4, C2009,20,77,3,4 for fragment #5, and C2009,20,77 ,2,55 for fragments #6 and #9. Although these fragments do not represent terminal particles *sensu stricto*, they were found at the termini of sidetracks. Therefore, they can be described as "quasi-terminal particles".

Experimental Procedures: Prior to TOF-SIMS analyses, each sample was cleaned by Ar^+ sputtering. During the measurements, the particle sections were raster-scanned for 6–12 hours with a pulsed Ga^+ primary ion beam with a beam diameter of ~0.3 µm, a pulse length of ~1.5 ns, and 10 kHz repetition rate. Both polarities were analyzed in two consecutive measurements. Further technical details are given in [8].

Results: Imaging TOF-SIMS results are summarized in Fig. 2. Element ratios relative to Mg for bulk particles are given in Table 1. CI chondritic element ratios as a proxy for solar system abundances are given for comparison [9]. Besides bulk element ratios for all analyzed samples, chemical compositions of individual regions within the fragments were determined.

Terminal Particle. This particle is dominated by a Mg-rich area (Fig. 2) with element ratios consistent with olivine (Fo_{87}) and some attached Si- and Al-rich material. The bulk Si/Mg-ratio of 1.1 is close to chondritic (Table 1).

Fragment #4 has a similar chemical bulk composition as the terminal particle, but higher alkali metal concentrations (Table 1). The bulk Si/Mg-ratio is 1.2. The chemical composition of the Mg-rich area (Fig. 2) is consistent with olivine (Fo_{81}).

Fragment #5 has a higher Si content (Si/Mg = 2.1), suggesting some contribution from aerogel. The Mg-dominated portion has an olivine-like composition (Fo_{79}). Another region is rich in Ca (Fig. 2) and from its chemical composition consistent with pyroxene ($En_{60}Fs_{13}Wo_{28}$). An Al-rich region was also found (Fig. 2). Some areas are rich in Na.

Fragment #6. Because of a strong enrichment in Si (Si/Mg = 17), which is probably due to aerogel, a distinction between olivine-like or Ca-poor pyroxene-like compositions cannot be made, not even for the Mg-rich region (Fig. 2) of this fragment. Another area is enriched in Na and Al (Fig. 2).

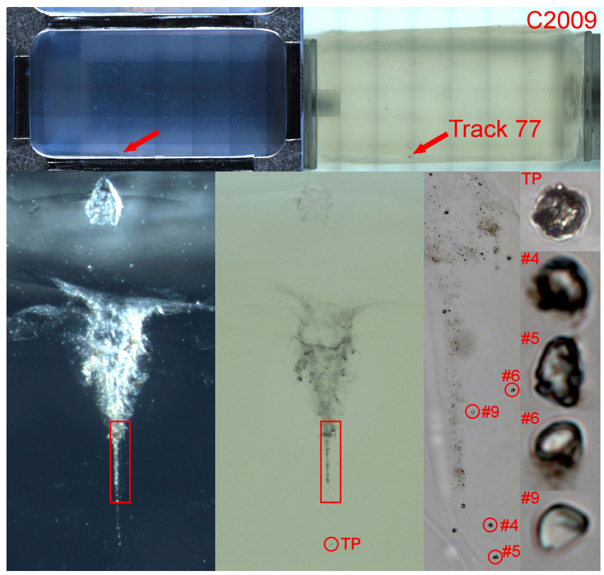

Fig. 1. Stardust cometary aerogel cell C2009 with impact Track 77 in reflected (top left) and transmitted light (top right), respectively. The bottom row shows, from left to right, side views of Track 77 in reflected and transmitted light, an enlargement of the area (red frames) from which fragments #4, #5, #6, and #9 where extracted, as well as close-ups of these fragments and the terminal particle (TP) embedded in acrylic. The length of the track is ~3.1 mm; the maximum bulb width is ~400 µm.

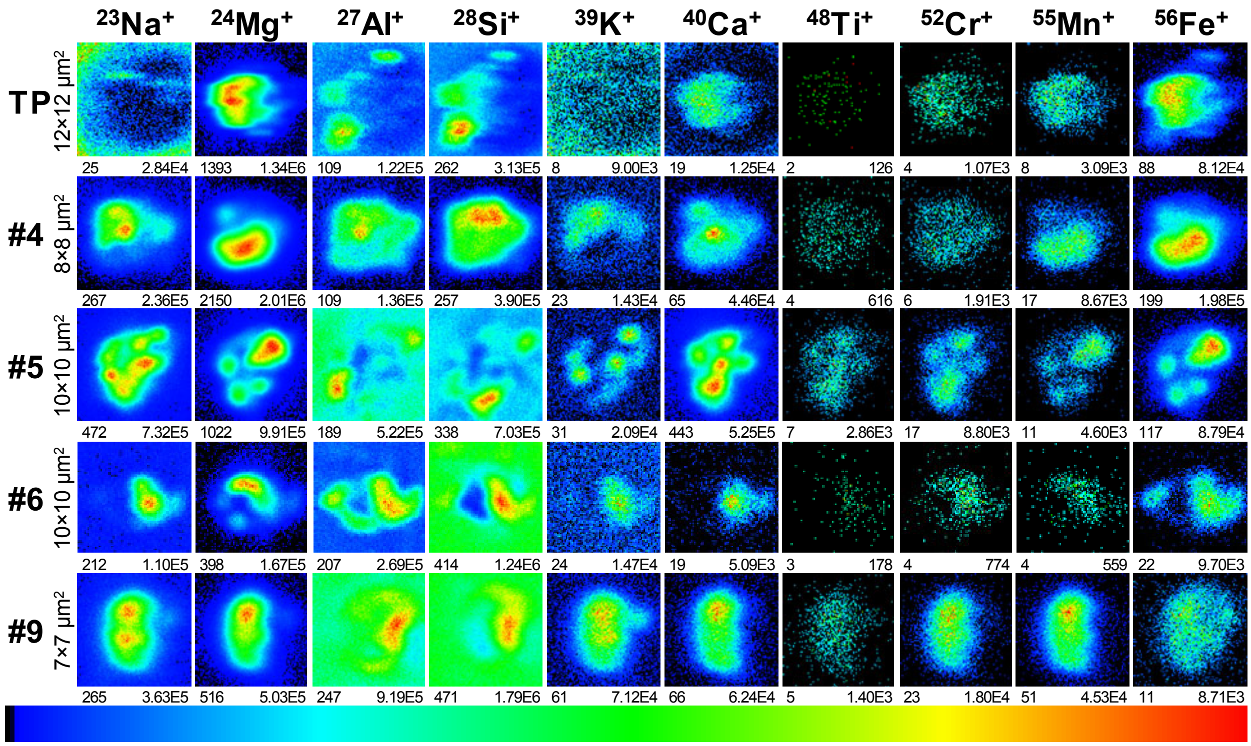

Fig. 2. TOF-SIMS secondary ion images for samples from Track 77 from cometary aerogel cell C2009. All individual ion images use the linear color scale shown, where black corresponds to zero counts and red is used for the maximum intensity given below every image. The other number underneath each image is the integrated intensity of the entire field of view.

Table 1. Atomic element ratios relative to Mg = 100[a]

	CI	TP	#4	#5	#6	#9
Li	0.0053	0.0029(3)	0.019(1)	0.030(1)	0.014(2)	0.004(1)
O	710	390(10)	420(10)	510(20)	2300(100)	930(40)
Na	5.34	0.147(2)	3.11(1)	19.02(2)	15.59(5)	16.31(3)
Mg	100	100.0(1)	100.0(1)	100.0(1)	100.0(3)	100.0(2)
Al	7.91	4.7(1)	5.01(5)	15.0(1)	100.6(2)	40.6(1)
Si	93.1	111.5(2)	123.8(2)	207.0(4)	1709(3)	486.3(9)
K	0.351	0.043(1)	0.102(1)	0.294(2)	0.96(1)	2.08(1)
Ca	5.69	0.358(4)	0.986(7)	23.49(4)	1.40(2)	5.27(3)
Sc	0.0032	0.0010(3)	0.0028(4)	0.009(1)	0.008(3)	0.007(1)
Ti	0.223	0.011(2)	0.035(3)	0.31(7)	0.11(1)	0.31(2)
V	0.0273	0.0030(6)	0.0041(6)	0.027(2)	0.009(3)	0.022(3)
Cr	1.26	0.104(3)	0.119(3)	1.18(1)	0.61(2)	4.89(4)
Mn	0.889	0.31(1)	0.588(8)	0.64(1)	0.41(2)	12.40(7)
Fe	83.8	16.60(6)	27.43(6)	24.7(1)	16.1(2)	3.51(6)
Co	0.209	0.007(2)	0.013(2)	0.019(3)	0.06(1)	0.003(4)
Ni	4.59	0.012(6)	0.3(1)	0.08(2)	0.4(1)	0.03(3)

[a]Errors are 1σ, given as last significant digit in parentheses

Fragment #9 is also dominated by aerogel (Si/Mg = 4.9). Compared to the other fragments, this sample shows strong enrichments in Cr and Mn, while Fe seems to be depleted (Fig. 2 and Table 1). Cr- and Mn-rich *Stardust* particles with low Fe concentrations like this have been reported previously [10, 11].

Discussion: As observed for other terminal particles before [4, 5], the terminal particle investigated in this study is less intermingled with aerogel than material extracted from bulbous parts of *Stardust* tracks, which show Si/Mg-ratios of 40–64 [3]. From their Si/Mg-ratios (1.2–17), the quasi-terminal fragments studied here, however, lie between genuine terminal particles and material from bulbs. They seem to be more compact than the fine-grained cometary matter that typically ends up in bulbous cavities, thermally altered and heavily mixed with aerogel.

To obtain a comprehensive picture of the Wild 2 matter collected by *Stardust*, all material from along the aerogel tracks needs to be analyzed. In case of Track 77, it is highly desired also to analyze the cometary matter that is sitting in the walls of the bulbous cavity. Since this fine-grained fraction is more difficult to extract from the aerogel, the *Stardust* samples studied so far show a strong selection bias towards compact terminal or quasi-terminal particles.

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References: [1] Brownlee D. et al. (2006) *Science, 314,* 1711–1716. [2] Tsou P. et al. (2003) *J. Geophys. Res., 108,* E8113. [3] Stephan T. et al. (2008) *Meteoritics & Planet. Sci., 43,* 285–298. [4] Stephan T. and van der Bogert C. H. (2008) *LPS XXXIX,* Abstract #1508. [5] Stephan T. and van der Bogert C. H. (2008) *Meteoritics & Planet. Sci., 43,* A147. [6] Stephan T. (2008) *Space Sci. Rev., 138,* 247–258. [7] Joswiak D. J. et al. (2008) *LPS XXXIX 39,* Abstract #2177. [8] Stephan T. (2001) *Planet. Space Sci., 49,* 859–906. [9] Anders E. and Grevesse N. (1989) *Geochim. Cosmochim. Acta, 53,* 197–214. [10] Zolensky M. E. et al. (2006) *Science, 314,* 1735–1739. [11] Zolensky M. et al. (2008) *Meteoritics & Planet. Sci., 43,* 261–272.