COMET WILD 2 SAMPLE TRACK 3D IMAGES AND S-XRF STEREO MAPS

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Introduction: The NASA Stardust mission to comet Wild 2 returned to Earth in 2006 with cometary material trapped in aerogel [1]. The cometary particles were captured at a relative velocity of 6.1 km/s, creating three-dimensional (3D) tracks containing void space, compressed aerogel, melted aerogel, and fragmented cometary material [1]. Each track represents a unique hypervelocity impact event. The nature of each track forming event, including the original state of the impactor, is recorded in 3D track morphology and material distribution. Tracks were cut from sampling tiles in thin aerogel "keystones" [2] translucent to optical light.

Methods: We used a Zeiss LSM 510, and after 2010 a LSM 710, laser scanning confocal microscope (LSCM), located at the American Museum of Natural History to acquire 3D imagery of tracks at high resolution (< 80 nm/pixel in x and y, ~300 in z the optic axis) [3]. LSCM is preferable to other methods of imaging because it quickly produces high-resolution 3D images of the distribution of compressed aerogel and particles larger than 100 nm along the track without disturbing or destroying the sample. We developed 3D deconvolution methods to use an experimental or a theoretically calculated point spread function (PSF) for first-order corrections of optical aberrations induced by light diffraction and refractive index mismatches [4]. Experimental PSF's were obtained using latex beads incorporated into aerogel during manufacture [4]. Attempts to adapt the LSM 710 for Raman spectroscopy of mineral grains were not successful.

We performed synchrotron x-ray fluorescence (S-XRF) mapping of most tracks at the Advanced Photon Source beamline13-ID, with most tracks mapped at 2 microns/pixel. We developed rotating, tiltable holders for aerogel keystones so we could raster map horizontal tracks at two angles ~15° apart, providing stereo-pair coverage [5,6].

Results: LSCM data and S-XRF maps for 15 tracks are available (Table). LSCM images illustrate track morphology and fragmentation history. Image segmentation techniques provide quantifiable volumetric and dynamic measurements [7]. Over 10 terabytes of data were collected over the course of the project, including LSCM images of beads and analog tracks shot with specific mineral phases [8], now curated at JSC.

track	full ID number	S-XRF	LSCM
68	C2126,2,68,0,0	x Feb 2011	x Oct 2012
82	C2092,1,082,0,0	x Aug 2007	x Jul 2007
102	C2012,1,102,0,0	x Feb 2014	x Feb 2014
117	C2065,1,117,0,0	x Aug 2014	x Feb 2014
128	C2012,4,128,0,0	X Nov 2008	x Oct 2010
129	C2012,5,129,0,0		x Oct 2010
131	C2012,7,131,0,0	x Apr 2013	x Mar 2013
140	C2061,2,140,0,0	x Jun 2009	x Oct 2010
143	C2103,10,143,0,0	x Apr 2013	x Mar 2013, Dec 2013
151	C2112,1,151,0,0	x Jun 2009	x Oct 2010
152	C2035,2,152,0,0	x Jun 2009	x May 2009, Oct 2010
163	C2117,2,163,0,0	x Jul 2010, Feb 2011	x Feb-Jun 2010
164	C2063,3,164,0,0	x Nov 2010	x Dec 2009, Nov 2010, May 2013
166	C2103,21,166,0,0	x Feb 2011	x May 2011, May-Jul 2013
169	C2088,1,169,0,0	x Apr 2013	x

Conclusions: These track data offer the ability to search track geometry and chemical maps to identify specific particles of interest (e.g., rich in HFSE) for detailed chemical and isotopic analysis. These tracks and particles are available from the JSC Curation Facility for allocation to qualified investigators for specific, targeted investigations.

Data Repository: All the data described here is being incorporated into the NASA JSC Stardust Curation database. Specific track data may also be obtained from the first author (DSE).

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