TRACKS IN STARDUST COMETARY AEROGELS: COMETARY PARTICLE STRUCTURE AND SIZE DISTRIBUTION.

M. J. Burchell[1], N. Pushkin[1], A. T. Kearsley[2], F. Hörz[3]. [1]School of Physical Science, Ingram Building, Univ. of Kent, Canterbury, Kent, United Kingdom (M.J.Burchell@kent.ac.uk). [2]Dept. of Mineralogy, The Natural History Museum, South Kensington, London SW7 5BD, United Kingdom. [3] ARES, NASA Johnson Space Center, Houston, TX 77058, USA.

Introduction: The NASA Stardust mission returned cometary dust samples from comet 81P/Wild-2 in Jan. 2006 [1]. The dust grains were captured in aerogel at an encounter speed of 6.1 km s^{-1} ([2] gives a review of aerogel and its use to capture dust grains). During the preliminary examination (PE) period an optical scan of the whole cometary tray collector revealed 256 probable impact features with track width > 100 µm. Two aerogel blocks (out of 132) were removed from the collector and examined with higher resolution side view images showing a wide variety of tracks in the aerogel. Based on these surveys (and analysis of craters in supporting aluminium foils) a particle size distribution was presented [3]. In total during PE, 20 aerogel blocks were removed and imaged and 186 tracks (length > 50 µm and width > 8 µm) identified. These data yielded a further particle size distribution [4]. Here we discuss this size distribution, the track morphology and implications for the structure of the cometary dust particles from Wild-2.

Track Shape: A range of track morphologies were observed in the Stardust cometary aerogel [3], classified into three Types (A, B and C). Type A are relatively long, slender, carrot shaped tracks. Type B have an initial bulbous cavity followed by slender A Type styli emerging from beneath them. Type C tracks simply have a bulbous cavity with no styli beneath them. All three types can be reproduced in the laboratory [4]: Type A are from well consolidated grains (which can however have multiple components and whose terminal grain is not equal in size to the impactor). Two mechanisms have been suggested for producing Type B., impact by *either* volatile rich grains whose vaporisation drives expansion of a cavity, combined with survival of better consolidated subgrains traveling in the forward direction producing terminal subgrains at the end of the styli; *or* break up of aggregates during capture, with fragments radiating outward, again some better consolidated sub-grains penetrate forwards creating the styli beneath the track. Type C could be the result of either of the two possibilities for B, but with no large terminal sub-grains.

Attempts to model volatile-driven expansion of a cavity in aerogel suggest that this is at best a minor contributor to the Type B and C tracks in Stardust aerogel [5]. Here we show that laboratory light gas gun (LGG) shots of weakly bound aggregate projectiles made of sintered glass spheres or mineral grain aggregates glued together by organic polymers, both give recognizable Type B tracks, along with some Type C, with morphology similar to Stardust tracks.

Particle Size: LGG experiments using soda lime glass beads provided calibrations of pre-impact grain size vs. Type A track size [4]. Track length data were not applicable for all track Types, so track volume was used, assuming the incident particle KE was the critical factor in track volumetric growth. Surprisingly, several differing particle size distributions can be inferred from Stardust, depending on which data set is used [3, 4]. These particularly diverge at small particle sizes and also seem to differ from the size distribution obtained from craters in the aluminium foils, and that reported by both DFMI and CIDA during encounter [3, 4].

The answer appears to lie in the spatial clustering of impacts in the aerogel and foils. Small tracks are observed to occur in statistically significant groups (large tracks show less of an effect) [6]. Any numerical analysis is thus biased at small sizes by how many clumps are included in the area surveyed. Data from different parts of the aerogel collector can thus significantly alter the apparent dust flux at small particle sizes (< 10 µm). This in turn biases the index of the size (mass) distribution reported.

Conclusion: Wild 2 cometary dust had two distinct components, small, well consolidated grains and larger, more weakly bound aggregates. Dust captured in the aerogel collectors is dominated at small (micrometer scales) by well consolidated (albeit still probably aggregate) grains, found in clusters indicating a common origin from a larger particle which broke up before impacting the detectors. The index of the cumulative size distribution ranges from -0.86 to -1.22 (in the aerogel) and -2.55 for DFMI, depending on which data set is used; the shallower slopes are less affected by breakup of large grains before capture, the steeper ones are dominated by it.

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