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MICROCRATERS IN ALUMINUM FOILS EXPOSED BY STARDUST. The Stardust Cratering Team:

Friedrich Hörz (Team-Lead)[1], J. Borg[2], J. P. Bradley[3], J. Bridges[4], D. E. Brownlee (PI)[5], M. J. Burchell[6], M. J. Cole[6], Z. R. Dai[3], Z. Djouadi[7], C. Floss[8], I. A. Franchi[4], G. A. Graham[3], S. F. Green[4], P. Heck[9], P. Hoppe[9], A. T. Kearsley[10], J. Leitner[11], H. Leroux[7], N. Teslich[3], K. K. Marhas[8], C. S. Schwandt[12], T. H. See[12], F. J. Stadermann[8], T. Stephan[11], D. Troadec[7], P. Tsou[13] and M. E. Zolensky[1], [1]NASA Johnson Space Center, ARES, Mailcode KR, Houston, TX, 77058 (friedrich.p.horz1@jsc.nasa.gov), [2]UMR CNRS, Paris, [3]LLNL, Livermore, [4]Open Univ., Milton Keynes, [5]Univ. Washington, Seattle, [6]Univ. Kent, Canterbury, [7]Univ. Lille, Villeneuve, [8]Wash. Univ., St. Louis, [9]MPI, Mainz, [10]NHM, London, [11]Univ. Münster, [12] ESCG/NASA JSC, Houston, [13]JPL, Pasadena.

Objectives: The Stardust Mission exposed ~1039 cm^2 of aerogel and ~153 cm^2 of aluminum-foil to the particle flux of comet Wild 2. The expected population of microcraters on these foils represents a substantial science opportunity, complementing the analysis of individual particles trapped in aerogel. Owing to the much higher shock stresses upon encounter of the dense aluminum foils, the projectile remnants residing in the bottom, walls, and rim area of these foil craters will be more severely altered, most likely molten and possibly vaporized, however, compared to those recovered from aerogel. Nevertheless, beginning with the investigation of multi-layer thermal blankets from the Solar Maximum Mission and extending into the Long Duration Exposure Facility, and more recent opportunities on space exposed surfaces [1, 2], it was demonstrated that compositionally diverse particle types can be distinguished readily on aluminum (and other) substrates with modern analytical instruments.

In addition, the size frequency distribution and total flux of particles in the comet's coma – using passive collector instruments that are returned to Earth – is much better determined with non-porous targets than with highly porous materials. Experimental evidence and empirical analyses of space- exposed aerogels revealed that it is difficult, if not impractical, to extract the initial particle size or mass from either the detailed morphologic characteristics of a penetration track, or from the size of the trapped residue in aerogel [*e.g.*, 3, 4]. The physical cohesion of a prospective impactor (*e.g.*, a single micro-crack) substantially controls the penetration outcome in aerogel, because projectiles of otherwise identical bulk-properties can fragment or completely disaggregate, producing dramatically different track morphologies that range from classical carrot- shaped tracks to cylindrical cavities and bulbous pits [3, 4]. In contrast, the cratering flow fields and thus the morphology of small microcraters in non-porous targets are relatively invariant [5]. As a consequence, the crater populations on the Stardust aluminum foils will become the primary features, vastly superior to penetration tracks, to deduce initial size or mass distributions and associated fluxes of the dust-particles encountered during Stardust's flyby of comet Wild 2. These determinations constitute the primary objective of the Stardust Cratering Team, and they will greatly complement the flux measurements of the active experiments on board the space craft [6].

Crater Calibration: The conversion of a measured crater diameter to projectile diameter will be much simpler and more precise on Stardust than on any previous, space-exposed surface, because all Stardust craters were produced at a constant encounter speed of 6.1 km/s, which is well within experimental capabilities of light gas guns. All previously studied crater populations had to be interpreted via assumed mean velocities and via substantial extrapolations of experimental observations. As a consequence, interpretation of the Stardust craters will be fairly straightforward, provided suitable calibration experiments exist.

We conducted such experiments using the small caliber light gas guns at the University of Kent and at the NASA Johnson Space Center for inter-laboratory comparisons and cross calibration [see 7]. We employed spare flight hardware foils (Al 1100 series; 0.004") ~100 µm thick, and precision-sieved, spherical soda lime glass projectiles ranging in diameter from 11 µm to ~100 µm; the foil was backed by a massive plate of Al 6061 T6 identical to the Stardust collector tray, thus assuring a high-fidelity target structure. The experimental impact velocities varied from 5.9 to 6.2 km/s, with most at 6.0 to 6.1 km/s. The results are illustrated in Figure 1 and yield a linear relationship of crater diameter (D_c) and projectile size (D_p) of $D_c/D_p = 4.62$ for projectiles of some 2.2 g/cm^3 density. Impactors >50 µm will penetrate the foil and terminate in the underlying collector frame.

Projectile Residues: We produced additional foil craters using monomineralic powders (*e.g.*, olivines, various pyroxenes and plagioclases, hornblende, carbonates, oxides, sulfides) or ground rocks (*e.g.*, basalt, Allende meteorite, coal) to sharpen sample preparation methods and analytical procedures for the compositional, spectral and isotopic analyses of the projectile residue that will reside in the Stardust foil craters. We demonstrated in a series of papers [8, 9, 10] that such compositional studies are possible and that substantial science may be extracted from projectile residues in microcraters using state of the art instrumentation. Some of these papers also introduce significant advances in sample preparation methods that were not available earlier.

Preliminary Investigations: The Stardust sample capsule will land January 15, 2006 in Utah; current plans are to distribute foil-samples to the Cratering Team by early February. We will report at LPSC on the preliminary characterization of the crater populations and their implications for particle fluxes, possibly on the compositional diversity of Wild 2 particles using electron and ion beam instruments.

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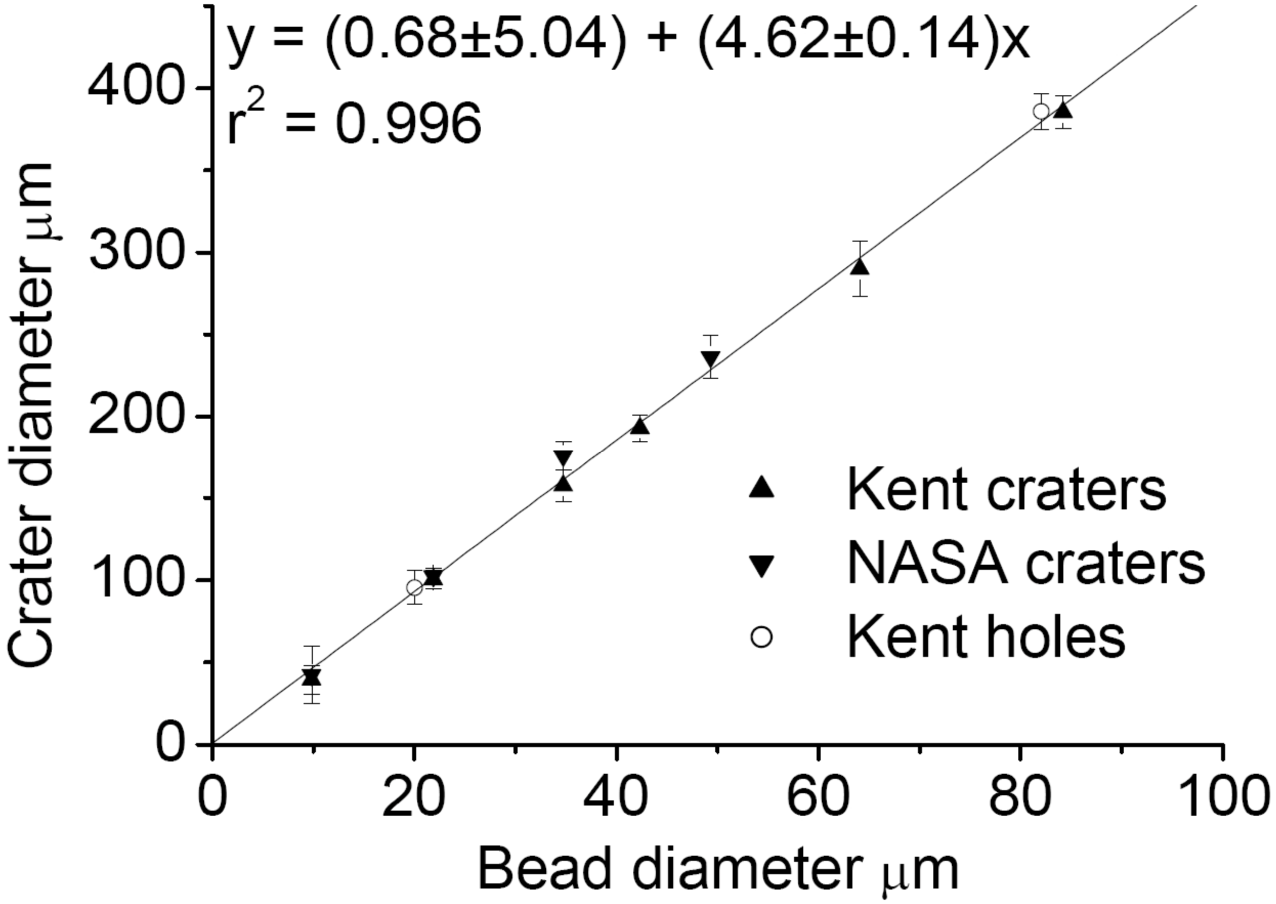

Figure 1. Projectile size versus crater diameter, measured from rim crest to rim crest, in soft aluminum 1100 foils. The open symbols relate to free-standing foils.