HOW THE SHAPE AND VOLUME OF IMPACT TRACKS IN STARDUST AEROGEL REFLECT COMETARY DUST PROPERTIES: EXPERIMENTAL EVIDENCE.

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Introduction: The Stardust collector shows diverse aerogel track shapes created by impact of Wild 2 dust [1]. Tracks have been classified [2] into types A, B and C), based on relative dimensions of the elongate 'stylus' (in Type A "carrots") and broad 'bulb' regions (Types B and C), with smaller 'styli' in Type B. Theoretical models [3] have partly explained mechanisms of track formation, but experimental confirmation has been limited. Using a diverse suite of projectiles shot at aerogel targets, under Wild 2 encounter conditions, we now describe differences in impactor behaviour and aerogel response (Fig. 1) that result in the observed range of Stardust track shapes. We compare tracks made by monomineralic grains, natural mineral aggregates, meteorite powders, artificial aggregates (with known sub-grain size), and diverse organic materials.

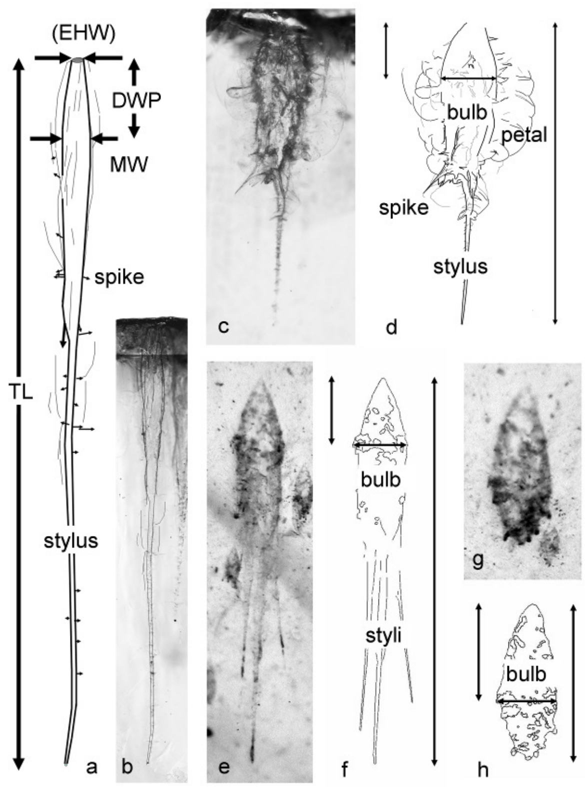

Fig. 1. Experimental aerogel impact tracks: a-b) Type A; c-f) Type B; g-h) Type C. Measurements used for quantification of track shape (total length, TL, and maximum width, MW) follow conventions of [2].

Methods: All projectiles were fired as sabot-filling 'buckshot' (mainly polydisperse) powders at ~ 5 - 6 km s^{-1} in the light gas gun (LGG) at Canterbury [4], giving numerous impacts on a small area of aerogel. Each shot used only a single projectile type, or materials of very different grain size and/or properties. Targets were ~ 30 kg m^{-3} constant-density or Stardust-type 5-50 kg m^{-3} graded silica aerogel. Cross-calibration was made for monodisperse projectiles of two compositions on the two target types. Track dimensions were measured from calibrated macrophotographs.

Results: Impacts of glasses and robust mineral grains generated elongate, narrow Type A tracks (Table 1), but with differing levels of abrasion and lateral branch creation. Meteorite powders and natural mineral aggregate particles produced predominantly Type B shapes. Artificial, acrylate-cemented aggregate particles produced diverse Type B or Type C, dependent upon their sub-grain dimensions. Organic materials created mainly Type C, with some short squat tapering tracks, which we designate as Type A*.

Projectiles	**Track MW/TL Avg ± Stdeva**	**Tracks**
Soda lime glass beads	0.059 ± 0.009	A
Basalt glass NKT-1G	0.066 ± 0.018	A
Olivine (Fo ~ 88)	0.071 ± 0.009	A
Diopside	0.087 ± 0.020	A
Feldspar (An ~ 84)	0.056	A
Pyrrhotite	0.080 ± 0.015	A
Cronstedtite	0.028	A
Lizardite (natural , porous aggregate)	0.342 ± 0.145	B>C>A
Meteorite powders		
Allende powder	0.169 ± 0.098	B>A
Murchison powder	0.207 ± 0.142	B>C>A
Orgeuil powder	0.257 ± 0.066	B
Artificial ggregates		
Fine diopside, coarse pyrrhotite, acrylate	0.182 ± 0.142	A>B>C
Fine olivine, diopside and pyrrhotite, acrylate	0.445 ± 0.115	C>B
Fine olivine, SiC, TiC, Si_3N_4, TiN, Al_2O_3 and diamond, acrylate	0.469 ± 0.175	C>B
Organic materials		
Acrylate adhesive	0.593 ± 0.054	C
Poly methyl methacrylate	0.467 ± 0.057	C>A*
Poly oxymethylene	0.539 ± 0.101	C>>B>A*
Glycine	0.419 ± 0.068	C>B>A*
^{15}N doped Urea	0.941	C=A*
Coal (sub-bituminous)	0.427 ± 0.123	C>B>A*
Coal (anthracite)	0.277	B
Graphite	0.389 ± 0.126	C=B

Table 1: Projectiles, track dimensions and shapes.

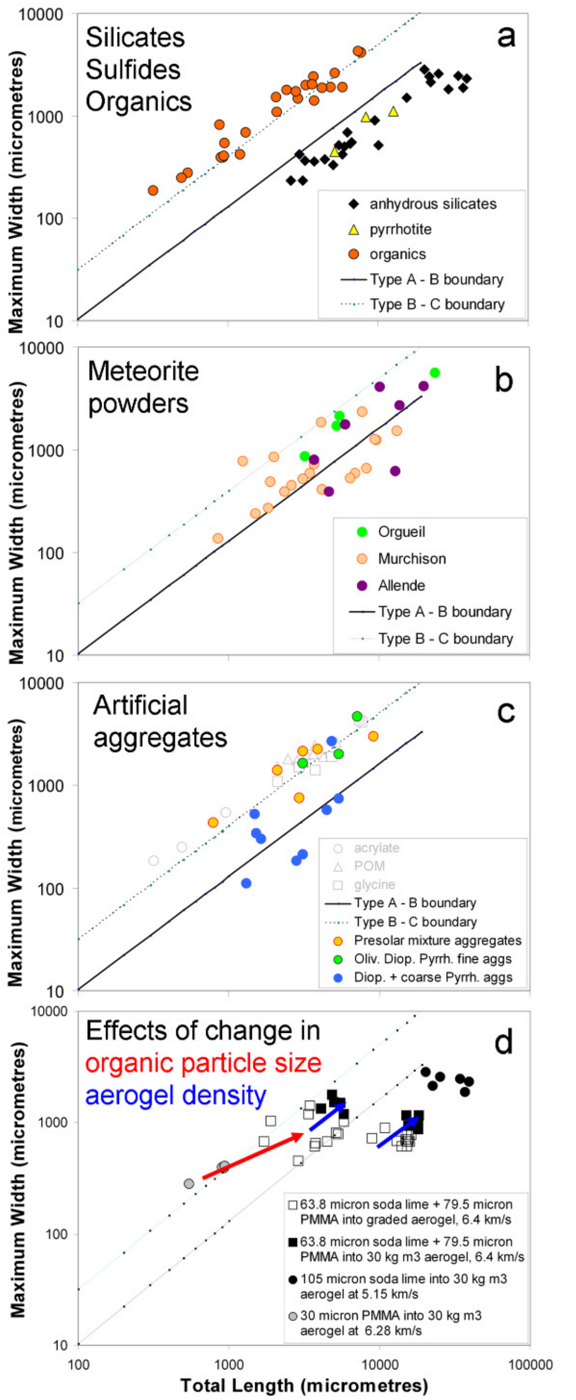

Fig. 2. Comparison of track shapes for different projectiles on: a – c) 30 kg m^{-3} and d) also 5 – 50 kg m^{-3} Stardust-type graded density aerogel targets.

Discussion: Creation of Type A tracks by robust monomineralic, monocrystalline grains (Fig 2a) is no surprise. We attribute the wide range of sizes and shapes seen in impacts of meteorite powders (Fig 2b) to heterogeneity in these carbonaceous chondrites, with coarsely crystalline particles giving Type A tracks, and polymineralic finer-grained matrix making Type B and C. The role of sub-grain size in controlling B vs. C is confirmed by our artificial aggregates (density ~ 2.4 g cm^{3}), coarser sub-grains gave more Type B (and A) tracks (Fig. 2c). Impacts by small organic particles are of distinctive shape (Fig. 2a), although coarser organic grains may create longer tapering tracks (Fig. 2d).

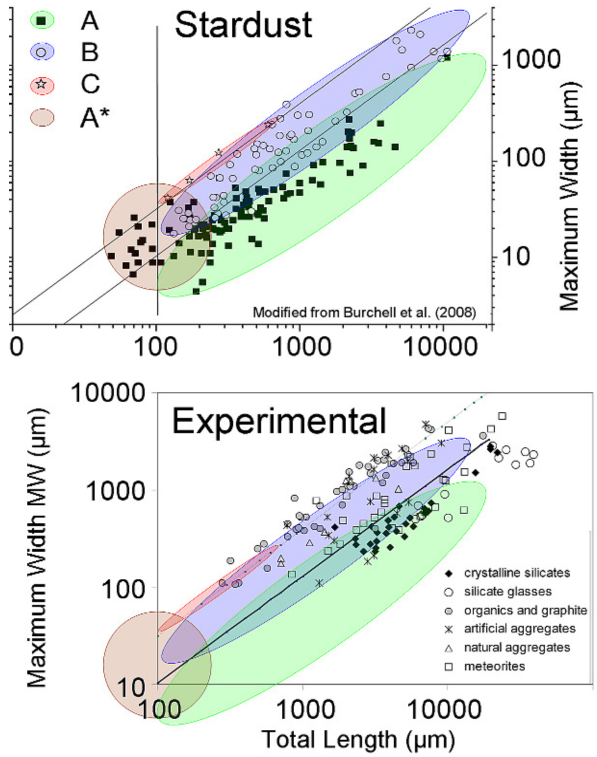

Fig. 3. Comparison of aerogel track shape from Stardust (Wild 2 cometary dust) with experimental LGG shots.

Conclusions: Creation of Type B and C tracks is controlled by impactor internal structure, sub-grain size and overall strength, rather than bulk grain density [5], or volatile content. Organic particles create Type C, or squat Type A* tracks, with length to width ratios reflecting both specific composition and impactor grain size. Type A* tracks on Stardust have so far received little detailed attention, being small, but our experiments suggest they may be rich in volatiles. Comparison to the published shape data for Stardust aerogel tracks (Fig. 3), suggests that the larger Type B tracks on Stardust were made by particles with properties similar to carbonaceous chondrite meteorite powders.

References: [1] Hörz F., et al. (2006) *Science 314,* 1716-1719. [2] Burchell M. J., et al. (2008) *Meteoritics and Planetary Science 43,* 24-40. [3] Trigo-Rodriguéz J. M. et al. (2008) *Meteoritics and Planetary Science 43,* 75-86. [4] Burchell M. J., et al., (1999) *Meas. Sci Tech., 10*, 41-50. [5] Niimi et al. (2011) *LPS XLII,* Abstract #1934.