ASSESSMENT OF THE PRESERVATION OF IMPACT RESIDUES IN STARDUST ANALOGUE CRATERS USING ADVANCED EDX IMAGERY WITH AN ANNULAR SDD.

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Introduction: Studies of experimental Stardust analogue craters from projectiles impacted onto aluminium foil have shown dependence of crater ellipticity and rim morphology on projectile size, shape, velocity and trajectory [1]. When particles impact perpendicular to the target, residue can be found throughout the bowl shape [2], and as much as ~55 % of the impacting particle can be preserved [3]. Here we show how novel energy-dispersive X-ray spectroscopy (EDX) reveals more information as to preservation, modification and distribution of impact residue.

Method: Light gas gun shots at the University of Kent fired 22 µm soda lime glass projectiles onto 100 µm thick Al 1100 foil targets at ~6 km/s. EDX images of craters with different impact angles were acquired using an annular Bruker silicon drift detector (SDD) on an FEI Quanta field emission scanning electron microscope. To enhance spatial resolution for element analysis, revealing features <100 nm in size, low acceleration voltage (9 kV and 2.6 kV) were applied.

Results: The oblique impacts show an uneven crater floor with multiple steps in the downrange direction. The maps show a link between distribution of impact residues and impact angle. As the impact angle departs from perpendicular, the residue distributions initially appear to shift so that they are concentrated in the downrange direction of the crater. The crater surface shows that both the silicate projectile residue and aluminium target have characteristic flow textures, the silicate showing filaments which resembles a Pele's hair type morphology. At crater steps, aluminium also grades into elongated filaments in the downrange direction. Both components have clearly undergone melting. Previous work using focused ion beam sectioning and transmission electron microscopy [4] has demonstrated intimate mixing and compositional blending between impactor and aluminium deeper within melt layers during impact. The presence of micrometre-scale aluminium blebs on top of silicate melt (Fig. 1) suggests that in the latest stages of melt movement, the two melts were essentially immiscible, and aluminium with a flow like morphology was deposited on top of already solidifying silicate melt.

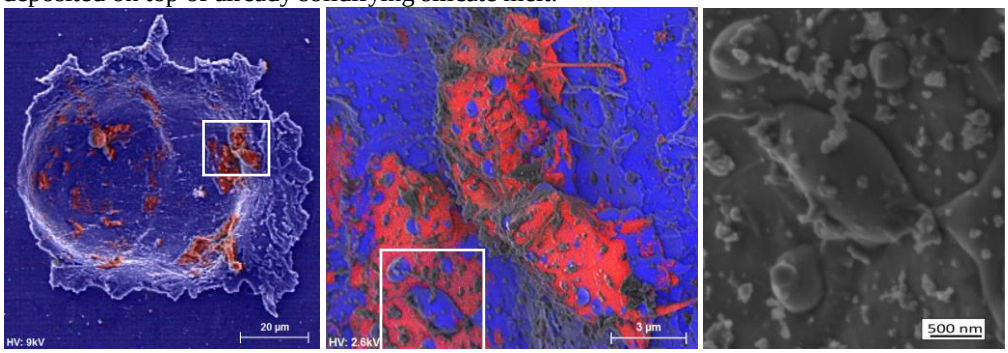

Fig. 1 (a) EDX map (blue: aluminium, red: oxygen) with SEI overlay at low magnification show locations of impact residue throughout all the complex topography in an experimental Stardust analogue crater (9 kV, 416 kcps, 10 min, 250x 269 pixel, 370 nm pixels). (b) EDX map at high spatial resolution of the rectangle shown in (b) showing elongated silicate filaments and aluminium blebs on silicate melt. (2.6 kV, 2.2 kcps, 11 h 23 min, 584x483 pixel, 28 nm pixels). (c) SE micrograph of the rectangle in (b) showing that aluminium with a characteristic flow texture was deposited on top of silicate melt.

Conclusions: An annular SDD can show relationships between even tiny impact residues throughout complex crater shapes, without the necessity of applying a conductive coating or working in low vacuum – both of which might contaminate the surface. The technique should be used as a preliminary reconnaissance method on all Stardust cometary dust craters to give vital information as to the location of specific dust residue components (e.g. distinctive refractory phases) before selection and preparation for other analysis techniques.

References: [1] Wozniakiewicz P. J. et al. 2014 *Meteoritics and Planetary Science* 49:1929–1947.. [2] Wozniakiewicz P. J. et al. 2015 *Meteoritics and Planetary Science* 50: 2003–2023 [3] Kearsley A. T. et al. 2011 *Meteoritics and Planetary Science* 46:A120. [4] Wozniakiewicz P. J. et al. 2012 *Meteoritics and Planetary Science* 47:708–728.