TRANSMISSION ELECTRON MICROSCOPY ADVANCES REVEAL SUBTLE COMET DUST DIFFERENCES.

H. A. Ishii1 and J. P. Bradley1. 1Hawaii Institute of Geophysics & Planetology, University of Hawaii at Manoa. E-mail: hope.ishii@hawaii.edu.

Introduction: Comet dust returned by NASA’s Stardust mission to comet 81P/Wild 2 was expected to resemble chondritic porous interplanetary dust particles (CP IDPs), a unique class of meteoritic material consistent with cometary origins: anhydrous, fine-grained, highly porous, inherited presolar isotope anomalies and ~chondritic composition [A]. An abundant CP IDP component is glass embedded with metal and sulfides (GEMS), typically 50-250 nm diameter low-Fe glass matrices with Fe(Ni) metal and sulfide inclusions down to sub-nanometer dimensions. The deceleration process (ablation, abrasion, recondensation and solidification) experienced by Wild 2 dust in braking from 6 to 0 km/s during capture in silica aerogel resulted in GEMS-like objects, an unfortunate product of finely-intermixed comet dust and silica that superficially resembles GEMS [B]. Some terminal particles in aerogel impact tracks have fine-grained (fg) material associated with large mineral(s). Researchers debate whether this fg-material is indigenous to Wild 2 and shielded by the terminal particle during passage through the aerogel or whether it results from the deceleration process. We applied transmission electron microscopy (TEM) advances in rapid, multi- SDD-detector, high S/N EDX mapping to Wild 2 dust and likely-cometary CP IDPs for detailed comparison of Wild 2 fg-material and GEMS.

Samples and Methods: We examined ultramicrotomed sections of GEMS-rich CP IDPs U217B19 (8 µm) and U220A19 (10 µm) and the terminal particle (8 µm) of Stardust track “Febo” (NASA C2009,2,57,2,28), comprised of a large (~4 µm) Fe(Ni) sulfide, smaller Mg-rich pyroxene and associated fg-material. TEM-EDX mapping was performed on two FEI Titan 80-200 kV (S)TEMs (NCEM, Oregon State U), each with 4 Bruker SDD detectors at 200 kV with pixel size as small as 3 nm.

Results and Discussion: EDX maps reveal subtle differences between GEMS in CP IDPs and fg-material in Febo: GEMS are discrete and rounded, whereas discrete boundaries are difficult to define in the fg-material. Previous analysis reported Febo fg-material as chondritic (excepting Si due to aerogel) [C], but in most of this section, it is variably depleted in Mg (~25-35x) and Ca (~15-98x), in contrast to GEMS (within ~2-3x chondritic). Of 4 regions deemed GEMS-like in HAADF images, 2 are within ~2-3x chondritic; however, their element distributions are unlike GEMS in CP IDPs. Within one ~500 nm object, 150-200 nm subgrains of partially reduced sulfide, melted enstatite and a Ca-bearing pyroxene produce a chondritic composition. Thus, Febo fg-material is consistent with deceleration debris from an incident particle comprised of sulfide and at least 2 pyroxenes. Indigenous GEMS in the Wild 2 sample, if they were present, are exceedingly hard to identify and likely destroyed by capture or diluted beyond recognition.


Acknowledgements: This work was supported by NASA LARS grant NNH11AQ79I (HAI). Work at the Molecular Foundry (NCEM, LBL) was supported by the Office of Science, BES, US DOE under Contract No. DE-AC02-05CH11231.