AN INCONVENIENT REALITY: TERRESTRIAL ALTERATION OF INTERPLANETARY DUST PARTICLES (IDPs) AND MICROMETEORITES (MMs).

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Introduction: Techniques used to study the elemental, isotopic and molecular compositions of IDPs and MMs have vastly improved with detection limits and spatial resolution for spectroscopy approaching ~1 nm for trace inorganic and organic constituents. There are implications for geochemistry, astrobiology and astrophysics but renewed scrutiny of atmospheric entry heating and terrestrial contamination is sorely needed. Most IDPs >10 μm in diameter were heated above 500°C, and MMs >50 μm above 800°C for several seconds during atmospheric entry [1]. While solar flare tracks and thermally sensitive minerals confirm that some survive atmospheric entry relatively intact, evidence of thermal alteration and contamination can be found at the nanometer scale in almost all of them.

Methods and results: We compared small and large IDPs and MMs and performed *in-situ* heating experiments on small IDPs and analogues to reassess the effects of heating, and multi-detector, high solid-angle energy-dispersive x-ray spectroscopy (EDX) to reassess terrestrial contamination. From this study we conclude the following:

Atmospheric entry heating effects, often subtle but especially evident in larger IDPs and MMs (e.g. Fig. 1), have been interpreted in terms of temperature and thermal gradients. However, redox gradients are likely equally or potentially even more important with grains at surfaces exposed to atmospheric oxygen responding very differently to interior grains in organic carbon matrix. At 300-400°C sulfides within some amorphous silicates (GEMS) mobilize, accumulate at grain surfaces and may oxidize to magnetite rims if exposed to atmospheric oxygen [2]. There is evidence that 2C-pyrrhotite, the most common sulfide in CP IDPs may be a thermal transformation product of a lower-temperature cubic sulfide [3]. At ~400°C organic carbon densifies and by ~500°C it has a lacey, vesiculated morphology consistent with some prior studies but inconsistent with others [e.g. 4-6].

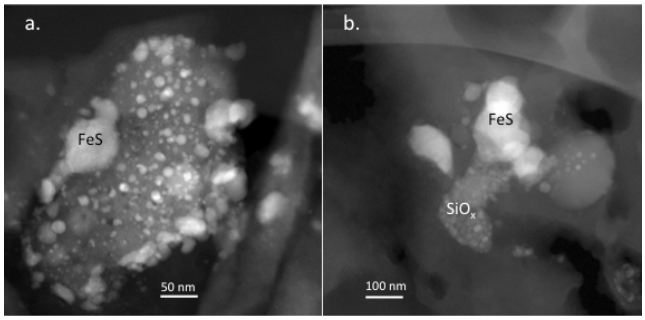

Figure 1: *(Right) Darkfield images of thermally altered GEMS in micrometeorite UCAMM0833-21. Ripened and rounded inclusions in GEMS with sulfide-decorated surfaces (left) and segregation of Fe-sulfides ("FeS") from silicate+FeNi metal ("SiO_x") (right) are due to atmospheric entry heating.*

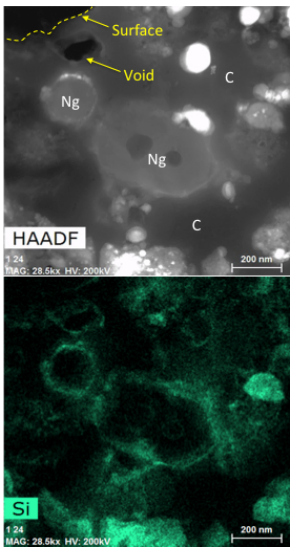

Figure 2: *(Left) Darkfield HAADF image (top) and Si x-ray map (bottom). Silicone oil close to IDP surface (shown) results in Si accumulating and mixing with indigenous silicates and sulfides around denser organic nanoglobules ("Ng") and more diffusely distributed in lower density organic matrix ("C").*

Terrestrial contamination of IDPs and MMs has long been recognized; examples include stratospheric S and Br and exposure to aqueous leaching. High signal-to-noise x-ray mapping with trace element detection indicates that common terrestrial elements (e.g. Na, P, and K), some of astrobiological significance, can be significant contaminants at the nanoscale. IDPs collected in silicone oil are contaminated with silicone oil that is very difficult to detect using techniques like IR and SXRF. From a study of 200 IDPs that included silicone oil retention tests Schramm et al. [7] conclude that as much as 10 wt. % of the Si in some IDPs may be attributable to retained silicone oil.

Conclusions: Understanding terrestrial alteration of IDPs and MMs is fundamentally important issue and most studies are performed by individual researchers examining different IDPs, using different analytical methods and reporting often conflicting results. This needs to change; future allocations of IDPs and MMs should stipulate sample preservation for reallocations with the goal of a wider community participation in assessing terrestrial alteration in the same samples.

References: [1] Love, S.G. and Brownlee, D. E. (1996) *Meteoritics & Planetary Science* 31: 394-402. [2] Bradley, J. P. et al. (2014) *LPS XXXXV*, Abstract #1178. [3] Dai, Z. and Bradley, J. P. (2001) *Gecohim. Cosmochim. Acta* 65: 3601-3612. [4] Sandford, S. A and Bradley (1989) *Icarus* 82: 146-166. [5] Flynn, G. J. In *Accretion of extraterrestrial Matter Throught Earth's History* (Springer US, 2001) pp.107-127. [6] Matrajt G. et al (2006) Meteoritics 41: 903-911. [7] Schramm, L. S. et al., (1989) *Meteoritics* 24: 99-112.