Organic components in interplanetary dust particles and their implications for the synthesis of cometary organics

Conference or Workshop Item

ORGANIC COMPONENTS IN INTERPLANETARY DUST PARTICLES AND THEIR IMPLICATIONS FOR THE SYNTHESIS OF COMETARY ORGANICS.

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Introduction: The organic matter (OM) in interplanetary dust particles (IDP) is commonly associated with low-ordered organic compounds such as ketone and hydrocarbons with aliphatic and aromatic moieties [1-4]. The anhydrous chondritic porous (CP) IDPs share a cometary origin [5], and are the most primitive astromaterial that have evaded parent body alteration processes. This study compares the organic compositions of CP-IDPs to their texture, chemical & isotopic distributions, which provides insights into the processes that led to the observed high porosity texture [6] and organic composition [7] of comet 67P/Churyumov-Gerasimenko.

Samples and Methods: Five IDPs (L2036-CA1, L2055-T1, L2055-U1, L2071-K1 and L2076-Q1) were picked by a micromanipulator and pressed flat with a spectroscopic grade sapphire window into annealed high-purity gold foils mounted on aluminium stubs. Electron images were obtained with a FEI Quanta 650 field emission gun scanning electron microscope at Natural History Museum London. The OM of the IDPs was analyzed by a Jobin-Yvon Horiba LabRam HR Raman microprobe with a 514 nm laser at the The Open University (OU) (laser power ≈ 60 μW). H, C, N, and O isotopic analyses were performed by a NanoSIMS 50L ion microprobe at OU.

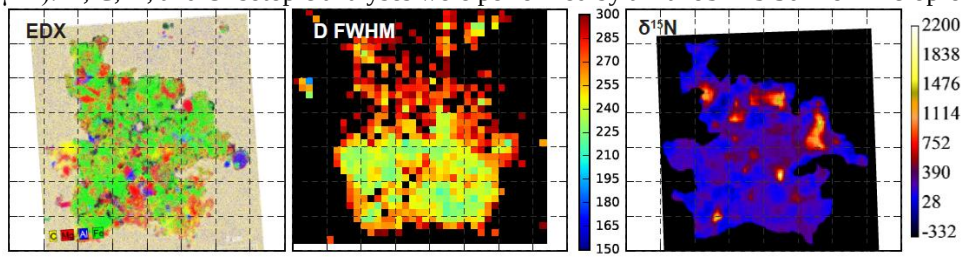

Figure 1. *EDX combined C-Mg-Al-Fe, Raman D band FWHM, and $\delta^{15}N$ isotopic ratio maps of L2076-Q1.*

Results and Discussion: The IDPs are fine-grained, porous CP-IDPs that are composed of anhydrous minerals such as Mg-silicates and low-Ni sulphides, and display a bulk elemental composition similar to that of chondritic materials [8] (***Figure 1***). The 'fluffy' texture is similar to the grains collected in the coma of 67P [6]. C-rich phases often occur in the IDP matrix as fine-grained material around silicate grains, where the organics (e.g. polyoxymethylene on 67P [7]) could be synthesized by irradiation of preexisting ices [9], and sublimation of ices concentrated the organics for polymerization and grain surface reactions.

The Raman parameters of the IDPs in this study form a continuum that span the most primitive OM to the most heated IDPs studied to date (***Figure 2***). The presence of magnetite rims and the degree of OM structural order of L2076-Q1 indicate that the particle has been heated during atmospheric entry, which contrasts to the unheated Grigg–Skjellerup IDPs L2055-T1 and L2055-U1. Atmospheric entry heating induces a twofold heating effect on the IDP IOM. Cracking leads to fragmentation of large IOM structure into light hydrocarbons, while unshielded OM subjects to high-temperature annealing causing sp^2 clustering.

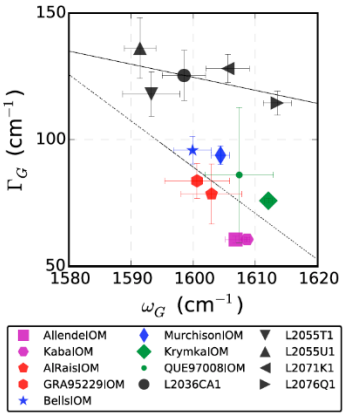

Figure 2. *C Raman band parameters of the OM in the IDP samples and chondritic OM.*

The Raman parameters of the IDP- and chondritic-OM are incongruent to each other. Such variation can be explained by the disordering of chondritic-OM from nanocrystalline graphite to low sp^3 hydrogenated amorphous carbon, where most sp^3 sites are bonded to hydrogen or heteroatoms, likely with an increasing H content, higher aliphatic/aromatic ratio, and reducing sp^2 cluster/domain sizes. The enrichments in the heavy isotopes suggest that the organics are indigenous to the IDPs (***Figure 1***; ***Table 1***). The bulk $\delta^{15}N$ value of L2055-T1 is typically lower than other IDPs, which also indicate that this IDP has been heated to a minimal extent as the ^{15}N carrier is prone to thermal decomposition.

Table 1. *Bulk isotopic compositions of the IDPs.*

	$\delta^{13}C$ (‰)	$\delta^{15}N$ (‰)
L2036-CA1	–45.6 ± 1.3	383.3 ± 4.6
L2055-T1	–23.7 ± 0.5	947.1 ± 2
L2055-U1	–16.5 ± 0.6	205 ± 1.9
L2071-K1	–26.8 ± 0.7	151.2 ± 2.7
L2076-Q1	–41.8 ± 0.9	279.5 ± 3.4

References: [1] Busemann H. *et al.* (2009) *EPSL, 288,* 44-57. [2] Clemett S.J. *et al.* (1993) *Science, 262,* 721-725. [3] Flynn G.J. *et al.* (2004) *ASR, 33,* 57-66. [4] Matrajt G. *et al.* (2004) *A&A, 416,* 983-990. [5] Brownlee D. *et al.* (1995) *LPSC, 26.* [6] Schulz R. *et al.* (2015) *Nature, 518,* 216-218. [7] Wright I.P. *et al.* (2015) *Science, 349.* [8] Zolensky M. *et al.* (1993) *GCA, 57,* 3123-3148. [9] Bernstein M.P. *et al.* (1995) *The Astrophysical Journal, 454,* 327.