ADVANCED SEM-EDX AND ISOTOPE MAPPING OF A REFRACTORY GRAIN IN A FINE-GRAINED IDP

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Introduction: It is well documented that cometary samples returned from Wild2 contain material that must have formed at high T, presumably in the inner Solar System (SS) [1]. This has led to the suggestion for transport of materials from the inner to the outer solar nebula [1], or possibly for formation in local high temperature regions associated with giant planetary embryos [2]. Here we focus on an Interplanetary Dust Particle (IDP) of probable cometary origin composed of a fragment of a melilite-olivine refractory grain within a fine-grained silicate matrix. Detailed comparison of such fragments in cometary IDPs with those reported in meteorites can provide critical constraints on some fundamental SS formation mechanisms.

Methods: The IDP, Sizergh (Collector L2071, cluster 3), was analysed by Raman, FEG-SEM and NanoSIMS 50L following procedures in [3,4]. SEM-EDX spectrum images were acquired at high spatial resolution using low accelerating voltages (5 kV) with an annular Bruker FlatQUAD SDD. Advanced data processing included peak deconvolution to separate low energy X-ray lines, and chemical phase mapping which detects similarly composed areas with the help of mathematical methods.

Results: Net intensity element and chemical phase maps reveal the presence of a fragment (4x9 µm) composed of forsteritic olivine surrounding melilite, held within fine-grained material that forms the rest of the IDP (total IDP size 15x20 µm). The fine-grained material appears to be a mix of ~100nm to 1µm sized silicate, carbon and sulphide phases, similar to other chondritic-porous (CP) IDPs. NanoSIMS isotope imaging reveals the olivine has $\Delta^{17}O = -14.3 \pm 10$ ‰, the melilite $\Delta^{17}O = -21.5 \pm 22$ ‰, with the surrounding chondritic porous material having $\Delta^{17}O = 1.8 \pm 4$ ‰ (all 2σ errors).

Discussion: The fine-grained material in Sizergh is similar to that measured in many other anhydrous CP-IDPs which, along with its primitive organic Raman signature, suggests that it is probably of cometary origin. The ^{16}O-rich composition of the melilite-olivine fragment indicates it is a refractory grain, possibly an amoemoid olivine aggregate (AOA). This fragment, presumably formed at high T in the inner SS, must have been transported to the comet-forming region, for which we assume a similar mechanism as suggested for Stardust refractory material [1]. The fact that the olivine and melilite have $\Delta^{17}O$ values within error of other refractory materials in meteorites, and each other, indicates that this fragment did not experience secondary alteration on a parent body or with nebular gas during transport.

This study documents that low voltage SEM-EDX at high spatial resolution, below sub-µm scale, represents a step forward for assessing the composition and distribution of fine-grained phases in IDPs. This is not the first time that refractory material has been found in a cometary IDP, highlighting that Wild2 is not an unusual comet and that we must continue to rethink our understanding of the early SS and comet-forming region.

References: [1] McKeegan K. D. et al 2006. *Science* 314: 1724-1728. [2] Bridges J. et al. 2012. *EPSL* 341-344: 186-194. [3] Starkey N. A. et al. 2013. *MAPS* 48: 1800-1822. [4] Starkey N. A. and Franchi I. A. 2013. *GCA* 105: 73-91.