MICROMETEOROID IMPACTS ON THE HUBBLE SPACE TELESCOPE WIDE FIELD AND PLANETARY CAMERA 2: SMALLER PARTICLE IMPACTS.

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Introduction The radiator shield on the Wide Field and Planetary Camera 2 (WFPC2) was subject to optical inspection [1] following return from the Hubble Space Telescope (HST) in 2009. The survey revealed over 600 impact features of > 300 µm diameter, from exposure in space for 16 years. Subsequently, an international collaborative programme of analysis was organized to determine the origin of hypervelocity particles responsible for the damage [2]. Here we describe examples of the numerous smaller micrometeoroid (MM) impact features (< 700 µm diameter) which excavated zinc orthotitanate (ZOT) paint from the radiator surface, but did not incorporate material from underlying Al alloy; larger impacts are described by [3]. We discuss recognition and interpretation of impactor remains, and MM compositions found on WFPC2.

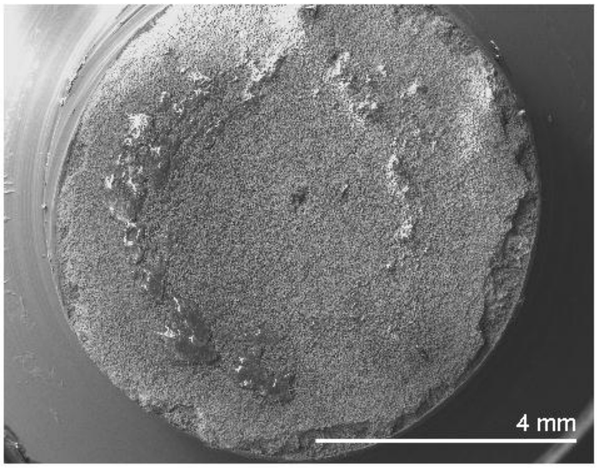

Fig. 1. WFPC2-97: Typical smaller micrometeoroid impact, Secondary Electron Image (SEI) of a core [2].

Methods: Uncoated core samples were examined using backscattered electron imagery (BEI) in a Zeiss EVO 15 LS scanning electron microscope (SEM) at NHM, with digital elevation models (DEM) created from stereo pairs for shape (especially depth) measurement (Fig. 2). Energy dispersive X-ray (EDX) maps were created using a silicon drift detector (SDD) and INCA SmartMap software, and a Bruker XFlash 5060F pole-piece mounted quad detector at Bruker, in Berlin. Carbon-coated samples were examined with JEOL *7600F and 5910LV SEMs* at JSC. Point spectra were collected from within and outside impact features. Locations of impact melts were compared to the unaffected paint surface, to recognise incorporation of impactor material. This required detailed characterisation of the radiator paint [4]. Due to the irregular surface topography and porosity of ZOT paint, matrix correction was not attempted. For spectra collected at NHM, deconvolution was performed using the Spectrum Processing function in INCA software, giving X-ray counts in element peaks and background (sigma). These data were used to establish whether MM indicator elements were detected above statistically defined background (3 x sigma), plotted using protocol of [4].

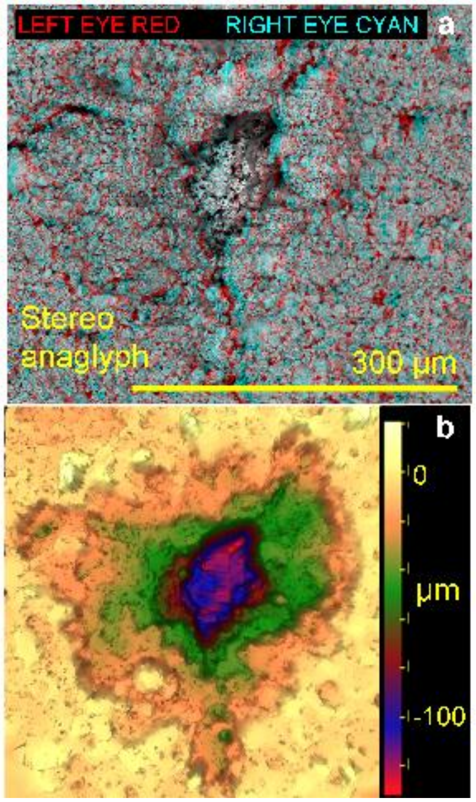

Fig. 2. WFPC2-339: a) Stereo anaglyph of BEI images; b) DEM shows crater is restricted to the ZOT paint layer, and does not excavate the underlying Al alloy.

Results: The smaller impact features contained frothy impact melt, mostly containing compoents of the

ZOT paint.. Comparison of EDX spectra to clean paint composition showed that locally, impact melts had enrichment of Mg and Fe (e.g. Fig. 3) without significant increase in Al, indicating that these elements were not derived from the alloy beneath. These resemble silicate MM analogue impacts [4]. A few craters contained Fe and Ni enrichments, indicating probable MM metal, or Fe and S (e.g. Fig. 4) like experimental sulfide MM analogues of [4].

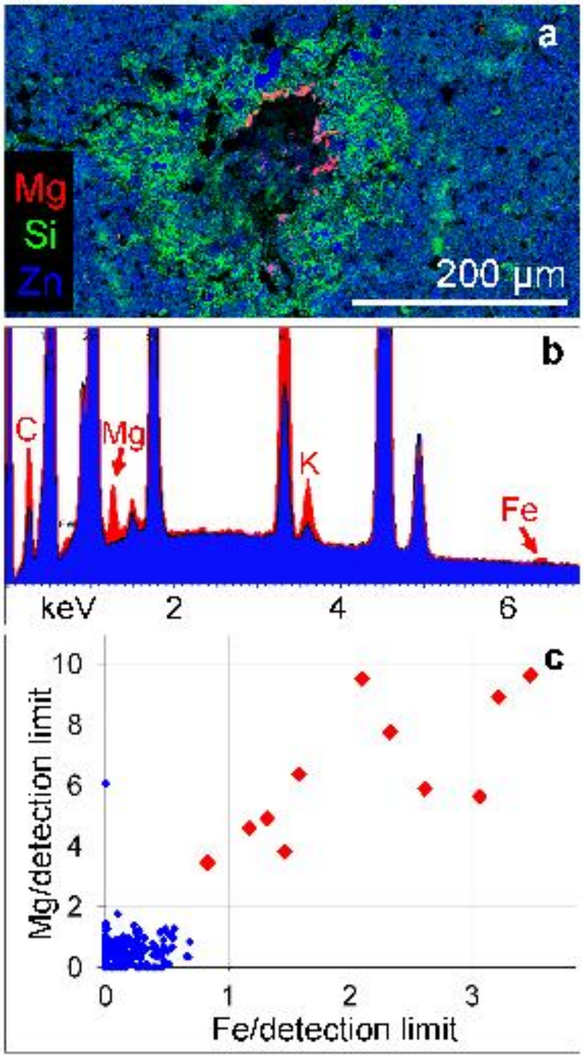

Fig. 3. WFPC2-339: a) EDX maps show Mg enriched in melt around pit; b) EDX spectrum melt (red) compared to unaltered paint (blue); c) Mg and Fe enrichment in frothy melt (red), above levels in paint (blue).

Conclusions: The WFPC2 smaller craters give a snapshot of the natural dust particle population encountered by spacecraft during long space exposure in low Earth orbit. Despite effects of hypervelocity impact, they preserve a record of diverse MM compositions.

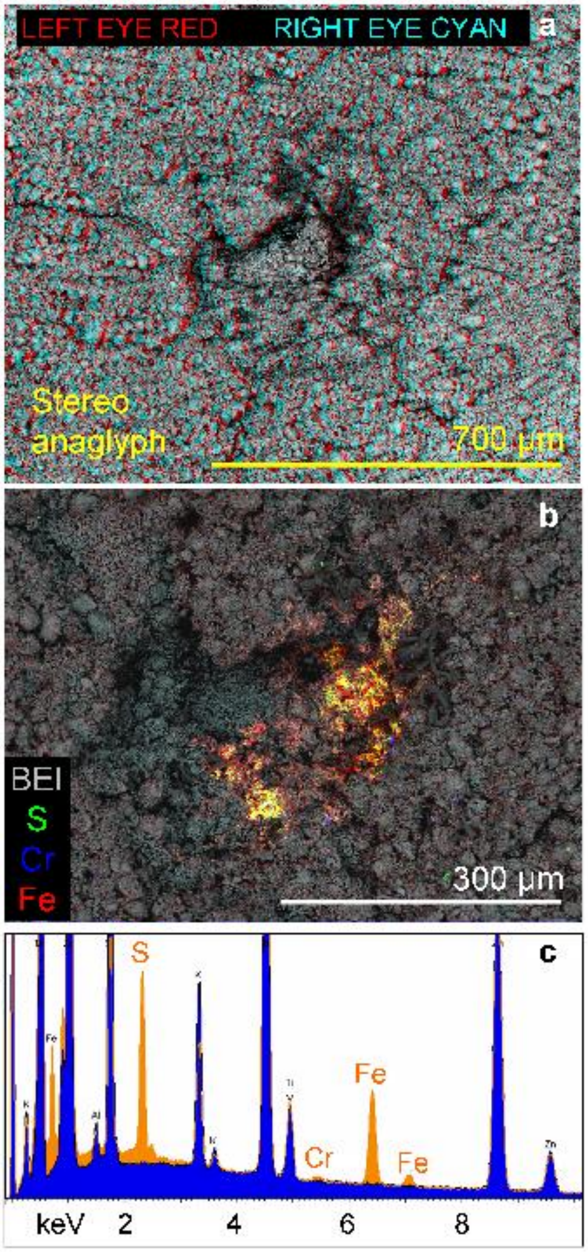

Fig. 4. WFPC2-156: a) BEI stereo anaglyph; b) EDX maps show Fe and S enriched in melt; b) EDX spectrum melt (orange) compared to unaltered paint (blue).

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References : [1] Opiela, J.N. et al. (2012) *NASA/TP-2012-217359* [2] Anz-Meador P. et al. (2013) Proc. 6th European Conf. Space Debris, ESA SP723: s1b_anzme.pdf, CD-ROM [3] Kearsley A. T. et al. (2014) *LPSC* 45 submitted [4] Kearsley A. T. et al. *MAPS* submitted.