MICROMETEOROID IMPACTS ON THE HUBBLE SPACE TELESCOPE WIDE FIELD AND PLANETARY CAMERA 2: LARGER PARTICLES. A. T. Kearsley[1], G. W. Grime[2], J. L. Colaux[2], V. V. Palitsin[2], C. Jeynes[2], R. P. Webb[2], D. K. Ross[3,4], P. Anz-Meador[3,4] , J.C. Liou[4], J. Opiela[3,4], T. Griffin[5], L. Gerlach[6], P. J. Wozniakiewicz[1,7], M. C. Price[7], M. J. Burchell[7] and M. J. Cole[7] [1]Natural History Museum (NHM), London, SW7 5BD, UK (antk@nhm.ac.uk) [2]Ion Beam Centre, University of Surrey, Guildford, [3]Jacobs Technology, Houston, TX, USA [4]NASA-JSC, Houston, TX, USA, [5]NASA-GSFC, USA, [5]consultant to European Space Agency, ESA-ESTEC, Noordwijk, The Netherlands [6]School of Physical Science, University of Kent, Canterbury, CT2 7NH, UK.

Introduction: The Wide Field and Planetary Camera 2 (WFPC2) was returned from the Hubble Space Telescope (HST) by shuttle mission STS-125 in 2009. In space for 16 years, the surface accumulated hundreds of impact features [1] on zinc orthotitanate paint, some penetrating through into underlying metal. Larger impacts were seen in photographs taken from within the shuttle orbiter during service missions [2], with spallation of paint in areas reaching 1.6 cm across, exposing alloy beneath. Here we describe larger impact shapes, the analysis of impactor composition, and the micrometeoroid (MM) types responsible.

Fig. 1. The WFPC2 radiator shield wrapped in Llumalloy sheeting at the Johnson Space Center (NASA-JSC), locations of the large craters indicated by arrows.

Methods: Samples were cut using the technique of [3], and examined in a Zeiss EVO 15 LS scanning electron microscope at NHM. Digital elevation models (DEM) were created from stereo pairs, to reveal the shape and size of features (e.g. Fig. 2b). A silicon drift energy dispersive X-ray detector (EDX) was used to collect point X-ray spectra and maps. Although data were collected under quantitative analysis conditions and matched to analysis standards, due to the complex surface topography and porosity, matrix correction was not attempted. Instead, spectral deconvolution was performed, using Oxford Instruments INCA software to measure X-ray counts in characteristic element peaks and background (sigma), to establish detection above a statistically defined background (3 x sigma). After characterisation of both the paint and underlying alloy, incorporation of impactor remains was recognised in two types of analytical plot [4], validated by experiments in the light gas gun at the University of Kent [5].

Results: 63 impact features > 700µm across, each with paint spallation > 300 µm, showed combinations of five main components (e.g. Fig. 3): a) an exposed surface of Al alloy, often with adhering fragments of paint; b) a bowl-shaped pit or field of compound pits, penetrating into the alloy; c) frothy impact melt, derived mainly from paint (Fig. 3); d) droplets/coatings of alloy-dominated metal melt; and occasionally e) retained fragments of the impacting particle (Fig 4).

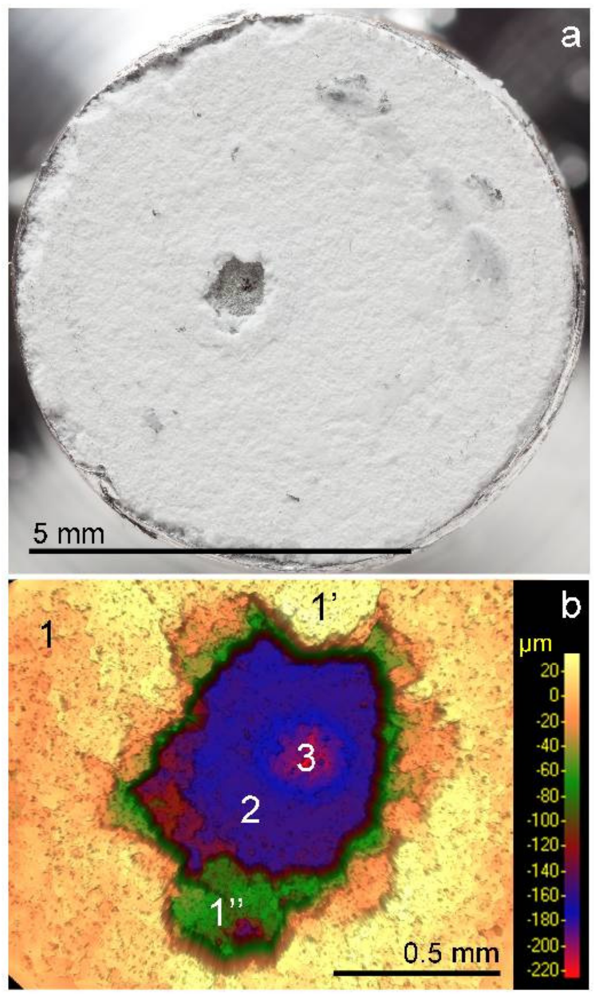

Fig. 2. WFPC2 sample 121: a) optical image; and b) DEM, showing: *1* paint external surface; *1"* partially exfoliated paint; *2* exposed surface of aluminium alloy; *3* compound crater pits in the surface of alloy.

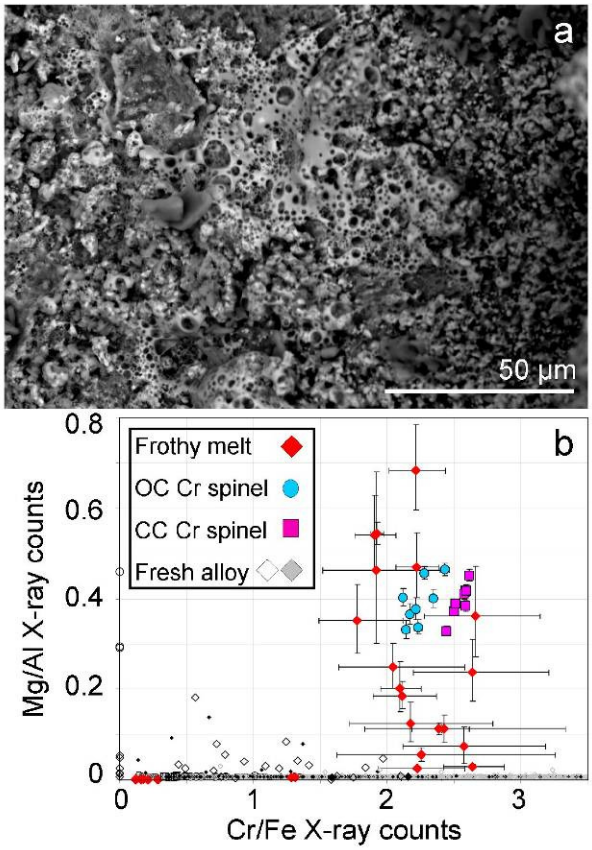

Fig. 3. WFPC2 sample 121: a) BEI of frothy impact melt outside compound pits; b) plot of melt composition in Mg/Al versus Cr/Fe X-ray counts compared to ordinary and carbonaceous chondrite Cr-rich spinels.

In most features, EDX of frothy impact melt (Fig. 3a) showed enrichment of elements indicating the MM composition (eg Cr-rich spinel, Fig. 3b). The commonest signature was increased Mg and Fe, and occasionally S, Ca and Ni. Impactor fragments were found in X-ray maps of three large craters, revealing Mg, Si and O-bearing compositions: one non-stoichiometric; one probably pyroxene; and one a shocked Mg-rich olivine (Fig. 4). If no clear signature was seen in EDX data, the impact was submitted for ion beam analysis [6].

Conclusions: The WFPC2 radiator surface preserved a signature of impacts by MM across a wide size range, from the smaller particles of [7] to large Mg silicate, sulfide and oxide grains. Impact features penetrating to the alloy layer occasionally contain fragments of the impactor, fused to the surface within melt (Fig. 4). More frequently, the nature and composition of the impactor could only be determined by long duration (200 s) EDX spectra of impact melt, in which subtle traces of material other than the paint or alloy could be distinguished and interpreted.

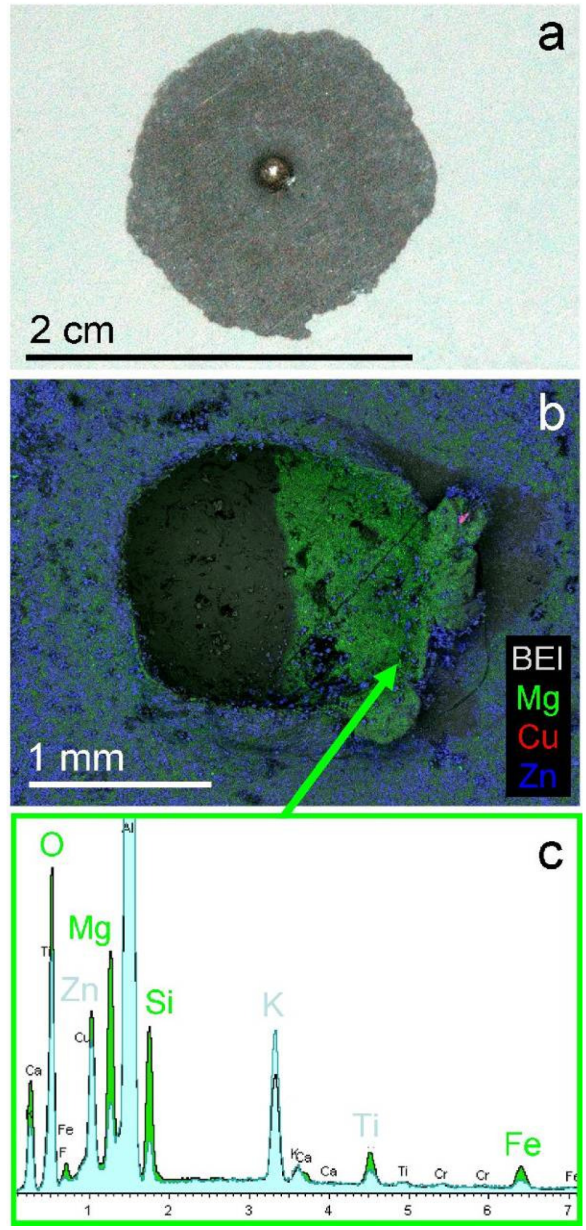

Fig. 4. WFPC2-424: a) optical image; b) EDX maps c) Mg-, Fe-silicate fragment, probably shocked olivine.

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