IMPACTS ON THE HUBBLE SPACE TELESCOPE WIDE FIELD AND PLANETARY CAMERA 2: EXPERIMENTAL SIMULATION OF MICROMETEOROID CAPTURE. M. C. Price[1], A. T. Kearsley[2], P. J. Wozniakiewicz[1,2], J. Spratt[2], M. J. Burchell[1], M. J. Cole[1], P. Anz-Meador[3,4], J.C. Liou[4], D. K. Ross[3,4], J. Opiela[3,4], G. W. Grime[5], J. L. Colaux[5], V. V. Palitsin[5], C. Jeynes[5], R. P. Webb[5], T. Griffin[6] and L. Gerlach[7]. [1]School of Physical Science, University of Kent, Canterbury, CT2 7NH, UK (mcp2@star.kent.ac.uk) [2]Natural History Museum (NHM), London, UK [3]Jacobs Technology, Houston, TX, USA [4]NASA-JSC, Houston, TX, USA [5]Ion Beam Centre (IBC), University of Surrey, UK [6]NASA-GSFC, USA [7]consultant to ESA, ESA-ESTEC, Noordwijk, The Netherlands.

Introduction: Hypervelocity impact features have been recognized on painted surfaces returned from the Hubble Space Telescope (HST) [1]. Here we describe experiments that help us to understand their creation, and the preservation of micrometeoroid (MM) remnants. We simulated capture of silicate and sulfide minerals on the Zinc orthotitanate (ZOT) paint and Al alloy plate of the Wide Field and Planetary Camera 2 (WFPC2) radiator, which was returned from HST after 16 years in low Earth orbit (LEO). Our results also allow us to validate analytical methods [2] for identification of MM (and orbital debris) impacts in LEO.

Fig. 1. a) HST seen from orbiter Discovery during service mission 3A (STS-103) in 1999. The 2.2 m wide WFPC2 radiator surface is covered in white ZOT paint.

Methods: WFPC2 samples were extracted by coring at JSC [1]. 237 cores were examined by scanning electron microscopy (SEM) at NHM. 29 'blank' cores revealed no impact and only minor surface contamination. One 'blank' with no impact, and one core with a small impact (~250 µm diameter) were mounted in resin, cut and polished to provide vertical sections, in which the radiator structure [1] and distribution of impactor residue (Fig. 2) were measured.

Fifteen 'blank' samples were used as experimental targets in the light gas gun (LGG) at Canterbury [3]. Six shots fired fine polydisperse powder grains of: olivine, pyrrhotite (2 shots), alumina, aluminium and iron at stub-mounted cores, impacting perpendicular to the target at ~ 7.5 km s^{-1}. Projectile sizes were restricted to < 125 µm to prevent large scale spallation of paint from the relatively small core top surface. Experimental and LEO impacts were compared using backscattered electron imagery (BEI) and energy dispersive X-ray (EDX) maps. Digital Elevation Models (DEM) were constructed from BEI stereo pairs. Long duration (200 s) EDX spectra collected from impact melts and background areas of paint and alloy, were processed and plotted as [2]. A Cameca SX100 wavelength dispersive X-ray (WDX) microprobe mapped impact residue in a cross section of a LEO crater (Fig. 2).

Results: Impacts by olivine and pyrrhotite reproduced most of the physical features seen in the smaller (< 600 µm diameter) WFPC2 impacts (e.g. Fig. 2).

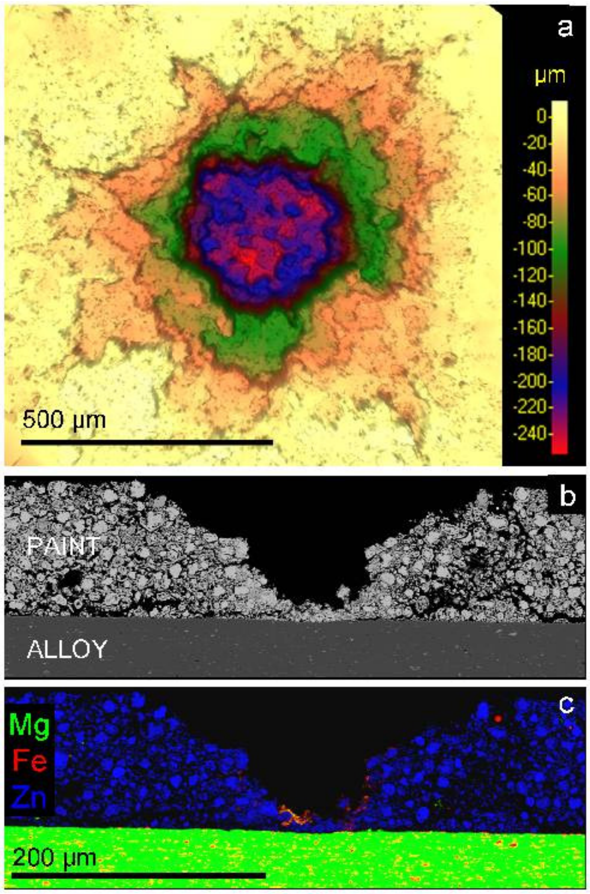

Fig. 2. WFPC2-11, an impact from LEO: a) DEM; vertical section b) BEI and c) WDX maps, showing Mg and Fe in MM residue lining the crater shaft and floor.

Impacts show combinations of 4 parts: 1) a downward tapering 'cone' from spallation of the paint surface, extending outward into radial gullies; 2) a subvertical 'shaft' through the lower part of the paint; 3) an exhumed surface of underlying alloy. In larger impacts a very broad shaft reveals an extensive area of metal with a fourth distinctive feature: a bowl-shaped pit or field of compound pits, excavated into alloy. Traces of impactor were found in both frothy melt (largely derived from paint), and in alloy melt on the pit surface.

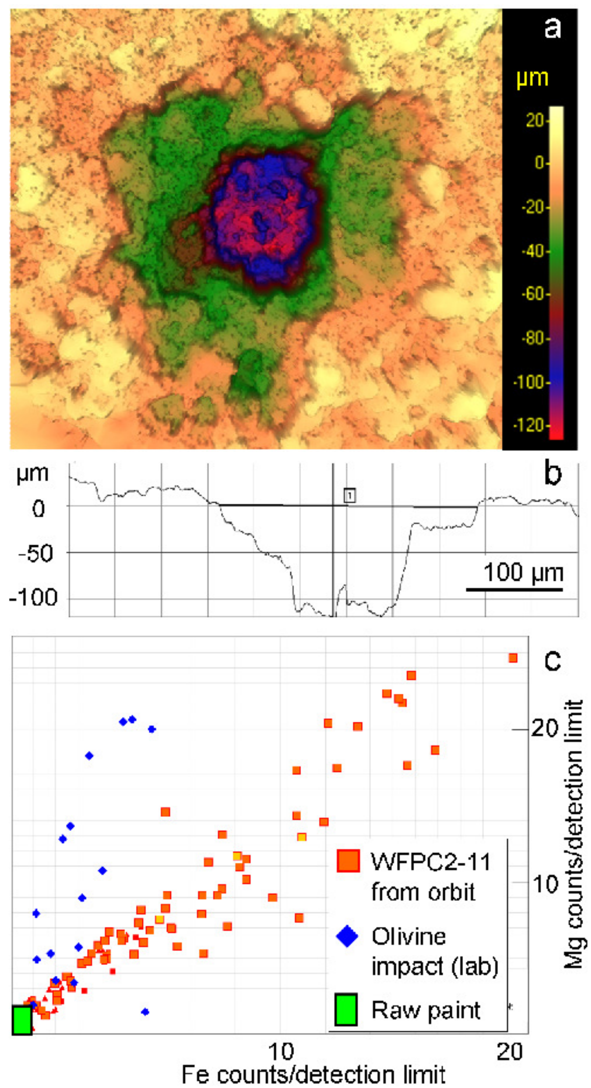

Fig. 3. Olivine LGG shot: a) DEM of impact onto WFPC2 paint; b) depth profile showing no penetration to alloy; c) plot comparison with impact in Fig 2., both showing impactor Mg and Fe added to the paint.

LGG olivine impacts are a good match for many WFPC2 features, although LEO impacts show greater diversity of Mg:Fe ratios. But does porous WFPC2 paint complicate preservation of iron sulfide remnants, by S loss due to shock heating (as in Stardust [4])?

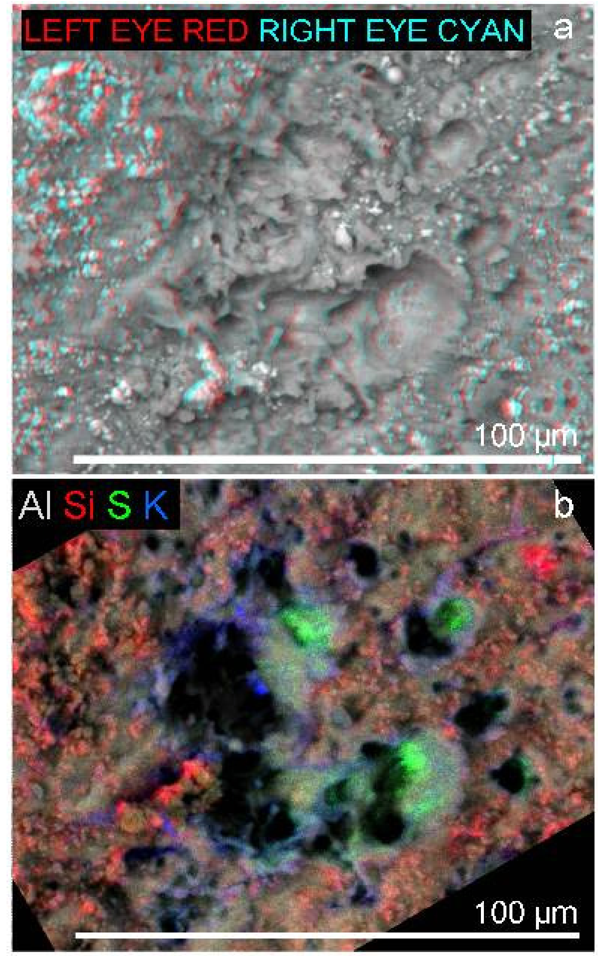

Fig. 4. Pyrrhotite LGG shot: a) Stereo BEI and b) EDX maps of compound pits in alloy surface, paint spalled.

Some sulfur is retained with iron in impact melt (Fig. 4), but impact-driven sulfur movement may also occur. More detailed study like [5] is required. Not all S-rich patches on WFPC2 are related to impact [1] as rapid growth of $KHCO_3$ crystals on the surface of ZOT paint, aided by moist air, can scavenge atmospheric sulfur.

Conclusions: LGG shots show residue from two important MM components can be recognized in impacts on paint and alloy components. Although made at relatively low velocity compared to asteroid and comet derived MM in LEO (20 -70 km s^{-1}), giving smaller impacts and less shock processing, the resultant features and residue compositions do closely resemble those formed on WFPC2 during exposure to space.

References: [1] Anz-Meador P. et al. (2013) Proc. 6th European Conf. Space Debris, ESA SP 723: s1b_anzme.pdf, CD-ROM [2] Kearsley A. T. (2012) *ESA 40001105713/12/NL/GE TN-1* [3] Burchell M. J. et al. (1999) *Meas. Sci. Tech., 10*, 41-50. [4] Ishii H. et al. *Science* 37(319): 447-450 [5] Wozniakiewicz P. J. et al. (2012) *Meteoritics & Planet. Sci., 47,* 708-728.