COSMIC DUST COLLECTION AND ANALYSIS USING THE CAPTURE CELL TECHNIQUE ON SPACE SHUTTLE FLIGHT STS-3/OSS-1

J.A.M. McDonnell, W.C. Carey, and D.G.Dixon, Space Sciences Laboratory, University of Kent at Canterbury, Canterbury, England CT2 7NT.

The Microabrasion Foil Experiment (MFE) from the University of Kent was exposed to space for eight days in March 1982, during the third Space Shuttle flight, the "Pathfinder" OSS-1 mission.

As a passive detector, MFE comprises a double layer foil structure of one square metre total area. The top layer of 5 micron aluminium foil is held 1.0 mm above a Kapton sheet by a gold-coated brass grid and forms an array of capture cells - effectively a miniature meteoroid bumper as proposed by Whipple [1] for spacecraft protection. After deployment MFE was returned to Canterbury for analysis.

The MFE was designed to record and measure the high-velocity microparticle flux in near-earth orbit for particle masses > 10^{-12} g. The nature of the capture cell detector also allows debris and vapour from such impacts to be retained for later examination by energy dispersive x-ray analysis in the scanning electron microscope.

Laboratory analysis of the returned foils commences with a visual inspection of the aluminium on a light table to locate penetrations. These are compared to pre-flight records and new perforations examined in detail for evidence of hypervelocity impact. This simple technique is quite capable of detecting holes of about 1 micron in diameter. Analysis of promising impact sites can then made with the scanning electron microscope.

Presenting the first hypervelocity impact foil penetration returned from space, figure 1 shows a penetration 20 microns in diameter. Features of the lips on both the top and underside yield evidence that this is a true hypervelocity impact. This was caused by a particle much greater than a marginally penetrating mass; the associated impact zone on the Kapton is shown in figure 2. The Kapton is heavily damaged and exhibits evidence of melting in the central region with discrete particles embedded around the periphery. The underside of the foil around the penetration was also covered with sub-micron particles which may be condensed matter from the impact or splash-back debris from the Kapton. Energy dispersive x-ray spectroscopy (EDS) was used to examine all this impact debris and deduce its origins.

The particles at the edge of the Kapton impact zone were found to be aluminium and are likely to be from the aluminium foil as previous studies have shown [2] that target material is distributed around the edge of the impact products in hypervelocity penetrations. The heavily damaged central region on the Kapton impact contained at least one particle rich in calcium but any redeposited vapour may be too thin for analysis with EDS. The particles on the aluminium foil underside were mostly too small for accurate individual EDS analysis but were roughly categorised into two morphologies: "globular" being the most common and a few larger ones classed as "irregular". The "irregular" particles showed an iron signal whereas the "globular" particles did not. The former also showed a sulphur peak in some cases.

A second penetration is of 8 microns diameter and appears to be due to a lower velocity particle which has remained as a distinct liner inside the aluminium. In this case there is no associated impact feature on the Kapton. EDS analysis of the liner reveals it to be rich in iron and it is ascribed tentatively to an iron-rich cosmic dust grain.

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At present less than a third of the experimental area has been examined and analysis of two crater sites is by no means complete. This technique has however demonstrated even to date its value as a means of flux measurement and as a way to return extra-terrestrial matter to Earth for analysis.

Consideration of the entrant crater diameter of 20 microns in the top foil (figure 1) and only micron depth damage in the Kapton (figure 2) demonstrates the very effective performance of the meteoroid bumper principle first proposed by Whipple before the advent of spaceflight.

Data from complementary analytical techniques will be presented yielding evidence of particle composition and mass.

REFERENCES:
1.Whipple,F.L. (1952) Physics and Medicine of the Upper Atmosphere, Univ. of New Mexico Press (Alberquerque).
2.Watson R.W., Becker K.R., Gibson F.C. Proc. 6th Symposium on Hypervelocity Impact. Aug. 1963 Cleveland Ohio.

Figure 1. Hypervelocity Impact Penetration in MFE Aluminium Foil.
(a) top side (b) underside

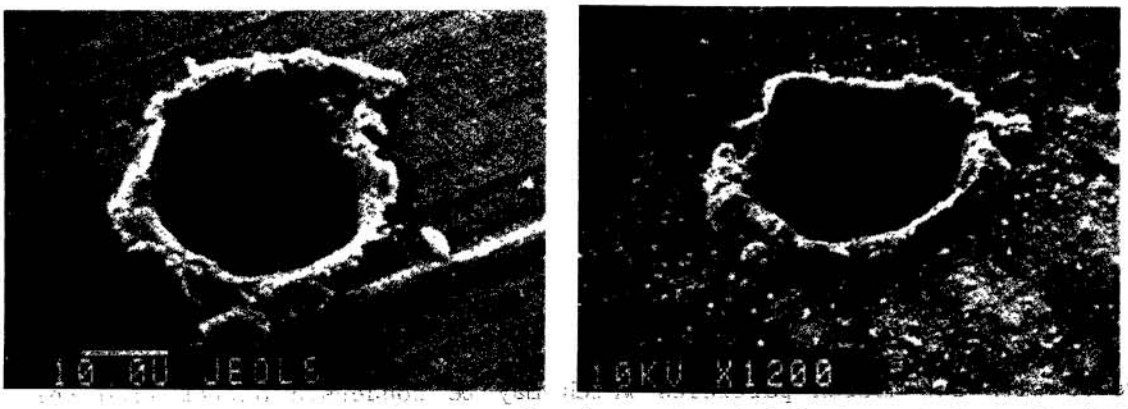

Figure 2. Impact Zone on MFE Kapton sheet.