MORPHOLOGY AND CHEMICAL ANALYSES OF RESIDUES FROM IMPACTS INTO MLI-BLANKETS ON EURECA; Monica M. Grady and A. Sexton, Dept. of Mineralogy, The Natural History Museum, Cromwell Road, London SW7 5BD, U.K., I. P. Wright, Planetary Sciences Unit, Dept. of Earth Sciences, The Open University, Walton Hall, Milton Keynes MK7 6AA, U.K. and G. Drolshagen, ESA-ESTEC, P.O. Box 299, 2200 AG Noordwijk, The Netherlands.

The Space Shuttle Atlantis (STS-46), carrying the European Retrievable Carrier (EURECA) was launched from Cape Canaveral on July 31st 1992. EURECA was deployed using the remote manipulator system of the Shuttle on 2nd August 1992 at an orbital altitude of ~ 426 km, ascending to its operational orbit of ca. 500 km within 5 days of deployment. After orbiting the Earth for approximately 11 months, EURECA was retrieved by the Space Shuttle Endeavour (STS-57) on June 24th 1993, and returned to the Kennedy Space Centre. In common with other satellites, EURECA was covered with thermal insulation blankets (multi-layer insulation, or MLI; Fig. 1). During exposure in space, the MLI blankets were bombarded by various particles, as witnessed by a record of impact holes. We have examined these holes, with a view to discerning the relative fluence of natural micrometeoroids and space debris, and obtaining an approximate value for the flux of particles at a height of 500 km during 1993. The holes penetrate the top (β-cloth) layer of the blanket, the kapton light block underneath and several of the Al foil reflective layers (RL) below. Impact holes are generally ellipsoidal in shape, and vary in mean diameter from ca. 60 to 1300 μm; the size distribution is approximately bimodal (Figure 2), although the total number of holes is small, at 63, with maxima at 250-350 μm (n=20) and 450-500 μm (n=7). One of the largest holes, ~ 610 μm in diameter, is shown in Fig. 3a.

Preliminary studies showed that several particles were located on the outermost surfaces of the blankets, and are probably contaminants introduced during deintegration. However, at least two of the particles are fused into the β-cloth, implying that these particles are from low velocity impacts onto the satellite. For other impacts, where the impactor has clearly penetrated the MLI, results so far show that the depth to which the particles have penetrated varies between specimens from 1 layer to 14 layers, the highest frequency of penetration being through the topmost, β-cloth layer only. Thus far, there is no clear relationship between depth of penetration and size of impact hole in the features analysed. Many of the foils through which a particle has passed contain parts of that particle across their surfaces. The number of these particles tends to increase with increasing depth of penetration. They are often found close to the impact but not exclusively so. So far only one particle has been found immediately adjacent to an impact and bearing approximately the same dimensions.

Chemical analyses of residual material around the impact holes were undertaken to ascertain whether the impactors were dominantly natural (micrometeorites containing Si, Mg, Fe, etc.), or space debris (mainly Al or Ti oxides from fuel and paint flakes, etc.) [1]. Several particles have been analysed to date, showing a variety of compositions. Sample EU210.ac2.1 has been examined in detail. From an original impact hole diameter in the β-cloth of ~ 610 μm (Fig. 3a), the particle penetrated through 14 of the 20 Al foil layers. Six particles, (plus several fragments of β-cloth and dacron netting) were found within the foil layers close to the impact, mainly between Al foil layers RL6, 7 and 8. There was no residue or particle at the final layer of penetration. Initial analysis by analytical SEM indicates that the particles are space debris, presumably mainly from the EURECA satellite itself. The 6 particles from this sample are: 2
particles of Au/Ag/Pd alloy (possibly from electrical components); 1 particle of Fe (no Ni or other elements found); 2 composite particles of KCl (possibly from sea-spray or human waste; ref. 2) sited on a larger grain containing Mg and Si (Fig. 3b) and 1 particle of CaO.

Following the initial survey of the impact residues, although the MLI blankets remain the property of ESA, they will be curated under the auspices of EUROMET, and made available for wider study. For further details, contact the authors (M.Grady@nhm.ac.uk; I.P.Wright@open.ac.uk).

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![Figure 1](image1.png)

Structure of a typical MLI-blanket from EURECA.

![Figure 2](image2.png)

Frequency distribution of crater diameters of 63 penetration events on EURECA.

![Figure 3a](image3a.png)

**Figure 3a:** Sample EU210.ac2.1 (a) Crater in the top layer (β-cloth), diameter ~ 610μm. The impact penetrated through to layer RL 14. (b) Back-scattered electron (BSE) image of 50μm composite particle found on RL 7.

![Figure 3b](image3b.png)