P.157

APOLLO WINDOW METEOROID EXPERIMENT, S-176, B. G. Cour-Palais, NASA-MSC, Houston, Texas 77058, R. E. Flaherty, NASA-MSC, Houston, Texas 77058, M. L. Brown, LEC, NASA-MSC, Houston, Texas 77058, and D. S. McKay, NASA-MSC, Houston, Texas 77058

Results of optical and scanning electron microscopic examination of the Apollo 14 and 15 command module heat-shield windows emphasize; (1) the morphology of the micrometeoroid craters; (2) implications as to the dynamic properties of the meteoroid; (3) analysis of any meteoritic residue in the crater; and (4) correlation with the flux of particles deduced from satellite meteoroid detectors, the recovered Surveyor III camera housing, lunar rocks, and earlier spacecraft window examinations.

Ten possible meteoroid impacts are identified of which five were found on Apollo 7, one each on Apollos 8, 9, and 13 and two on Apollo 14. No impacts larger than 200 microns diameter were found on the Apollo 15 window in a preliminary survey.

A scanning electron microscopic examination of the two Apollo 14 impact craters, one about 25 microns diameter, and the other 85 x 130 microns, reveal low angle spallation and radial fractures, a shattered central zone and lack of a rounded pit. They are typical of low to medium velocity impacts and reduce the probability of a meteoroid origin.

The Apollo 13 impact crater is characteristic of a hypervelocity event with a roughly circular spall zone of 430 to 460 microns diameter and a molten central pit. The pit is unusual in that it is distinctly elliptical measuring 130 x 110 microns. The spall zone is formed by low angle fractures and contains about 10 major radial fractures. About 3/4 of the way in from the outer edge, the spall steepens sharply and forms an annulus surrounding the pit. It is clear that the lip of the pit was spalled away and only a portion of the original pit remains. The pit and spall zone contain the same particulate contamination from the spacecraft thrusters, sea-water and mylar heat-shield coating as found on all the window surfaces from previous missions. No trace of any projectile material was found in or around either the Apollo 13 or 14 pits.

Meteoroid mass calculations for each of the probable impacts are based on a spall diameter to meteoroid diameter ratio of 100 to 1 and a mass density of 2 gm/cm^3. Flux calculations consider partial shielding of the window surfaces by the Lunar Module in cislunar space and total shielding during the lunar orbital phase. The results are compared with a near-Earth meteoroid environment model (1) shown by the solid line in Figure 1.

The flux estimates obtained from Apollos 8, 10, 12, 13, 14, and 15 are seen to be an extension of the lunar surface data points obtained from the Surveyor III camera examination (2) and the Lunar Orbiter penetration detectors (3); and the Apollo 7 result in Earth orbit is in agreement with the reference environment model. The ratio of the near-Earth meteoroid flux to the interplanetary flux is 2.04 by comparing the Apollo 7 result with the other Apollo data. This is in agreement with the expected gravitational enhancement of the meteoroid flux due to the Earth's field.

Assuming that the Surveyor III interplanetary mass distribution for the lunar

P158

surface (2);

$$\mathrm{Log}_{10}\ N(m^{-2}S^{-1}) = -10.80 - 0.56\ \log_{10}\ m(g)$$

is applicable to the lunar rock crater distributions of Hörz et al (4), the resulting data points for rocks 12017 II and 12073 III show very good agreement, if an average exposure age of 2800 years is used. This would indicate that the current interplanetary meteoroid mass distribution has not changed significantly over an appreciable time.

References

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P. 159

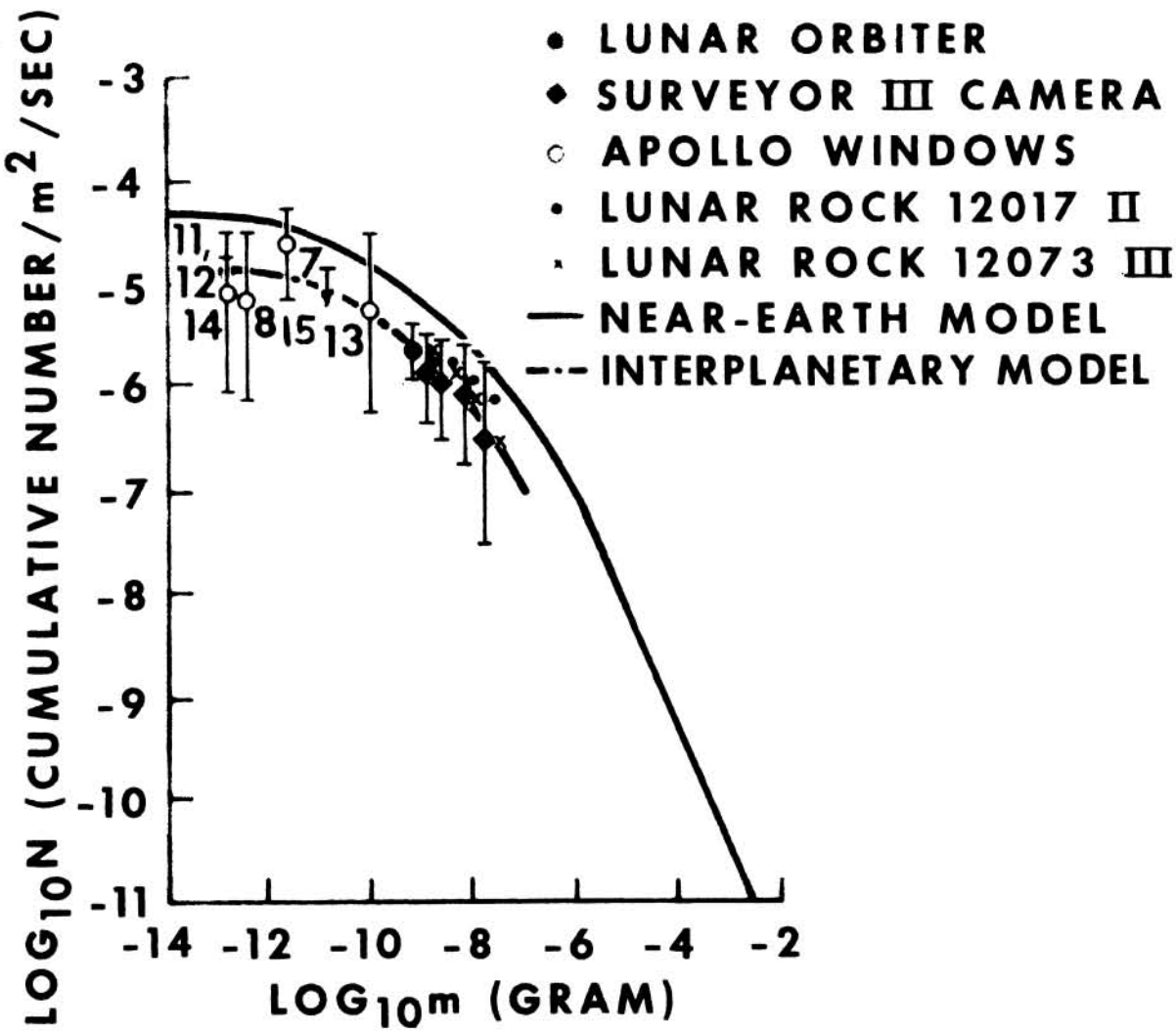

Fig. 1. Logarithmic cumulative mass flux plot for meteoroids less than 10^{-2} g mass. The Apollo 7 data point is the only one for near-Earth orbit. The other Apollo data were obtained essentially outside the Earth's gravity field and compare well with the Surveyor III shroud and rock results.