COMPOSITION AND MODAL FREQUENCIES OF HYPERVELOCITY PARTICLES <1 mm IN DIAMETER IN LOW-EARTH ORBIT; R.P. Bernhard[1], T.H. See[1] and F. Hörz[2], [1]Lockheed ESC, C23, Houston, TX, 77058, [2]NASA Johnson Space Center, SN4, Houston, TX 77058.

Introduction: We have continued to systematically analyze the projectile residues associated with hypervelocity impact features on the surfaces of the "Chemistry of Micrometeoroid Experiment" (CME) that was in low-Earth orbit (LEO) for 5.7 years aboard the Long Duration Exposure Facility (LDEF). Details of the CME instrument are presented in [1]. Last year we reported [2] on the systematic analysis, via SEM-EDX methods, of all craters >20 µm in diameter (*i.e.*, 199) on the collectors from LDEF's trailing edge (location A03; 0.85 m^2 of high-purity gold), and ~200 craters >75 µm in diameter from the aluminum 1100 (>99% aluminum) substrates from the forward-facing surfaces. This latter group represents <20% of all craters on the A11 collectors, because the particle flux is substantially higher for the forward-facing orientations relative to the trailing-edge surfaces [3 & 4]. To date, we have analyzed some 600 craters on the A11 aluminum collectors, yet this report summarizes only 400 features, because not all of the results have been completely reduced and entered into our database.

Compositional Classes of Particles: As previously described by [2 & 3], the distinction between natural and man-made impactors can generally be made with ease, and, in many cases, impactors can be assigned to compositional subclasses. Among the natural particles, those of chondritic compositions dominate, followed by monomineralic residues of either olivine or pyroxene, and Fe-Ni sulfides. Man-made particles of pure aluminum abound on the gold surfaces and a "miscellaneous" category was established which is dominated by paint flakes, but also includes metal alloys such as stainless steel, and Cu and Ag containing electronic components. The relative frequencies of these particle types as a function of crater size are illustrated in Figure 1.

Craters With No Detectable Residue: Note in Figure 1 that ~50% of all craters do not contain detectable residues, most likely due to loss by complete vaporization. Using mean impact velocities of 12 and 19 km/s for natural particles encountering the A03 and A11 surfaces [4], and equation-of-state (EOS) for aluminum 1100 and gold [5], one calculates rather similar peak pressures (430 GPa for the aluminum and 460 GPa for the gold) for both CME surfaces using model projectiles composed of anorthosite [EOS by 6]. These pressures will lead to almost complete vaporization of anorthosite [6]. Nevertheless, it is important to emphasize that aluminum projectiles cannot be detected on the A11 aluminum substrates (*i.e.*, a significant frac-tion of the "unknown" craters could be the result of aluminum projectiles).

Modal Projectile Frequency and Flux: Using the above mean impact speeds of [4] for all craters resulting from natural impactors, and those of [7] for man-made particles ($V_{mean;\ A03}$ = 1.75 km/s; $V_{mean;\ A11}$ = 7.85 km/s) we converted the measured crater diameters into projectile masses using the equations of [1] for the

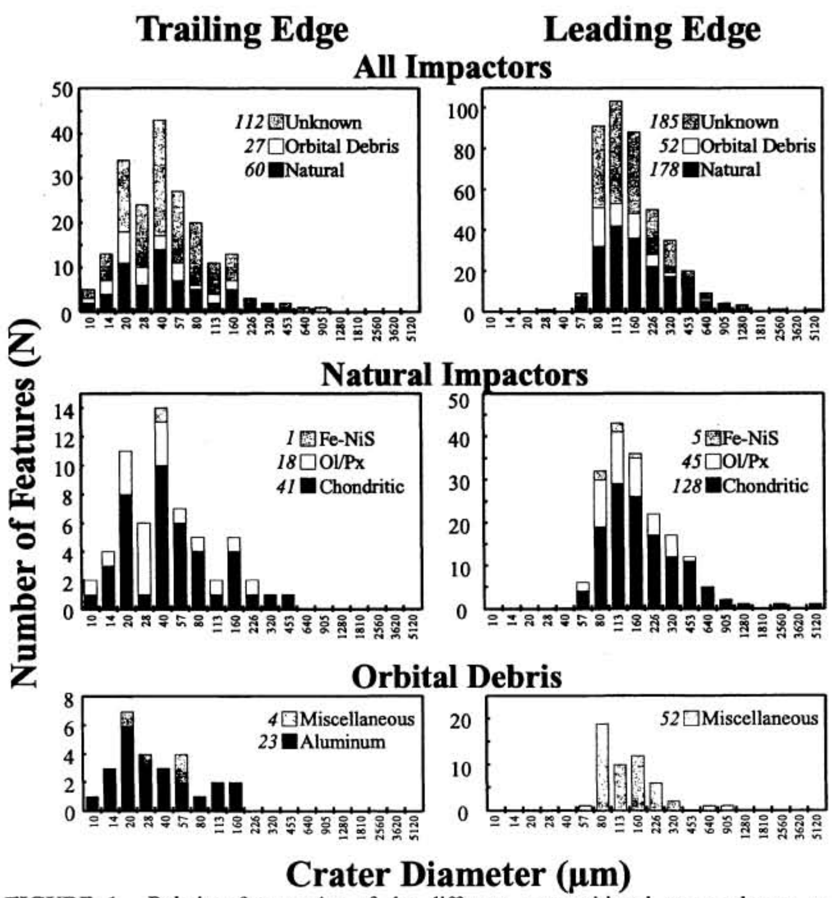

FIGURE 1. Relative frequencies of the different compositional crater classes, as defined by this study, of ~600 impactors that encountered the trailing- and leading-edge CME surfaces.

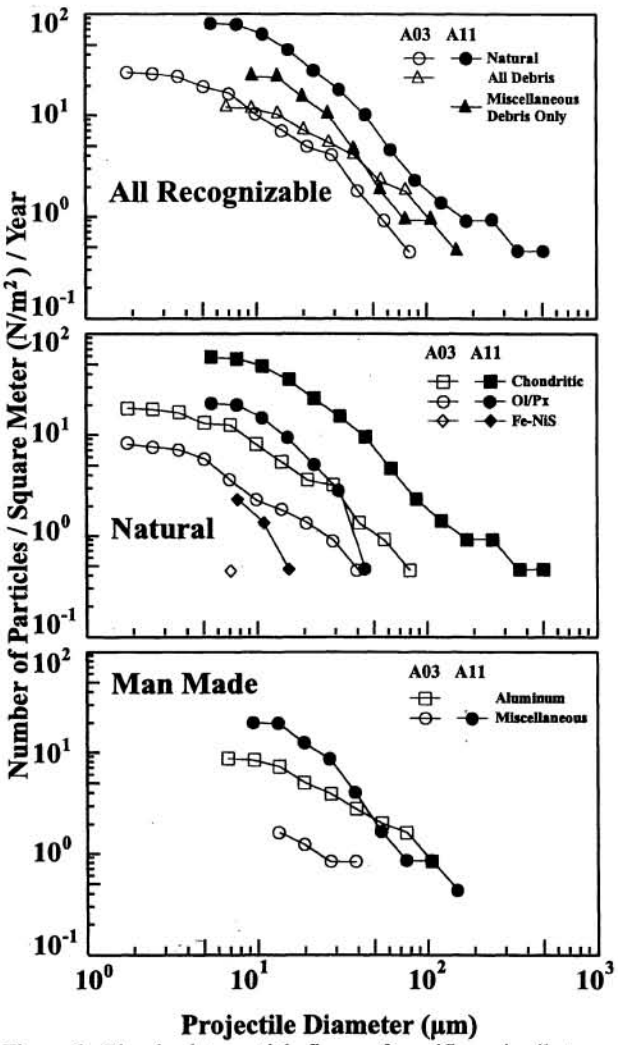

Figure 2. The absolute particle fluxes of specific projectile types, both natural and man-made.

gold surfaces, and those of [8] for aluminum collectors, assuming a projectile density of 2.7 g/cm^3. This conversion resulted in the cumulative mass-frequencies and fluxes for specific particle classes that are depicted in Figure 2. The relative (modal) frequency of the three major natural particle classes seems invariant with viewing direction. Furthermore, natural particles seem to dominate the forward-facing direction (A11), yet the frequency of man-made particles equals, if not exceeds the natural impactors for the trailing edge (A03). These data were modeled in detail by [7] who concluded that a substantial population of presently unaccounted for debris sources must exist in highly elliptic, low-inclination orbits. Such orbits are typically occupied by transfer vehicles of geosynchronous payloads. If the modal frequency of man-made particles observed for the A03 surfaces were applied to establish the (possibly) missing aluminum impactors on the A11 surfaces, one would obtain more craters than have been observed. We have difficulties understanding these findings as they seem to be inconsistent with considerations regarding particle dynamics, which require that the substantial population of aluminum impactors on the rear surfaces should somehow be manifested on the forward-facing surfaces as well [7].

Concluding Remark: Relative frequencies of projectile types as inferred from the observed frequency of laboratory analysis versus crater size (Figure 1) may differ significantly from the relative and absolute frequencies based on projectile mass (Figure 2). The wide range of impact velocities (1.7 to 19 km/s) required to determine projectile masses call for substantially different conversion factors of crater diameter to projectile mass. This may cause "small" and "low" velocity craters in Figure 1 to be associated with "massive" projectiles (*i.e.*, resulting in an effective shift to the right in Figure 1), whereas a "large" crater assigned to "fast" projectiles would yield a relatively modest projectile mass, resulting in an effective shift to the left in Figure 1. Note that the frequency of orbital debris particles seems substantially smaller than that of natural impactors in the trailing-edge data of Figure 1, while Figure 2 portrays debris particles to be more populous that natural impactors.

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