INTRODUCTION: We complemented our preliminary survey [1] of the compositional variety of hypervelocity particles in low-Earth orbit by analyzing additional craters >20 μm in diameter that formed in gold-substrates exposed on the trailing edge (location A03) of the Long Duration Exposure Facility (LDEF). The objective was to complete the inventory-type assessment of the compositional variety and possible sources of hypervelocity particles in low-Earth orbit. Dynamic arguments identify collectors on LDEF's trailing edge to be dominated by natural cosmic dust that, furthermore, should have the slowest mean encounter-velocities of all possible pointing directions of LDEF instruments [2]. The high purity gold collectors (>99.99% Au) in combination with the relatively modest encounter speeds should permit the characterization of statistically significant numbers of impactors; a total of 198 craters were analyzed.

SAMPLE PROCESSING, SELECTION AND ANALYSIS: The collectors consisted of seven gold-panels, each 0.5 mm thick, and of some 0.12 m² surface area; none of the collectors was completely penetrated. Optical crater scanning revealed 238 craters >20 μm in diameter (1), all of which were dislodged by a punching device, that rendered specimen-discs of 12 mm diameter, each containing an impact in its center. We report here on all craters encountered on 6 panels, the 7th remaining unanalyzed at present. Analysis employed SEM-EDX methods. Because our preliminary efforts at 15 KeV and count times of mostly 200s did not detect any projectile residue in approximately 70% of all craters[1], we diligently experimented with electron-beam current, optimization of take-off angles, and count times. We reanalyzed all craters which previously showed no projectile signature and the newly dislodged specimen with accelerating currents of 25-30 KeV and unusually long count times (500-1000s); also, a (variable) number of analysis spots was selected per each specimen. Those features that continued to yield "no" spectral lines beyond background levels were particularly scrutinized for morphological and chemical evidence of projectile remnants. Despite these substantial efforts, the fraction of craters that contain non-detectable projectile residues via SEM-EDX methods is approximately 50%. Those residues that can be detected may be classified into natural and man-made particles as illustrated in Fig. 1, with each source containing distinct subgroups.

NATURAL COSMIC DUST: Some 30% (n = 57 of 198 specimen) of all impactors are interpreted to be natural cosmic dust. Three major subclasses can be identified: (1) "CHONDRITIC" residues contain Si, Mg, and Fe as major components with minor quantities of Al, Ca and S. Typically, these residues are melts that contain very little clastic material, if any. These particles must be compound aggregates of chondritic bulk-composition. (2) Monomineralic silicates of either olivine or pyroxene. While also typically molten, some clastic detritus is occasionally preserved, including cases with unmelted fragments of sufficient size for detailed TEM and other phase chemistry work. There also is evidence in some craters that "chondritic" matrix was part of a large, single-mineral projectile. All craters that contain substantial quantities of clastic material are relatively shallow, indicative of low impact velocity. (3) Ni-Fe-S rich materials, i.e. common sulfides in carbonaceous meteorites.

MAN-MADE ORBITAL DEBRIS: We interpret 30 craters to be produced by man-made debris. They include Fe, Ni, Cr-rich materials (stainless steel; n=2) and one event each produced by paint (Ti, Zn, and Al) pure Ag (solder?) and Cu (electrical component?) particles. The far majority of man-made craters (n=25), however, yields nothing but a single Al-line. At crater diameters >20 μm the likelihood of Al-02-spheres, produced during solid fuel rocket firings, seems small and we seem left with fragments of metallic aluminum. Clearly, the preponderance of Al-impactors is difficult to understand. Also, the total fraction (demonstrably >10% of all impacts) of man-made particles impinging on LDEF's trailing edge was unexpected and indicates that sources from highly elliptical orbits, such as geosynchronous payloads or their transfer vehicles, were underestimated in the past (Kessler, pers. comm.).

NO RESIDUE CRATERS: In general, such craters are relatively deep and are characterized by pervasive flows of melted Au, suggesting, on average, high impact velocity and associated, complete vaporization of the projectile. Following the arguments of (2), the distribution of encounter velocities of natural and man-made particles with LDEF's trailing edge make it likely, that the far majority of these events was caused by natural particles.

CONCLUSION: Approximately half of the impacts in infinite-halfspace gold collectors on LDEF's trailing edge yields analyzable projectile residue via SEM-EDX methods, yet the other half requires still more sensitive methods, such as ion-microprobe, to determine whether and what traces of the impactor(s) remain.