CRATERS IN ALUMINUM 1100 TARGETS USING GLASS PROJECTILES AT 1-7 KM/S; R.P. Bernhard [1], T.H. See [1], F. Hörz [2], and M.J. Cintala [2], [1]Lockheed-ESC, C23, 2400 NASA Road.1, Houston, TX 77058, [2]NASA Johnson Space Center, Solar System Exploration, Houston, TX 77058

INTRODUCTION: We report on impact experiments using soda-lime glass spheres of 3.2 mm diameter (D_p) and aluminum targets (1100 series). The purpose is to assist in the interpretation of LDEF instruments and in the development of future cosmic-dust collectors in low-Earth orbit. Because such instruments demand understanding of both the cratering and penetration process, we typically employ targets with thicknesses that range from massive, infinite half-space targets, to ultrathin films (*e.g.,* [1]). This report addresses a subset of cratering experiments that were conducted to fine-tune our understanding of crater morphology as a function of impact velocity (V). Also, little empirical insight exists about the physical distribution and shock-metamorphism (unmelted / melted / vaporized / fractionated) of the impactor residues as a function of encounter speed, despite their recognized significance in the analysis of space-exposed surfaces [2, 3, 4].

Soda-lime glass spheres were chosen as a reasonable analog to extraterrestrial silicates, and aluminum 1100 was chosen for targets, which among the common Al-alloys, best represents the physical properties of high-purity aluminum (*i.e.*, one of the choice materials for stacked, thin-film collectors). These materials complement existing impact studies that typically employed metallic impactors and less ductile Al-alloys (see [5] or [6] for summaries). We have completed dimensional analyses of the resulting craters and are in the process of investigating the detailed distribution of the unmelted and melted impactor residues via SEM methods, as well as potential compositional modifications of the projectile melt(s) via electron microprobe. The following progress report concentrates on the dimensional analysis.

RESULTS: Figure 1 shows "low" velocity (<4.5 km/s) craters in cross-section (at identical scales; V indicated by insert). Note that the craters' depth-diameter relationship (P/D_c) changes from relatively deep structures at <3 km/s, to aspect ratios that closely resemble "hemispherical" structures (P/Dc = 0.5) typical for V > 4 km/s [5]. Measurements of the depth-diameter ratios are plotted in Figure 2 and the experimental craters are obviously not perfect hemispheres. Craters in aluminum resulting from 5-7 km/s impacts typically yield an average of $P/D_c \cong 0.56$. Although the experimental trends in Figure 2 seem to indicate that relative crater depth increases again with increasing velocity, this is not the case as demonstrated by depth-diameter measurements of ~400 craters in aluminum 6061-T6 alloy from LDEF [7]. Average values for P/D_c of 0.589, 0.581 and 0.574 were observed on surfaces from the trailing, leading and space-facing directions that have mean encounter velocities of ~22, 13, and 17 km/s, respectively. LDEF results and experimental observations suggest that the relationship of $P = 0.5\ D_c$ is only approximately correct, when calculating projectile sizes from crater diameters or depths.

Figure 3 illustrates the relationship of crater diameter (D_c; measured at the initial target surface) to impact velocity. The slope of a linear regression line through the D_c measurements reveals a velocity exponent of 0.564, modestly smaller than the 0.666 resulting from generally larger craters of [5], and substantially larger then the 0.44 from much smaller events [8]. The cause of these variances is unknown at present.

Finally, Figure 4 presents select "high-velocity" craters (>4.7 km/s) in plan view, providing a preview of the ongoing SEM and microprobe studies that concentrate on the characterization of the projectile residues. The hummocky

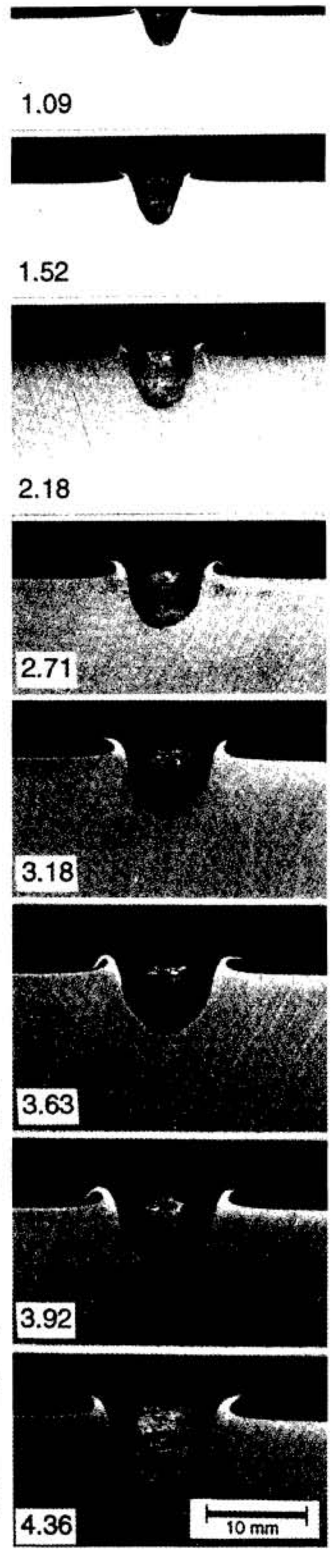

Figure 1.

CRATERS IN Al 1100 TARGETS WITH GLASS PROJECTILES: Bernhard, R.P. *et al.*

interior of the 4.7 km/s crater is composed of unmelted glass fragments that float on top of a glass liner. The number of unmolten fragments decreases with increasing speed and the projectile is completely molten at V >6 km/s. Note the substantial radial velocity component of the melt: starting at ~5.8 km/s an increasingly larger area of the crater bottom is devoid of melt, because larger and larger melt fractions will drape the walls and/or be ejected from the crater altogether. These observations suggest limited utility of massive targets as dust collectors, because large fractions, possibly all, of the projectile may escape the crater cavity at very high encounter speeds typical for low-Earth orbit. The projectile residue remaining in ~50% of all LDEF craters is below detection thresholds via SEM-EDX methods [2].

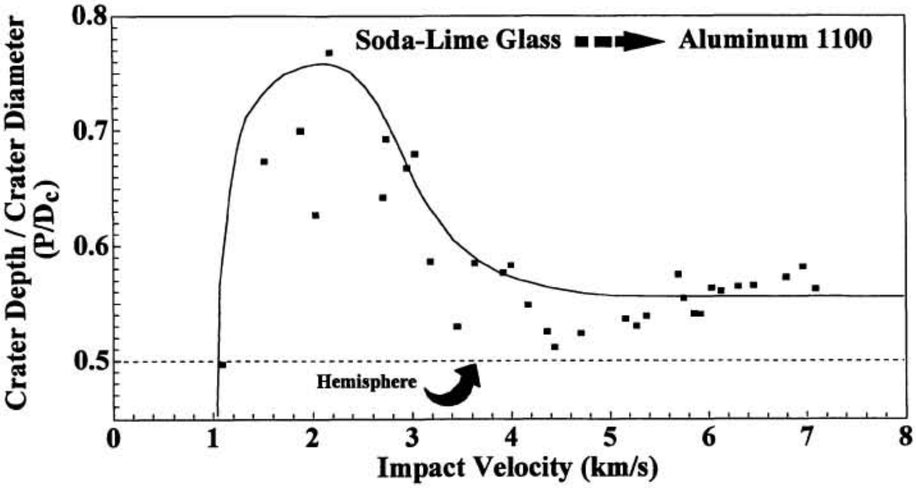

Figure 2.

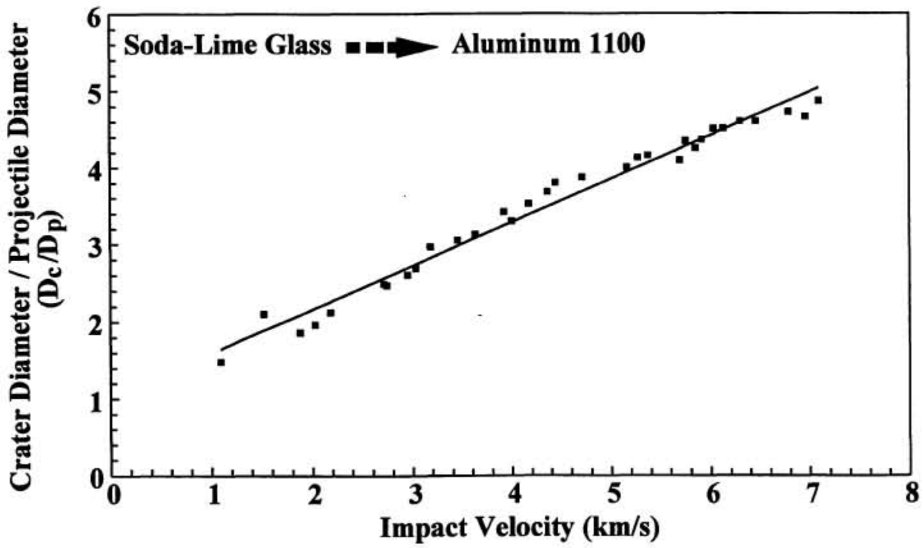

Figure 3.

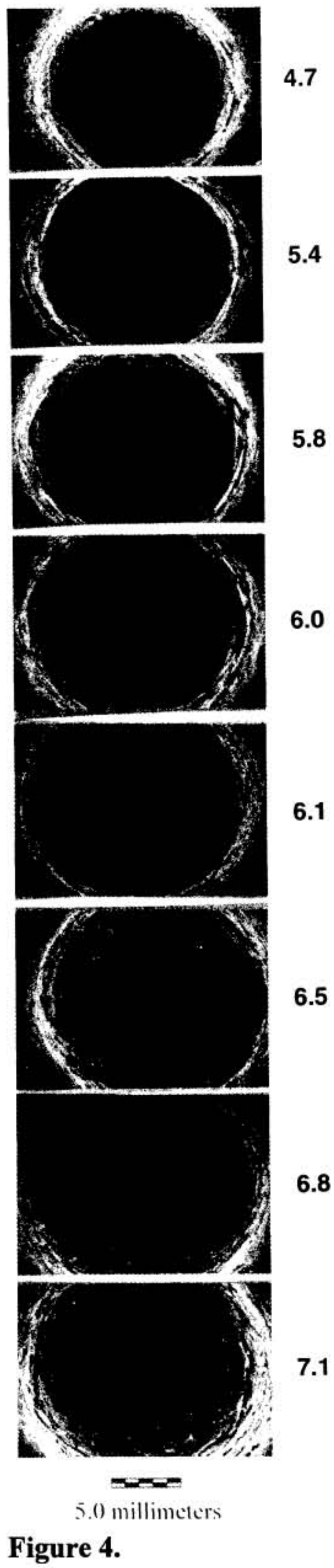

Figure 4.

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