LABORATORY IMPACT EXPERIMENTS: EJECTA VELOCITY DISTRIBUTIONS; E.V. Ryan and D.R. Davis, Planetary Science Institute, Tucson AZ

The mass-velocity distribution for fragments following catastrophic impact is a vital factor for understanding asteroid collisions. Presently available data on fragment velocities are sparse, as these types of measurements can be difficult to obtain. In a low-velocity impact study conducted by Waza *et al.* (1), it was shown that material property differences between target and projectile can affect the resultant ejecta velocity distribution. In addition, Fujiwara (2) found that antipodal fragment velocities tend to increase with increasing specific energy Q (projectile kinetic energy/target mass).

With this in mind, we have implemented an experimental program (3) that uses a variety of target and projectile material types over a range of impact speeds (350 m/s to 5500 m/s). The objective is to explore how the variation of these parameters might influence post-impact velocity distributions. Also of interest is determining approximately what fraction of impact collisional energy is being partitioned into ejecta kinetic energy (f_{KE}). We report here on results obtained from the analysis of 31 collisional disruption experiments using cement-mortar targets, where in addition to the above-mentioned parameters, target structure was also varied.

Figures 1(a) and (b) show representative cumulative mass-velocity distributions for two rock-rock (as opposed to rock-metal) impact experiments. The slope of the mass-velocity distribution is a parameter used in numerical simulations of asteroid collisional evolution. A linear fit to the data for these two collisions provides us with an average slope of -2.4. This is in good agreement with the work done by Gault *et al.* (4), who found the slope in the cratering regime to be ~-2.25.

Table 1 summarizes the results for 13 of the total 31 rock-metal (aluminum or steel projectiles) impact experiments, where it was possible to measure fragment velocities for 50% or more of the ejecta mass. Values based on the 31 impacts as a whole are given in brackets for comparison. The target types used were strong homogenous mortar (compressive strength S_c ~3.5×10^8 dynes/cm^2), weak differentiated (weak mortar mantle, strong mortar core), and preshattered (previously fractured strong mortar). Although there is some variation with target type, the mean fragment velocity is about 10 m/s, which is an order of magnitude less than that postulated for asteroid families (~200 m/s). Further analysis suggested a relationship between specific energy and mean ejecta speed, such that as Q was increased, mean fragment speed increased. This is similar to what Fujiwara (2) found for the antipodal velocities. Also included in the table is an estimate of the energy partitioning coefficient f_{KE} which we found to range from 1-2%, consistent with the results of Fujiwara and Tsukamoto (5). For rock-rock impacts, f_{KE} may be much higher (16-60%).

Our general observations of the ejecta velocity field are consistent with those discussed by Fujiwara and Tsukamoto (5). Namely, most (~80%) of the measured ejecta mass is travelling at only 0.1-0.5% of the impact velocity. Larger fragments tend to move more slowly than smaller fragments, and overall fragment speed is a function of initial position with respect to the impact site--velocities reach a maximum near the impact point, and are greater for surface as opposed to interior fragments. In the case of our differentiated targets, and for homogenous targets which resulted in core-type destruction, the velocity of the core is usually 3-4 m/s.

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References: (1) Waza, T., Matsui, T., and Kani, K. (1983), *JGR*, **Vol. 90**, 1995-2011; (2) Fujiwara, A. (1987), *Icarus* **70**, 536-545; (3) Davis, D.R. and Ryan, E.V. (1990), *Icarus* **83**, 156-182; (4) Gault, D.E. and Heitowit, E.D. (1963), *Proc. 6th Hypervelocity Impact Symp.*, Vol. 2, 419-516; (5) Fujiwara, A. and Tsukamoto, A. (1980), *Icarus* **44**, 142-153.

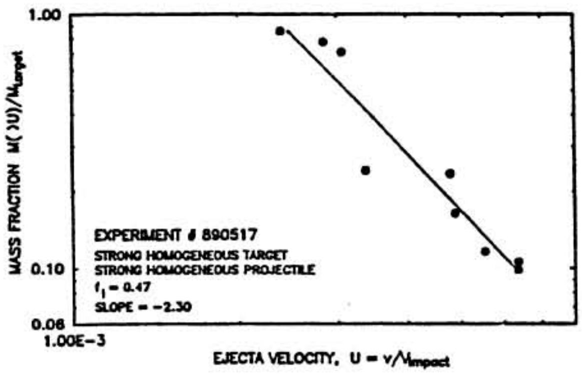

Figure 1(a)

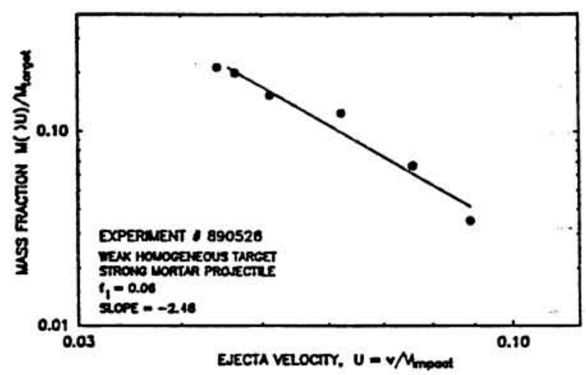

Figure 1(b)

TABLE 1

SUMMARY: FOR MODERATELY CATASTROPHIC IMPACTS WHERE % EJECTA MEASURED WAS ≥50% (13 IMPACTS OUT OF A TOTAL OF 31 IMPACTS)

AVERAGE VALUES

TARGET TYPE	$\bar{V}$ MEAN FRAGMENT VELOCITY (m/s)	MASS-VELOCITY DISTRIBUTION SLOPE	% f_{KE} † (LOWER LIMIT)
Strong Homogeneous	**7 [14]***	**2.44 [1.85]**	**2.1 [7.5]**
Weak Homogeneous	**5 [7]**	**2.95 [2.36]**	**0.7 [2.6]**
Preshattered	**15 [17]**	**1.86 [1.11]**	**2.3 [4.9]**
Weak Differentiated	**10 [10]**	**1.98 [1.61]**	**2.1 [1.7]**

*** [ ] THESE VALUES ARE BASED ON THE TOTAL (31) IMPACT EXPERIMENTS**
† FOR ROCK-ROCK IMPACTS, f_{KE} CAN RANGE FROM 16-60%