https://ntrs.nasa.gov/search.jsp?R=19860021131 2020-03-20T13:27:03+00:00Z

N86-30603

# INTACT CAPTURE OF HYPERVELOCITY PARTICLES

Peter Tsou
Jet Propulsion Laboratory, Pasadena, California

Donald E. Brownlee
University of Washington, Seattle, Washington

Arden L. Albee
California Institute of Technology, Pasadena, California

INTRODUCTION Knowledge of the phase, structure, and crystallography of cosmic particles, as well as their elemental and isotopic compositions, would be very valuable information toward understanding the nature of our solar system. This information can be obtained from the intact capture of large mineral grains of cosmic particles from hypervelocity impacts. Hypervelocity experiments of intact capture in underdense media have indicated realistic potential in this endeavor [1]. The recovery of the thermal blankets and louvers from the Solar Max spacecraft [2] have independently verified this potential in the unintended capture of cosmic materials from hypervelocity impacts. Passive Underdense media will permit relatively simple and inexpensive missions to capture cosmic particles intact, either by going to a planetary body [3] or by waiting for the particles to come to the Shuttle or the Space Station.

Experiments to explore the potential of using various underdense media for an intact comet sample capture up to 6.7 km/s were performed at NASA Ames Research Center Vertical Gun Range. Explorative hypervelocity experiments up to 7.9 km/s were also made at the Ernst Mach Institute. These experiments have proven that capturing intact particles at hypervelocity impacts is definitely possible. Further research is being conducted to achieve higher capture ratios at even higher hypervelocities for even smaller projectiles.

EXPERIMENTS A wide range of polymer underdense foam media, with both open and closed cell structures, was used as capturing targets. The foam densities varied from 9 to 528 mg/cc; both uniform media density and combinations of densities were used. Several fibrous target materials with a density range from 36 to 430 mg/cc were also utilized, as were multiple layers of thin organic films. Most of the capturing experiments were performed under vacuum; for selected experiments, gas with several different molecular weights was also back filled.

The projectiles used were mostly polished aluminum spheres of 1.5 to 3.2 mm diameter and accelerated with a two-stage light-gas gun from 1 to 7.9 km/s. In order to assess the effect on more realistic, fragile, and comet-like particles, projectiles of Pyrex glass, Wellman meteorite, Epoxy-bonded Allende meteorite powder, and Epoxy-bonded olivine/FeS/glass microspheres were used. For speeds higher than the capability of the Ames facility, limited explorative experiments were also made at the University of Munich on a plasma drag gun with about 100 micron sized glass spheres at about 8 to 12 km/s.

RESULTS The experiments seemed to show that polymer underdense media were superior to other types of underdense media for capturing particles intact at about 6 km/s. Fibrous materials tend to break up the projectiles. The typical track left in the underdense medium is characteristically carrot-shaped as shown in Figure 1. The track has two distinct sections: the burn section, B, and the shear section, S. The burn track is marked distinctly with black residues from pyrolysis or melt, and the diameter is very much larger than the projectile diameter. The width of the shear track, on the other hand, is nearly the same as the projectile diameter and is devoid of any burnt residues. The entry hole size, a, is on the order of one to three times the projectile diameter. For a given foam density the maximum track diameter, b, seems to be proportional to the projectile speed; and for a given speed, the maximum track diameter seems to increase with foam density, while the stopping distance shortens with increased foam density. Higher hypervelocity experiments using a plasma drag gun indicated an expected scale down of the stopping distance because of a decrease of kinetic energy due to considerable smaller projectile mass.

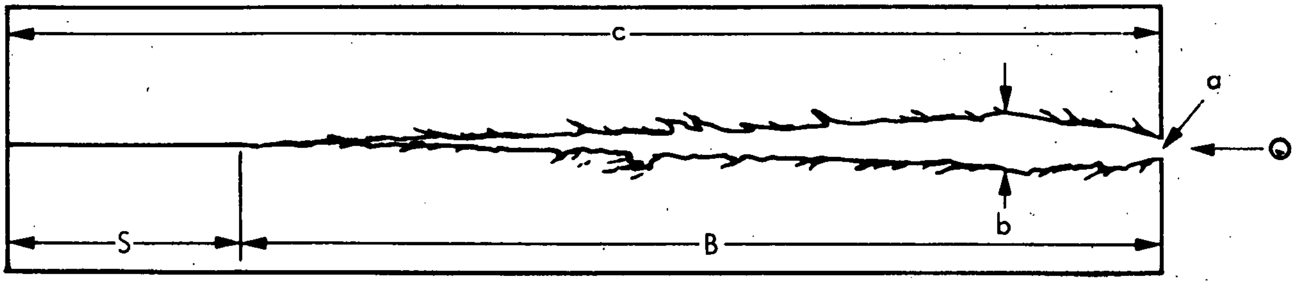

Figure 1. Underdense Intact Capture Track

The projectiles' captured-mass to original-mass ratio for aluminum projectiles becomes to less than one for projectile speeds greater than about 2 km/s for a 16 mg/cc expanded polystyrene foam. The capture ratio decreases with increased speed. Up to 83% of the projectiles original mass has been captured at 6.3 km/s for 3.2 mm size projectiles. About 60% has been captured at 7.9 km/s for 1.5 mm size projectiles.

For more cometary-like projectiles, disks of Wellman meteorite, epoxy-bonded Allende meteorite powder, and olivine/FeS/glass microspheres were accelerated. Figures 2, 3, and 4 show the captured Wellman, epoxyed Allende, and olivine mixture at 3.5 km/s, 2.3, and 3.9 km/s, respectively. Note that the circular perimeter of the Wellman projectile is still intact in Figure 2. The capture ratio of epoxyed Allende was 72% and the cross-section in Figure 3. shows that the loss of the projectile is due to shear rather than melt. Large chunk intact capture of olivine mixture has been achieved at 3.9 km/s to date as shown in Figure 4 and 5, respectively the before impact and after impact SEM image. Intact projectile grain capture has been achieved up to 6.7 km/s.

FINDINGS These intact capture experiments provide very positive and encouraging results for the intact capture of cosmic dust of speeds around 5 km/s. As increased understanding of intact capture in underdense media is gained, an optimum underdense medium should be designed to achieve the desired capture ratio at a specific hypervelocity and for a specific particle type. The ability to capture conglomerated fragile cosmic particles and the development of methods to detect small particles in the underdense media is one of the objectives to be achieved in the near term development.

Based upon the entry hole size and capture track characteristics found in the underdense medium, the projectile speed, projectile impact direction, and momentum can be estimated from calibrated data. The capture of micrometeorite in underdense medium achieves both the intact capture of the particle as well as retaining the pertinent record of the particle flight data: elemental and isotopic composition, mineralogy, velocity, and mass.

ORIGINAL PAGE IS
OF POOR QUALITY

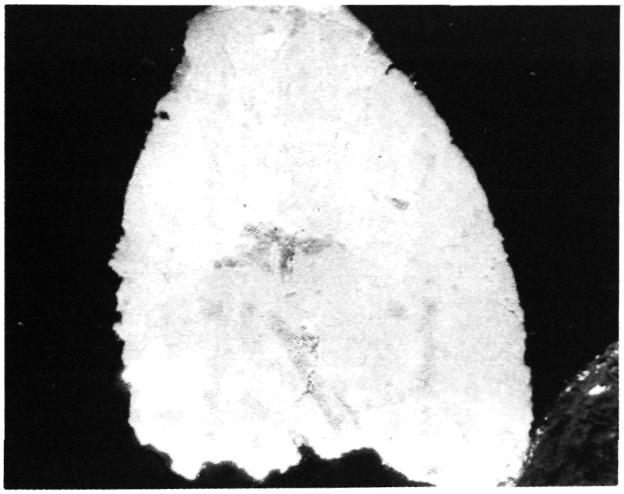

Fig. 2 Captured Wellman

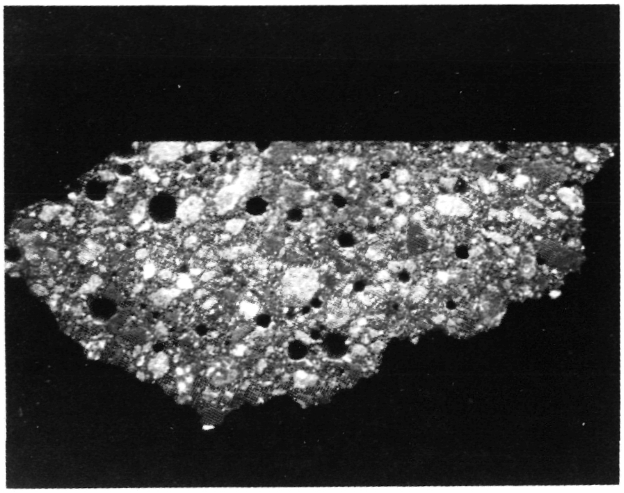

Fig. 3 Captured Epoxyed Allende

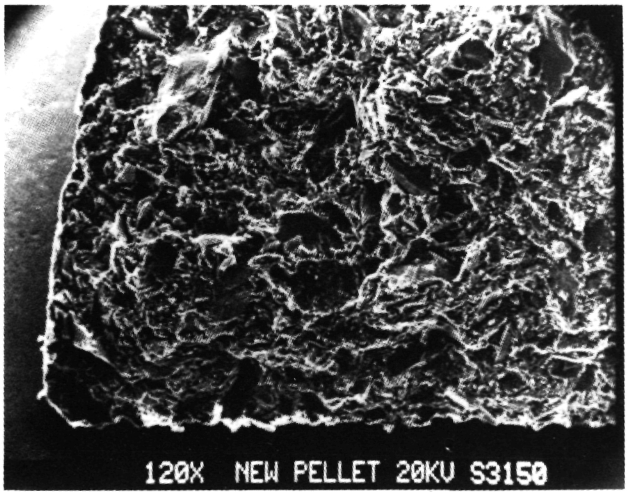

Fig. 4 Unshot Olivine/FeS/Glass

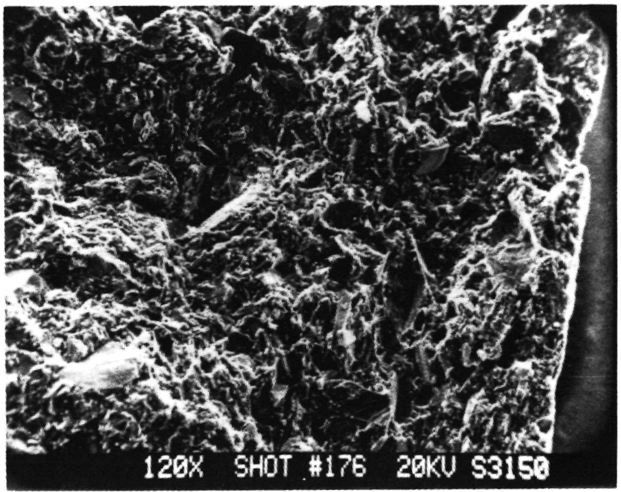

Fig. 5 Captured Olivine/FeS/Glass

The next-phase goal in the intact capture experiments will be to capture a substantive portion of simulated cometary particle intact at 6 then at 9 km/s with minimum modification of the phase, structural, and crystallographic information of the particle.

ACKNOWLEDGEMENTS Without the cooperative support of the NASA Ames Vertical Gun Range, Ernst Mach Institute, and University of Munich, this research would not have been possible. This work was carried out, in part, by the Jet Propulsion Laboratory, California Institute of Technology, under NASA contract.

REFERENCES

[1] Tsou, P. et al. (1984) Lunar and Planet. Sci. XV, p. 866-867.

[2] Schramm, L. S. et al. (1985) Lunar and Planet. Sci. XVI.

[3] Tsou, P. et al., "Comet Flyby Sample Return," AIAA 23rd Aerospace Science Conference, AIAA-85-0465, 1985.