EFFECT OF INITIAL CONDITIONS ON IMPACT FLASH DECAY. C. M. Ernst and P. H. Schultz, Brown University, Department of Geological Sciences, Box 1846, Providence, RI 02912 (Carolyn_Ernst@brown.edu).

Introduction: Light flashes due to thermal heating and vaporization are produced during hypervelocity impact events. The shape of such a flash's light curve may be used to determine certain initial conditions of the impact. The measured flash peak intensity depends on the impact velocity and angle and varies with target and projectile type, as shown in previous studies [1,2]. Here, we examine the dependence of the flash decay curve on initial conditions for macroscopic impacts.

Experiments: Laboratory experiments performed at the NASA Ames Vertical Gun Range (AVGR) allow the use of particulate (as well as solid) targets that more closely simulate the surfaces of planetary bodies. The experiments were performed in near-vacuum conditions (< 0.5 Torr) in a chamber large enough to allow the free expansion of the impact plume and ejecta without interference from chamber walls [3]. Previous photometric studies used only solid target materials and the analysis of the evolution of the light curves was limited to shorter times due to interactions with the walls [4]. A photodiode system with a rise time of 40 ns and a spectral range of 350 – 1100 nm recorded the impact flash signatures from above and from the side. Particulate (pumice dust, sand, sieved perlite, and powdered dolomite) and solid (solid pumice blocks, and frozen water-saturated perlite with a coherent crust) targets were impacted by Pyrex and copper spheres (0.318 – 0.635 cm, 0.299 g and 0.318 cm, 0.150 g respectively) with velocities between 4.05 – 6.14 km/s. Impact angle ranged from 30 – 90 degrees (from the horizontal). Under these conditions, Pyrex fails completely on impact.

Analysis: A sample flash curve for a Pyrex impact into pumice is shown in Figure 1. Two components can be seen, which may represent two superimposed curves: an intensity peak lasting from 50 – 100 □s, and a long-lasting decaying blackbody signal. This first component represents a light curve signature of the projectile depending on impactor velocity and angle [1], as well as size, density, and composition. The thermal plume produced by the impact emits the long-lasting signal, and is related to the target. Trendlines fit to the decay curves show a power-law dependence on time where $I \sim t^{-\square}$. Sample decay curves and their decay exponents (□) are shown in Figure 2.

Results: The value of □ is constant for a given set of target, projectile, and viewing conditions but changes with varying parameters.

Projectile. Initial projectile parameters include impactor velocity, angle, and density. As impact angle decreases from 90 - 30 degrees, the decay time becomes longer (□ decreases). Preliminary results show that decay time increases with increasing projectile size. There is no apparent velocity dependence, which implies that □ does not depend on the peak intensity of an impact under the conditions tested. There also seems to be no dependence on projectile density. These results are consistent with a decay time dependent on the amount of excavated radiators comprising the thermal plume. The portion of the plume contained inside of the transient crater decreases with impact angle, exposing more sources to detection. Also, the amount of impact-generated particles that become a part of the above-target radiating plume increases with decreasing impact angle [5].

Target. The targets varied in three ways: strength (solid versus particulate surfaces), grain size (coarse- versus fine-grained dolomite), and density (sand, pumice, and perlite). Two different sets of experiments were made using solid versus particulate surfaces of similar composition. Pumice dust and pumice block impacts resulted in a smaller □ for the particulate surface. Consistently, perlite and frozen perlite impacts resulted in a smaller □ for the unfrozen perlite particulate target. These results are consistent with a greater excavation efficiency in particulate targets.

Variations in grain size for a given particulate target composition also effect □. Fine-grained dolomite particles produce a longer decay time (smaller □) than coarse-grained dolomite. This is consistent with the interpretation that more radiating particles will be created from a finer-grained target. Lastly, for the particulate silicates (sand, pumice, and perlite), □ decreases with increasing target density as shown in Figure 3.

Viewing Conditions. Most experiments were viewed through ports both from above, but some were observed from the side of the using quarter-space configurations [6]. Impacts viewed from above produced a longer decay time (smaller □). The side view captured a vertical section through the radiating plume, essentially looking inside of the plume and crater cavity. Such experiments, therefore, allow the study of contrasting light sources from inside the crater and the evolving plume above and may help to further understand the impact process.

Implications: Light curves recorded from impacts may be used as a strategy for remotely assessing the nature of planetary surfaces [3]. If most of the initial impactor conditions are known, the remaining variables can be calculated using impact flash decay curves. The □ measured in an impact event can be compared to those obtained in the laboratory to determine whether a given surface is solid or particulate. The decay curve, along with studies of impact-produced emission lines [7] could be used to determine chemicals present at or just below the surface, and thus determine the composition of the target material.

An upcoming application for this type of remote sensing is the Deep Impact mission, to be launched in 2004. In this mission, a copper projectile will impact into Comet Temple 1, and the resulting light flash and crater will be studied. The projectile density, size, angle, and velocity will all be known and controlled quantities. The impact flash decay signal may help to determine the surface properties of the comet.

The masses of impactors hitting the Moon during the Leonid meteor shower also have been estimated from the resulting light flashes [8]. Since the composition of the surface of the Moon is better understood than any other extraterrestrial surface, studying the impact flash decay, along with the peak intensity, may allow for improved calculations of size or other initial projectile parameters.

Conclusions: Impact flash decay rate is highly dependent upon initial conditions, especially of the target material. It is a cooling blackbody signature indicating the number of impact-generated radiators. Analyzing the impact flash decay may allow the characterization of the physical nature of the target's upper surface layer, whereas the peak intensity of the flash is related to the nature of the impactor.

References: [1] Ernst, C.M. and P.H. Schultz (2002) *LPS XXXIII,* #1782. [2] Eichhorn, G. (1976) *Planet. Space Sci.,* 24, 771-781. [3] Schultz, P.H. et al. (1996) *LPS XXVII*, 1149-1150. [4] Kadono, T. and Fujiwara, A. (1996) *JGR*, 101, E11, 26,097-26,109. [5] Schultz, P.H. (1996) *JGR*, 101, E9, 21,117-21,136. [6] Eberhardy, C.A. and P.H. Schultz (2003) *LPS XXXIV*, this volume. [7] Adams, M.A. et al. (1997) *LPS XXVIII*, 3-4. [8] Ortiz, J.L. et al. (2000) *Nature*, 405, 921-923.

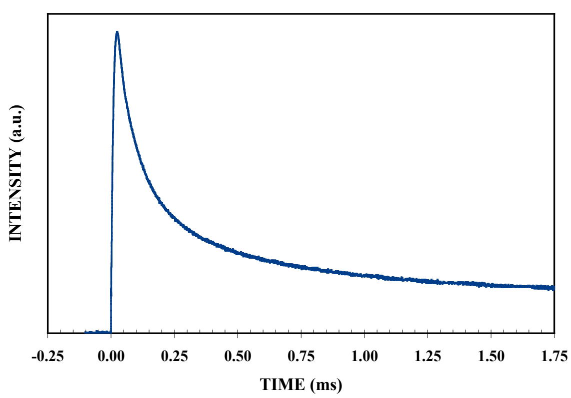

FIGURE 1. Light curve as recorded by the photodiode of a typical Pyrex impact into pumice dust. Two components can be seen: an intensity peak lasting from 50 – 100 □s that depends upon projectile parameters, and a long-lasting decaying blackbody signal dependent on target parameters.

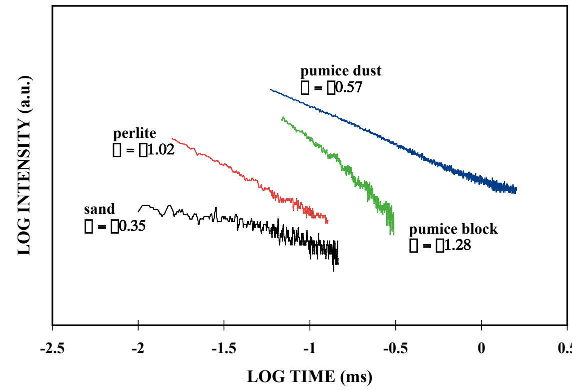

FIGURE 2. Decay curves and their decay exponents (□) for several target types. Time is measured from the initial flash signal.

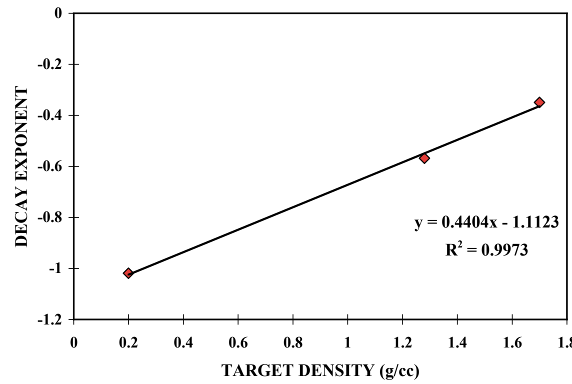

FIGURE 3. Average value of the decay exponent (□) versus target density for sand, pumice, and perlite particulate targets for 30 degree impacts viewed from above. The best-fit equation shows a linear relationship. Velocity and peak intensity do not affect □.