# EXPERIMENTAL INVESTIGATION OF THE DISTRIBUTION OF SHOCK EFFECTS IN REGOLITH IMPACT EJECTA USING AN EJECTA RECOVERY CHAMBER.

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**Introduction:** Because the mass-flux of solar system meteoroids is concentrated in the ~200 µm size range [1,2], small-scale impacts play a key role in driving the space weathering of regoliths on airless bodies. Quantifying this role requires improved data linking the mass, density and velocity of the incoming impactors to the nature of the shock effects produced, with particular emphasis on effects, such as production of impact melt and vapor, that drive the optical changes seen in space-weathered regoliths. Of particular importance with regard to space weathering is understanding not only the composition of the shock melt created in small-scale impacts, but also how it is partitioned volumetrically between the local impact site and more widely distributed ejecta. To improve the ability of hypervelocity impact experiments to obtain this type of information, we have developed an enclosed sample target chamber with multiple-geometry interior capture cells for in-situ retention of ejecta from granular targets. A key design objective was to select and test capture cell materials that could meet three requirements: 1) Capture ejecta fragments traveling at various trajectories and velocities away from the impact point, while inducing minimal additional damage relative to the primary shock effects; 2) facilitate follow-up characterization of the ejecta either on or in the cell material by analytical SEM, or ex-situ by microprobe, TEM and other methods; and 3) enable the trajectories of the captured and characterized ejecta to be reconstructed relative to the target.

**Methods.** The aluminum-walled cylindrical target chamber (Fig. 1a) with its interior set of capture cells supports impact experiments performed with both the horizontal light-gas gun (LGG) and the vertical gun in the Experimental Impact Laboratory (EIL) at NASA-JSC [3,4]. The interior of the chamber contains a target-holder assembly attached to the cylinder's base/rear plate (Fig. 1b), a side-mounted capture cell assembly positioned at an adjustable 30-40º launch angle (as measured from the target's surface) (Fig. 1b), and mounts for four capture cells positioned on the interior of the front plate around the entrance hole (Fig. 1c). The front-plate capture cells are specifically designed to capture highly shocked ejecta that leaves the impact point on high-angle trajectories. The expendable, high-density polyethylene target holder is easily machined to hold desired amounts of granular sample in a cylindrical container volume of variable diameter and depth. A thin "drum skin" of stretched mylar film holds the powdered sample in place prior to impact. The simple mounting arrangement can support capture cells of a wide variety of dimensions and materials, ranging from aerogel blocks to the bare and/or resin-coated graphite plates successfully used in the initial set of test experiments.

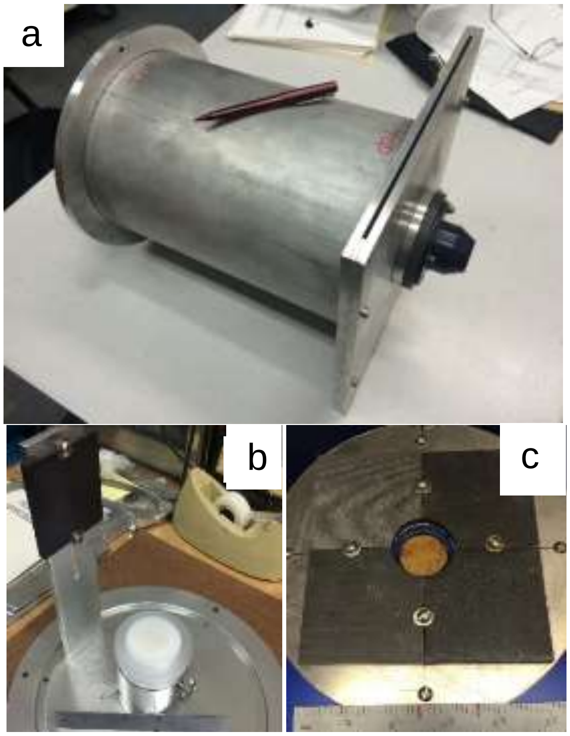

*Fig. 1. (a) Exterior view of target chamber with entrance port shown at right, rear plate at left. (b) Interior assembly with sample holder (white) and side-mounted graphite capture cell, (c) Graphite capture cells of different density mounted to interior of front plate.*

**Results.** Initial consideration of capture cell materials that could potentially meet performance (and cost!) requirements settled on 5-mm thick, molded graphite plates of different grain size and density [5]. In addition to their ability to capture and retain ejecta based on their physical properties, the plates offer excellent low-Z substrates that could be transferred directly into the SEM for electron-beam imaging and analysis of ejecta particles in-situ. To further reduce modification/damage of the ejecta particles when they impact the collector cell, and improve their retention on the surface, the plates can be coated with a soft, water-soluble mounting wax (Crystalbond® 555 [6]). This offers an additional low-density layer to slow the ejecta particles gently, with easy separation of the ejecta samples by dissolving the wax in warm water.

The integrated chamber and capture-cell assembly was tested in two impact experiments using 65-mg alumina projectiles (3.18 mm in diameter) launched into powdered olivine (Twin Sisters dunite, 175-147 µm grain size) at 4.7 and 5.0 km s$^{-1}$. The 5.0 km s$^{-1}$ experiments used the assembly in its final design configuration, with a wax-coated graphite cell on the side-mounted collector and four graphite capture cells of variable density, one of which had a wax coating, on the interior front plate (Fig. 1). Figure 2 shows the distribution of ejecta on the front plate (Fig. 2a), and side-mounted (Fig. 2b) graphite collector cells. The larger white speckles on the side collector plate are ejecta particles made up of mm-size olivine aggregates that formed shallow crater-like depressions in the wax coating upon impact (Fig. 2b).

Preliminary analytical SEM characterization of ejecta particles deposited on the front-plate capture cells in the 5.0 km s$^{-1}$ experiments showed almost exclusively mechanical comminution effects in the olivine powder. Possible indications of shock melting in a minor fraction of grains require further confirmation and are currently being evaluated by detailed SEM study.

**Conclusions.** Our preliminary findings are that the graphite collector plates, both “dry” and with the wax coating, performed well in meeting the baseline requirements and objectives of the overall design. The wax coating is particularly interesting in its ability to keep larger aggregated particles of ejecta intact upon impact on the collector surface. Preparation and characterization of these aggregates by SEM methods is currently underway. Future work will test the assembly with a greater variety of target materials, including asteroid regolith analogs.

**References:** [1] Öpik E. J. (1960) *Mon. Not. Roy. Astron. Soc*. 120, 404-411. [2] Housen K. R. et al. (1979) *Icarus* 39, 317-351. [3] F. Hörz et al. (1994) NASA Tech. Mem. 104797, 317 pp. [4] Cintala M. J. et al. (2015) *S. W. Airless Bodies*, 2061. [5] Ohio Carbon Blank, Inc. [6] Aremco Products, Inc.

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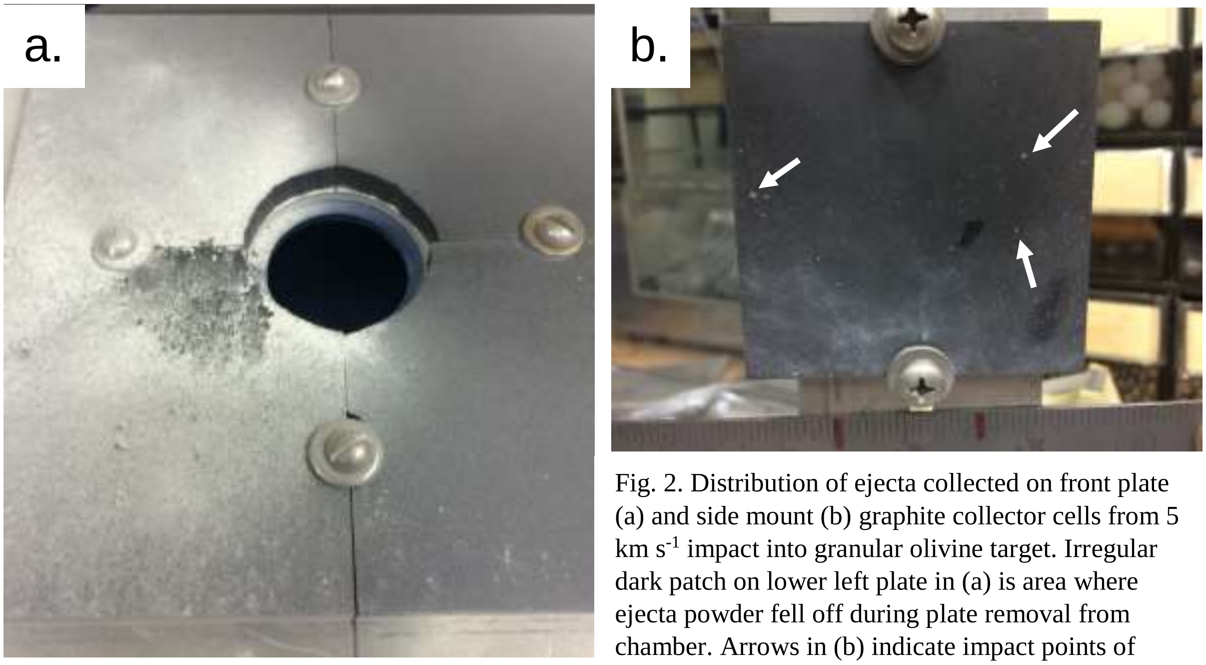

Fig. 2. Distribution of ejecta collected on front plate (a) and side mount (b) graphite collector cells from 5 km s$^{-1}$ impact into granular olivine target. Irregular dark patch on lower left plate in (a) is area where ejecta powder fell off during plate removal from chamber. Arrows in (b) indicate impact points of larger ejecta particles made up of aggregates of olivine grains (see text).