Two vertical gun experiments: central pit formation models and patterns in layered ejecta deposits. S. E. Peel[1] and D. M. Burr[1], [1]Department of Earth and Planetary Sciences at the University of Tennessee, Knoxville. (speel1@vols.utk.edu).

Introduction: Vertical gun experiments use high velocity projectile guns to investigate impact crater processes. We are currently developing two investigations that will utilize vertical gun experiments: (1) testing volatile content and material strength effects on central pit formation and (2) testing the effect of different vertical patterns of volatiles in the target on the formation of layered ejecta deposits (LEDs) and dry, or "radial", ejecta deposits. Here we describe these two experiments *and invite feedback.*

Methods: Two vertical gun facilities are available to researchers in the U.S. The Johns Hopkins University Applied Physics Laboratory's (JHU/APL) Planetary Impact Laboratory [1] has a low speed (80-800 m/s) Vertical Gun Range with multiple angles possible and projectiles ≤1cm in diameter. It can accommodate various planetary conditions (e.g., of Mars), including atmospheric. The Ames Vertical Gun Range [2] can accelerate projectiles to ≤7 km/s and is able to range launch them anywhere between 0^{o} and 90^{o} to the horizontal. Various conditions can be met through this facility as well. The investigations under development would use one or both of these facilities.

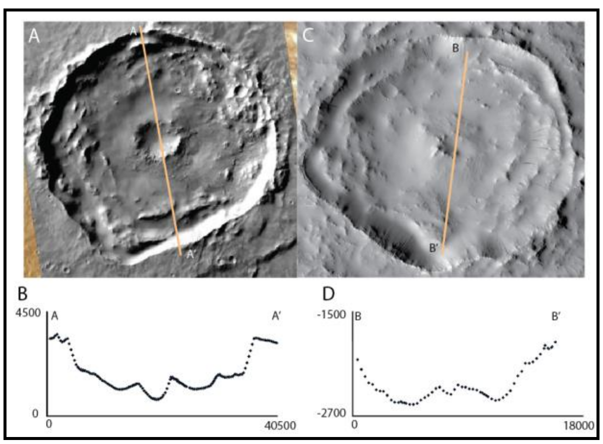

Fig. 1: Craters with floor (A, B) and summit (C, D) central pits in CTX images (A, C) and showing relative elevations of the floors (B, D) in MOLA PEDR data.

<u>*Central Pit Formation Investigation*</u>: Central pits are centrally located, approximately circular depressions that form to the floors and central uplifts of some complex craters during crater formation [Fig. 1; e.g., 3-5]. These features are found in craters across the solar system, most of which have no atmosphere [e.g., 5-11]. Because of the range of material properties that must, therefore, allow for central pit formation, the formation of these features is not well understood and many models exist. Previously hypothesized mechanisms for central pit formation call upon different material properties of the target [e.g., 12-19]. Despite the number of central pit formation mechanisms that have been proposed, experimental testing of these proposed mechanisms using vertical gun facilities have been rare [16].

In order to test central pit formation models [as grouped in 20] that call upon different conditions in the target, including with depth, we are attempting to design an experiment utilizing different target materials scaled for appropriate target strength for use in a vertical gun experiment.

<u>*Ejecta Emplacement Investigation*</u>: Layered ejecta deposits (LEDs; Fig. 2) are characterized by a fluidized morphology [21]. This morphology is distinct from the more common "radial" type of ejecta characteristic of bodies such as the Moon [21]. LEDs are hypothesized to be formed due to the presence of volatiles within the target [e.g., 22].

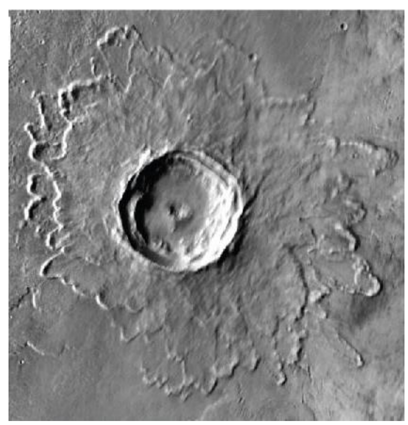

Fig. 2: Mars LED ejecta crater in THEMIS Day IR.

Models (Fig. 3) indicate that material from the target depth that forms central structures (including central pits and their rims) is ejected more slowly and later than the material above it during the excavation stage of crater formation [23]. Therefore, the ejecta that is potentially the most informative about central structures is deposited nearest the craters and forms the uppermost material of the ejecta deposit.

Based on this understanding of the initial target distribution of ultimately ejected material, we hypothesize that *LEDs and radial ejecta emplacement follow a pattern controlled by "dry" and "wet" vertical stratification in the impact target* (Fig. 4).

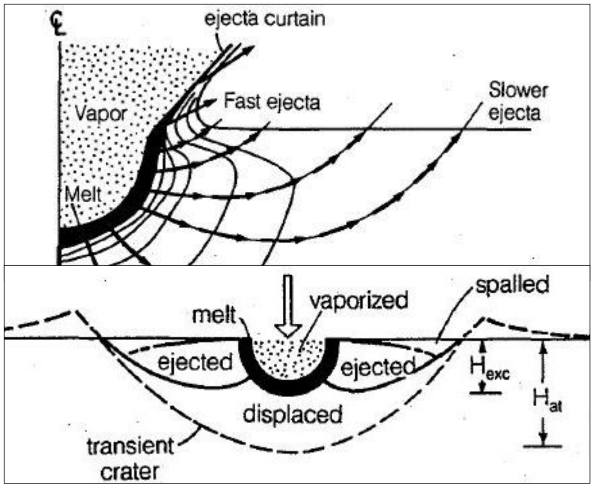

Fig 3: (Above) Excavation flow field geometry [Fig 5.9 in 23]. Material higher within each ejecta "streamtube" ejects at a greater velocity than deeper material. (Below) Initial positions of ejected and displaced material(s) [Fig. 5.13 in 23].

Potential Implications: The goal of this work is to collect data to constrain explanations for craters with both dry and LED types of ejecta, including ejecta that exhibit both types. If our experiments show that stratification of volatiles in the target do result in the hypothesized patterns of ejecta morphology, observations of these ejecta patterns on planetary surfaces can be used to constrain the distribution of volatiles in the target at the time of impact.

<u>*Current Unknowns of Methodology*</u>:

(1) How is the strengths of the bodies of interest, including at the base of excavation depth, scaled to the experiment? How does one scale the transition of those strengths with depth?

(2) What appropriate materials are used in impact crater experiments, and where is that information available?

(3) How does the type of contact between materials of different strengths (at experimental scales) affect material/layer strength?

(4) What should be the characteristics of the analog impactor? For example, should it be designed to disintegrate?

(5) For volatile-rich bodies, would it be necessary to take into account the increased amount of vaporization to be expected, or, to explore deeper processes, is it appropriate to scale the properties expected at depth? If so, how is this scaling accomplished?

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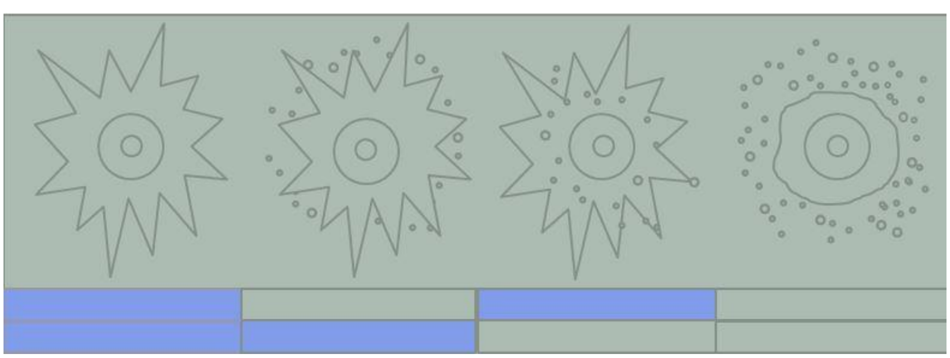

Fig. 4: Hypothesized pattern of ejecta deposits formed by variable volatile populations at depth. (Top) Cartoons of expected ejecta morphologies: (from left to right) LED, LED above radial, LED below radial, radial only. (Bottom) Hypothesized relative positions (specifying no relative thickness) of volatile-rich (blue) and volatile-poor (gray) target material pre-impact.