Emplacement of Crater Ejecta on Low-Gravity Worlds

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Introduction: To address how granular media are mobilized by ejecta processes on small bodies, we propose a suite of ejecta emplacement experiments on human-tended suborbital flights (ideally proposed through NASA ROSES) that build upon proposed reduced gravity experiments on parabolic aircraft flights. We will use an "ejecta catapult," which will be a subscaled version of the larger laboratory catapult successfully used by Runyon and Barnouin (2016; 2018, in review). Our scientific objectives are to quantify granular ejecta runout distances, velocities, thicknesses, and regolith erosion depths for proximal ejecta facies on small bodies (e.g., Figure 1). The investigation results will better inform provenance and geologic context of any returned samples or surface remote sensing data.

Collisions between solid solar system objects are among the longest-operating and most pervasive of geologic processes. Meteoroids colliding with small bodies form craters and expel ejecta. For bodies that are 10s km in size, much of the ejecta moves slowly enough to remain gravitationally bound and re-impacts the ground (e.g. Richardson et al., 2007), despite their low gravities. Ejecta emplacement as an agent of geomorphic change has been characterized for worlds with significant gravity (Runyon and Barnouin, 2016; Runyon and Barnouin, 2018, in review) using laboratory experiments that simulate the flight and emplacement of granular ejecta curtains. With recent and upcoming missions to asteroids or other small, irregularly shaped bodies (henceforth, "asteroidal bodies"), understanding the emplacement mechanics, resulting geomorphology, and implications of ejecta emplacement on such worlds will be important for fully understanding asteroidal bodies' geologic structure and evolution (including lateral and horizontal stratigraphy), and for placing returned and meteorite samples in their proper geologic context. These imperatives motivate our proposed research.

Methods: Figure 2 illustrates how our proposed science glovebox would operate to simulate an ejecta curtain in reduced gravity. A simple spring system would linearly accelerate the glovebox between 1–5 mm/s^2 to simulate a ~10s km asteroid's gravity.

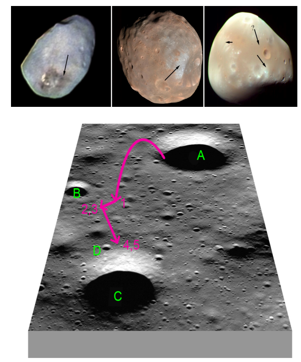

Figure 1. Top: Impact crater ejecta facies on asteroidal bodies, highlighted by arrows. Left to right: Nix (Image credit: New Horizons/NASA/SwRI/APL), Phobos, Deimos (Image credit: HiRISE/NASA/UA). Despite low gravity (typically <5 mm/s^2), most ejecta are retained on mid sized (~10s km) bodies (Holsapple & Housen, 2007). Bottom: Possible ejecta/regolith mobilization: Image modified from Apollo 16 image a16-090712, credit NASA.

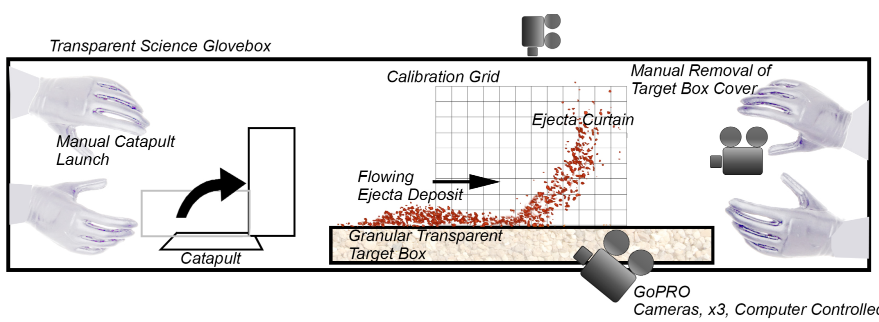

Figure 2. A science glove box would house the small catapult (left), which would fire fine granular media such as salt (pink grains) onto a clear-sided box at right. Three GoPRO cameras (blue boxes) would record the deposition dynamics and resulting geomorphology from three orthogonal perspectives (side, top, front).

References: Runyon, K.D., Barnouin, O.S., 2016. LPSC Abstract #1075; Runyon, K.D., Barnouin, O.S., 2018. In Review; Richardson. J.E., Melosh, H.J., Lisse, C.M., Carcich, B., 2007. Icarus, 191, doi:10.1016/j.icarus.2007.08.033.