POST-IMPACEMENT VOLUME LOSS FROM MARTIAN LAYERED EJECTA: Joseph M. Boyce, and Peter J. Mouginis-Mark, Hawaii Institute of Geophysics & Planetology, University of Hawaii, Honolulu, HI 96822.

Introduction: The narrow, high rampart ridges at the edge of ejecta layers on single (SLE) and multi-layered ejecta (MLE) craters present a conundrum whose solution may provide insight on volatiles within the ejecta.

Background: Ramparts ridges commonly develop at the leading edge of poly-dispersive geophysical granular flows such as landslides, debris flows, and Martian layered ejecta deposits [1-8]. Such ramparts can form on the flanks of both dry- and water-rich granular flows [9-15]. Ramparts are the products of particle segregation processes that cause accumulation of coarse particles at the flow's leading edge where they forms a high friction barrier whose grains favor inertial grain collisions [5, 6, 9-16]. This high friction front tends to slow the finer-grain, lower friction body of the flow that pushes it along [5, 9-15]. As a result, during emplacement, the thickness of the flows immediately behind the high-friction fronts are typically the same height, or nearly so, as the rampart they push along. However, whether the flows are wet or dry potentially can have a substantial effect on their final morphometry.

For example, after dry geophysical granular flows halt, their ramparts tend to be nearly the same height as the thickness of the flow body immediately behind them. This difference in height is mostly a result of differential compaction caused by grain size differences in the rampart (coarse particles) and flow body (finer particles) [17, 18]. For example, the ramparts of dry long runout landslides are, at most, only <25 % higher than the flow body immediately behind them (e.g., slides that are clearly dry because of their location such as Tsiolkovskiy on the Moon is ~25 % [19], and Ghanan on Ceres is ~10 % [data from 20]). Consequently, we suggest that dry granular flow would have ramparts that are < 25 % higher than the flow body behind.

However, this is not the case for flows containing substantial fluid (i.e., water or gas). In these flows, depending on fluid content, fluid can substantially add to their volume (as well as enhancing fluidity by decreasing yield strength). When these flows halt, the fluid leaks out (or freezes and sublimates) causing deflation proportional to the volume of fluid they contain, in addition to the effects of grain size on compaction. Added to these effects, distal rampart ridges of water-rich, granular flows have been found to be nearly dry during their emplacement [e.g., see 10], and hence show no post-flow deflation due to water loss. As a result, in such flows, there should be little post-flow deflation of their ramparts. But, immediately behind it the body of the flow, if water saturated and the water pressure high enough, would deflate due to water loss and effects of grain size on compaction. As a consequence, we suggest that the presence of considerable fluid (likely water or water vapor) in ejecta would cause ramparts that substantially exceed 25 % higher than the flow body immediately behind them.

Data: Average h_f/h_r ratio of test subjects: We investigate this concept for Martian layered ejecta craters by measuring (using MOLA PDER data, and CTX based DEMs) the thickness (in an average of 5 places) of the outermost ramparts (h_r), and the thickness of flow bodies (h_f) immediately behind them (Fig. 1). This was done for six single layer ejecta (SLE), four double layer ejecta (DLE) Type 1, and ten multi-layer ejecta craters (MLE) to obtain the average ratio of h_f/h_r for each crater.

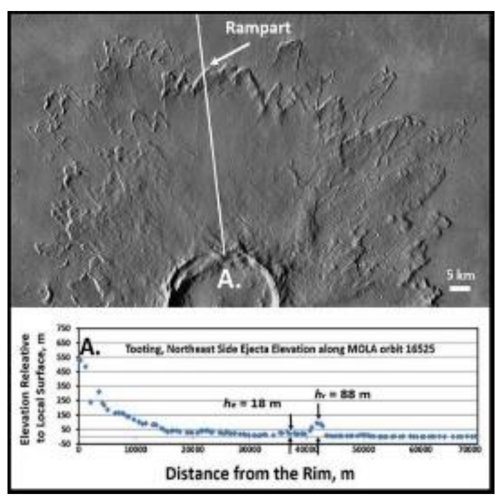

Figure 1. Example of measurment of ramparts on MLE crater, Tooting crater (~ 29 km dia.), on Mars.

Results: The average h_f/h_r ratio of the layered ejecta of craters mentioned above are plotted in Figure 2. This plots shows that all h_f/h_r ratio values are well below the value for dry flows, with the average h_f/h_r ratio all types of layered ejecta craters is ~0.29 (ranging by ± 0.17). However, we have found that there is a considerable range in h_f/h_r ratio values along each rampart (Figure 2), but have not yet collected enough data to determine if there are significant differences from crater type to crater.

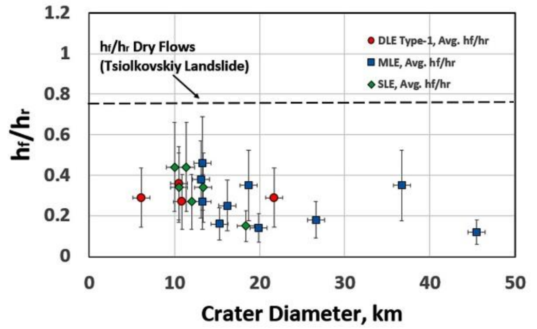

Figure 2. The ratio of the thickness of flow bodies (h_f) to the thickness of their outermost ramparts (h_r). The error bars are the standard deviation of the average measurement values for each rampart and ejecta thickness indicating considerable variation in these values along ramparts.

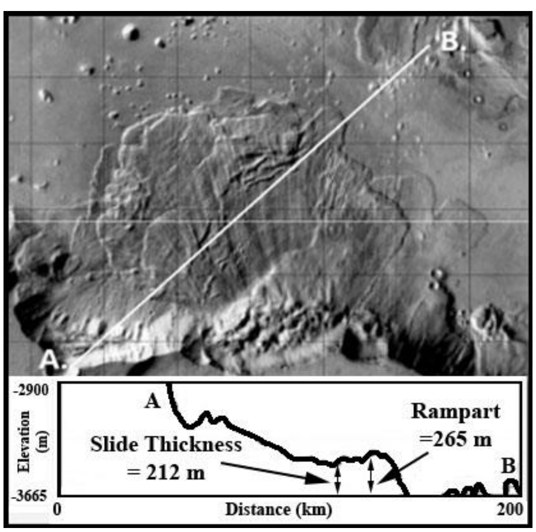

Figure 3. Example rampart on distal edge of a long run-out landslide in Valles Marineris (8°S, 315°E). Images is from THEMIS day time IR mosaic, elevation data from MOLA.

For comparison purposes, the h_f/h_r ratio for the rampart at the distal edges of an example Martian, long runout landslide (8°S, 315°E) in Valles Marineris was measured (Fig. 3). Its h_f/h_r ratio is ~0.80, about the same as the rampart of dry long runout landslides on the Moon [18], and Ceres [19]. This suggests little deflation, and hence, likely little water in this slide, consistent with the conclusions of [21].

Conclusions: If the deflation model we outlined here applies to Martian ejecta ramparts, then our measurements suggest that the outermost ejecta layer of Martian layered ejecta deflated an average of > 50% compared with completely dry poly-dispersive flows. Assuming that the deflation is mainly due to fluid loss, then as much as half of the original volume of the outer ejecta layers of craters was fluid [11 - 13]. Furthermore, our measurements suggest that the materials of some large landslides in Valles Marineris were dry, in agreement with [21].

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