SINGLE AND MULTI-LAYERED EJECTA CRATERS: CHARACTERISTICS OF MORPHOLOGY AND ASSESSMENT OF POSSIBLE MECHANISMS OF EJECTA EMPLACEMENT.

Joseph M. Boyce, and Peter Mouginis-Mark, Hawaii Institute of Geophysics and Planetology, University of Hawaii, Honolulu, Hawaii 96826, jboyce@higp.hawaii.edu

Introduction: This investigation is focused on collection of morphologic information for fresh Martian single layered ejecta (SLE) and multi-layered ejecta (MLE) impact craters and their ejecta deposits in both the southern highlands and northern lowlands in order to 1) test if the material properties of these two major terrain types affect the morphology of these craters, 2) determine any important differences between crater types, as well as any important differences within each major type, and 3) test and constrain previously proposed emplacement models for fluidized ejecta. These models link crater morphology to the state (i.e., solid, liquid, gas), location (i.e., surface, subsurface, atmosphere), and amount (a surface, or subsurface source implies a larger inventory than just atmosphere) of Martian volatiles. Consequently, it is important to understand which models apply to specific Martian craters and which models do not. To date we have identified and preliminarily characterized the morphology of 14 fresh SLE, MLE, and double-layered ejecta craters (DLE) that have small-scale morphologic features on their ejecta blankets that suggest minimum amounts of degradation, well-developed secondary crater fields, and few superposed impact craters.

We are in the process of comparing the morphologic traits of each crater type as a basis for determining subtle formational differences and to test previous classification schemes. Preliminary results suggest that the most widely accepted classification scheme of [1] is adequate for fluidized ejecta craters on Mars. At this preliminary phase of the study, we have compared the specific morphologic traits of diameter, depth, and rim heights of fresh SLE, DLE, and MLE craters and have found systematic differences in d/D relationships from area to area that suggest differences in strength of target materials. The anomalous target materials are found in southern Utopia Planitia, Isidis Planitia, and southeastern Acidalia Planitia regions, while no regions with anomalously weak materials have been identified. Recent THEMIS data provide new details to observations that suggest that the ejecta deposits of the different types of craters have systematic differences in morphology because of differences in emplacement mechanics. For example, inner ejecta layers of DLE craters are always cut by straight grooves that change to more curved troughs outward of the boundary with the outer layer (Figure 1 a) [2]. While there is also a radial component (although more weakly developed than on DLE craters) to the inner ejecta layer of SLE and MLE craters, several morphologic facies can be present such as ripple-like troughs and ridges concentric to the crater center, and small blocky knobs, mesas, and ridges. The inner ejecta of SLE and MLE craters thins rapidly outward to a terminal rampart a few tens of meters high, while on DLE craters this layer thins rapidly to a moat (ejecta a few meters thick) and then thickens (up to ~150-200 m on large DLE craters like Bacolor) outward to the scarp at the edge of the layer. The outer ejecta layers of both DLE and MLE craters show a variety of morphologies suggestive of flow. However, the ejecta of MLE craters is typically thinner than that of DLE craters of the same size and terminates in a rampart that is narrower and higher than that of DLE craters (Figure 1 b). All types of fresh craters have secondary crater fields (Figure 1 c). However, secondary craters are rare around DLE craters. Recent evidence suggests this is due to production of incompetent blocks that would normally produce secondaries by these craters. In contrast, abundant secondary craters are common around fresh SLE and MLE craters, even those found in the Noachian highlands. These secondary craters range in size from the limit of resolution up to ~ 0.15 R (where R is the radius of the parent crater). In places, the continuous ejecta deposits have overridden secondary craters and have had smaller

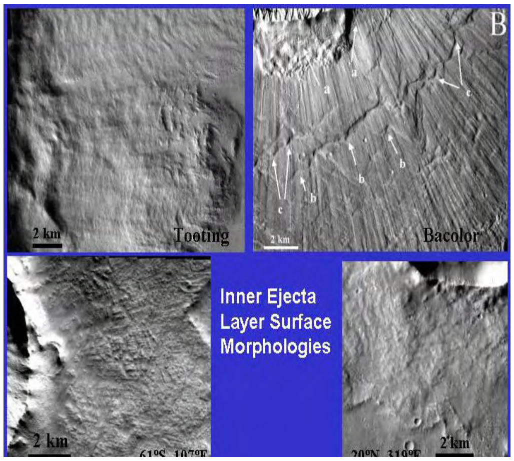

Figure 1 (a)

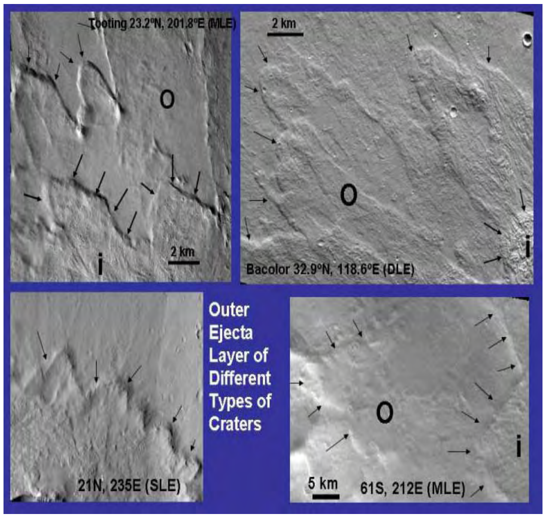

Figure 1 (b)

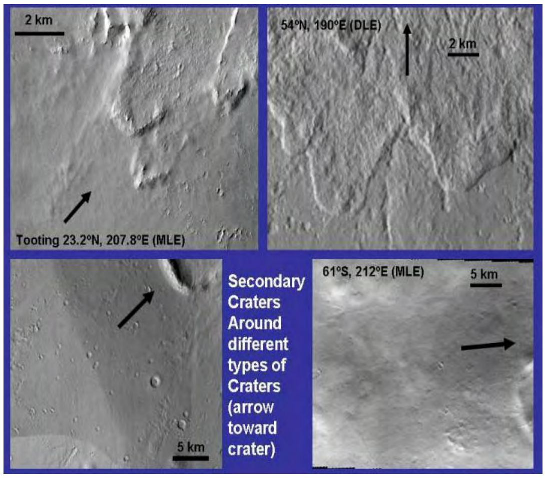

Figure 1 (c)

Figure 1. A comparison of the different fluidized ejecta facies for SLE, DLE and MLE craters. Figure 1 (a) shows the inner ejecta layer morphology. Figure 1 (b) shows the morphology of the outer ejecta layers for DLE and MLE craters as well as the thin outer deposits around the outer edges of SLE crater ramparts. Figure 1 (c) includes examples of secondary fields around fresh craters of each type. All images are segments of THEMIS VIS images.

secondary craters formed on top on those deposits. In addition, in many places different types of craters of nearly the same age form adjacent to one another (Figure 2) as noted by Boyce and Mouginis-Mark [2]. This suggests that either the subsurface of Mars is much more heterogeneous than expected from geologic mapping or that there have been many dramatic fluctuations in the climate of Mars during the time period the craters formed.

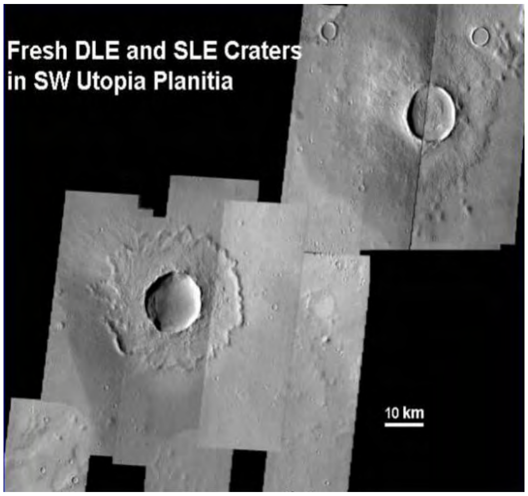

Figure 2

Figure 2. Two different types of craters (SLE on the left and DLE crater on the right) of nearly the same size (~ 12 km diameter) and morphologic freshness (i.e., age) located within ~ 75 km of each other in southwestern Utopia Planitia. Moasaic of THEMIS VIS images.

References: [1] Barlow, N. G., et al. (2000) *J. Geophys. Res.*, 105, 26,733 – 26,738.; [2] Boyce, J.M., and P. J. Mouginis-Mark, (2006) *J. Geophy. Res.*, 111, E10005, doi:10.1029/2005JE2638.