Morphology of Martian Double Layered Ejecta Craters and the Speed of Ejecta Emplacement: P. Mouginis-Mark & J. M. Boyce, Hawaii Institute of Geophysics & Planetology, Univ. Hawaii, Honolulu, Hawaii 96822; pmm@higp.hawaii.edu

Introduction: The higher spatial resolution of THEMIS VIS (19 m/pixel) and MOC (1.5 – 6.0 m/pixel) data compared to Viking Orbiter images (typically 40 – 150 m/pixel) has provided many news insights into the morphology of impact craters on Mars. The ejecta deposits surrounding many of these impact craters have been enigmatic since the first Viking Orbiter images illustrated their non-lunar character [1]. Unlike on the Moon and Mercury, Martian impact craters typically possess lobate deposits that appear to have been fluidized at the time of emplacement [2-5]. Typically this has been attributed to the presence of volatiles (water or ice) within the target material at the time of crater formation, although alternative models that include atmospheric effects have also been proposed [6, 7]. Although never explicitly stated, it seems implicit in the literature that ejecta moved quite rapidly across the surface (a few hundreds of meters per second [8]). Here we draw on many THEMIS and MOC images to show that this is not the case, and that ejecta velocity may have been only a few tens of meters per second. These data also show several unique characteristics of double layered ejecta (DLE) craters that suggest a strikingly different mode of formation compared to single layered ejecta (SLE) or multi-layered ejecta (MLE) Martian craters. We will review our observations at the workshop.

Observations of DLE Craters: Our analysis shows that DLE craters are typically 15 to 25 km in diameter and differ from the other types of Martian craters in the following ways: (1) DLE craters lack secondary craters; (2) ejecta layers of DLE craters lack distal ramparts; and (3) radial striations exist only within DLE ejecta, and that these striations cross both the inner and outer ejecta layers. We also find several intriguing features on DLE craters that are good indications of slow ejecta emplacement at the surface for almost the entire radial distance from rim to distal margin. Such features include: (a) the occurrence of radial striations within the ejecta layer that extend almost towards to primary crater almost all the way to the rim crest (Fig. 1); (b) the inability of ejecta to flow into a pre-existing depressions (usually an older impact crater) even within a few kilometers of the rim of the younger crater (Fig.1); (c) the deflection of ejecta around obstacles, which in cases measured to date range from 60 – 300 m high (Fig. 2); (d) the non-radial path of segments of the ejecta layers, which appear to be controlled by topography on the ejecta surface that may be only few tens of meters high (Fig. 3).

Conclusions: The presence of striations very close to the preserved crater rim crest of DLE craters argue against atmospheric deceleration playing an important role in the ejecta emplacement process. We believe that only by ejecta falling onto the outer rim and then moving radially across the surface can the observed striations or scour marks be created. The outer layer of DLE craters was emplaced at a relatively low velocity and as a series of pulses rather than as a single surge. This is demonstrated by the fact that the material was diverted by subtle topographic variations associated with the earlier parts of the ejecta emplacement process. We hope that our observations will further help to constrain numerical models of ejecta emplacement on Mars currently under development.

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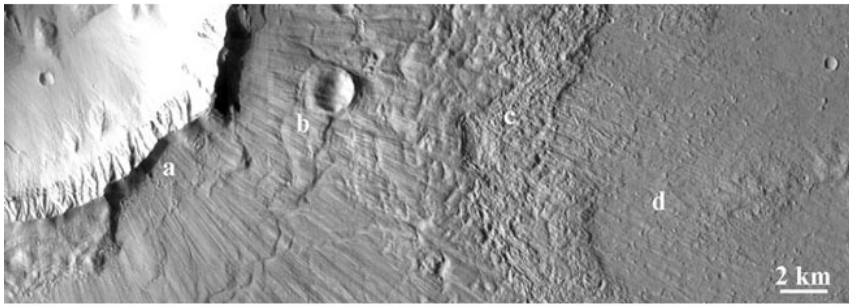

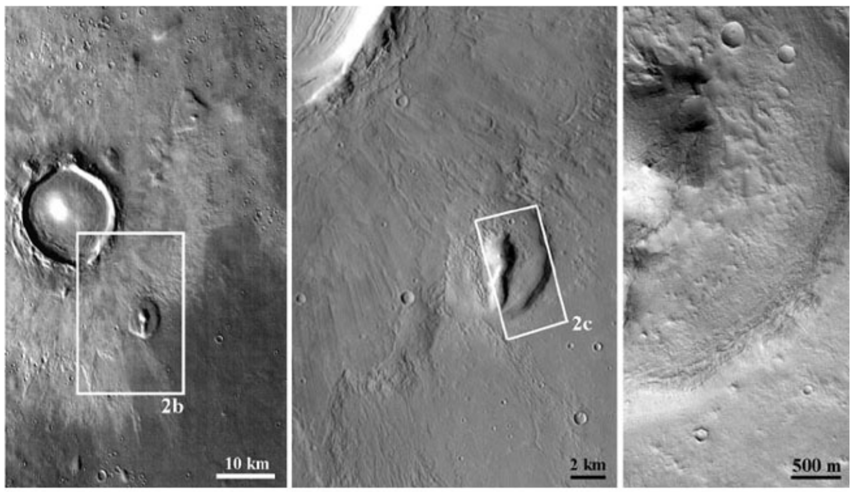

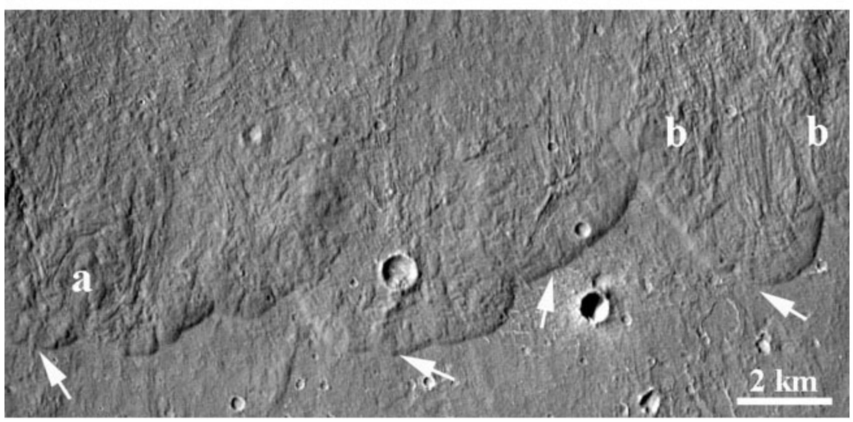

Figure 1 (top image): THEMIS view of the inner ejecta layer of a 20.3 km diameter crater in E. Utopia Planitia. Several key attributes of DLE craters are seen here, including the radial scouring that extends to the rim crest (a), the inability of the ejecta to over-top even low obstacles (b), post-emplacement deformation, perhaps suggesting rheomorphic flow, of the boundary of the inner layer (c), and the continuation of the radial striations on to the outer ejecta layer (d). Figure 2 (middle row): (a) THEMIS daytime IR view of a 16.1 km dia. DLE crater in W. Utopia Planitia. Note the obstacle ~12 km from the rim of this 15.9 km diameter crater. (b) THEMIS VIS image of the same obstacle, which MOLA data reveal is ~290 m high. (c) MOC image of the side of the obstacle facing away from the crater. The absence of scouring or other signs of ejecta on this surface shows that the ejecta flow was insufficient to over-top this obstacle. Figure 3 (bottom image): THEMIS VIS image of the distal edge of the outer layer of a DLE crater in Utopia Planitia. Arrows point to locations where small surface flows have spilled over the edge of the ejecta and extend onto the surrounding plain. "a" denotes an obstacle that has diverted ejecta flow. Channeling of the ejecta has taken place between the two obstacles marked "b".