MARTIAN IMPACT CRATER EJECTA AND INTERIOR MORPHOLOGIES: NEW INSIGHTS FROM MGS AND ODYSSEY DATA ANALYSIS. N. G. Barlow, Dept. Physics and Astronomy, NAU Box 6010, Northern Arizona University, Flagstaff, AZ 86011-6010 Nadine.Barlow@nau.edu.

Introduction: New data from the Mars Global Surveyor (MGS) and Mars Odyssey missions are revising our understanding of the morphologic and morphometric characteristics of martian impact craters. MGS Mars Orbiter Camera (MOC) and Odyssey Thermal Emission Imaging System (THEMIS) visible (VIS) imagery are allowing identification and analysis of features well below the resolution limits of Viking Orbiter imagery. MGS Mars Orbiter Laser Altimeter (MOLA) data provide the first detailed view of crater and ejecta topography. Odyssey THEMIS IR data allows determination of the thermophysical properties across the crater and any associated ejecta deposits. The enhanced resolutions and overall clarity of these data are producing a much improved understanding of the correlations between certain features and insights into the possible origins of crater-associated morphologies.

We are nearing completion of the *Catalog of Large Martian Impact Craters, version 2.0*, a revision of the original *Catalog of Large Martian Impact Craters* which provided information on 42,283 craters ≥ 5-km-diameter across the entire martian surface as derived from the Viking 1:2,000,000-scale photomosaics [1]. *Catalog 2.0* revises many of the original data columns based on reanalysis of each crater using MGS and Odyssey data. In addition, new morphologic and thermophysical data are being included for each crater. Latitude-longitude coordinates of each crater's center are being revised to the MDIM-2.0 coordinate system. A new crater preservation system has been developed based on MOC and THEMIS image analysis, MOLA topography, and THEMIS IR thermophysical characteristics [2]. Some questionable craters identified from Viking Orbiter imagery have been removed from the revised *Catalog* but additional craters identified in MOLA topography are being added. We expect to release *Catalog 2.0* by the end of 2004. Analysis of data in *Catalog 2.0* is supporting some previously reported correlations among crater ejecta and interior features [e.g., 3], but some new trends are beginning to be revealed.

Ejecta Morphologies: The nomenclature recommended by the Mars Crater Consortium (MCC) [4] for describing martian ejecta structures continues to work well with a few exceptions. Single layer (SLE), double layer (DLE), and multiple layer ejecta (MLE) nomenclature which are then further modified with descriptors of rampart vs pancake edges, radial vs "fluidized" patterns, "pedestal" occurance, and level of ejecta sinuosity, describe essentially all the ejecta morphologies seen on Mars. A few patterns, such as the striations seen on the ejecta blankets of many double layer craters, however, are not covered by the current nomenclature system and the MCC needs to discuss whether these require further adjustment of the nomenclature system.

Approximately 25% of all craters in the original *Catalog* are having their ejecta morphologies revised based on MGS and Odyssey data analysis. While the SLE morphology continues to dominate across the planet, the improved clarity and higher resolution of MOC and THEMIS data are resulting in the identification of more craters displaying the DLE and MLE morphologies.

DLE craters continue to be found concentrated in the Arcadia, Acidalia, and Utopia regions of the northern plains (primarily between 35°N and 65°N) [3], but an increasing number are beginning to be identified in the southern hemisphere's 35°S to 65°S latitude zone. The concentration of DLE craters in the southern zone remains much lower than in the northern zone: DLE craters in the southern zone constitute ~10% of all craters displaying an ejecta morphology compared to ~40% in the northern zone. While the inner ejecta layer displays similar ejecta mobility ratios between the northern (average EM = 1.5) and southern (average EM = 1.4) zones, the outer layer extends much further around craters in the northern zone (average EM = 3.5 in north compared to 2.8 in south) (Table 1).

Costard [5] suggested that pancake (Pn) craters found in the northern plains might be double layer craters whose outer ejecta layer has been removed. The current analysis supports this idea. Several craters previously classified as single layer Pn structures are now seen to actually be DLE craters. Pn craters also tend to be found in the same regional locations as DLE craters, they display the non-rampart edge typical of the inner DLE ejecta layer, and they have EM values very similar to EM for the DLE inner ejecta layer (average of 1.6 for Pn compared to 1.5 for inner DLE layer in northern zone) (Table 1). Therefore this study supports the hypothesis that the Pn ejecta morphology is the result of destruction of the outer ejecta layer in DLE craters.

Pedestal (Pd) craters have been proposed to be craters whose ejecta has armored the surface immediately adjacent to the crater, preventing the eolian erosion which strips away the surroundings and thus leaving the crater and its ejecta perched above the surrounding terrain. Our current analysis of Pd craters finds they tend to be small craters (average D ~2-3 km) concentrated in regions believed to be ice-rich, such as the high-latitude northern plains [6] and possible ancient paleolake environments [7]. This study finds that many of the high-latitude Pd craters are concentrated in the same areas as DLE craters. Close inspection reveals both SL and DL ejecta layers in the Pd morphology. EM values for Pd craters can be quite high [8] and are similar to the largest values seen for SLE and the outer layer of the DLE morphologies. We propose that Pd craters form by impacts which do not completely penetrate through an ice-rich fine-grained mantle. The resulting ejecta consists of less-volatile rich material which produces a cap over the underlying volatile-rich mantle. As conditions on Mars change, the surrouding mantle loses some of its ice, lowering the terrain below the level of the pedestal crater and its ejecta. This mechanism removes the problem of the Pd symmetry which has been a concern with the eolian erosion model.

The MLE morphology continues to be found surrounding larger craters (~20 to 50-km diameter) than the those associated with the SLE morphology (up to ~20-km-diameter in the equatorial region). MLE craters are concentrated in the equatorial region, particularly along the dichotomy boundary.

Central Pits: Central pits are more common in martian impact craters than in lunar or mercurian craters of equivalent sizes. Their origin has been attributed to impact into volatile-rich targets [9], a hypothesis supported by observations of regional concentrations of central pit craters along the rim and/or outer rings of large impact basins [10] where fracturing may have concentrated volatile reservoirs. Central pits occur on the crater floor in place of a central peak ("floor pits") or atop central peaks ("summit pits"). Floor pits can be further characterized as "symmetric" or "asymmetric" in shape. MOC and THEMIS imagery are revealing many more central pits than previously recorded from Viking image analysis. Approximately 35% of central pits occur in craters which also display a ML ejecta morphology. Many others are seen in older craters which no longer retain an ejecta blanket, indicating that the volatile-rich conditions producing central pits have been long-lived in many regions. Currently we do not see regional or diameter variations between the occurrence of floor pits versus summit pits.

Summary: MGS and Odyssey data analysis is revealing that martian impact craters display a wide range of morphologic variety. The improved clarity and higher resolutions of the MOC and THEMIS data are permitting improved classification of crater ejecta and interior morphologies. Although little difference has yet occurred in our analysis of ejecta morphology as a function of crater diameter and location on the planet, new insights are resulting from the present analysis. The current analysis supports the idea that craters displaying a pancake ejecta structure are actually DLE craters where the outer ejecta layer has been removed (or is indistinguishable at current resolutions). We propose that pedestal craters form by impact into an ice-rich mantle from which the ice subsequently sublimates, causing the surrounding terrain to lower. Central pits are more common than previously thought and are often associated with craters displaying an MLE morphology. The process producing central pits (impact into volatile-rich targets) apparently has been occurring for much of martian history due to the existence of central pits in craters with a variety of preservation ages.

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Table 1: Comparison of ejecta mobility ratio values for the different ejecta morphologies at latitudes poleward of 40°.

	Minimum EM	Maximum EM	Average EM
SLE, Lat ≥ 40N	0.2	6.4	1.8
DLE, Lat ≥ 40N			
Inner Layer	0.4	3.3	1.5
Outer Layer	1.5	10.6	3.5
MLE, Lat ≥ 40N	0.8	4.7	2.8
Pn, Lat ≥ 40N	1.0	3.1	1.6
PD, Lat ≥ 40N*	1.6	5.0	3.7
SLE, Lat ≤ 40S	0.7	3.3	1.6
DLE, Lat ≤ 40S			
Inner Layer	0.9	2.0	1.4
Outer Layer	1.6	4.5	2.8
MLE, Lat ≤ 40S	2.2	3.3	2.5
Pd, Lat ≤ 40S*	1.6	6.0	3.8

*Pd crater analysis shown here only includes craters ≥5-km-diameter.