MARTIAN IMPACT CRATERS AS REVEALED BY MGS AND ODYSSEY. N. G. Barlow, Dept. Physics and Astronomy, Northern Arizona University, Flagstaff, AZ 86011-6010, Nadine.Barlow@nau.edu.

Introduction: A variety of ejecta and interior morphologies were revealed for martian impact craters by Viking imagery. Numerous studies have classified these ejecta and interior morphologies and looked at how these morphologies correlate with crater diameter, latitude, terrain, and elevation [1, 2, 3, 4]. Many of these features, particularly the layered ("fluidized") ejecta morphologies and central pits, have been proposed to result when the crater formed in target material containing high concentrations of volatiles.

The *Catalog of Large Martian Impact Craters* was originally derived from the Viking 1:2,000,000 photomosaics and contains information on 42,283 impact craters ≥5-km diameter distributed across the entire martian surface. The information in this *Catalog* has been used to study the distributions of craters displaying specific ejecta and interior morphologies in an attempt to understand the environmental conditions which give rise to these features and to estimate the areal and vertical extents of subsurface volatile reservoirs [4, 5].

The *Catalog* is currently undergoing revision utilizing Mars Global Surveyor (MGS) and Mars Odyssey data [6]. The higher resolution multispectral imagery is resulting in numerous revisions to the original classifications and the addition of new elemental, thermophysical, and topographic data is allowing new insights into the environmental conditions under which these features form. A few of the new results from analysis of data in the revised *Catalog* are discussed below.

SLE, DLE, and MLE morphologies: The three major ejecta morphologies seen around relatively fresh craters on Mars are the single layer ejecta (SLE), double layer ejecta (DLE), and multiple layer ejecta (MLE) morphologies, defined by the number of ejecta layers surrounding the crater [7]. Improved image resolution is allowing correct classification of many craters which either were not classified in the original Catalog or which were misclassified. As such, the total number of craters displaying any type of ejecta morphology have increased, as have the numbers for each ejecta type.

SLE craters continue to dominate among the ejecta types at almost all latitudes and longitudes. DLE craters continue to dominate in the 30° to 60°N latitude zone, particularly in Acidalia, Arcadia, and Utopia. However, we are identifying increasing numbers of DLE craters in the 30° to 60°S latitude region. As Mouginis-Mark et al. [8] have noted, DLE craters have very specific morphologic characteristics which are not seen with SLE or MLE craters.

MLE craters continue to dominate in the 25-50 km diameter range, primarily in the ±30° latitude zone. MLE craters are primarily concentrated along the dichotomy boundary but our new analysis is revealing higher concentrations in both the plains and highlands than seen with the previous Viking-based studies. MLE craters have much higher ejecta extents and sinuosities than SLE craters, suggesting that the ejecta flow was more fluid.

Pancake and Pedestal Craters: Pancake (Pn) craters are those in which the ejecta blanket displays an apparent convex terminus rather than the distal ridge (rampart) seen for most martian ejecta blankets. MOLA data suggest that many if not all of these pancake ejecta blankets actually do display a slight ridge, but from visual inspection this ridge is not obvious. This study finds that single layer pancake (SLEPn) morphology displays many of the same characteristics as the inner layer of the DLE morphology. These similarities include general morphology, ejecta extent (ejecta mobility ratio of 1.6 for SLEPn versus 1.5 for inner layer of DLE), and sinuosity (both have lobateness values near 1.1). In addition, many of the SLEPn craters in the original *Catalog* are now seen to actually be DLE craters where the outer layer is highly degraded or was not visible to Viking cameras (often because of the pervasive clouds occurring at high latitudes during the Viking missions). All of these observations support Costard's [3] proposal that SLEPn craters are simply the inner layer of DLE craters where the outer layer is either eroded away or difficult to observe at available resolutions.

Pedestal (Pd) craters are craters where both the crater and the surrounding ejecta are elevated above the surrounding terrain. Pd craters tend to be quite small and most are below the 5-km-diameter cutoff of the revised *Catalog*. Pd craters are typically attributed to eolian deflation of fine-grained materials surrounding the crater [9]. However, our analysis has found that Pd craters tend to occur in the same regions as DLE craters and display similar ejecta extents and sinuosities as the outer layer of the DLE morphology. Pd craters tend to occur in areas where Odyseey's GRS instruments have detected high concentrations of water.

They also tend to occur in areas composed of fine-grained materials, according to visual observations and thermal inertia data. These are many of the same areas where recent obliquity-climate models propose ice sheets during high obliquity periods [10]. We propose that Pd craters may form by impact into these fine-grained volatile-rich deposits. Later sublimation of the volatiles lowers the surrounding surface, leaving the crater and ejecta blanket perched above the surroundings.

Central Pit Craters: Mars is the only terrestrial planet which shows an abundance of impact craters with central pits. These pits are commonly attributed to outgassing of subsurface volatiles during crater formation [11], although impacts by comets have also been proposed [12]. Recent 2D and 3D modeling of impacts into soil-water/ice mixed targets have revealed that temperatures under the central region of the crater are higher than in the surrounding material, which can vaporize any existing water/ice [13]. The sudden outgassing of this vapor could lead to central pit formation.

Martian central pit craters can be divided into “floor pits” and “summit pits” (pits on top of central peaks). Barlow and Bradley [4] found that craters containing summit pits tended to be smaller than those containing floor pits and that central pit craters tended to concentrate along the outer rings of large impact basins. Fracturing of the surface during ring formation and concentration of volatiles along these fractures was proposed to explain the observed distribution of central pit craters.

MGS and Odyssey data are revealing central pits in more craters than were observed from the Viking analysis. Our current analysis [14] suggests that central pit craters are typically larger than 20 km in diameter. Craters with central pits display a range of preservational states, from degraded to pristine. This suggests that the subsurface volatiles responsible for central pit formation have been present throughout much of martian history, up to recent times. Many of the fresher craters which display a central pit are surrounded by a MLE morphology, suggesting that the conditions which lead to formation of a multiple layer ejecta blanket also favor the formation of central pits.

Summary: Analysis of the higher resolution multispectral data from MGS and Odyssey instruments is providing a more detailed view of impact craters and their associated ejecta and interior features. These new images, combined with the topographic, thermophysical, and elemental data also obtained by instruments on these missions, are revealing more details of the ejecta and interior morphologies which can be used to constrain the environmental conditions which produce these features. Subsurface volatiles continue to be strongly indicated by the majority of these observed features.

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