MARTIAN IMPACT CRATERS: THE NORMAL AND THE UNUSUAL. Nadine G. Barlow, Dept. Physics and Astronomy, Northern Arizona University, NAU Box 6010, Flagstaff, AZ 86011-6010. Nadine.Barlow@nau.edu.

Introduction: Our group has conducted a number of studies investigating the characteristics of martian impact craters. Many of these studies have provided insights into the normal characteristics of martian impact craters, such as their ejecta extents, ratio of central pit diameters to crater diameters, and the distributions of specific ejecta and interior morphologies. Other characteristics are more unusual, such as the extreme ejecta extents of craters in high-latitude regions. Here we summarize the current status of these studies.

Crater Catalog Revision: We have completed revision of the northern hemisphere craters except for those in MC12 (i.e., most of Arabia) and MC01D-J (surrounding the north polar cap). The portion completed contains 11360 craters ≥5-km-diameter, compared to the original Viking-based catalog which contains 10395 craters within in the same regional and diameter range. Of these 11360 craters, 4772 (42%) display a classifiable ejecta morphology. 5003 (44%) of the 11360 craters display a classifiable interior morphology.

Ejecta Characteristics: The 4772 craters displaying a classifiable ejecta morphology are divided into seven general categories: single layer rampart (SLE), double layer (DLE), multiple layer rampart (MLE), radial (Rd), diverse (Di), pancake (Pn), and pedestal (Pd). Details about ejecta sinuosity are contained in the catalog but are not discussed here. Table 1 shows how the morphologies are distributed.

Table 1: Ejecta Morphologies

TYPE	#	%
SLE	2489	52.0
DLE	1033	22.0
MLE	882	19.0
Rd	30	0.6
Di	95	2.0
Pn	208	4.4
Pd	35	0.7

Table 1 shows that SLE craters dominate among the ejecta types, consistent with earlier studies [1, 2, 3]. However, the higher resolution and improved clarity of the MOC and THEMIS data used in this analysis have changed the relative proportions of the different ejecta types, increasing the percentage of DLE, MLE, and Di craters and lowering the number of SLE.

Ejecta extent is measured through the ejecta mobility (EM) ratio, given by:

$$EM = (\text{max extent of ejecta})/(\text{crater radius})$$

EM for SLE craters ranges between 0.5 and 8.2 with an average value of 1.48. MLE craters have an EM range between 1.2 and 6.5 with an average of 2.50. The inner layer of DLE craters have EM values ranging between 0.4 and 3.3 with an average of 1.48 while the outer layer ranges between 1.4 and 9.8 with an average of 3.28. No strong variations in EM are seen among plains versus highlands regions. EM tends to increase poleward.

Central Pit Craters: Of the 5003 craters displaying an interior structure, 14% of them show a central pit. Central pits are subdivided into floor pits, where the pit lies directly on the crater floor, and summit pits (N = 215), where the pit lies atop a central rise or peak. Floor pits are further subdivided into asymmetric pits (N = 31) and symmetric pits (N = 446). Floor pits are approximately twice as common as summit pits.

On icy moons such as Ganymede, floor pits tend to occur on top of an updomed floor, likely resulting from rebound of the icy-target under the crater floor [4, 5]. We have used MOLA topography to determine if martian floor pits also occur on updomed floors. Our results show no indication that updomed floors occur in martian central pit craters. This is consistent with the lower target ice concentrations expected for Mars.

Craters containing central pits range in diameter from 5 km (the minimum diameter included in the Catalog) to 125.4 km. Symmetric floor pits range in size from 5.0 to 114.0 km while asymmetric floor pits are seen in craters ranging in diameter from 9.7 to 72.1 km. Summit pits are seen in craters with diameters from 6.1 km to 125.4 km. No strong regional variations are seen in the distribution of pit craters versus non-pit craters or among the different pit craters.

High Latitude Crater Morphologies: Several craters with extremely high EM ratios are seen at high northern latitudes. Often these craters display a “typical” double layer ejecta blanket superposed on an extensive ejecta layer which becomes discontinuous at its outer edges (Fig. 1). The underlying ejecta deposit shown in Figure 1 extends 17.4 crater radii from the rim; other examples extend over 7 crater radii. These craters do not show the typical attributes of MLE craters, as noted by [6], and a different formation mechanism is implicated. We have thus far identified 4 examples of these types of craters with diameters ranging from 5.5km to 12.6 km. All are found poleward of 68°N latitude.

These craters display characteristics similar to those of smaller pedestal (Pd) craters which are found at lower latitudes. Pd craters are typically <2-km-diameter and the majority in the northern hemisphere are found in the 45°N to 60°N latitude zone [7, 8]. We have proposed that the Pd craters form by the sublimation of ice contained in fine-grained deposits surrounding the craters, thus causing the surroundings to lower relative to the crater. Theoretical studies suggest that impact melt generation is greater for impacts into ice-rich materials [9] and observational evidence at Haughton Crater on Devon Island, Canada, supports this idea [10]. We have proposed that excess amounts of impact melt are produced during Pd crater formation in ice-rich deposits which helps to armor the ejecta against the ice sublimation process [7, 8]. We propose that the higher latitude, high-EM craters noted here may be the larger crater and/or higher latitude equivalent of Pd craters. In this case, ice from the surrounding material has not sublimated and therefore no "pedestal" characteristic is observed. However, we suggest that the extensive underlying ejecta layer is largely composed of impact melt.

Conclusions: Martian impact craters display a variety of features. Many of these show global distributions and are interpreted as normal craters features on Mars. These include the layered ejecta morphologies and interior morphologies such as central peaks and central pits. There are a number of similarities between craters on Mars and Ganymede, including the presence of layered ejecta blankets [11, 12, 13] and central pits [5], although detailed analyses reveal some subtle differences. One example of such a difference is the lack of crater floor updoming in martian floor pit craters compared to those on Ganymede. We also see differences in martian impact crater morphologies with location on the planet. These structures differ from the "normal" crater morphologies and are thus termed "unusual". An example of an unusual morphology are the high-latitude craters with an extensive ejecta deposit underlying the normal double layer ejecta structure. We propose that excess amounts of impact melt are produced during crater formation in the ice-rich high latitude region. This impact melt helps to produce and retain the extensive ejecta deposit. Further analysis of the southern hemisphere craters will help us further constrain the conditions under which such morphologies are produced.

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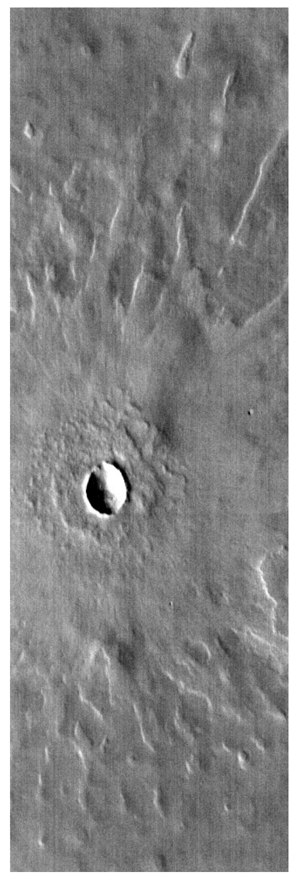

Figure 1. Several craters at high northern latitudes display an unusual ejecta morphology which consists of a typical double layer morphology superposed on a very extensive ejecta deposit which becomes very discontinuous at its outer edges. This crater is 5.5-km in diameter and is located at 68.27°N 266.36°E (THEMIS image I04073002)