ANALYSIS OF IMPACT CRATERS IN THE 0-20°N, 0-30°E REGION OF ARABIA TERRA, MARS AND IMPLICATIONS FOR VOLATILES. M. E. Landis and N.G. Barlow, Department of Physics and Astronomy, Northern Arizona University, Flagstaff, AZ 86011-6010, USA (lel56@nau.edu; Nadine.Barlow@nau.edu)

Introduction: The Arabia Terra region of Mars is a unique area for study due to the presence of crater morphologies resulting from possible interaction with volatiles. Arabia Terra is the largest expanse of ancient heavily-cratered terrain in the Martian northern hemisphere and is one of the few equatorial regions where neutron analysis suggests present-day enrichment in H_2O [1]. Arabia Terra has been proposed to be an ancient basin with long-term H_2O enrichment [2]. A way to investigate the role that H_2O has played in the history of Arabia Terra is to examine the morphologies and morphometries of impact craters in this area.

Impact craters are useful in this analysis for three reasons: (1) the original shape and depth of impact craters is well-constrained and related to crater diameter, (2) craters excavate into the subsurface and their resulting morphologies can be tied to the distribution and concentrations of subsurface volatiles, and (3) crater size-frequency distribution analysis allows us to constrain the timing of volatile-rich processes which have modified craters from their original morphologies.

Methodology: We are classifying morphologies and morphometries of all impact craters ≥1-km-diameter in the 0°-20°N 0°-30°E region of Arabia (part of a larger project investigating the role of volatiles throughout this region). We are utilizing imagery from Mars Odyssey Thermal Emission Imaging System (THEMIS) and Mars Reconnaissance Orbiter Context Camera (CTX) to measure crater diameters and classify interior morphologies. We also are using Mars Global Surveyor Mars Orbiter Laser Altimeter (MOLA) data to determine crater depths for the larger craters and shadow estimate techniques to determine depths for smaller craters. We have expanded Barlow's *Catalog of Large Martian Impact Craters* [3] to include all craters between 1 and 5 km diameter in the study region.

Table 1. Number of craters ≥5-km-diameter falling into each morphology category and percentage of total craters in the catalog.

Morphology	Number	% of Total
Central Pit	21	2.0%
Central Peak	9	0.8%
Layered Ejecta	359	33.4%
Chaotic-type Textures	88	8.2%
Inverted Crater	20	1.9%
Lineated Floor Deposits	35	3.3%
Nested Crater	5	0.5%
Scalloped/serrated Rim	269	25.0%
Terrain Softening	6	0.6%
Floor Pits	96	8.9%
Ejecta Blanket Infilling	102	9.5%
Sand Dunes	76	7.1%
Layered Deposits	176	16.4%
Floor Ridges	148	13.8%
Total with floor deposits	705	65.5%

Crater Morphology: We have divided interior morphologies for craters ≥5km-diameter into several categories by comparing THEMIS and CTX images of the identified craters to exemplars for each category. THEMIS visual (18 m/px) and daytime infrared (100 m/px) images were primarily used, but CTX images (6 m/px) were utilized where a determination could not be made due to low resolution in the THEMIS images. Some morphologies are primary and provide insights into volatiles at the time of crater formation. These morphologies include central pit, central peak, and nested crater ("inverted sombrero") morphologies as well as layered ejecta blankets. Other morphologies result from subsequent modification of craters by geologic processes. We have several categories of floor deposits, including sand dunes, lineated deposits, ejecta from nearby craters, and layered deposits. Other modification classes include chaotic-type textures, scalloped or serrated rim, inverted craters, floor pitting, floor ridges, and terrain softening. The percentage of craters in each category is shown in Table 1. Several of these features are attributed to impact into subsurface ice (layered ejecta, central pits, and terrain softening) [4, 5] while others have been proposed to result from impact into sedimentary layers possibly deposited in marine environments (nested craters) [6]. Lineated floor deposits may be ice-rich glaciers [7] and layered floor deposits may have been deposited in crater paleolakes [8]. Thus classification and analysis of these features allows us to investigate the spatial and temporal distribution of volatiles in Arabia Terra.

Crater depth calculations. We measured current depths of craters ≥5-km-diameter using JMARS software and the MOLA data set. Crater depth measurements were obtained for the lowest point in the crater, excluding depths due to morphological features like central pits. This measurement was subtracted from the elevation of the surrounding surface to determine the current crater depth.

Original crater depths (d) were calculated using the 1/10 transient diameter relationship [9]. The transient diameter equals the final diameter for simple craters. The transient diameter (D_t) for complex craters is related to the observed rim diameter (D_r) and the simple-to-complex transition diameter (D_{sc}) [10]:

$$D_t=D_{sc}^{0.15\pm0.04}\, D_r^{0.85\pm0.04}$$

D_{sc} in Arabia Terra was taken as 7 km [11, 12]. For complex craters, the minimum and maximum original depths within the error of the above equation were averaged to find an original depth for comparison.

Current and original crater depths were compared in terms of percent lost from the original crater depth. This process of comparing current and original depths and crater morphologies will be repeated with craters in the diameter range of 1-5 km. Depths will be derived from shadow length estimates for craters with diameters less than 3 km.

Results and Future Work: We have added over 16,500 craters in the 1-5-km-diameter range to the 1076 craters ≥5-km-diameter listed in Barlow's crater catalog for the study region. Classification of interior morphologies and calculations of original depth for craters in the study region above 5 km is complete. The current data for d-D relationships in the study region is shown in Figure 1. Depths for craters smaller than 3-km-diameter are being determined using shadow measurements due to resolution limitations with MOLA. Upon inclusion of the small crater data, the depth-diameter (d-D) plot will be reexamined to give a more specific value for D_{SC} in this region.

The d/D relationship for all craters included in the survey from 3 to 15 km is shown in Figure 2. The data suggest that 3-5 km diameter craters are abnormally deep. These results may indicate that these small craters are excavating into (but not through) fine-grained weak regolith materials. No regional variations in the distribution of these abnormally deep craters are seen. This region of Arabia Terra has been explored by the Opportunity rover and is known to be covered by a hematite deposit. This deposit and other fragmented materials likely comprise the weak regolith layer influencing the d/D values of small craters.

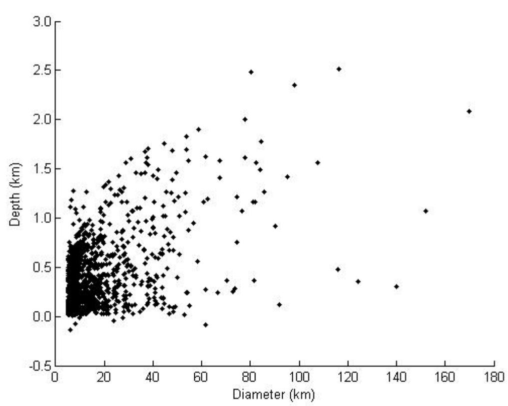

Figure 1. Depth versus diameter measurements for craters ≥5-km-diameter in the study region of Arabia Terra.

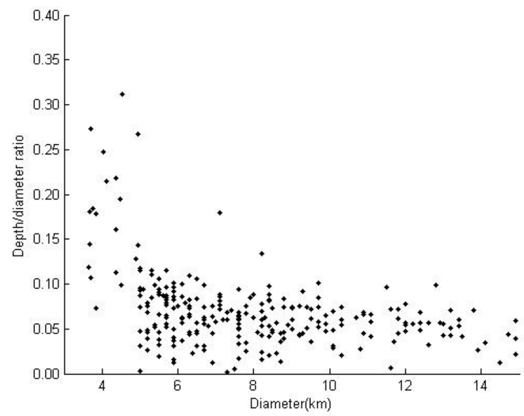

Figure 2. Depth diameter relationships for craters in survey from 3 to 15 km.

Upon completion of data collection, we will use ArcGIS to investigate correlations between the distribution of specific morphologies and parameters such as latitude, longitude, elevation, surface composition, etc. We are interested especially in looking at the distribution of those morphologies that are proposed to form from impacts into ice-rich and possible marine targets to determine if these scenarios are supported by the evidence. Continuing topics for research in this project include examining additional small diameter craters to put constraints on the depth of the weak regolith layer, and to use crater size-frequency distribution analysis for each morphology type to establish age constrains on the processes producing these features and the role of subsurface and surficial volatiles.

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