THE ROLE OF VOLATILES IN THE EVOLUTION OF IMPACT CRATERS IN SOUTH-CENTRAL ARABIA TERRA.

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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 1-5-km-diameter in the study region.

Crater Morphology: We have divided interior morphologies for craters ≥3km-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. CTX images (6 m/px) were utilized where a determination could not be made using THEMIS images alone. We cataloged floor deposits with both primary impact and modification type morphologies [4]. Crater morphology types identified in this study is shown in Table 1 with ≥5-km-diameter craters included.

Crater depth calculations. We measured current depths of craters ≥3-km-diameter using JMARS software and the MOLA data set. Details of our analysis are summarized in previous work [4].

Current depths have been derived using shadow depth measurements and MOLA topography data. Current and original depths have been compared to give relative ages of the craters with ≥3-km-diameter.

Results: 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 ≥5-km-diameter is complete. Craters with a diameter between 3 and 5 km have had current depths measured

Table 1.

Morphology	Number	% of Total Craters
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	97	9.0%
Ejecta blanket infilling	102	9.5%
Sand dunes	76	7.1%
Layered Deposits	176	16.4%
Floor ridges	150	13.9%
Total with floor deposits	705	65.5%

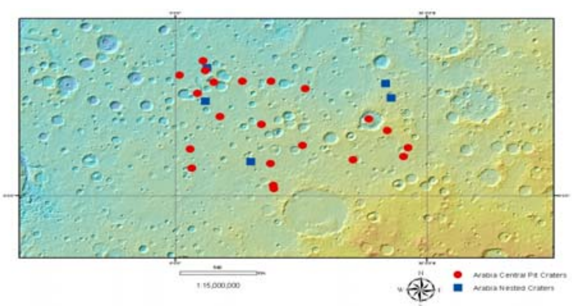

Figure 1- A MOLA topography map of the study region shows central pit craters as red circles and nested craters as blue squares.

and floor deposits classified.

We have begun an analysis of crater distribution by examining two particular morphologies in the ≥5-km-diameter craters in the study region. A map of ≥5-km-diameter craters showing central pit or nested crater morphologies with a MOLA topography overlay is included in Figure 1. Central pit craters are a morphology linked to subsurface volatiles, and they occur evenly throughout the study area. Nested craters occur in this same study area in mid-range elevation parts of the study area, indicated by the green color on the MOLA topography overlay. If nested craters in this case were linked to impact into marine environment, they would be expected to occur on the lower (blue) elevation areas. This is an interesting initial result that will be analyzed further in the course of this study.

Figure 2 shows the distribution of craters that show

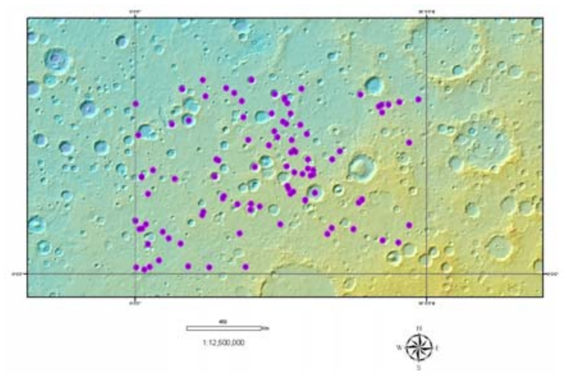

Figure 2- A MOLA topography map of the study region shows the locations of craters that have floor pitting.

small floor pits with a MOLA topography overlay. These non-central pit features are generally small compared other features on the crater floor. Craters that show this type of floor deposit are distributed mostly towards lower and mid-elevations of the study area, with fewer at the high elevations. Floor pitting has been proposed to be due to secondary impact of ejecta into impact melts on the floor of the crater [5,6]. This primary impact feature may be an indicator of subsurface volatiles at the depth of the initial impact.

We have found that craters in the 3-5-km-diameter range can reach a limit in number of MOLA tracks. This results in the MOLA depth measurements of the crater being different than the shadow depth method of measurement. 14 3-4-km-diameter craters that had depths that closely matched between the two measurement methods are included in a depth diameter plot (Figure 3). The high depth diameter ratios suggest that the study region may have looser material in the near surface region that is affecting smaller crater depth diameter ratios.

Future Work: Upon the addition of calculated original depths for 3-5km-diameter craters, we will have completed the data set for the set of craters in the study area. We will use ArcGIS to investigate correlations between the distribution of specific

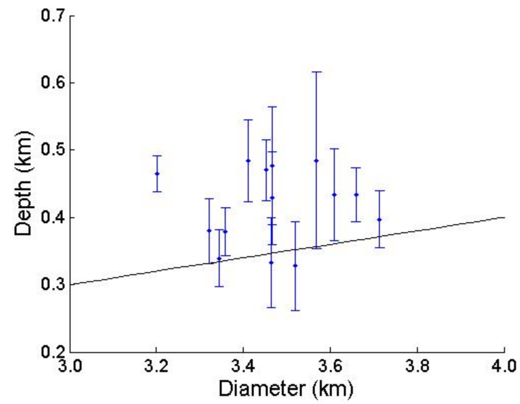

Figure 3- A plot of craters with closely matching MOLA and shadow depth technique measurements. The blue points indicated the location of the flat floor shadow depth value. The error bars represent the difference between the shadow depth measurement technique and MOLA calculations.

morphologies and parameters such as latitude, longitude, elevation, surface composition, etc. in the additional floor deposit categories. We are interested in correlating morphology types linked to subsurface volatiles to locations and epochs within the study region's history. We will also compare our estimates of epochs where subsurface volatiles were present with climate models in order to give insight into the history of volatiles in the Arabia Terra region.

References: [1] Boynton W. V. et al.(2002), *Science 297*, 81-85. [2] Dohm J. M. et al. (2007), *Icarus 90*, 74-92. [3] Barlow N. G. (2006), *LPS XXXVII*, abstract #1337. [4] Landis M.E. and Barlow N.G. (2012), *LPSC XXXXIII*, abstract #1255. [5] Tornabene, L. L. et al. (2012), *Icarus 220*, 349-368. [6] Boyce, J.M. et al. (2012), *Icarus 221*, 262-275.