IMPACT CRATER ANALYSIS OF SOUTHCENTRAL ARABIA TERRA AND IMPLICATIONS FOR VOLATILES

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Introduction

Why Arabia Terra?

- Presence of crater morphologies resulting from possible interactions with surficial and subsurface volatiles
- Largest area of heavily cratered terrain in the northern hemisphere of Mars and extensive record of processes occurring in the area.
- Neutron analysis suggests present day H_2O enrichment [1]
- Ancient Arabia Terra may have experienced long term water enrichment [2]

Project Questions

- How have crater morphologies been affected by subsurface volatiles in the Arabia Terra region of Mars?
- What times and locations can we confine volatile rich formations to using crater analysis?

Methodology

This project has classified the morphologies and morphometries of all impact craters ≥1-km-diameter in the 0°-20°N 0°-30°E region of Arabia Terra (part of a larger project investigating the role of volatiles throughout Arabia Terra). We utilize image data from from the Mars Odyssey Thermal Emission Imaging System (THEMIS) and Mars Reconnaissance Orbiter Context Camera (CTX) to measure crater diameters and identify and classify interior morphologies (Figure 1).

We also use Mars Global Surveyor Mars Orbiter Laser Altimeter (MOLA) data to determine crater depths for craters ≥5-km-diameter and shadow estimate techniques to determine depths for smaller craters. Craters between 3-5-km-diameter had depths calculated from shadow depth techniques assuming both flat and parabolic floors [3,4]

We have expanded Barlow's *Catalog of Large Martian Impact Craters* [5] to include all craters between 1- and 5-km-diameter in the study region.

We used the CraterStats2 program to perform size-frequency distribution analysis and determine the ages of each morphology type [6]. The CraterStats2 isochron for the entire study region is shown in Figure 2.

Crater Morphologies

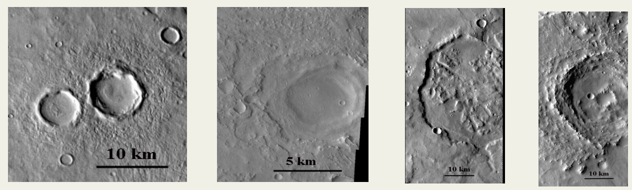

Figure 1- Examples of different crater morphologies. From left: Terrain softening, nested crater, chaotic texture, and central pit.

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, and CTX images (6 m/px) were used when a higher resolution image was needed to make a determination. Morphology statistics are listed in Table 1.

Layered ejecta, central pits, and terrain softening have been linked to high subsurface volatile content [7,8] while nested craters have been proposed to result from impact into marine environments [9]. Lineated floor deposits may be ice-rich glaciers [10] and layered floor deposits may be paleolake sediments [11]. The distributions and formation ages of these crater morphologies give information about the history of volatiles in this study region of Arabia Terra.

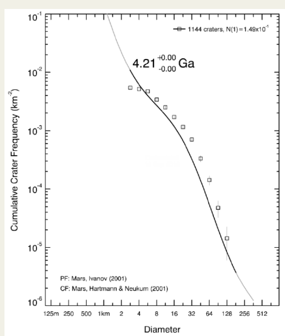

Figure 2- An example CraterStats 2 plot showing a crater distribution plot for all craters ≥3km-diameter in southcentral Arabia Terra. The binned data are plotted as squares with accompanying error bars, and the dark black line is the best-fit isochron. The isochron age and number of craters used in calculating the isochron are indicated on the plot. The zero error bars are an artifact of the program display.

Table 1-The number of craters of ≥3-km-diameter that fall into each morphology category and percentage of total craters in the catalog is recorded below.

Morphology		Number	% of total craters
Primary Impact	Central Pit	22	1.92%
	Central Peak	10	0.87%
	Nested Crater	5	0.44%
	Inverted Crater	20	1.74%
	Layered Ejecta	359	31.30%
Modification	Terrain Softening	14	1.22 %
	Ejecta blanket infilling	103	8.98%
	Scalloped/serrated rim	272	23.71%
Floor Deposits	Chaotic-type textures	85	7.41%
	Floor peaks	163	14.21%
	Sand dunes	78	6.80%
	Layered deposits	182	15.87%
	Floor pits	107	9.33%
	Lineated Floor Deposits	46	4.01%
	Floor ridges	151	13.16%
	Total with floor deposits	749	65.30%

Results and Discussion

- We have expanded Barlow's *Catalog of Large Martian Impact Craters* [5] to include morphology and depth information for craters ≥3km-diameter.
- Of the 1147 craters ≥3km-diameter in southcentral Arabia Terra, 65% displayed some type of morphology, including morphologies that have been linked to subsurface and surficial volatiles like terrain softening and central pit craters.
- Nested craters in this region of Arabia Terra occur at medium elevations instead of at solely low elevations (Figure 3). The age given by CraterStats2 for nested craters is 1.48±0.66Gyr (Table 2).
- Ages of the remaining crater morphologies are consistent with formation during the Late Heavy Bombardment era. Ages for each morphology are listed in Table 2.
- The age of nested craters, terrain softening, and central peak craters are significantly younger than for the other morphologies by about 1-2 Ga. However the study area only contains about 10 craters for each of these classes, so this could be an effect of small statistics. The addition of crater data from other regions of Arabia Terra will better constrain the formation times for these morphologies.
- Small craters displaying unusually high d/D ratios occur throughout the study region (Figure 4, 5). They also tend to occur in areas where large impacts have previously occurred. This suggests that the material excavated by the small craters is weaker than the underlying material. The high d/D small crater results support the idea that Arabia Terra has undergone a major resurfacing event [12].

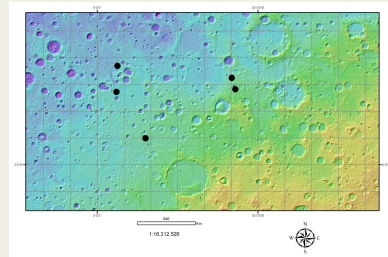

Figure 3-The distribution of nested craters in southcentral Arabia Terra. The nested craters fall along mid-range elevations on the MOLA overlay background.

Table 2-Ages for each morphology type are listed. Ages were found using the relative crater distribution fitting program CraterStats2.

Morphology		Age (Ga)
Study region		$4.21^{+0.00}_{-0.00}$
Primary Impact	Central Pit	$3.48^{+0.06}_{-0.11}$
	Central Peak	$2.92^{+0.38}_{-0.89}$
	Nested Crater	$1.48^{+0.66}_{-0.66}$
	Inverted Crater	$3.72^{+0.04}_{-0.05}$
Modification	Terrain Softening	$1.89^{+0.56}_{-0.56}$
	Scalloped/serrated rim	$4.03^{+0.01}_{-0.01}$
Floor Deposits	Chaotic-type textures	$3.93^{+0.02}_{-0.02}$
	Floor peaks	$3.98^{+0.01}_{-0.01}$
	Sand dunes	$3.92^{+0.02}_{-0.02}$
	Layered deposits	$3.99^{+0.01}_{-0.01}$
	Floor pits	$3.92^{+0.01}_{-0.02}$
	Lineated Floor Deposits	$3.77^{+0.03}_{-0.03}$
	Floor ridges	$3.90^{+0.01}_{-0.01}$

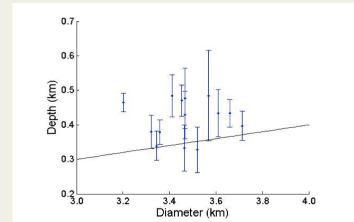

Figure 4-The depth-diameter ratio of fourteen craters 3-5km that display high d/D ratios. The black line shows the 1/10 d/D ratio

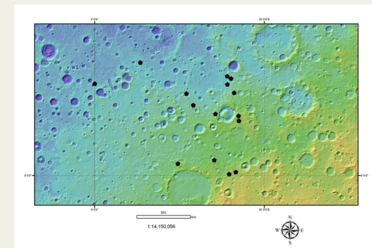

Figure 5-The locations of high d/D craters are shown plotted against the MOLA elevation background.

References

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Acknowledgements

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