# Investigating Indicators of Volatile-Rich Material in Arabia Terra, Mars.

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## Introduction:

The history of water on Mars is a crucial question for our understanding of the geologic history of the planet. Arabia Terra is a region that can help us address this question. This region is located on the lowland-highland dichotomy boundary and contains the largest expanse of heavily cratered terrain in the Martian northern hemisphere. The northern plains are proposed to be the location of ancient oceans, and evidence of this may lie in the morphology of the craters located along the edge of Arabia Terra. Because of its location, Arabia Terra provides us with a window into the extent of the role volatiles have played in shaping the Martian surface. This uniqueness of Arabia Terra has prompted previous studies but all have been limited in their spatial extent and/or features studied. Our study will provide a complete look at the extent to which volatiles have influenced the impact crater record in the Arabia Terra region.

## Arabia Terra Characteristics:

The Arabia region (Figure 1) presents us with a unique opportunity to evaluate the extent to which volatiles have shaped this region of Mars. The western portion of Arabia consists of the lowest exposure of heavily cratered terrain on the planet while the eastern portion is of similar elevation as the rest of the Martian highlands. These two portions of the region have distinctly different crater densities [1], which suggests different geologic processes have dominated in each region. Analysis of Mars Global Surveyor's Mars Orbiter Laser Altimeter (MOLA) data have led to the proposal that the western portion of Arabia is an exposed portion of the ancient basement material which underlies the northern plains deposits [2]. Crater size-frequency distribution analyses indicate that Arabia formed during the Noachian period [3-5]. Since its formation, Arabia has undergone extensive modification [6]. Geomorphic indicators suggest liquid water as the most likely erosional agent [7-9]. Geomorphic characteristics [6] combined with neutron spectrometer data [10-11] suggest that Arabia contains an abundance of ground ice. In summary, Arabia is a unique region in its elevation for heavily cratered terrain and its water abundance. This region has been heavily influenced by liquid water in its past and evidence of this lies in the geomorphology of the craters present there.

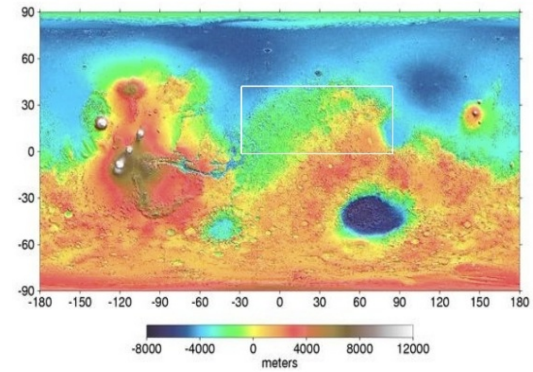


Figure 1: The Arabia Terra region is located in the Northern hemisphere and covers the Martian lowland-highland boundary. The study region lies between 27.5°- 85° E and 0°- 40° N (outlined in the box above). Arabia contains some of the heaviest cratered land in the Martian lowlands. (Image credit: MOLA science team)

## Project Outline:

This study is using the large number of impact craters to investigate the role of subsurface and surficial volatiles (presumed to be mainly $H_2O$ in liquid and solid states) on the evolution of Arabia Terra. The ancient age of Arabia Terra means that this region retains large numbers of impact craters. The original morphology and morphometry of impact craters are well described [12] and thus comparing current crater characteristics to those of a pristine crater of similar size provides insights into the geologic processes which have modified the crater since its formation. Impact craters in Arabia Terra display a wide variety of morphologies which are suggestive of the role of volatiles. Some, such as layered ejecta morphologies and central pit structures, are produced during crater formation and are suggestive of high concentrations of subsurface volatiles at the present time. Examples of nested craters (also called inverted sombrero craters) are similar in appearance to terrestrial craters formed in marine environments and may have formed during periods when water covered part of this region. Other morphologies, such as lineated material which has been interpreted to be ice-rich/glacial deposits, suggest a modification role of surficial volatiles. This project will extend the current coverage of the *Catalog of Large Martian Impact Craters*, version 2.0 [13] in the Arabia Terra region to craters in the 1-5 km diameter range. Interior morphology classifications will be updated for all craters using the following classes: central pit, central peak, lineated floor deposits, terrain softening, nested craters, scalloped/serrated rims, inverted craters, and chaotic-type floor textures. Ejecta morphologies also will be updated, specifically for the layered ejecta classes. Crater preservational state will be determined using the technique of Barlow [14]. Crater size-frequency distribution analyses of craters with specific morphologies will be used to constrain the time period during which these craters formed and thus provide limits on when particular conditions producing these features occurred.

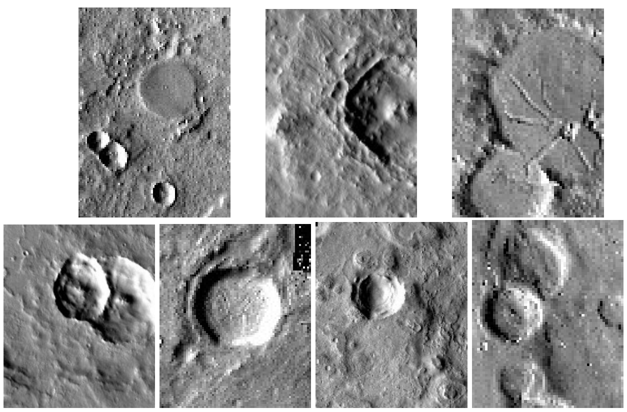

Figure 2: THEMIS images of the classification morphologies. From left to right, inverted crater, central pit, chaotic floors, layered ejecta, lineated floors deposits, nested craters, and terrain softening.

## Compilation of the GIS Database:

The entirety of the Arabia Terra region will be included in the final catalog but currently the study region covers the area 27.5° - 85° E and 20° - 40° N (the northwest quadrant of Arabia Terra). We have classified 3500 craters in the 1-5 km diameter range within this region, which will be combined with the data on craters ≥5-km-diameter in the *Catalog of Large Martian Impact Craters*. The information contained in the catalog includes the latitude and longitude of the crater center, major and minor diameters of the crater, ejecta morphology, interior morphology, preservational state, and underlying geologic unit. We are using ESRI's ArcGIS software to determine crater coordinates and measure crater diameter. The base map for this project is the THEMIS daytime infrared (IR) 100-m/pixel global mosaic. We are using MOC and THEMIS visible and infrared images for the classification and preservation identification process . Higher-resolution HRSC and HiRISE images will be utilized when available and compositional information will be obtained from CRISM and OMEGA. Each crater will be classified based on its preservational state. Preservational state is assigned on a scale from 0.0 to 7.0 based on morphometric, morphologic, and thermophyiscal properties [14] . A crater given a preservational state of 0.0 is a ghost crater while a 7.0 would be a pristine crater.

## Determination of the Role of Volatiles in Producing Observed Morphologies:

The specific morphologies that are being noted in the classification process, layered ejecta, central pits, terrain softening, and chaotic floor textures, are all indicators of subsurface ice, and possibly liquid water. Scalloped crater rims and inverted craters are indicative of erosion, a process in which liquid water could play a major role. Distribution maps will be produced and frequency analysis of all these morphologies will be performed. With this information we will be able to determine the areal and temporal extents of the processes producing these morphologies. This will help us constrain the processes by which these features were created.

## Acknowledgments:

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## References:

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