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Gullies and the latitude dependant mantle: comparing Terra Cimmeria & Argyre Planitia

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1. Introduction

"Follow the water" has been an important theme for exploration of Mars. Under current atmospheric conditions, liquid water is only metastable at the surface. Using high-resolution images of Mars, we see kilometer-scale features with an alcove, channel and a debris apron – "gullies". These gullies resemble water-carved steepland channels on Earth [1, 12]. Previous global-scale studies covering both hemispheres of Mars have been conducted [2, 8-10], but using datasets with limited coverage, but as high-resolution coverage of the planet continues to grow, full-coverage, global-scale studies become possible.

Previous work has shown that gullies are common in the mid-latitudes and show variation in slope-face orientation with respect to latitude [2,9-11]. The variations in orientation are suggested to result from obliquity driven climate change [7], whereby when Mars' axial tilt is large, the average daytime temperatures are sufficient for melting of near-surface ice to occur. Previous work [4, 14] has suggested that gullies may originate from the melting of a surface unit known as latitude-dependent mantle (LDM). LDM is interpreted to be rich in ice and dust and was deposited during previous glacial epochs [14]. The method by which gullies form, their associations to LDM and relations to recent ice ages are still under debate. We will analyze the relationship between gullies and LDM by comparing two regions: (1) Terra Cimmeria where gullies are not always associated with the LDM and (2) Argyre Planitia, where gullies are almost always associated with the LDM [6]. We will compare gully-distribution, orientation, and topographic properties (e.g. slope) between these areas. Here we report on the first results: the Terra Cimmeria study.

1.1 Study Areas

The work executed so far includes the mapping of gullies in the Terra Cimmeria region (Fig. 1). The Terra Cimmeria region is located in the southern highlands of Mars, one of the oldest and most heavily cratered regions on the planet. Our second study area is Argyre Planitia, the second largest impact basin in the southern hemisphere of Mars (Fig. 1).

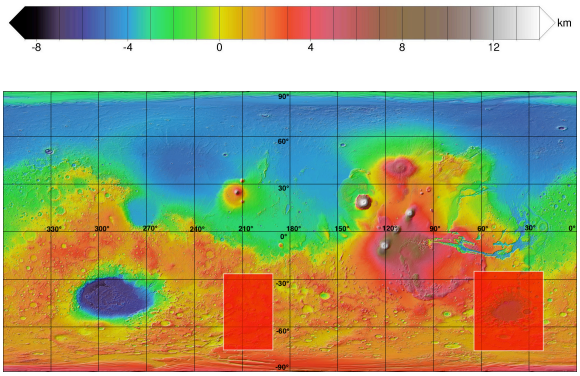

Figure 1: Mapping areas denoted by red polygons over Mars Orbiter Laser Altimeter (MOLA) Shaded Relief / Colourised Elevation Map. Right: Terra Cimmeria mapping area. Left: Argyre Planitia mapping area. Lat./Lon. grid projected at 30° x 30°

2. Approach

Products from the Context Imager (CTX) [12] on board the Mars Reconnaissance Orbiter (MRO) spacecraft were rendered using the GIS program 'Java Mission-planning and Analysis for Remote Sensing' (JMARS) [5]. Each area in the Terra Cimmeria study zone (Fig. 1) that was covered by CTX was examined to search for gullies. To avoid mapping other types of mass wasting, only when a channel was present was the feature recorded. Identified gullies were digitized by drawing a polygon over individual gullies or groups of gullies. For each polygon the image ID and quality of the image were also recorded.

Illumination effects continue to increase the difficulty of mapping gullies with the CTX dataset, even when contrast stretches are applied. The limitations of this type of mapping may result in unmapped gullies that are obscured in shadow.

3. Summary of Observations

More than 1400 images from the Context Imager (CTX) instrument on board the Mars Reconnaissance Orbiter (MRO) spacecraft have been explored for gullies in the Terra Cimmeria region. From our preliminary observations in this region [2], we see

the confirmation that gullies are most common in the mid-latitudes (between 30° and 50°S). Our observations also agree with previous studies in that the orientation of gullies varies from dominantly pole-facing in the mid-latitudes (Fig. 2) to a lack of orientation preference farther south [3, 9](Fig. 3). Regarding the association of gullies with the mantle unit, Terra Cimmeria has a mixed population of gullies with and without mantle.

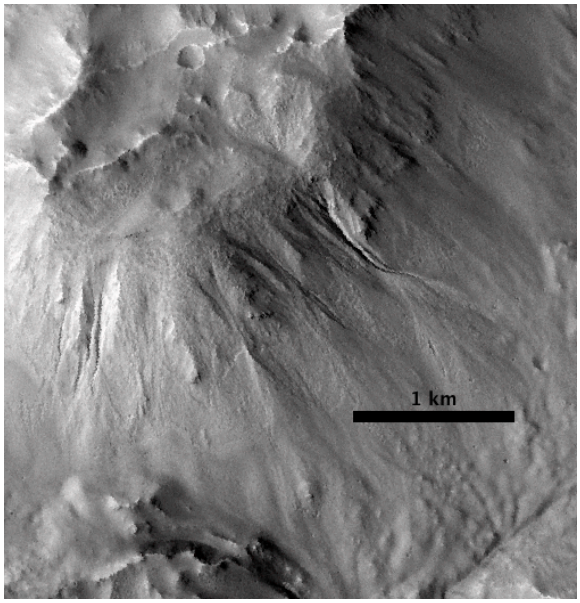

Figure 2: Pole-facing gullies at the northern rim of Horowitz crater (~31.5°S, ~140.7°E), north is up. CTX image B10_013685_1481_XN_31S219.W

4. Continuing Work

The next steps will include looking for morphometric differences in the Terra Cimmeria and Argyre Planitia regions. Argyre Planitia is dominated with gullies in the mantle unit [13], in contrast to Terra Cimmeria. Morphological classification (similar to [1]) of the gullies in both regions will also be performed. Other data such as: orientation, slope, elevation, and topographical position index will be extracted and analyzed from both of the study areas. This data will help assess the orbital parameters required to destabilize the LDM [6] and help to determine if there are systematic differences between gullies with and without associated LDM.

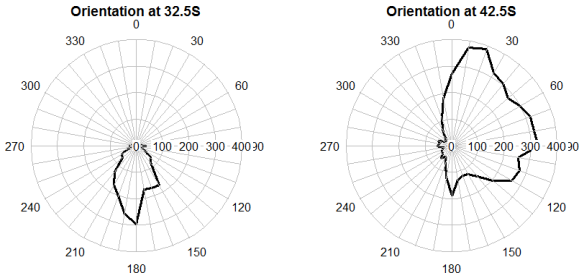

Figure 3: Gully-orientation in the Cimmeria region at 32.5°S and 42.5°S; 0 is equator-facing and 180 is pole-facing. Radial scale is nr. of pixels with gullies.

Acknowledgements

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