RELATIONSHIP BETWEEN HOST MATERIAL AND GULLY MORPHOLOGY ON MARS. Tanya N. Harrison[1*], Gordon R. Osinski[1], and Livio L. Tornabene[1,2]. [1]Western University, Department of Earth Sciences/Centre for Planetary Science and Exploration, 1151 Richmond St, London, ON, N6A 5B7, Canada (*tharri43@uwo.ca). [2]SETI Institute, Mountain View, CA 94043, USA.

Introduction: Martian middle- and high-latitude gullies were first observed in Mars Global Surveyor (MGS) Mars Orbiter Camera (MOC) images in 1997 [1]. Appearing to be geologically young [1], they quickly became a feature of interest for the Mars science community. A number of different models have been proposed to explain the formation of gullies, including both "dry" [e.g., 2,3] and "wet" [e.g., 5–7] mechanisms. In this study, the "wet" mechanisms are explored in detail, which involve the release of liquid water/brine from shallow [1] or deep [4] aquifers or through the melting of near-surface ground ice [e.g., 5] or snowpacks [e.g., 6,7].

Geomorphologic observations of gullies in high-resolution MOC narrow-angle (~1.5–12 m/pixel) and Mars Reconnaissance Orbiter (MRO) Context Camera (CTX, ~6 m/pixel) and High Resolution Imaging Science Experiment (HiRISE, ~0.25 m/pixel) images support formation by fluid flow based on the presence of fluvial characteristics such as streamlined features, terraces, and banked and sinuous channels [e.g., 1,8,9]. Some authors have attempted to determine which formation mechanism is suggested based on gully morphology alone [e.g., 10,11]. Here we present observations demonstrating that the substrate material through which gully channels incise plays a significant role in overall gully morphology.

Methods: Analysis of MOC, CTX, and HiRISE images of gullied landforms was conducted using Java Mission-planning and Analysis for Remote Sensing (JMARS) software [12].

Observations: Gully morphology varies significantly depending on the material through which the channel incises. Figure 1a–b shows examples of gullies with channel heads in crater walls, which incise into aeolian dunes that have superposed the crater wall, while Figure 1c shows dune gullies in Russell Crater. The morphologies of all three examples are nearly identical, with low-sinuosity channels lacking debris aprons commonly seen with typical crater/valley/scarp-wall gullies. Alcoves, also typically (but not always) associated with crater wall gullies, are not present in these examples.

Changes in morphology of a single gully system as it cuts through different lithologies are also observed. Figure 2a shows an example of a gully channel (38.7°S, 181.8°E) that originates in a relatively bare portion of exposed rock in a crater wall. Mantling ("pasted on") material [6] is present lower down the crater wall. Where the channel intersects this material, the alcove/gully walls abruptly become deeper.

Differences in gully morphology within individual craters are also observed. Figure 2b shows a case of gullies occurring on two walls of a crater (39.5°S, 176.9°E) where the northern wall is covered by mantling material and the western wall appears to be relatively bare exposed rock (i.e., mantle-free). The gullies on the western wall display fine channels lacking large alcoves, whereas the gullies on the northern wall are larger with significantly deeper alcoves. Both sets of gullies have relatively small debris aprons.

Discussion: Differences in gully morphology between differing host materials has been investigated in terrestrial gullies. Rowntree [13] studied two sets of gullies in the Barringo District of Kenya: One incised into weathered basaltic rock, and the other in alluvial deposits. She found that gully morphology varied with soil texture and chemistry. V-shaped dendritic gullies formed in materials high in clay and sodium. U-shaped "entrenched" gullies were associated with high silt and low sodium content. These differences were attributed to a combination of differences in formation process and substrate properties; the U-shaped gullies formed from headward extension of incised channels into a host material prone to instability (the alluvial deposits) whereas the V-shaped gullies resulted from the vertical impression onto the slope surface of a rill network formed in host material prone to surface runoff (the basaltic rock). Other workers agree with the view that differences in gully morphology arise from variations in the interaction of the host material and formation process [e.g., 14,15], although variations can also arise from differences in the degree of activity and evolutionary state of the gully [16,17]. The extreme similarity in the morphology of dune gullies, such as those in Russell Crater, compared to crater wall gullies incising dunes suggests that the host material likely plays a key role in determining morphology. Diniega et al. [18] documented an example of dune gullies in Proctor Crater that more closely resemble crater wall gullies than those in Russell Crater, perhaps indicating a difference in the level of induration of the two dune fields (although gullies in both are undergoing present-day changes [18,19]).

Conclusions: While formation mechanisms play a large role in determining the morphology of gully systems, variations can arise due to the properties of the host material and the amount of activity at a gully site.

These factors must be taken into consideration when making comparative gully studies. Not only can the morphology give insight into the physical properties of the host material (e.g., erodibility, shear strength), but it may also inform us with respect to variations in the chemical properties (e.g., sodium content) of the regolith across different regions of Mars. Combined morphological studies and spectral analysis of MRO Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) data of gully systems will be conducted to further investigate this relationship.

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Figure 1 (left): a) HiRISE PSP_003979_1410 showing a gully incised into both a crater wall and mantling material. White box denotes the location of Figure 1b. **b)** Higher resolution view of the change in gully morphology at the crater wall/mantle contact. Image credit: NASA/JPL-Caltech/UA.

Figure 2 (below): a) Crater wall gullies in an unnamed crater near 52.7°S, 351.8°E. The gullies originate in the crater wall and then incise into aeolian dunes that have superposed the crater wall. Subframe of HiRISE image PSP_006821_1270. Image credit: NASA/JPL-Caltech/UA. **b)** Crater wall gullies in Avire Crater in HiRISE ESP_012206_1390 that incise into dunes superposed on the crater wall. Image credit: NASA/JPL-Caltech/UA. **c)** Dune gullies in Russell Crater. Subframe of MOC NA M19-01170. Image credit: NASA/JPL-Caltech/MSSS.