DETERMINING THE FORMATIONAL PROCESSES OF MARTIAN FLUVIAL TERRACES USING REMOTELY SENSED OBSERVATIONS. A. R. Weintraub[1], C. S. Edwards[1], T. J. Joyal[2], [1]Dept. of Physics and Astronomy, Box 6010, Northern Arizona University, Flagstaff, AZ, arw366@nau.edu; [2]School of Earth Sciences and Environmental Sustainability, Box 5694, Northern Arizona University, Flagstaff, AZ

Introduction: The surface of Mars displays strong evidence of past fluvial activity. The time line of such activity has been well constrained by [1, 2], and believed to cease ~3.5 Gya. However, the frequencies of these events (i.e., episodic vs continuous nature) are highly contested. Shedding light on this debate would provide insight into the poorly constrained environmental conditions (i.e., wet, dry, cold, warm) during valley network formation. Valley networks are commonly studied because they hold the greatest promise for fluvial feature detection, such as terrace structures [2, 3]. Typical terrace architecture consists of an abandoned floodplain, called the terrace tread, and a steep cliff face, called the terrace scarp, leading from the tread down to the current floodplain, adjacent to the stream channel. These features are particularly informative because they are excellent indicators of the form-process relation, where the architecture of a feature is a unique consequence of formational processes [4]. By understanding these processes, it is possible to interpret conditional changes necessary to initiate such processes. This produces a snapshot of the environmental conditions at the time of their formation. This study has the potential to improve Earth-based fluvial studies by providing a remote sensing technique for terrace structure characterization where field observations are restricted or inaccessible.

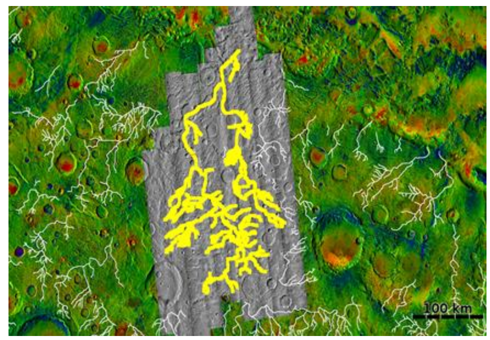

Figure 1. Licus Vallis (highlighted in yellow) from the global valley network map by [2]. Context camera (CTX) images (grayscale) allow visible imagery of Licus Vallis. The base map is a thermal IR global map from Thermal Emission Imaging System (THEMIS).

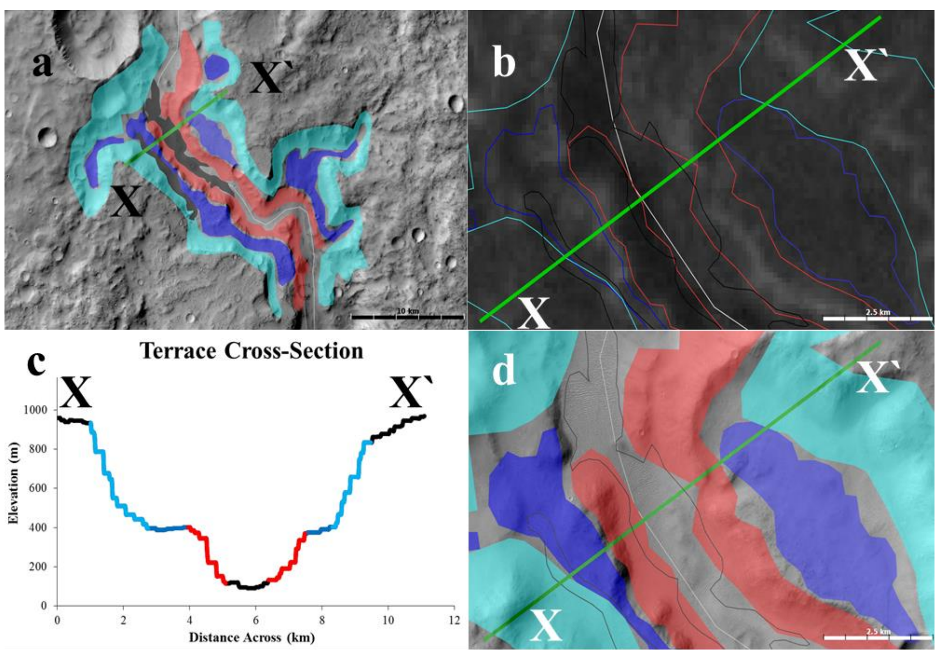

Figure 2. (a) geomorphic map of a 20 km length of Licus Vallis in JMARS overlaid on CTX images, based, east and west valley walls (light blue), main east and west tread (dark blue), and lower east and west scarp (red), presence of dune features (black), stream channel (white line), path used for cross-section (green line); (b) thermal inertia values (lighter color, greater value) from THEMIS; (c) topographic cross-section generated from X–X' using HRSC MOLA Blended DEM 200 meter/pixel; (d) close-in image of western tread, with small aeolian dune features (black lines).

Observation Framework: Terrace structures were identified using the Java Mission Planning and Analysis for Remote Sensing (JMARS) Geographic Information System (GIS) [5]. This work is limited to 30 major valley networks with previously calculated ages [1]. Figure 1 shows an example of a valley network used for terrace identification. Previously generated global valley network maps [2] are overlaid on these areas to further constrain the search for terraces.

Preliminary Identification: Preliminary identification of terraces will evaluate large-scale features. To be considered a terrace in this preliminary search, the following conditions must be met; a) The width of the valley must be 1 km, b) The tread and scarp must laterally extend 200 meters, satisfying the resolution restriction for thermal inertia values from THEMIS and slope data generated from High Resolution Stereo Camera (HRSC) and the Mars Orbiter Laser Altimeter (MOLA), c) the slope of the tread must be less than 10º, but the scarp slope must exceed 10º. The surface will be observed primarily through the slope data from HRSC MOLA Blended maps. However, visible imagery from CTX, permitting 6 meters/pixel resolution, will be used in an attempt to detect smaller terraces. If a channel reach resembles a terrace, additional images from the High Resolution Imaging Science Experiment (HiRISE) and HRSC can be employed to generate higher resolution. To further ensure the criteria for terrace identification are satisfied, a cross-section will be plotted from HRSC MOLA Blended digital elevation model (DEM) global map within JMARS (see Figure 2 (c)). Terraces are then placed into one of three groups of identification likelihood, from high to low confidence.

Detailed Characterization: Terraces will be revisited for detailed characterization where extensive data collection of all 30 valley networks is performed. The following observations will be collected; a) THEMIS derived thermal inertia values for treads and scarps (if possible), b) Hydraulic radius, c) longitudinal profile, d) number of terrace treads, and e) volume of channel. Surface temperature, grain size, and albedo will be modelled with the thermal numerical model KRC [8].

Terrace Type: Remotely sensed data have not been used to develop a framework to distinguish erosional terraces from depositional terraces. However, major differences between erosional and depositional terraces can be found within the terrace scarp [7]. Erosional terraces are cut into bedrock, and therefore have scarps with solid, dense material, contrary to the sedimentary fill of depositional terrace scarps [7]. Terrace profiles generated along the length of the valley network from HRSC MOLA Blended DEM data will be used to determine if the treads are considered parallel or attenuating. If a terrace tread remains parallel to the valley network stream channel, the formational process is generally associated with base level changes, possibly related to tectonic activity. An attenuating terrace maintains a fixed base level, and may be caused by upstream controls, such as increased discharge or sediment load.

Example: Licus Vallis is an incised valley network aged at ~3.8 G [1]. Figure 2 (a) is an example of a mapped terrace in Licus Vallis, with treads and scarps determined using slope data. Figure (b) represents the thermal inertia values of the terrace. Where the slope is steeper, the thermal inertia is greater, illustrating the terrace scarp has a higher thermal inertia than the terrace tread. This may imply the terrace scarp is composed of bedrock. It may also imply the terrace tread is covered by a layer of fine-grained sediment, a strong indicator of an erosional terrace [7], which would agree with [1]. Figure 2 (c) depicts the topographic cross-section generated from HRSC MOLA Blended DEM data. The western tread extends for 1.013 km and the scarp extends laterally 0.954 km. The eastern tread extends for 0.579 km and this scarp extends laterally for 1.215 km. This satisfies the preliminary identification of large scale terracing identification. Figure 2 (d) indicates the presence of small aeolian features present within the channel and on the western tread, while only small impact cratering and very few dunes are present on the eastern tread. This indicates greater aeolian activity on the western side of the terrace. However, since dust may also be responsible, dust coverage maps from the Thermal Emission Spectrometer (TES) will be evaluated. Figure 2 (b) and (d) are examples of the more detailed characterization that will be used for terraces on the meter-scale.

Continuing Work: After preliminary and detailed characterization is complete, the technique to interpret the cause for erosional or depositional terrace formation will be developed. Once this is found, terraces can be studied across many different valley networks, and possible global trends can be studied.

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