INVESTIGATIONS OF TRANSVERSE AEOLIAN RIDGES ON MARS.

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Introduction: As noted first from Viking Oribter images [1,2] and more recently from Mars Global Surveyor (MGS) Mars Orbiter Camera (MOC) narrow-angle (NA) images [3,4], a population of aeolian bedforms exists that is morphologically and dimensionally distinct from Large Dark Dunes (LDD) fields, being generally brighter than, or of similar albedo to, the surrounding terrain [3]. These features are significantly smaller than the dark dunes (Fig. 1), appear to form normal to local winds, and tend to have simple, transverse, “ripple-like” morphologies. Whether these small martian bedforms represent extremely large ripples, small transverse dunes, or something entirely different is currently under debate, and so they have been designated “Transverse Aeolian Ridges” [5].

TARs are one of the most common landforms on Mars. As the smallest aeolian landforms observed from orbit, TARs are clearly important for understanding meso- and small-scale interactions between the surface and atmosphere. TARs are also indicative of the weathering and sediment transport regime on Mars and an understanding of their morphologies, morphometries, and composition can provide information on the composition, mobility, and availability of aeolian sediments on Mars. Moreover, the spatial distribution of TARs provides information about where on Mars aeolian sediments are concentrated. If we can determine if TARs were active only in the past, or whether TARs are mobile under today’s wind conditions, then we can begin to assess when and where TARs are/were active over Mars’ recent geological history. Thus TARs have the potential for being indicators of climate change on Mars.

Methodology: In this work we focus on the local/regional scale and thus have identified six regional study areas, each 5° by 5°, to investigate the behavior of TARs in detail; one in the northern hemisphere, three in the equatorial band, and two in the southern hemisphere. All HiRISE, CTX, and MOC images for each study area have been downloaded from the PDS, processed in ISIS, and ingested into an ArcGIS database. By exploring sediment sources, climate, and local topography/geology as potential factors, we can constrain potential formation mechanisms.

Mapping of surficial deposits: Surficial sediment deposit maps of each study area are being produced to trace sediment from source to sink, and to investigate whether LDDs and TARs share sediment sources and pathways. Initial results for one study area is shown in Fig. 2. Note that TARs are mostly found near LDDs or dark deposits, indicating a related source. Note also that nearly all of the deposits are found in local topographic lows, or sediment traps.

We are mapping TARs in terms of morphology and morphometry. For each of the study areas we are mapping the surficial deposits with a focus on sediment pathways, sediment sources, and interactions/associations between TARs and LDDs. We are primarily using CTX data for this task. We are mapping 1) TARs (including orientations, degree of saturation and morphological characteristics as described by [6,7], 2) LDDs and dark aeolian deposits, 3) possible sediment sources (e.g., layered terrains, dissected terrains or mass wasting deposits), and 4) the underlying geology for context. These maps can then be used to examine sediment transport pathways, to constrain sediment sources for TARs [8].

Morphologic and morphometric analyses: We seek to determine what factors control the morphology and morphometry of TARs. We are producing Digital Terrain Models (DTMs) from HiRISE stereo pairs for each study area to conduct morphologic and morphometric analyses of TARs. The first of these is completed and shown in Fig. 3. Figure 4 shows the profile of one TAR bedform as measured from the DTM, showing bedform height of 3 meters and width of 35 meters. We are taking height and width measurements for large numbers of TAR bedforms within each DTM to assist in calculating TAR volumes as a function of classification in order to estimate their sediment buget. We are also performing statistical analyses of TAR surface areas, degree of TAR clustering, and TAR equivalent sediment thickness and spacing. We are calculating the range of values, mean, and standard deviation for TAR lengths, widths, length/width ratios, heights, wavelength, and bedform saturation.

Comparison with local/regional meteorology, topography, and geology: By comparing the distribution of TARs with local/regional meteorology (with meso-scale GCMs), topography, and geology within our study areas, we can search for correlation with climate model data and look for effects of local topography on wind speed/direction and TAR distribution.

Compositional analyses: Compositional studies are being carried out using THEMIS, OMEGA, and

CRISM data to: 1) constrain the composition of TAR materials themselves, and 2) compare the composition of TARs to the composition of local LDDs and to local layered terrains (or other terrain units). We are testing the hypothesis that TARs are derived from local sources by comparing the composition of the bedforms to that of the terrain on which they rest. We are searching for evidence of compositional uniqueness within the dunes that could potentially contradict this hypothesis, and possibly be linked to a distal source region.

Crater counting and changes in high-resolution images: We are conducting crater count analyses on contiguous TAR fields, LDDs, and other associated terrains in HiRISE and CTX images in order to estimate formation ages. Investigating formation ages of TARs and TAR fields, and how they move and evolve over time can help us determine whether TARs are forming under current climate conditions, or are indurated/cemented and thus indicators of past climates. We are exploring how TARs evolve under the current climate regime by using time series high-resolution images to search for changes in morphology and position of TARs with time.

References: [1] Thomas P. (1981) *Icarus 48*, 76-90. [2] Thomas P. et al. (1999) *Nature 397*, 592-594. [3] Malin M.C. and Edgett K.S. (2001) *JGR 106*, 23,429-23,570. [4] Wilson, S.A. and Zimbelman J.R. (2004) *JGR 109*. [5] Bourke M.C. et al. (2003) *LPSC XXXIV*. [6] Balme M.R. et al. (2008) *Geomorphology 101*, 703-720. [7] Berman D.C. et al. (2009) *Icarus 213*, 116-130. [8] Bourke M.C. et al. (2004) *JGR 109*.

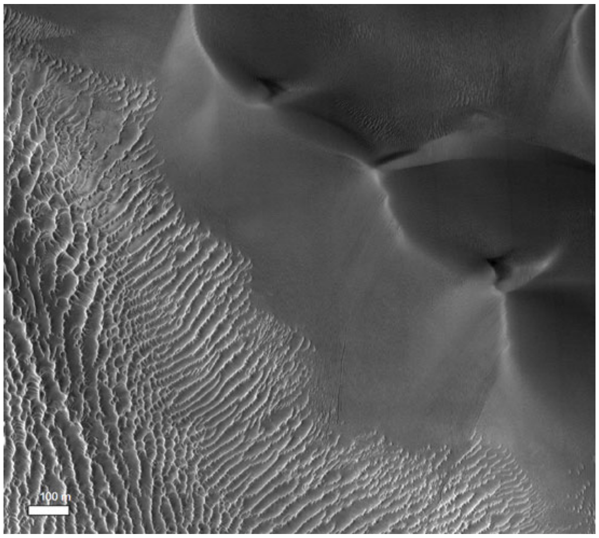

Figure 12. Example of TARs (lower left) alongside LDDs (upper right). HiRISE image PSP_003325_1355.

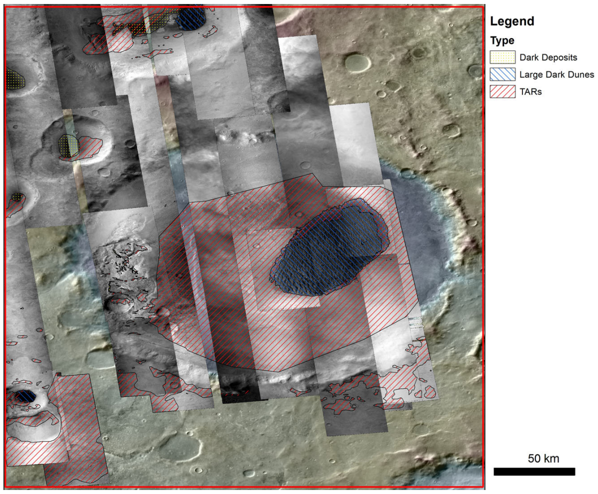

Figure 2. Study area in southern hemisphere around Proctor crater showing mapped regions containing TARs, Large Dark Dunes, and dark aeolian deposits.

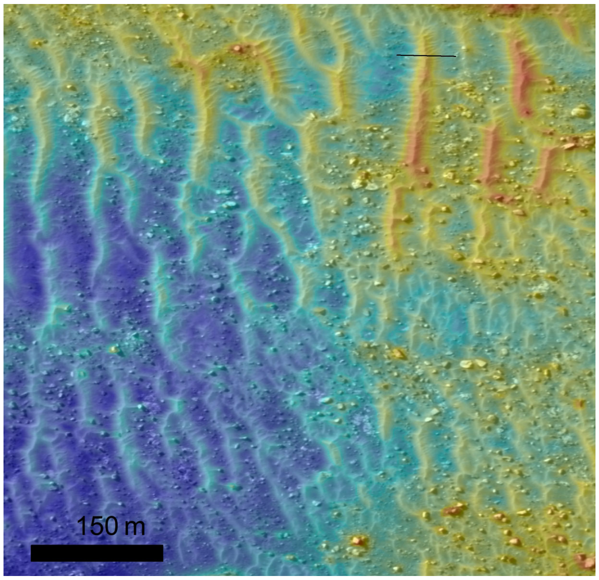

Figure 3. DTM of HiRISE images ESP_024449_1320 and ESP_024515_1320 with line indicating location of profile in Figure 4.

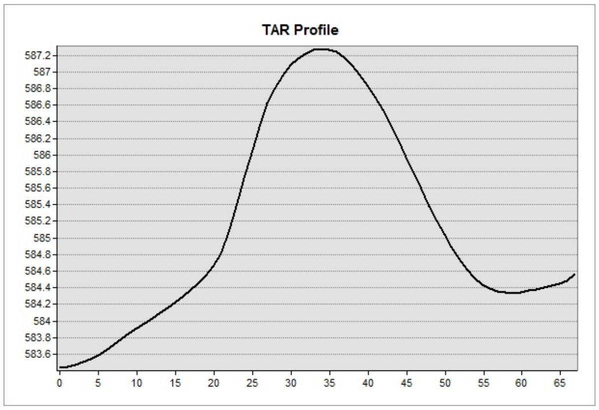

Figure 4. Profile of TAR bedform from DTM.