WIND-CARVED TRANSVERSE EROSIONAL RIDGES ON MARS.

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Introduction: At the most fundamental level, planetary surfaces may be divided into areas that are eroding and those that are depositional. Aeolian dunes were first recognized on Mars in Mariner 9 images [1,2], and have subsequently been documentd to be widespread [3-5]. Likewise, yardangs and ventifacts have been observed to be common aeolian erosional features on Mars [4]. While the presence of active aeolian dunes has been clearly established on Mars, some such features have been documented to migrate [6], whereas others have exhibited no detactable motion over several decades [7]. Features exhibiting similar morphology have also been interpreted to be exhumed fossil dunes due to their cratered surfaces [8]. We report that some martian mega-ripple-like landforms are primary erosional features.

Study Areas and Methods: We examined HiRISE images from Ius, Candor, and Ophir chasmas in the region of Valles Marineris. HiRISE provides images with a resolution of ~25-50 cm per pixel, a level of detail that was unavailable prior to the arrival of MRO at Mars. We also used data from the Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) and the Thermal Emission Imaging System (THEMIS) to help assess the physical nature of surface materials, assisting us in distinguishing between areas with significant sand or dust cover and areas of exposed bedrock or other well-consolidated material.

Obervations: Several lines of evidence demonstate that some transverse ridges are erosional features. The most compelling observation demonstrating the erosional nature of some trasverse ridges is the layered substrates that cut across sequences of mega-ripples. In addition, craters preserved in sequences of mega-ripples demonstrate such features are formed in cohe-isve materials, and thus are not active aeolian dunes.

Ius Chasma. A HiRISE image from the floor of Ius Chasma reveals clear evidence for pseudo-mega-ripples carved into cohesive layered substrate (Figure 1). Several craters that directly disrupt mega-ripple forms and the abundant fractures apparent in the substrate demonstrate the cohesive nature of the material composing the pesudo-mega-ripples. Here, layering within the substrate can be observed running across and through the full trough-to-crest relief of the ripple-like features. The continuity of layering apparent in eroded exposures demonstrates that the pseudo-mega-ripples are incised into a cohesive substrate.

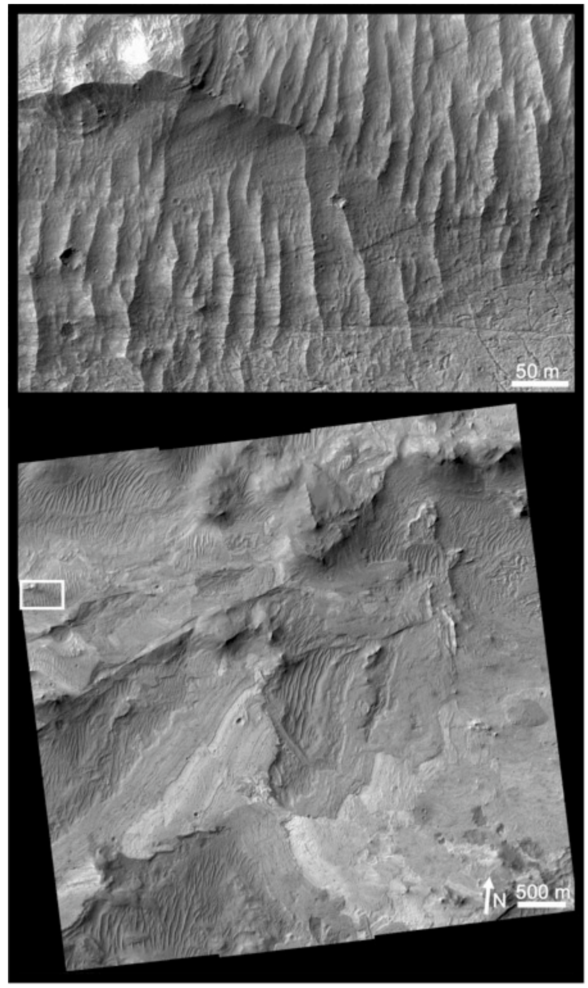

Figure 1: HiRise image of the floor of Ius Chasma (TRA_00823_1720_RED).

West Candor Chasma. A striking HiRISE image from the floor of West Candor Chasma (Figure 2) shows both depositional aeolian dunes (dark ripple forms in upper left and right of the context image in lower panel) and erosional transverse ridges (upper panel). The latter are cut into layered stratigraphy that strikes orthogonally across and extends through ripple forms from trough to crest, although the crests appear to be locally enhanced by darker aeolian deposits. That the topographic alignment of the erosional ripples swings around to parallel the active aeolian features (as is apparent across the upper half of lower panel context image) suggests that the pseudo-mega-ripples are active erosional features carved by contemporary prevailing winds.

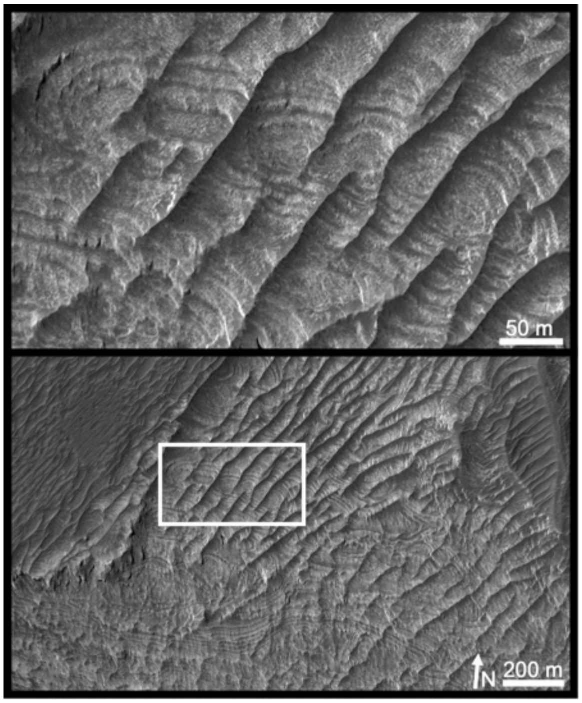

Figure 2: HiRise image of the floor of West Candor Chasma (PSP_00812_1730_RED).

West Ophir Chasma. A HiRISE image of the floor of West Ophir Chasma similarly shows transverse ridges carved into layered cohesive substrate to form pseudo-mega-ripples (Figure 3). In this image, layered, steeply bedded, cohesive substrate strikes orthogonal to transverse ridges running from lower left to upper right (upper panel). Variable erosion resistance to the layered substrate results in a series of high-standing, erosion-resistant ribs that extend uninterrupted from trough to ridge crest across numerous pseudo-mega-ripples. These transverse ridges are developed where a hard, cratered capping layer that forms a plateau remnant has been eroded (lower center of lower panel context image in Figure 3), a pattern that suggests breaching of a hard capping layer to expose relatively weak underlying material.

Discussion: Aeolian erosion offers the simplest explanation for these particular transverse ridges. Incision by flowing water is unlikely due to the lack of banks and lateral boundaries characteristic of fluvial erosion. That these ripple forms are carved into relativley weak substrate is indicated by their association with breaching of a more resistant capping layer that in places appears to control their distribution.

The presence of wind-carved transverse erosional ridges on Mars means that periocally spaced ripple-like martian landforms cannot be assumed to be depositional based on their morphology alone. This finding indicates the need to revisit the question of how many other such features are erosional, and how extensive such features are on the surface of Mars. We propose that transverse erosional ridges, such as those described here, be referred to as TERs in order to distinguish them from active transverse aeolian ridges (TARs).

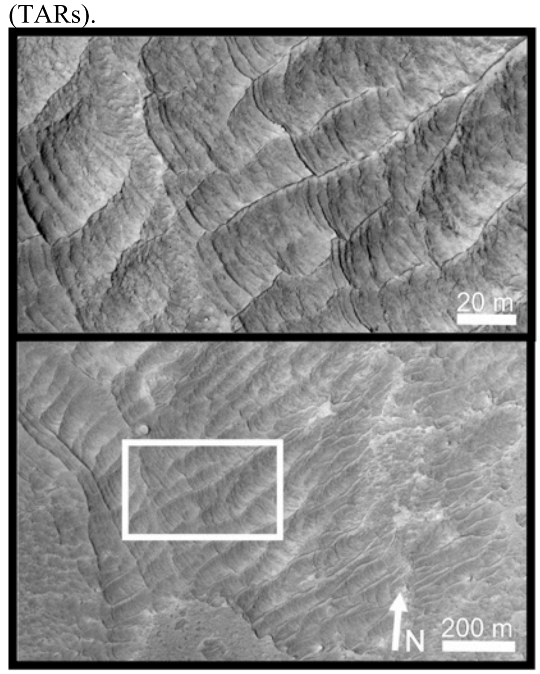

Figure 3: HiRise image of the floor of West Ophir Chasma (ESP_015974_1760_RED).

Based on our limited search of the available images, conditions for the formation of TERs appear to be optimal in topographic lows in the region of Valles Marineris. All of the TER exposures we located were from near the floor of chasmata. We suggest that consistently oriented, high velocity winds and a weak substrate favor development of TERs through a positive feedback in which characteristic vortices impose a length scale and spacing to the eroding land surface. In addition to the obvious implications for determining and mapping dominant wind orientations, this raises the possibility of inverting TER morphometry to estimate wind speeds. Finally, the existence of extensive areas of wind-eroded rhythmic bedforms on Mars provides a novel example of a landform first recognized from an extra-terrestrial example.

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