CHARACTERIZATION OF SMALL SAND DUNES ON MARS. M. B. Johnson[1] and J. R. Zimbelman[1],
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Introduction: Martian sand dunes have become subject to study in order to extract information about the surface environment of Mars, particularly wind flow patterns [1,2]. This project is supported by NASA MDAP grant NNX12AJ38G to document properties of ripples, dunes, and Transverse Aeolian Ridges and to assess their modes of formation [3].

Background: Movement of Martian sand ripples and dunes have been observed in diverse areas of the planet, first by the Spirit rover [4], and more recently by reconnaissance with the High Resolution Imaging Science Experiment (HiRISE) camera [2]. However, the method of sand transport is still widely debated. Because the positions of crests on the dune as well as the structure of the dune itself can be created and preserved by multiple wind directions repeating seasonally, ripple-scale patterns are a better indicator of recent wind flow [5]. Figure 1 displays a terrestrial study comparing ripples and the resultant sharp crests by Neilson and Kocurek. Additionally, HiRISE provides images with resolution as high as 25 cm/pixel [6] and has shown abundant ripple patterns on Martian dunes [7]. This provides the means for the documentation of aeolian features in this study, which will be carried out and analyzed over the course of a new grant.

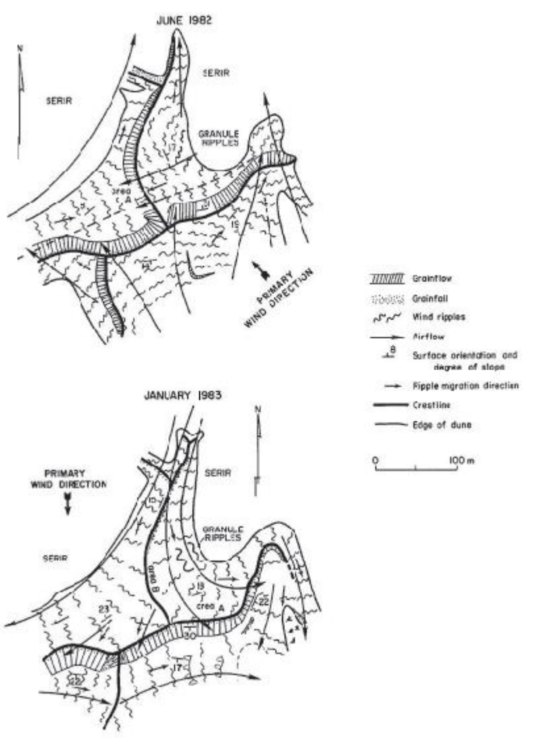

Figure 1: Mapped ripple and crest patterns of a mature star dune in the Dumont Dunes of California. Ripple patterns measured in the summer of 1982 (left) and the winter of 1983 (right) were used to identify the winds which modified the principle crests. Fig. 2 of [5].

Methodology: The initial efforts of this study have included mapping ripple patterns in four different HiRISE images using the Java Mission-planning and Analysis for Remote Sensing (JMARS) geospatial information system (GIS) [8]. The images used thus far are PSP_007663_1350, PSP_009571_1755, ESP_017762_1890, and PSP_010019_2635 representing areas of Hellespontes, Gale Crater, Nili Patera and Planum Boreum, respectively. Additional sites will be chosen with diversity of longitude and latitude as a high priority in order to compare many areas around the surface. Lines were drawn perpendicular to the crests across three adjacent ripples in order to document ripple wavelength from line length and wind direction from line orientation or azimuth (Figure 2).

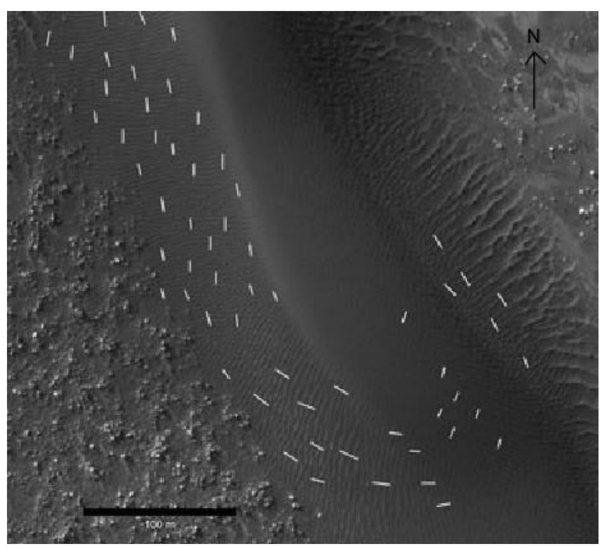

Figure 2: One linear dune of HiRISE image PSP_007663_1350 in Hellespontes from JMARS. This image is centered at 38.79E, -44.97N. Mapped white lines represent the length across three ripples and are oriented to be perpendicular to these ripples.

Because in most areas it is not possible to infer the unique wind direction from ripples alone, the line orientation has a 180 degree ambiguity [9]. For example, a crest with an East-West alignment may have been created by Northerly or Southerly wind. Therefore, the orientations have been displayed without arrow heads and results assume azimuths to be between 0 and 180 degrees. Actual orientations may be defined after further study.

Results: The first few months of study have yielded some preliminary results. It is evident that ripple patterns will provide valuable information about recent wind flow and the identification of areas with bimodal wind patterns. Small dunes with flow lines oriented parallel to the dune axis may cause their downwind elongation as seen in terrestrial studies [10], while complex dune shapes may be the result of the interaction between multiple wind directions or multiple dominant seasonal wind patterns. Figure 3 shows one instance of a linear dune with wind flow along the axis on the West side of the dune, as well as a more complex pattern associated with a linear dune termination zone in the Southern area of this image. This is just one example of the similarities between terrestrial and Martian wind patterns.

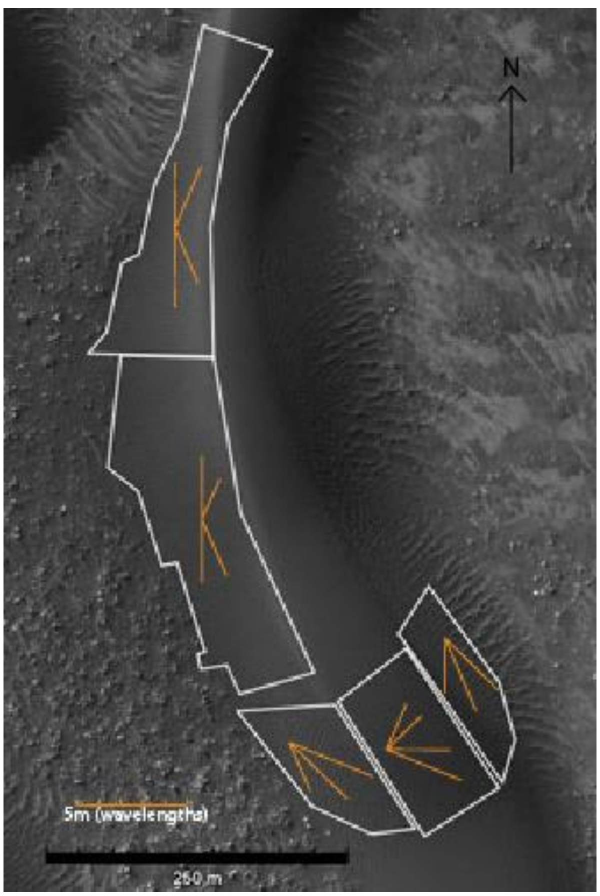

Figure 3: One linear dune of HiRISE image PSP_007663_1350 in Hellespontes from JMARS. This image is centered at 38.79E, -44.97N. White outlined areas represent regions with similar line azimuths, indicating areas with a common dominant wind direction. Orange lines represent the wind directions seen in that area with lengths scaled to the ripple wavelengths. All orange line lengths are on the same scale but have been exaggerated relative to the actual wavelengths in order to be seen in this figure. The orange line directions are shown to be between 0 and 180 degrees of azimuth.

Discussion: With additional Martian site evaluations, recent wind regimes and relationships between ripple patterns and dune structures in diverse areas of Mars will be compared. ESRI's Arc GIS ultimately will be utilized to perform more sophisticated analyses of the ripple pattern results. The future results of this project are expected to contribute to the comparisons between terrestrial and Martian dunes, and hopefully contribute to constraining meso-scale wind models of the surface of Mars.

Summary: Ripples on sand dunes provide valuable information about recent surface wind strength and direction. Furthermore, complex dune shapes are constructed by multiple wind patterns. By analyzing small Martian dunes in HiRISE images, wind regimes in these areas can be inferred and compared to current terrestrial and Martian wind models.

References:

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