Characterization of Small Sand Dunes on Mars

Abstract 2111

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Introduction

Martian sand dunes have become subject to study in order to obtain information about the surface environment of Mars, particularly wind flow patterns [1,2]. Movement of Martian sand ripples and dunes have been observed in diverse areas of the planet, first by the Spirit rover [3], 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. 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 [4].

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, but ripple-scale patterns indicate the most recent wind flow [5]. Terrestrial studies of ripples and the resultant sharp crests and structures describe the morphology of dunes influenced by multiple winds, including downwind elongation [6]. These provide models for comparison. Additionally, HiRISE provides images of the abundant ripple patterns on Martian dunes [7] with resolution as high as 25 cm/pixel [8]. This provides the means for the documentation of aeolian features in this study.

Procedure

The initial efforts have included ripple pattern mapping in four different HiRISE images using the Java Mission-planning and Analysis for Remote Sensing (JMARS) geospatial information system (GIS) [9]. The images used thus far are PSP_007663_1350 in Hellespontes, PSP_009571_1755 in Gale Crater, ESP_017762_1890 in Nili Patera, and PSP_010019_2635 in Planum Boreum. Additional sites will be chosen with diversity of longitude and latitude as a high priority to compare diverse areas.

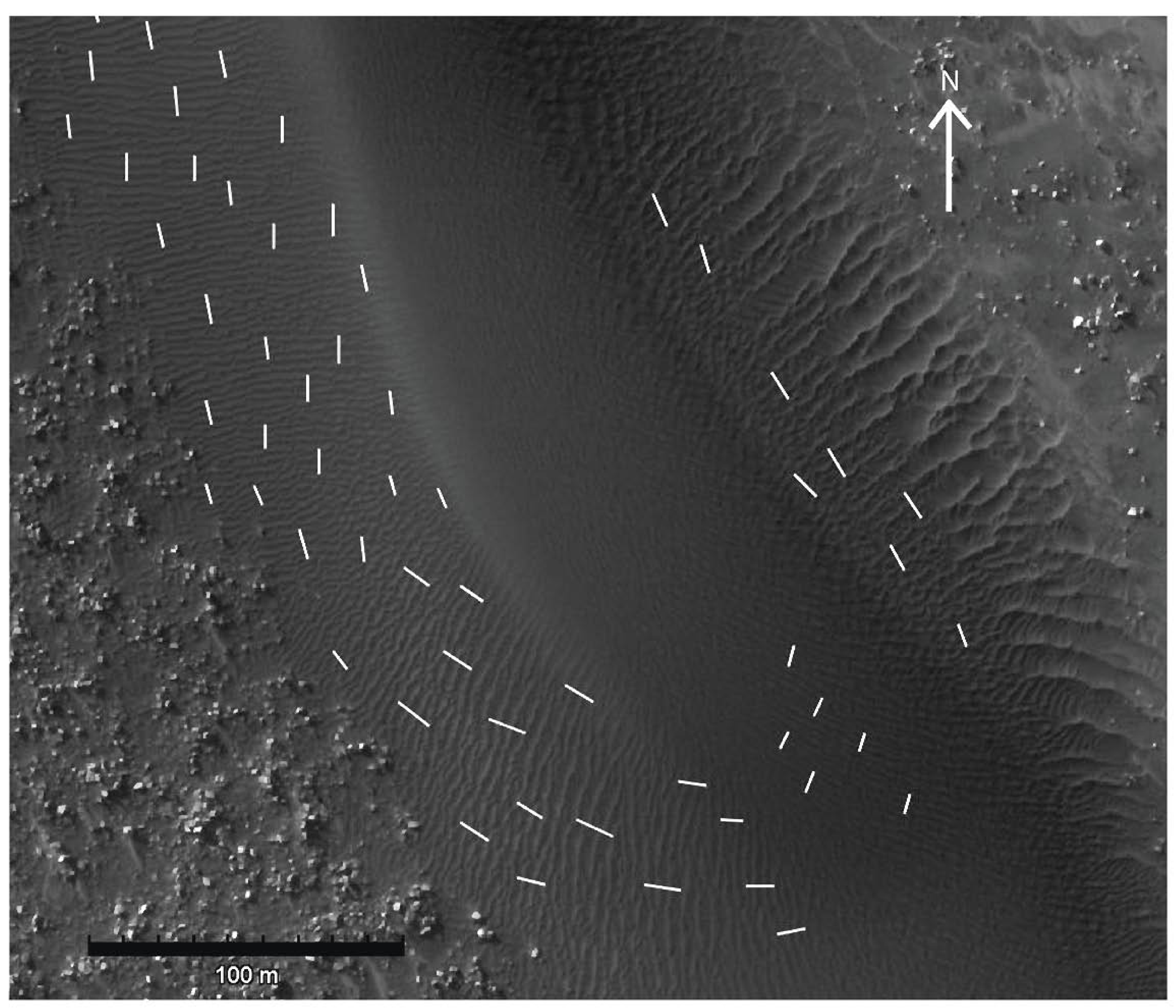

Figure 1: One linear dune from HiRISE image PSP_007663_1350 in Hellespontes from JMARS. This image is centered at 38.79E, -44.97N. Mapped white lines represent the length across three ripples and are oriented to be perpendicular to these ripples.

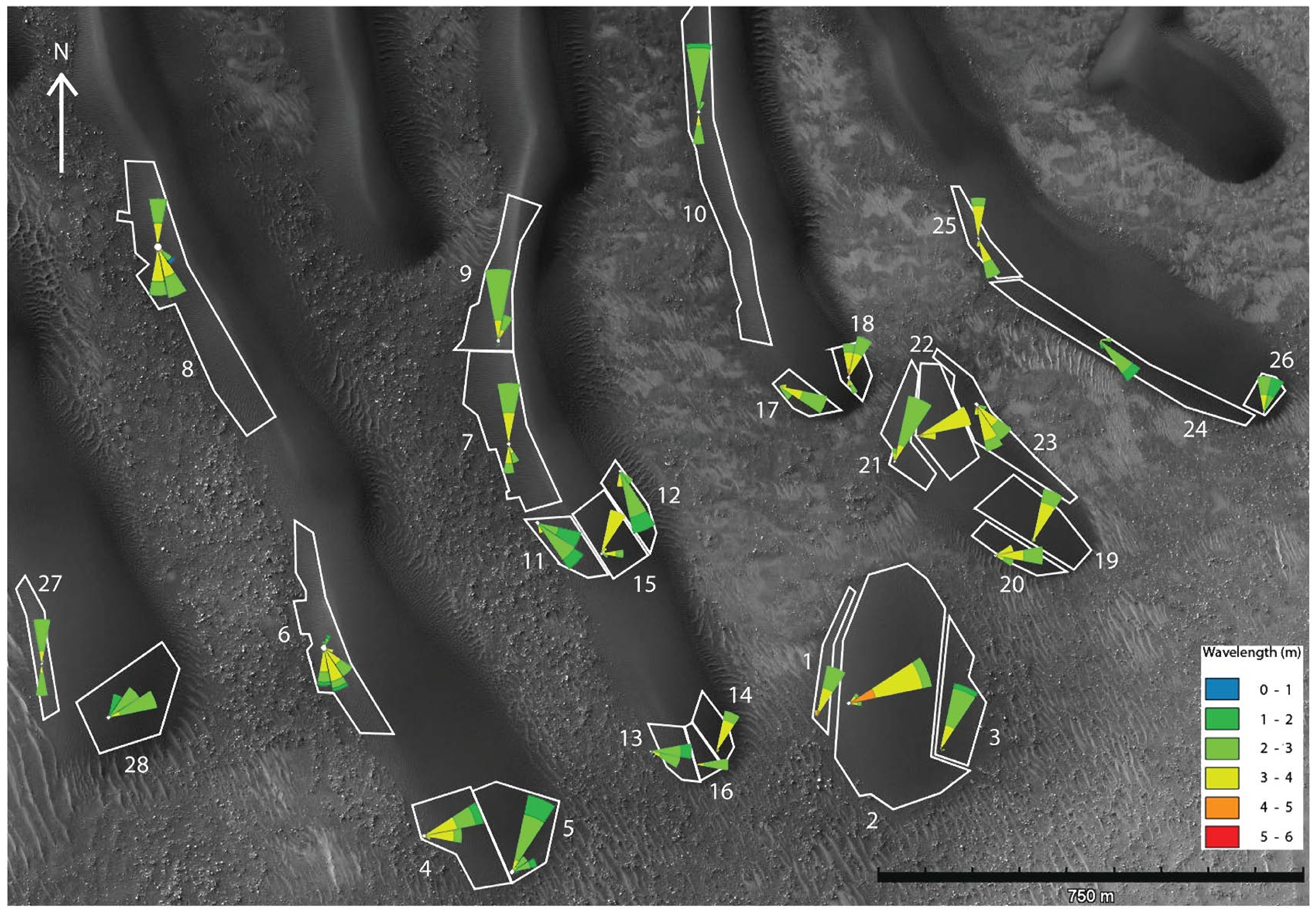

Figure 2: Linear dunes from HiRISE image PSP_007663_1350 in Hellespontes from JMARS. This image is centered at 38.8E, -45.0N. White outlines represent areas of similar ripple orientation. The roses are WRPLOTs of these ripples where vector length represents percentage of measurements in that area which fall in that cardinal direction. Similarly, the length of each color segment represents the percentage of measurements in that area which fall in that cardinal direction and are within a specific range of lengths. The WRPLOTs are scaled individually. 0-1 in the legend means ripple length greater than 0 and equal to or less than 1.

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 1). Measurement values were defined using JMARS tools. 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 [10]. Therefore, results will assume azimuths to be between 0 and 180 degrees. Actual orientations may be defined after further study.

Documented ripple lines were then categorized by their nearest cardinal direction (N, NNE, NE, etc.) and those with degree values larger than 180 were reflected across the rose in order to fall between 0 and 180. Wind roses were created from these data by means of Lakes Environmental WRPLOT [11]. The length of each vector in this program represents the percentage of measurements which fall in that cardinal direction. Similarly, the length of each color segment represents the percentage of measurements which fall in that cardinal direction and are within a specific range of wavelengths, according to the color legend.

Results

Figure 2 shows an image of Hellespontes with wind roses representing groups of ripple patterns. The orientation of the inferred wind is, in general, parallel to the dune axis along the West sides of the dunes. This is displayed with the North-South trend in areas 7, 9, 10, and 27. However, areas 6 and 8 have other components in addition to the North-South wind. In areas 24 and 25, the inferred wind direction is dominantly parallel to the dune, which is not aligned North-South. The inferred wind direction of areas 21, 22, and 23 are tangent to the outside of the dune.

At dune terminations in the Hellespontes image, the left side rose points East, shown clearly in areas 13 and 20, while the right side rose points dominantly Northeast in areas 5, 14, and 19. Roses 11 and 17, which could be expected to point East, both trend toward the Southeast. Areas 12 and 18 are not as strongly correlated, but are different from the other right side terminations.

The inferred wind directions of the Gale Crater image (Figure 3) are clearly not parallel to the ridge slip faces as in the Hellespontes image. All areas show wind between the East and Southeast. For the majority of the areas, this direction is perpendicular to a prominent slip face.

Discussion

In Hellespontes, the wind flow follows the dune's axis along the West side of dunes which are oriented both North-South and Southeast. This shows that the wind flow follows the dune directionality and does not merely flow North-South. This provides evidence for the shaping of wind by the dune's structure. The curve in the longitudinal dune containing area 6 may contribute to the addition of wind components if this is true.

The differences between areas 11 and 17 and the rest of the right-side termination zones may be also be explained by the influence of dune structure as their location within the field is unlike the others. Area 11 is in the middle of a dune while 17 is very close in proximity to the beginning of another dune. There may be a correlation between these areas which can provide information about the elongation or separation of dunes in this area. However, this would also create further questions for the dune containing areas 21, 22, and 23, including at what point the wind direction changed and what the relationship is between this dune and the dune to its Northwest.

In the Gale Crater image, the wind regime is relatively unimodal with wind directions dominantly Southeast and perpendicular to the slip faces. This is typical of transverse dunes and additional seasonal winds cannot be assumed.

Additional Martian site evaluations will be analyzed and ESRI's Arc GIS will be used to perform more sophisticated analyses of ripple patterns. This project may contribute to the comparisons between terrestrial and Martian dunes and hopefully contribute to constraining meso-scale wind models of the surface of Mars.

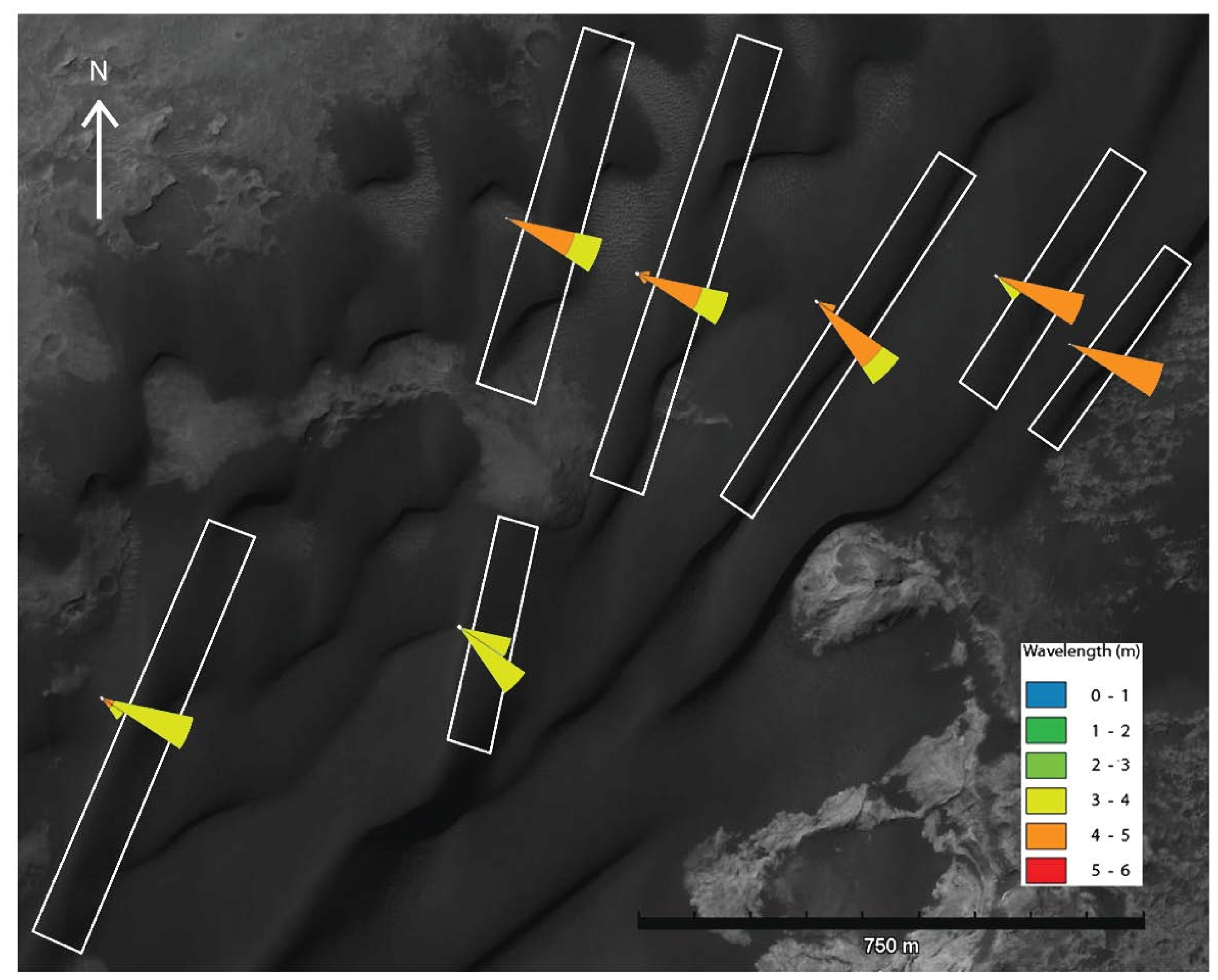

Figure 3: Transverse dunes from HiRISE image PSP_009571_1755 in Gale Crater from JMARS. This image is centered at 137.5E, -4.6N. White outlines and WRPLOTs are defined as in figure 2.

References

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