SURFACE SLOPE EFFECTS FOR RIPPLE ORIENTATIONS ON SAND DUNES IN LOPEZ CRATER, TERRA TYRRHENA REGION, MARS. J. R. Zimbelman[1] and M. B. Johnson[1], [1]CEPS/NASM, Smithsonian Institution, Washington, DC 20013-7012; zimbelmanj@si.edu; johnsonmb@si.edu.

Introduction: Ripple orientations have been documented using High Resolution Imaging Science Experiment (HiRISE) images of sand dunes at widely distributed sites across Mars, in order to identify the most recent wind directions at these locations [1]. Howard [2] derived an expression for how surface slopes on a sand dune can deflect ripple orientation with respect to the formative wind. Howard's equation was applied to measured ripple orientations on sand dunes in Lopez crater (14.55°S, 97.77°E), where a Digital Terrain Model (DTM) was derived from stereo HiRISE images. Results indicate that ripple deflection is not large when areas on and around slip faces are avoided.

Methodology: A DTM with one meter posting was produced using SOCET SET at the Astrogeology Branch, USGS-Flagstaff in June 2014 (Fig. 1). Stereo HiRISE images ESP_026609_1655 and ESP_026675 _1655 were obtained only six Earth days apart under excellent illumination conditions, which greatly fascilitated automated feature matching, something that has proved to be difficult for martian sand dunes. A slope map was derived from the DTM (Fig. 2), from which the direction and magnitude of the local maximum slope was obtained for locations where ripple orientation was documented; these data became the input to Howard's equation [2], which provided a quantitative evaluation of the magnitude and orientation of ripple deflection from the formative wind direction.

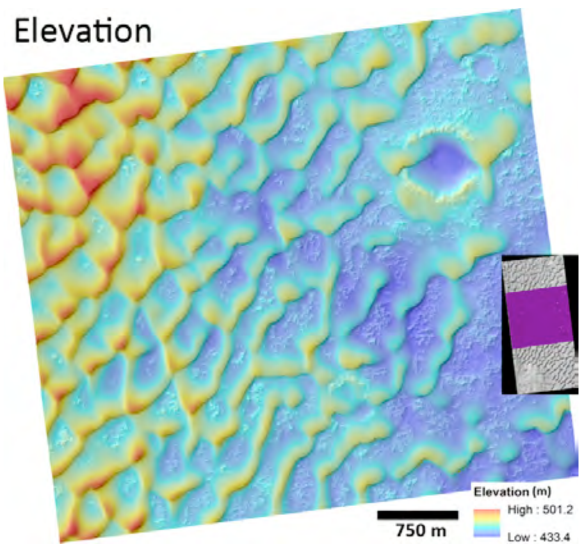

Figure 1. DTM of sand dunes in Lopez crater. Inset: DTM coverage on HiRISE image ESP_026609_1655.

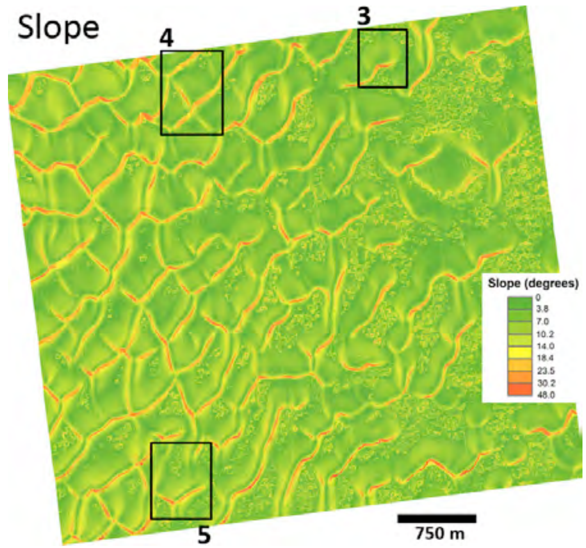

Figure 2. Slope map for sand dunes shown in Fig. 1. Boxes indicate areas shown in Figs. 3 to 5.

Results: The slope map (Fig. 2) revealed that 34% of the DTM has slopes between 0 and 5°, 41% has slopes between 5° and 10°, 21% has slopes between 10° and 20°, and 4% has slopes >20° (associated with current or former slip faces). Three dune areas (boxes in Fig. 2) illustrate the deflection results (Figs. 3-5) that should be applicable to the entire Lopez dune field. For a dune near the eastern margin of the dune field (Fig. 3), the dune has slopes that are <6° over the nearly the entire sand dune, resulting in deflection angles <5°; consequently, ripple orientations provide excellent indicators of the most recent surface wind [3]. In Fig. 3, this is illustrated graphically by the close correspondence of the red lines (measured ripple orientation) with the green lines (calculated deflection from actual surface wind), even in places where the maximum slope direction (yellow lines) is at a large angle with respect to the ripple orientation. These results changed slightly for dunes toward the western margin of the dune field (Figs. 4 and 5), mainly because these dunes have slopes up to 10°. The maximum deflection angle for these slightly steeper dune slopes is <17°, so that the ripples still provide very good indicators of the most recent wind, just not quite as close an agreement as for dunes with more shallow slopes. The DTM revealed slip faces oriented nearly parallel to the insolation direction (e.g., steep slopes running NW-SE across Fig. 4), where deflection angles are comparable to those obtained for ripples on slip faces with shadows, both approaching values of 27°.

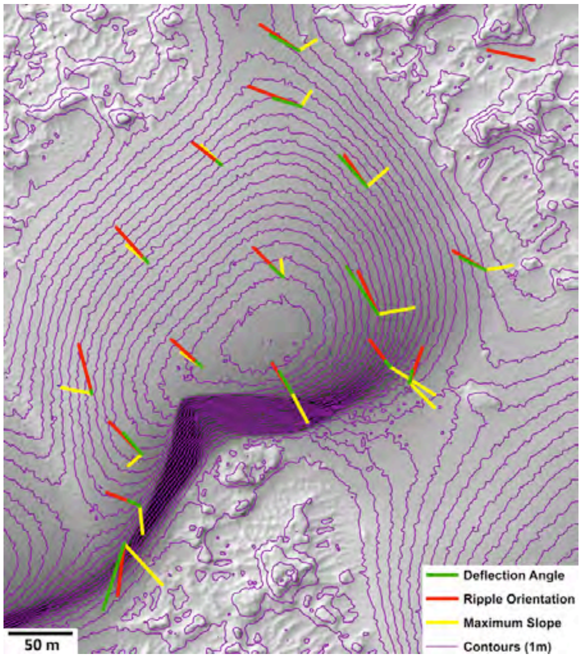

Figure 3. Sand ripple patterns on one sand dune (see Fig. 2). Red: measured orientation perpendicular to ripple crests, scaled to 10X the ripple wavelength (at image scale). Yellow: steepest local gradient, scaled to 5X the slope. Green: inferred surface wind after slope-induced deflection, scaled to 5X the angle. Purple: 1 m topographic contours.

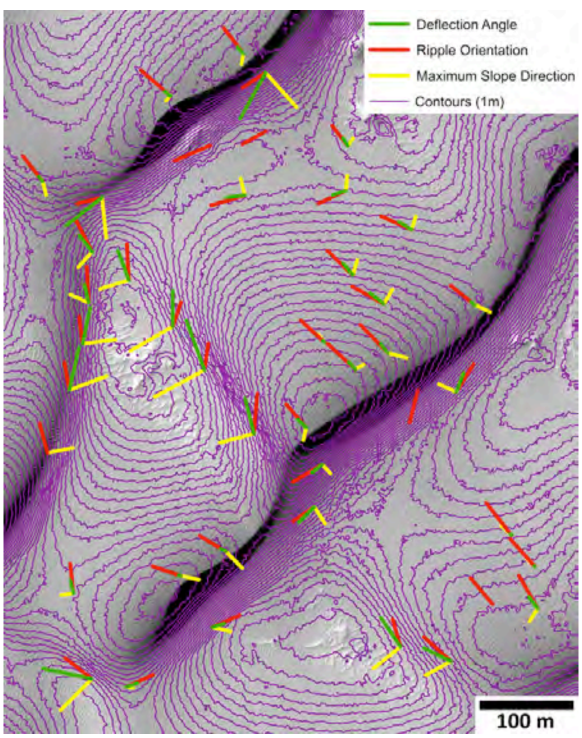

Figure 4. Sand ripple patterns (see Fig. 2). Line color scheme is the same as in Fig. 3, except yellow lines are scaled to 3X the slope.

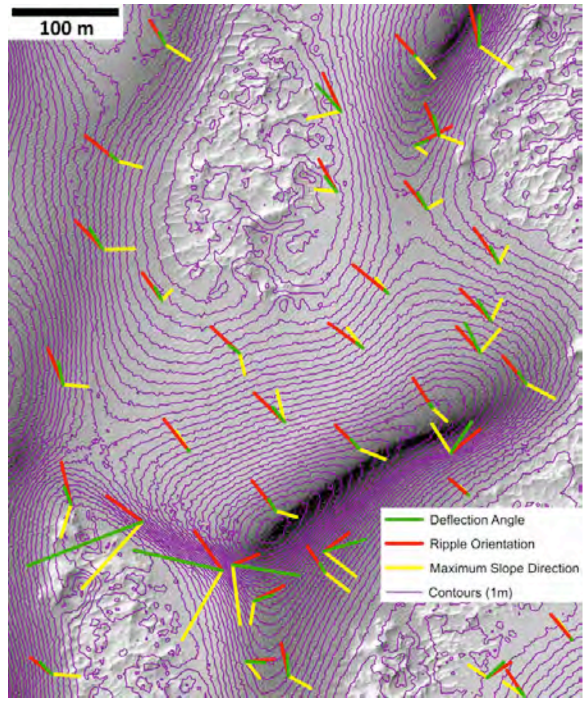

Figure 5. Sand ripple patterns (see Fig. 2). Line color scheme is the same as in Fig. 3, except yellow lines are scaled to 3X the slope.

The results for the magnitude of predicted deflection of ripples on the Lopez crater sand dunes support the premise that ripples on sand dunes are useful for evaluating recent wind patterns. Application of ripple mapping to Mars is an outgrowth of previous terrestrial studies where wind ripples provided a clear record of recent near-surface wind on sand dunes [4]. Taken together, both the small effect of calculated slope deflection and the experience from terrestrial ripple mapping support the case for use of ripple patterns to infer recent wind trends for sand dunes on Mars [e.g., 5].

Summary: Three-quarters of the area covered by sand dunes within Lopez crater have surface slopes $<10°$, where deflection angles are $<17°$. Consequently, ripples are very good indicators of the most recent surface wind on Mars, as long as areas either on or near slip faces are avoided.

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References: [1] Johnson M. B. and Zimbelman J. R. (2015) *LPS 46*, this conference. [2] Howard A. D. (1987) *Geol. Soc. Am. Bull.*, 88, 853-856. [3] Zimbelman J. R. and Johnson M. B. (2014) *Am. Geophys. Union*, Fall meeting abstract EP43B-3564. [4] Nielson J. and Kocurek G. (1987) *Geol. Soc. Am. Bull.*, 99(2), 177-186, doi: 10.1130/0016-7607(1987) 99<177. [5] Ewing R. C. et al. (2010) J. Geophys. Res. Planets, 115, E8, doi: 10.1029/2009JE003526.