PERVASIVE AEOLIAN ACTIVITY ALONG ROVER CURIOSITY'S TRAVERSE IN GALE CRATER, MARS

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Introduction: The Mars Science Laboratory (MSL) rover Curiosity landed on Mars on 6 August 2012, with the aim of searching for present and past habitable environments at Gale Crater [1]. During the exploration of Gale Crater, Curiosity will encounter a dark dune field, which lies along its path to Aeolis Mons (Mt. Sharp). Determining the current activity of these dunes from orbit provides a quantitative observational target for the rover to assess as it passes through the dunes.

Methodology: In order to assess aeolian activity and constrain the wind regime across the dune field, we examined dune and ripple morphology with High Resolution Science Experiment (HiRISE) images and derived digital terrain models (DTMs) (Fig. 1A). Dune slipfaces were mapped in ArcGIS, and slope and aspect angles were extracted from the DTM to derive density contours on an equal-area lower-hemisphere stereo plot (Fig. 1B). Ripple patterns were automatically mapped [2,3] using two orthorectified HiRISE images. Changes in the ripple and dune pattern were measured in the southwest portion of the dune field over three overlapping HiRISE orthoimages. The Mars Regional Atmospheric Modeling System (MRAMS) [4,5] was used to estimate the contemporary surface stresses and wind directions near the landing site.

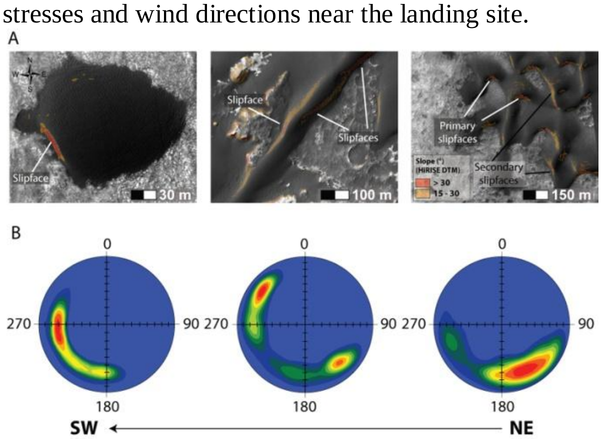

Fig. 1, A: Barchan and linear dunes in the landing site, B: Lower-hemisphere equal area density stereoplots for all the slipface surface vectors.

Dune and ripple morphology: The dune field is made up of barchans and linear dunes (Fig. 1A). Visual assessment and stereonet analysis of measured slipface surface vectors reveal three apparent slipface orientations (Fig. 1B). Ripple crestline orientations have a bimodal distribution, with two main modes at 45° and 330° (Fig. 2). The progression of morphologies from barchan dunes to linear dunes, and the presence of orthogonally oriented wind ripples indicate the presence of at least two prevailing winds, with likely modes from the NW and the NE [6].

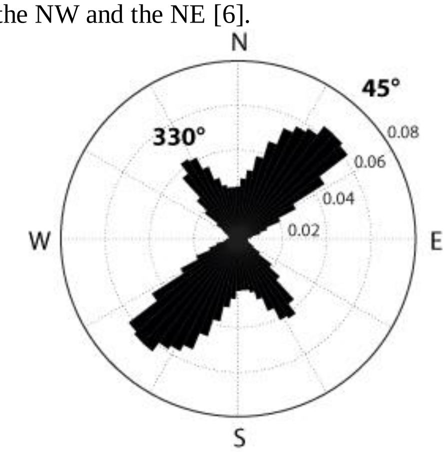

Fig. 2: Ripple length-weighted circular distribution in the MSL landing site.

Bedform migration: The ripple pattern oriented 330° changed consistently between Martian year (MY) 28 and 29 (2006-2008) with the ripples (n=180) migrating on average 1.27 m/MY (0.66 m/Earth year [m/EY]) toward the SW. The lee-slope toes of eight dunes moved 2 m, on average, toward the SW between MY 28 and MY 31 (2006-2011), at a mean rate of migration of 0.73 m/MY (0.4 m/EY) [6].

Modeled winds: MRAMS output indicate that the wind is heavily influenced by the topography of the Gale crater rim and mound, with the winds blowing mainly from the NE near the mound (Fig. 3A, B). The modeled shear stresses are always below the classical empirically derived saltation initiation threshold [7]. In the best case, a maximum stress ratio of 0.57 was obtained (meaning that the model shear stress is approximately half the stress needed to initiate saltation in this extreme case). Moving toward the SW the stress ratio increases (Fig. 3A) as the circular dispersion of the vectors decreases from NE to SW (Fig. 3C).

Discussion and conclusions: Our results suggest that the dune field in the MSL landing site is currently active and influenced by at least 2 winds. Winds from the NE appear to dominate and are responsible for the current ripple and dune migration within the southwest sector of the dune field. Such winds are consistent with the results from MRAMS and they appear to be related to regional flows interacting with both Aeolis Mons and the crater rim. The influence of a secondary wind from the NW provides one solution to the orientation of the linear dunes, which are oblique to both the east wind and the putative northwest wind. A wind from the NW would also explain the secondary set of wind ripple oriented at 45°. The MRAMS simulations analyzed here do not show any evidence of significant northwest winds near the dunes, which may be due to the short-term temporal resolution of the model at 4 sols in each of only four seasons.

Collectively, our findings show that the MSL landing site is an active environment, with the action of the wind being the major agent of landscape modification in the current atmospheric setting [6]. Roving between the dunes represents a unique opportunity to validate the accuracy of wind predictions and make the first ground observations of a known active aeolian environment on Mars.

References: [1] Grotzinger J. P. et al. (2012) *Space Science Reviews, 170*, p. 5-56. [2] Vaz D. A. (2011) *Planetary and Space Science, 59*, p. 1210-1221. [3] Silvestro S. et al. (2011) *Geophysical Research Letters, 38*, L20201. [4] Rafkin S. C. R. et al. (2001) *Icarus, 151*, p. 228-256. [5] Michaels T. I. and Rafkin S. C. R. (2008) *Journal of Geophysical Research, 113*, E00A07. [6] Silvestro S. et al. *Geology* (In Press). [7] Greeley R. and Iversen J. D. (1985) Cambridge University Press, 333p.

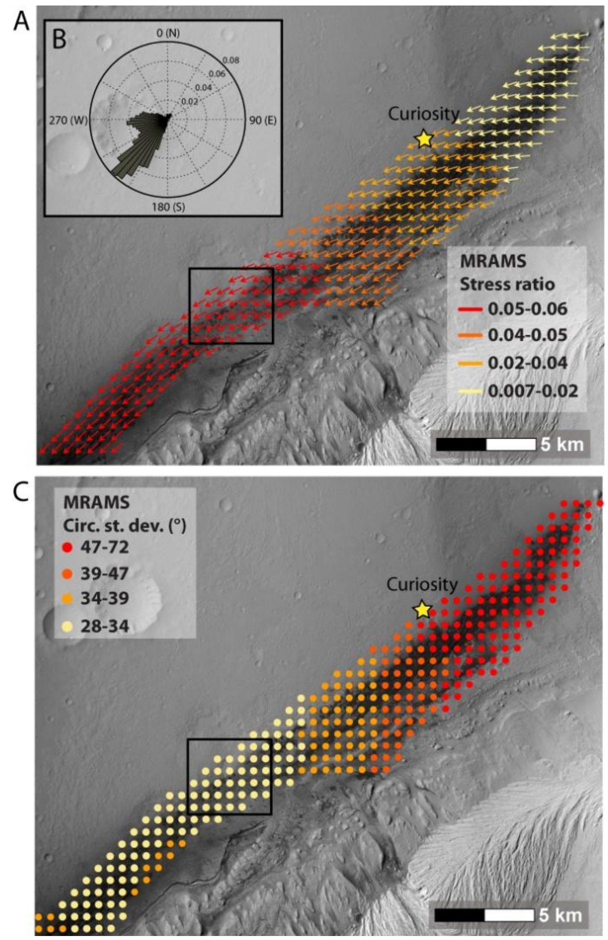

Fig. 3*: MRAMS modeled wind stresses and directions. Black boxes indicate the area where ripple and dune migration have been measured.* ***A****: Time-averaged stress ratio vectors,* ***B****: Circular distribution of the stress ratio vectors,* ***C****: Circular standard deviation associated with the mean vectors shown in A.*