MAPPING VENTIFACT ORIENTATIONS AS WIND INDICATORS WITH THE CURIOSITY ROVER AT GALE CRATER, MARS. L. Kim[1], K. W. Lewis[1], [1]Johns Hopkins University, Baltimore, MD (lkim45@jhu.edu)

Introduction: Geologic features called ventifacts form as rocks are eroded by the wind and can serve as indicators of the formative wind direction. We are able to observe these patterns with the cameras of the Curiosity Mars rover. Ventifacts are useful indicators of long-term wind for understanding atmospheric circulation at the rover's field site in Gale crater, particularly since the loss of the Curiosity REMS wind sensors. Previous work has mapped ventifacts along the rover traverse early in the mission [1], and more recently using the downward-looking MARDI camera [2,3]. Across the range of terrains encountered by the rover, there exist many examples of ventifacts in Gale Crater [1-3]. Ventifacts are found in many different forms on the surface; some appear as notches and flutes in the bedrock while others (and the majority mapped here) appeared as delicate stalks protruding out of bedrock. The latter are particularly useful indicators of wind direction, and indicate a dominantly unidirectional wind regime.

Methods: We expanded the search for ventifacts at Gale crater using the mast-mounted Mastcam and Navcam cameras from landing through sol 3345 of the mission. We looked for examples where ventifacts indicated a largely unidirectional wind orientation. We used a variety of visualization tools to map ventifacts in Mastcam and Navcam image data. We additionally used 3D information from stereo image observations from each camera to more precisely determine ventifact orientation.

The appearance of ventifacts and their respective orientations were classified and cataloged, and plotted in map view to evaluate larger scale pattern across the rover traverse. Our survey focused on well-developed stalk-like ventifacts, as seen in Figure 1. These features are only a subset of the wind indicators used in other surveys [3], but they are useful in indicating an unambiguous unidirectional formative wind orientation, and represent a long-term average of the wind patterns over time. On the other hand, they may be sensitive to lithology, forming only in more heterogeneous rock types or those with more resistant features like diagenetic concretions, as demonstrated by [2].

Results: In total, we recorded 36 sols where ventifacts recorded a single, clear wind orientation. This represents 1.08% of the sites analyzed from sols 0–3345. The occurrence of ventifacts in these specific locations likely arises dominantly from lithology, but may also be less apparent where wind patterns are not strongly unidirectional. With the exception of a few locations, the majority of mapped ventifacts are oriented pointing towards the southwest (SW) direction (indicating wind from the northeast).

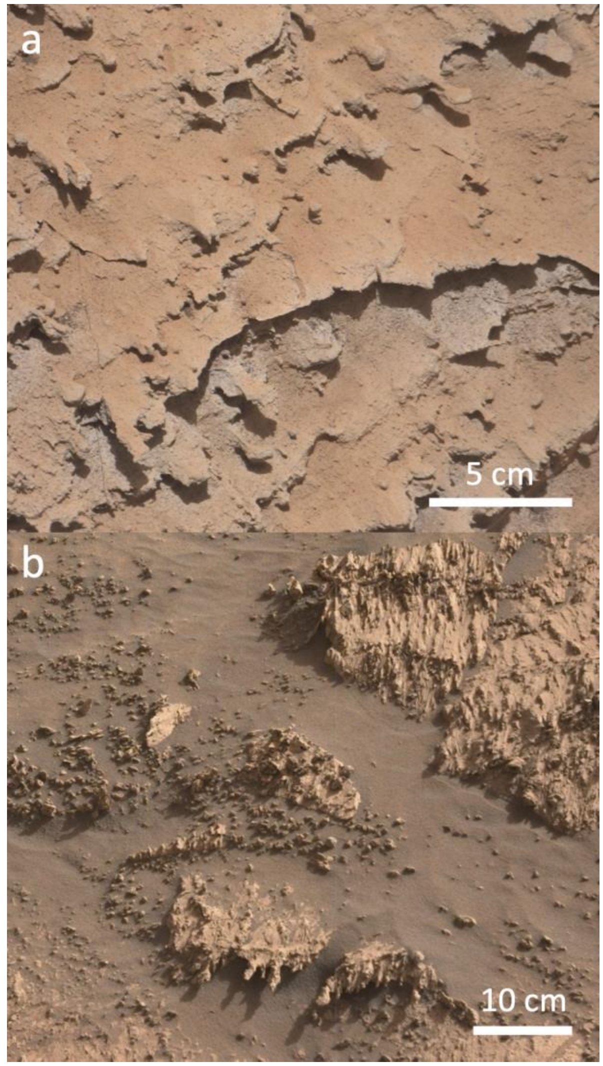

Figure 1: Exanples of "stalk-like" ventifacts in Curiosity Mastcam images that indicate a dominant long-term wind orientation, taken on a) sol 2735, and b) sol 3192.

Southwest oriented ventifacts were particularly concentrated in the azimuth range from 220°-260°. These results largely align well with the results of mapping from the MARDI camera [2,3]. This orientation is in general agreement with observed

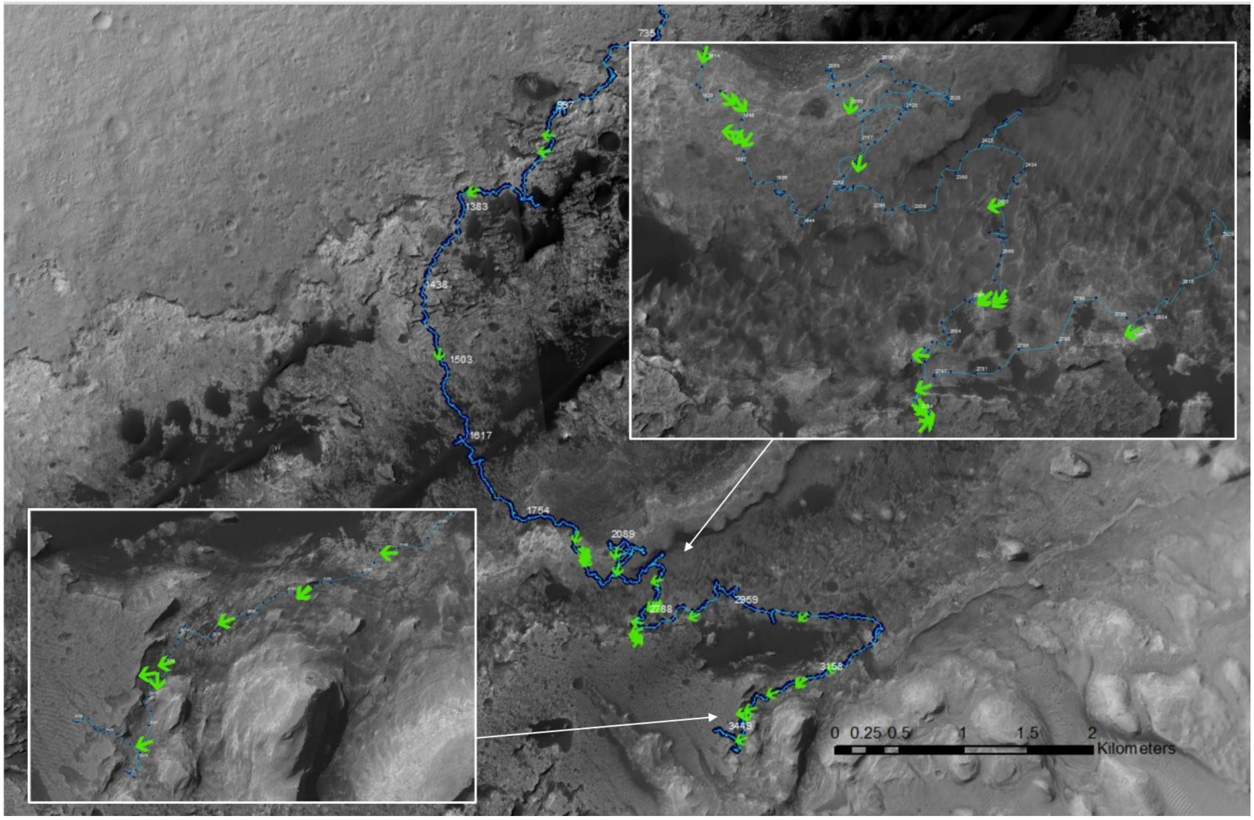

Figure 2: Overview map of all ventifacts idenfied within our survey with green arrows indicating the direction of the formative wind; north is up. The blue line is the path of the rover's traverse, with representative sol numbers indicated in white. Inset figures show two areas of higher-density ventifact occurrence on the Vera Rubin Ridge and in the Glen Torridon region.

sand motion from rover 'change detection' observations [5], but only partially agrees with expectations from atmospheric models of the modern day wind patterns in Gale crater [3,6]. Localized deviations from this pattern may indicate shadowing by local topography, interaction with local dune fields, and varying lithology. Ongoing work will investigate the cause of these anomalies.

In addition to the orientation of ventifacts mapped in this survey, their distribution along the traverse likely indicates several competing factors. Few stalk-like ventifacts are identified in the lower slopes of Mount Sharp below the Vera Ruben Ridge, or early in the mission prior to arrival at Mount Sharp. First, it is likely that the stalk-like ventifacts require a heterogeneous lithology to be expressed by the martian wind. Indeed, the pattern of mapped features matches well with the distribution of Chemcam observations on diagenetic nodular rock targets through the Glen Torridon region [4]. Additionally, the often delicate stalks (e.g., in Fig. 1b) likely require a fairly unidirectional wind regime to avoid being abraded by cross-winds; areas where these features are not found could have more bidirectional winds over diurnal or annual periods. Finally, the orientation of bedding relative to the land surface may play a contributing role; areas where the land surface is roughly parallel to bedding, as on the lowermost slopes of Mount Sharp [7], may provide fewer raised outcrop surfaces for initiating ventifacts of this morphologic type.

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