ROCK ABRASION FEATURES IN THE COLUMBIA HILLS. Bradley J. Thomson and Nathan T. Bridges, Jet Propulsion Lab, California Institute of Technology, MS 183-501, 4800 Oak Grove Dr., Pasadena, CA 91109 (bradley.j.thomson@jpl.nasa.gov).

Synopsis: This objective of this study was to map the position and orientation of ventifacts along the Mars Exploration Rover (MER) Spirit traverse in Gusev Crater. Here we report on Sols 700-810 in the Columbia Hills (Fig. 1). Mapped ventifacts in this traverse segment deviate substantially from previously mapped orbital wind indicators [e.g., 1], suggesting that local topography exerts a strong influence on aeolian processes in this region.

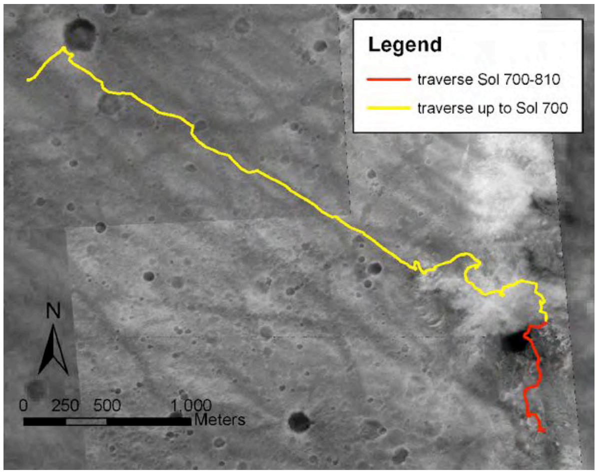

Figure 1. Spirit rover traverse through Sol 810. Base map is a portion of MOC images R13-01467 & R13-03051 overlaying THEMIS visible image V00881003.

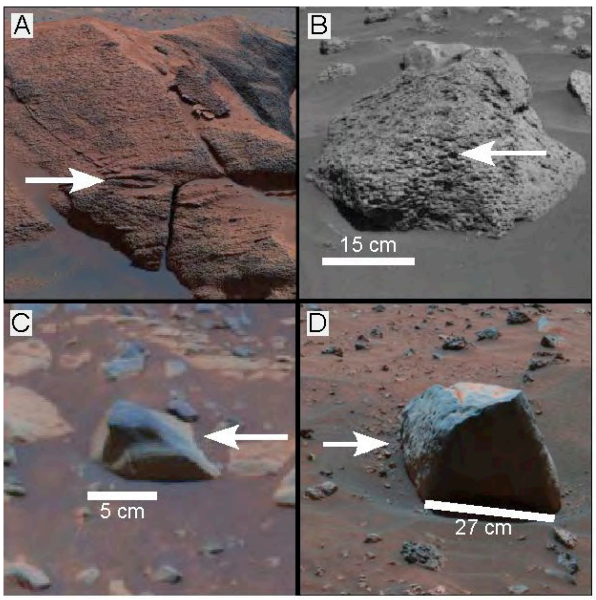

Figure 2a-d. Examples of Martian ventifacts in the Columbia Hills. White arrows indicate inferred formative wind direction. Pancam images from (a) Sol 698 (range data unavailable for scale bar), (b) Sol 738, (c) Sol 767, and (d) Sol 724.

Background: Ventifacts are wind-abraded rocks that are common in arid environments on both the Earth and Mars [e.g., 2, 3, 4]. They are formed by repeated impacts of wind-blown particles, and thus provide an integrated record of past and present aeolian activity. Examples of aeolian abrasion features on Martian rocks include pits, elongate pits, flutes, grooves, and faceted rocks (Fig. 2a-d).

Study goals: A recent study addressed erosional and depositional aeolian forms at the Spirit site through Sol 312 [1]. Here we focus on Sols 700-810 in the Columbia Hills (Fig. 1). In addition to assessing the specific orientations of ventifacts along the rover traverse, this study investigates potential correlations between local topography, sand availability, and rock abrasion features. This includes both small- and large-scale topographic effects. Small-scale effects of interest include the localization of abrasion features on rocks and particular rock facets around small topographic obstacles (such as crater rims, dips, saddles, and other large rocks); larger-scale effects include regional scale topographic constrictions and the acceleration of wind flow up hills [e.g., 5].

Method: Previously, a catalog of ventifact features visible in Pancam images was compiled [6]. This catalog has been extended and updated to include a qualitative indicator of the utility of the ventifacts identified as directional indicators. Once a candidate ventifact is identified, stereo ranging software is used to derive the positional information of suitable abrasion textural elements, in particular the end-points of grooves, flutes, elongate pits, and linear to sub-linear scour marks. Each pair of points is used to derive a vector indicating the inferred formative wind direction [1, 7]. These coordinates are then transformed from local rover-frame into a Mars-body fixed coordinate frame and then plotted along the rover traverse in a GIS (Fig. 3).

Results: *Ventifact orientations*. Measured ventifact orientations indicate a dominant mode oriented roughly to the east, indicating formative winds from west (see rose plot in Fig. 3). This trend is about ~45° from the directionality indicated by wind streaks observed from orbit [1], suggesting a strong influence of local topography and/or a possible change in dominant wind direction over time. In general, the degree of ventifact development appears greatest near ridge crests, which is qualitatively consistent with the effect of wind acceleration up topographic highs [e.g., 5].

Orientation of aeolian bedforms: In the recently acquired HiRISE [8] image of the landing site, a series of linear aeolian bedforms are evident to the east of the rover path in a local topographic low ("Inner Basin"). Features similar to these have been described as transverse aeolian ridges by some workers [e.g., 9] and ripple-like bedforms [e.g., 10] by others. Their symmetrical appearance in cross section makes it difficult to distinguish lee and stoss slopes, possibly suggesting bi-directional or reversing formative winds.

The long axes of these transverse aeolian ridges are oriented roughly north-south on the eastern edge of Fig. 3 (enlarged in Fig. 3 sub-frame B). This suggests (possibly bi-directional) formative winds blowing approximately east-west. The wind directions indicated by these ripple-like form appears to shift 90° around as one moves back along the traverse (to the north). Here the wind appears to be funneled between Lorre Ridge and Allegheny Ridge, indicating that the local topography exerts a strong influence on the wind direction.

These aeolian bedforms are actually compound linear forms; smaller, secondary, ripples-like features oriented at roughly right angles to the primary ridge crests are also evident in Fig. 3 sub-frames A-B. This may indicate a secondary wind direction (or set of secondary bi-directional winds). Alternatively, the larger ripples could be fossil forms and the smaller ripples may reflect the current, active wind regime. Since larger forms concentrate wind flow along their lengths, the second-order forms may be geometrically constrained to form at right angles.

Implications: The large range of ripple orientations suggests that multiple scales of topography in the Columbia Hills strongly influence both the orientation and strength of local winds. HiRISE images over the rover traverse thus provide invaluable tools for correlating ventifacts mapped from rover-based images with the geologic and topographic context inferred from orbit.

References: [1] Greeley R. et al. (2006) *JGR*, *111*. [2] Greeley R. & Iverson J. D. (1985), *Wind as a Geologic Process on Earth, Mars, Venus and Titan*, 333. [3] Laity J. E. (1994) in *Geomorphology of Desert Environments*, 506-535. [4] Bridges N. T. et al. (2004) *Planet. Space Sci.*, *52*, 199-213. [5] Laity J. E. (1987) *Phys. Geog.*, *8*, 113-132. [6] Stone A. S. et al. (2006) *LPS XXXVII*, abstract 2080. [7] Bridges N. T. et al. (1999) *JGR*, *104*, 8595-8616. [8] McEwen A. S. et al. (2006 in press) *JGR*. [9] Wilson S. A. & Zimbelman J. R. (2004) *JGR*, *109,* E10003. [10] Malin M. C. & Edgett K. S. (2001) *JGR*, *106*, 23429-23570.

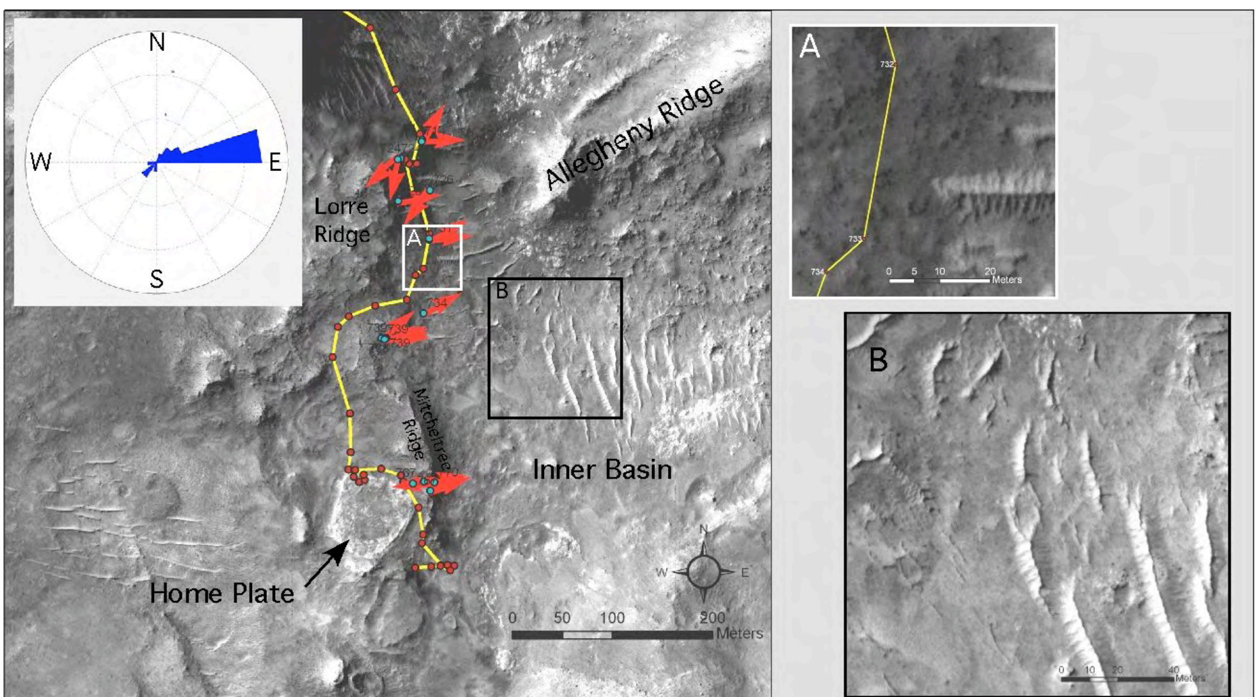

Figure 3. Spirit rover traverse in the Columbia Hills from Sols 700-810. Base map is HiRISE image PSP_001513_1655 (red CCDs), image resolution ~27 cm/pixel. Image subsets "A" and "B" highlight compound linear ripples east of the rover traverse. Linearity of larger ripple-like forms suggests bi-directional formative winds roughly N-S in subset A and roughly E-W in subset B.