MODIFICATIONS TO DUST DRAPES ON SOIL AT THE MER SPIRIT GUSEV SITE S.M. Metzger, Planetary Science Institute, 1700 East Ft. Lowell, Ste. 106, Tucson, AZ 85719-2395, Metzger@psi.edu

Introduction: Using MOC orbital images and several image sets from MER Spirit (Pancam, Navcam and MI), it is now possible to study at substantially different scales the effects on dust drapes over soil by dust devil vortices and other surficial processes.

Dust Devil Scour: MOC image R07-01606-04 covers 2.95 x 12.06 km at 1.44 m/pxl and includes the Spirit landing site atop numerous dust devil tracks. The central track cluster has too many overlapping trails to count. Windward crater rims clearly provide trigger points, producing track swarms in their lee.

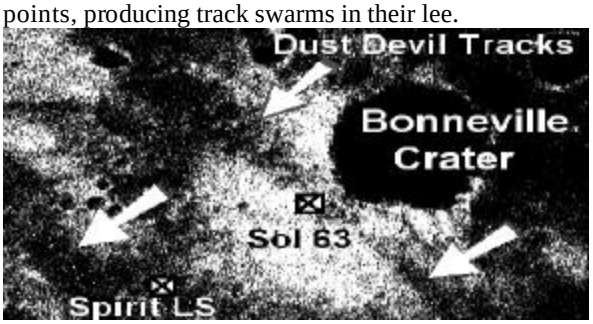


Figure 1 - MOC image of Spirit landing site dust tracks

From Sols 45 to 65, Spirit headed NE directly toward Bonneville crater. Figure 1 shows a 50m-wide DD track, immediately down slope from the crater rim, which crosses that Bonneville trek with an orientation from NW to SE. The Sol 63 scrutiny of "Plank" rock occurred along the southern boundary of this track. MOC image R07-01606-04 was acquired several months prior to Spirit's arrival and shows the track as less apparent than the track under the landing point, presumably having been re-covered by the ubiquitous air fall of fresh dust.

On Sol 63, Spirit used the MI to examine Plank. That image (2M131952663EFF1300P2957-M2M1) reveals a striated pattern of near-parallel microgrooves with a lower left-upper right orientation, seemingly etched or burrowed into the rock's dust drape (fig. 2). The dust drape has a clumpy texture whereas the microgrooves seem to have extended to the rock surface, which appears smooth and flat. Microgroove orientation is nearly parallel to the rover's path to Bonneville crater and thus perpendicular to the dust devil track.

The Pancam (2P131956762ESF1300P2530L3-M1) and Navcam (2N131869552-EFF12BOP193-3L0M1) images of Plank reveal it to be a well-developed ventifact whose faces are consistent with the wind directions that left the dust devil tracks (NW-SE). Small deflation moats encompass most rocks, including Plank. Pancam resolved dark, coarse sand-sized grains along Plank's moat. The microgrooves on Plank rock are interpreted to be impact trenches from saltating sand carried in the base of the vortex that created the dust devil track. The sand grains (or sand-sized aggregates) are presumably the same as those seen in the moat around Plank's perimeter.

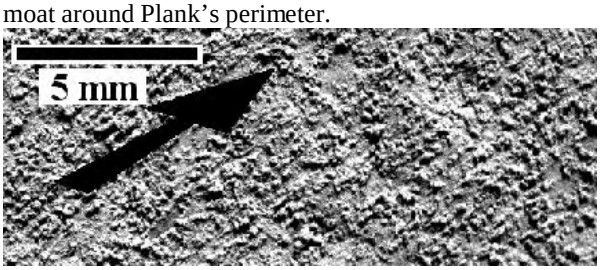
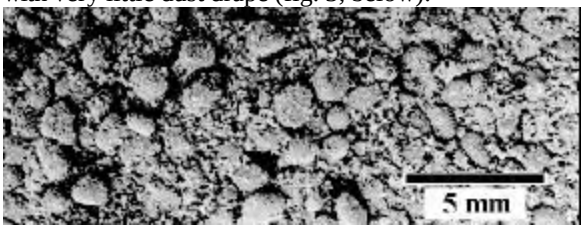


Figure 2 – Parrallel striations in a dust deposit, inferred as evidence of dust devil scour.

Given a vortex scour origin for the striations, and assuming that the Sol 63 track's dust devil was typical (a suggestion supported by a width similar to other tracks imaged in this region of Gusev), the extent of dust removal can be assessed. Using visual estimation methods, approximately 50% of the Plank surface has been scoured clear of its dust drape. The thickness of the remaining dust deposit is roughly 100 microns. Given a 50 m wide, 3 km long track with 50% removal of a 100 micron dust layer, this modest feature represents the airborne injection of 75 m^3 of "fluffy" (uncompressed air-fall drape) dust. It would be useful for aerosol transport models to know the aeolian erosion threshold of this combination of aeolian features.

Surficial Dust Accumulations: Spirit's MI has documented a wide range of dust deposits on the floor of Gusev crater and the Columbia Hills. At the landing site (and through sol39), it drove over basaltic sands with very little dust drape (fig. 3, below).



The partial erosion described above was found at the sol62-63 stop. Upon crossing beyond that track, however, a moderate dust layer had accumulated near the rim of Bonneville crater (left image, figure 4). Following a spectroscope measurement, the small dark patch of soil revealed when a "divot" of the compressed dust layer stuck to the instrument as it withdrew from the surface (top, center of the left image in fig. 4) provides a

demonstration of the dust's cohesion and adhesion. In the Columbia Hills, Spirit repeated the dust drape "smooshing" of a thicker deposit on sol240 (central image, figure 4), again with the adherence of a dust clod to the retracting instrument (with torn flaps #1, and folds #2 seen close up in the right image, figure 4).

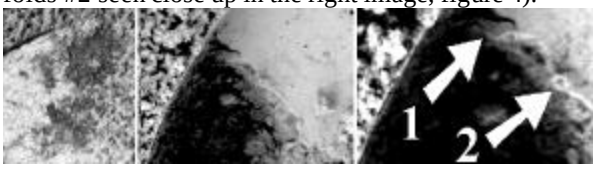


Figure 4 – Cohesive dust compression and alteration.

If human avatars can compress dust into coherent layers, natural processes may also indurate surficial dust accumulations. And geomorphic processes (ex. a passing low pressure cored, sand-blasting dust devil) may also disrupt those deposits. Several high-albedo clumps of material have been identified in Spirit's MI images from sols 314 and 341.

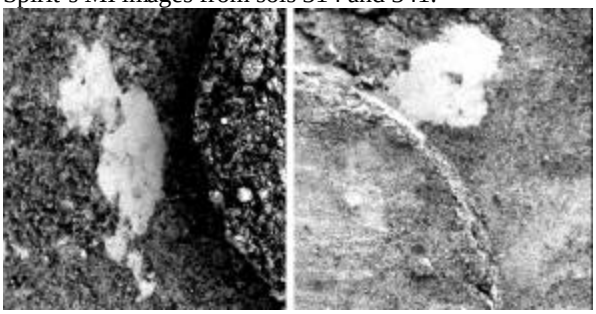


Figure 5 – Cohesive clods sol341 (L) and 314 (R).

If the white clumps are fragments of such compressible dust deposits, why are they scattered about the surface? Assuming MER was not responsible, why are they separated from their initial deposit? What wind (or mass movement, etc.) process was necessary to move them, how strong must it have been, and from where were they moved? Terrestrial equivalents include rip-up clasts and mud rollers (as in a fluvial or tidal environment), and mud flakes (3 cm diameter) torn from an encrusted playa by aeolian thermal vortices (personally pelting the PI). The point of removal may now expose lineations or strata that derive from, and reflect, variations in the depositional environment, potentially over considerable time scales or climates. Field measurements are required to quantify their erosive thresholds.

Aeolian Strategraphy: Although the aeolian accumulation of dust can result in massive deposits that appear to lack bedding structures (such as in loess beds found in China or the central US), minor fluctuations in environmental conditions can lead to layering, which consequently responds differently to erosion. Such variations can result from wind shifts, temperature change, humidity change, and shifts in sediment supply, among others. The transport capacity and competence of wind is very precise in the material carried; a minor increase can deliver, say, fine sand when only very fine sand was carried a moment before. Likewise, the steady shear stress exerted by routine wind regimes common on Mars will erode material in a gradual manner, increasing the chances to reveal subtle features.

Gentle, steady 5 to 10 m/s winds (at 1.5 m above the ground) have been observed at both Viking and the MPF landing sites [Ryan and Lucich, 1983, Schofield et al., 1997, and Ringrose et al., 2003] . When scaled to ground level, these fall below the predicted erosion threshold (u^*_t) of 2 m/s (at the surface-atmosphere boundary) for fine sand [Greeley and Iverson, 1985]. Other aeolian processes that operate in the same wind regime, however, are capable of moving surficial material into meaningful depositional patterns.

Although the search is still on for interesting examples in Spirt data, wind tails are common in the sheltered areas behind rocks and pebbles at the Mars Pathfinder Ares Vallis landing site. The tail behind rock "Barnacle Bill" extends approximately 30 cm, starting with an upwind width of 23 cm. It appears to be trimmed by erosion along the southern flank that faces the spacecraft. This reveals sub-parallel lineations due to undulation of the exposed face, interpreted here to be slip face bedding.

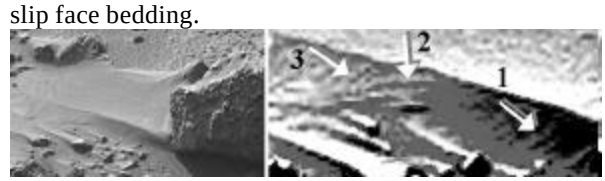


Figure 6 - Increasingly close-up views of the flank of the windtail behind the rock "Barnacle Bill" at the MPF Ares Vallis site, based on contrast enhancement of a super-resolution composite image (via Tim Parker, JPL, 1999 personal communication). Positioned at right angles to their layered lineation sets, arrow (1) points to steeply inclined lineations, arrow (2) are low-angle lineations which appear to truncate the (1) features, and arrow (3) are steep lineations which appear to form on top of (2). The downwind upper surface and flank of the windtail (to the left, best visualized in the center image) has several regularly spaced ripples.

Brief intense erosive wind events have been shown to quickly remove unconsolidated soil piles created by the Viking Lander arm. Therefore, dust devils may have provided the wind tail sculpting recorded in bed set #2. The present flank orientation, however, is directly downwind of the deflationary trough immediately upwind of Barnacle Bill., producing a horizontal roller "horseshoe" vortex. Dust drapes respond to and may preserve these processes.