CONSTRAINTS ON AEOLIAN DEGRADATION RATES ON MARS FROM ERASURE OF ROVER TRACKS.

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Introduction: The wheel tracks left by the MER rovers Spirit and Opportunity are unique artificial markings on the surface of Mars. The tracks stretch several kilometers across diverse terrain in two widely separated regions of the planet. The initial appearance and characteristics of the tracks were well documented by the science and navigation cameras aboard the vehicles at the time the tracks were formed. Orbital observations by Mars Global Surveyor and now Mars Reconnaissance Orbiter document the erasure of the tracks over a period of more than two Mars years. We are monitoring the erasure of the rover tracks as a means to better understand the mechanisms and timescales of aeolian alteration on Mars.

Several science questions are raised by these observations. First, what are the dominant mechanisms of aeolian obscuration? Does erasure occur primarily by airfall of dust, or redistribution of soil by surface winds? Second, are the processes gradual or episodic? Timescales for gradual processes such as dust settling are much easier to estimate than episodic processes such as severe winds. Third, how important are local surface properties in creating and preserving the tracks? In particular, we wish to know why some tracks remain persistently visible while others disappear quickly. This affects our ability to estimate obscuration rates elsewhere on Mars. Finally, how active are the wind streaks issuing from Victoria crater? Knowledge of the modern flux of sediment from these streaks may help constrain the age of this heavily eroded crater [1,2].

Spirit Track Observations: Spirit's wheels left conspicuous dark tracks in the dust-mantled soil of Gusev crater (Figure 1). Low albedo sand and gravel were exposed from beneath the bright dust mantle along Spirit's traverse from its landing site across the Columbia Hills. MOC images [3] show that the tracks near the landing site began to fade gradually in the weeks after they were made. Spirit's tracks approaching the Columbia Hills were rendered invisible before the arrival of MRO. Only two small sections of tracks from Spirit's traverse to Home Plate could be seen in early HiRISE images, in sheltered slopes on the southern flanks of Husband Hill and in the corridor west of Mitcheltree Ridge.

Figure 1: Tracks of Spirit in Gusev crater, sol 62.

High albedo, silica-rich soils ploughed up near Home Plate by the rover's stuck right front wheel remained visible until the global dust storm of 2007. Spirit witnessed the episodic erasure of its tracks at the height of the dust storm, when strong surface winds blew away the tracks and shifted the soil surrounding the rover over a period of just days (Figure 2).

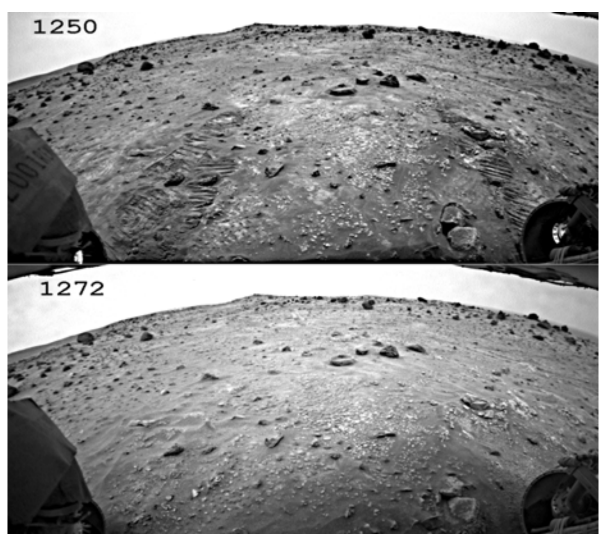

Figure 2: Erasure of Spirit’s tracks during the dust storm of 2007.

Opportunity Track Observations: Opportunity's tracks across Meridiani Planum to Victoria crater were barely visible in MOC images [4] at the time that they were made, and had largely disappeared before the arrival of MRO. Opportunity's tracks are slightly brighter than the undisturbed surface because the wheels press the darker hematite spherules into the soft soil. Only two short sections of pre-2006 tracks remain visible in recent HiRISE images, in topographically sheltered spots near the craters Fram and Erebus. However, the rover left conspicuous bright tracks in the smooth annulus surrounding Victoria crater as she traversed the crater's northern rim (Figures 3 and 4). Surprisingly, these tracks were scarcely altered by the 2007 dust storm, despite clear changes in the pattern of wind streaks emanating from the crater.

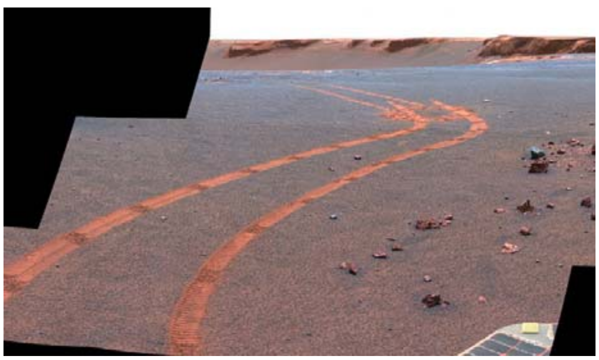

Figure 3: Opportunity's tracks skirting Victoria crater.

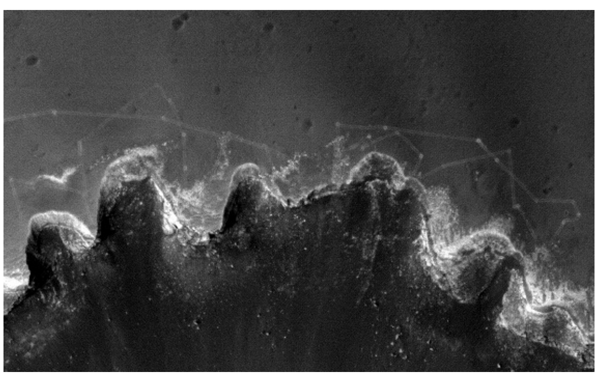

Figure 4: Victoria crater tracks from HiRISE.

Track Crossings: The most direct information about track degradation comes from surface observations of older tracks as the rovers re-encountered their earlier paths. Opportunity imaged 3 generations of tracks as she emerged from Victoria crater, the earliest made 700 sols prior to the latest. Surprisingly little alteration of the tracks was apparent after a Martian year. Sharp edges and protrusions were eroded away, and the red color and forward-scattering character of fresh tracks had faded, but the tracks were otherwise unchanged. Spirit similarly found little change in the appearance of bright soil excavated 300 sols earlier, as she retraced her route to the target Tyrone in February 2007 after her first winter hibernation. It was only after the dust storm of 2007 that Spirit documented older tracks that had been mantled by mm-thick deposits of bright dust.

Interpretation: These observations suggest that the gradual settling of atmospheric dust is relatively unimportant in erasing the tracks. The fact that tracks are preferentially preserved in areas that are sheltered from surface winds argues against airfall as the main mechanism of obscuration. Dust deposition is unlikely to be significant in Meridiani, where saltating sand keeps the surface clean. Older tracks crossed by both rovers show little indication of dust mantling. Even at Duck Bay, where Opportunity observed 3 generations of tracks, the fading of optical properties is better explained by sediment transported by surface winds (sand carried by saltation) than by dust deposition. This result is consistent with the slow rates of fading of slope-streaks elsewhere on Mars [5] and with the lack of accumulation of dust on the rovers themselves.

The timescales for track obscuration range from weeks to months, depending upon the setting. This result has important implications for our understanding of the age of the many fresh craters that have recently been discovered on Mars [6,7], and ultimately for bombardment rates and surface ages.

References: [1] Geissler, P.E., et al., JGR, 113, E12S31, doi:10.1029/2008JE003102, 2008. [2] Grant, J., et al., JGR, 113, doi:10.1029/2008JE003155, 2008. [3] http://www.msss.com/mars_images/moc/2005/01/03/ [4] http://www.msss.com/mars_images/moc/2005/01/24/ [5] Aharonson, O., et al., JGR, 108, doi:10.1029/2003JE002123, 2003. [6] Malin, M., et al., Science, 314, 1573–1577, 2006. [7] McEwen, A., et al., Seventh International Conference on Mars, 2007.