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Eolian Activity in the Martian Tropics

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Abstract

Combined observations from the MER rovers on the surface and the MRO HiRISE camera in orbit show that Martian winds actively alter the planet's surface on seasonal and geological time scales.

1. Sand Saltation

1.1 Sand Mobility

Sand motion was detected on the surface of Mars by the Mars Exploration Rover (MER) Opportunity, first at microscopic scales [1] and later in centimeter sized deposits such as Alicante near the rim of Victoria crater [2; see also 3]. Large scale dune movement has now been observed from orbit in many places on Mars, ranging from the equator to the north polar erg [4-7]. Dune changes have been documented in Endeavor crater, Opportunity's current destination [6]. Nearby in Meridiani, slip-faces were measured to advance as much as 1 m per Martian year in repeated HiRISE observations of dunes within an un-named crater located at 4.7° E, 3.1° N, [8]. Smaller ripples on these same sand dunes were noted to shift downwind at rates of up to ~2 m/Martian year.

1.2 Generation of Sand

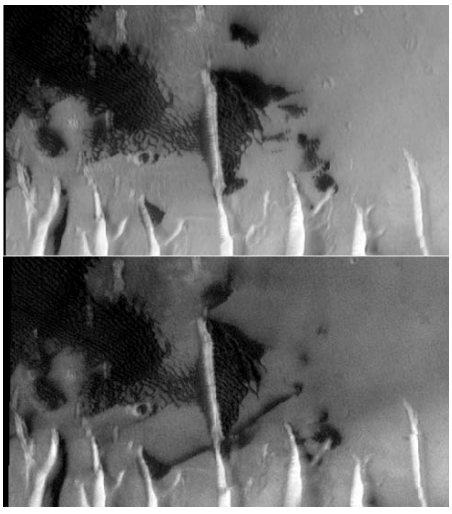
The confirmation that Martian sands are mobile presents a new puzzle, because repeated impacts onto the surface must eventually destroy the saltating sand grains by comminution and abrasion. What supplies the sand needed to replace the destroyed grains and balance the attrition? HiRISE has identified several candidate sand sources across the planet, typically dark deposits that are currently undergoing erosion. One of the most convincing examples is a layered deposit in the small crater Euphrates, within Pasteur crater at 24.8° E, 19.8° N. The dark bands within the layered deposit appear to be eroding to produce the sands in Euphrates and the active dunes downwind [8] (Figure 1).

1.3 Effects on the Landscape

The erosional effects of sandblasting can be seen at several sites where dunes are presently active. The serrated rim of Victoria crater in Meridiani is likely caused by erosion of the soft bedrock, as sand that was blown into the crater from the surrounding plains is blown out again, forming dark wind streaks that extend from the growing alcoves [2]. Similarly, a layered sedimentary deposit in Becquerel crater is being carved into north-south trending flutes and yardangs by the active dunes [8,9].

Eolian sediments also form deposits that modify the landscape in other ways. Sand dunes partially fill the interiors of craters such as Victoria and Endurance in Meridiani, reducing their depth:diameter ratios. Older deposits (granule ripples, sand dunes armored by coarser particles) can be seen in some cases to encroach on small craters, forming a basis to age-date these presently inactive ripples [10].

Figure 1: Shifting sands in Pasteur crater.



2. Dust Lifting

2.1 Dust Devils

Dust devil plumes and their tracks have been studied from orbit since their discovery in Viking images, but surface observations at close range by the MER rovers have yielded important new insights. At least 2×10^7 kg of dust is lifted each Martian year from Gusev crater alone, where hundreds of dust devils were seen each perihelion season by the MER rover Spirit [11] (Figure 2). Concurrent HiRISE observations showed that fewer than 1 in 100 of these dust devils leave visible tracks [12]. The track widths are larger than the average plume diameters measured by Spirit, suggesting that only the largest dust devils are energetic enough to penetrate the thin dust cover in Gusev crater.

Figure 2: A trio of dust devils in Gusev crater, Spirit sol 463.

2.2 Dust Storms

Much greater dust lifting takes place during dust storms, both local and global. Vast regions of Mars change appearance during dust storms each perihelion season, notably Solis Lacus, south of the Valles Marineris. Many of the wheel tracks left behind the MER rovers are erased each Martian year, usually during episodic strong wind events that take place during the perihelion season [13; see 3]. The most drastic surface changes to date took place during the global dust storm of July 2007, when atmospheric opacities reached a peak and winds were at their wildest, blowing dust into the rovers' eyes and contaminating optical systems even though some were covered.

3. Conclusions

Winds dominate the geological activity of Mars today. Future robotic and manned explorations depend critically on an understanding of Martian eolian processes.

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