A TALE OF TWO WIND PARADIGMS: UNRAVELING A PARADOX IN MERIDIANI PLANUM, MARS.

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Introduction: Meridiani Planum has been a focus of Mars research since at least the late 1990s when the Thermal Emission Spectrometer (TES; on the Mars Global Surveyor spacecraft) found a strong hematite signature there. It was rigorously vetted as a Mars Exploration Rover (MER) landing site using the Mars Orbiter Camera (MOC), the Thermal Emission Imaging System (THEMIS), and other instruments. In 2004 the MER Opportunity began its *in situ* exploration of a small portion of the region (that continues to this day). More recently, imagery from the High Resolution Imaging Science Experiment (HiRISE) and the Context Camera (CTX) aboard the Mars Reconnaissance Orbiter has greatly added to our ability to both perceive details and detect change on the surface.

Evidence for present-day aeolian activity within Meridiani Planum was observed by the MER Opportunity in the form of the deposition and erosion of basaltic sand in a dark streak at Victoria Crater [1]. Further such evidence from orbit was discovered in very high-resolution imagery (HiRISE, CTX, and/or MOC Narrow-Angle) of Endeavour crater, the current location of the Opportunity rover [2,3]. Present-day aeolian transport has also been detected elsewhere in and near Meridiani Planum, *e.g.*, [4,5,6].

Observationally-Inferred Wind Paradigms: The morphology and migration of intracrater large dark dunes (LDDs) implies net sand transport towards the southeast by NW winds (*e.g.*, [2,3,6]; see Fig. 1). However, these observations lie in stark contrast to dark sand transport on the plains. Orientations of dark streaks indicate that transport of dark sand from small craters (diameter <200 m) in Meridiani Planum is currently dominated by a SE wind (*e.g.*, [6]; see Fig. 2). Many craters smaller than a few kilometers in diameter have dark sand accumulations on the north side of the crater floor, which often appears to be a source of the dark streaks (*e.g.*, [1]). Although this SE wind does blow sand off the Endeavour crater dunes during southern hemisphere winter (L_s=85-180°), it does not influence migration rates of larger dunes or dominate dune morphology [3].

Paradox: In this limited region, winds with a significant northerly component dominate the LDD morphology (within larger craters), while winds with a significant southerly component dominate aeolian processes in the wake of smaller craters (diameter <~3 km). How can one reconcile the presence of opposing dominant winds in a tropical region of Mars, both of which are known to be currently moving sediment, but that appear to significantly act only on separate features and/or scales?

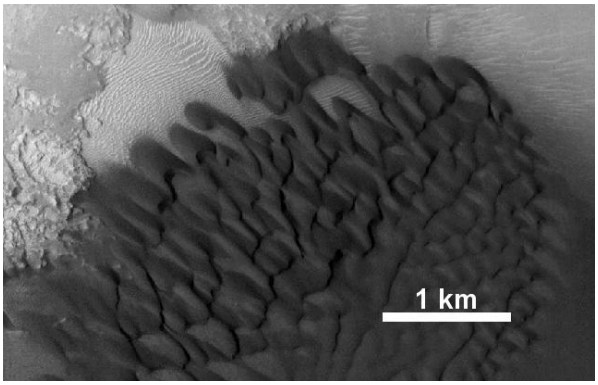

Figure 1. Barchans and barchanoid dunes in Bopolu crater. The morphology and migration of Meridiani Planum intracrater LDDs is dominated by a NW wind.

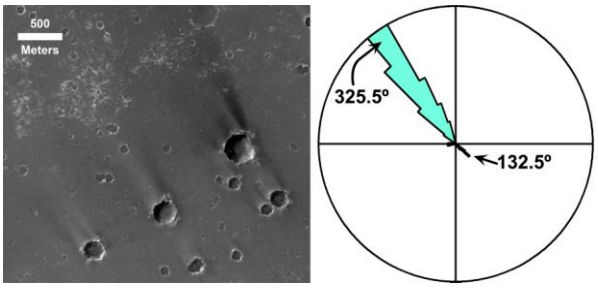

Figure 2. Dark sand streaks and their measured orientations in Meridiani Planum, most of which were formed by a SE wind (from [6]).

Towards Understanding: Does the key to understanding this riddle lie in a crater's dimensions (and implicitly, its particular interaction with winds)? A crater depth-to-diameter ratio (d/D) dependence on the placement (relative to the inferred formative wind) of intracrater sand accumulations was determined by [7]. However, in central Meridiani Planum (at least) that dependence is only partially consistent with observed intracrater features [6]. Perhaps [7] implicitly assumed a simplified interaction with the atmosphere versus what is occurring in Meridiani Planum?

MRAMS [8,9,10] mesoscale atmospheric modeling of Meridiani Planum has previously been performed at lower spatial resolutions (and only 4 seasons) [2] and now at higher spatial (<1 km, resolving the larger craters) and seasonal resolution (12 seasons). Figure 3 (resampled to ~2 km gridspacing for better clarity) illustrates that the larger craters (larger than few km in

diameter) selectively enhance the northerly winds, apparently to magnitudes that do significant aeolian work. This was pointed out for Endeavour crater in [2], but new model results suggest that it holds for all larger craters in the region. The simple assumption that the winds are relatively uniform (speed and direction) everywhere in the region (both on the plains *and* inside craters) appears to be invalid within Meridiani Planum.

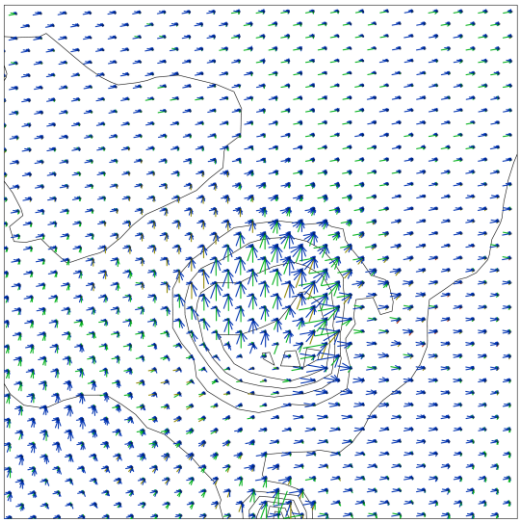

Figure 3: Example MRAMS results for Endeavour Crater (center) and its immediate surroundings (bottom: Iazu crater) at L_s~240°. Model topography (black contours) with each impulse representing winds in one of 20 equally-spaced directions at each gridpoint during each sol (length = maximum daily wind speed, color = relative frequency of that wind direction). Note that the strong (northerly) winds only appear to occur inside the craters.

Broader Implications: Topographic interactions with the atmosphere/wind are often of the "obstacle" variety (quasi-2D and fairly intuitive), but more complex interactions exist (3D and much less intuitive) that likely occur on Mars (*e.g.*, in the larger craters of Meridiani Planum). Future use of aeolian features/change as remotely-determined "wind vanes" should not summarily assume that a wind speed or magnitude in a local topographic region (such as a crater or plain) can be accurately extrapolated outside those features. Inferring a broad regional wind that affects all "non-sheltered" sand regardless of its topographic (and therefore wind-modulating) context is unwise. It may coincidentally work in certain locations on Mars, but not for locales with more subtle and/or complex wind regimes.

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