LOCAL AND REGIONAL AEOLIAN GEOMORPHOLOGY AT THE MARS PATHFINDER LANDING SITE AREA: EVIDENCE FOR PALEOWIND REGIME.
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Introduction: The final stages of fluvial sedimentation in the Mars Pathfinder landing site area appear to be related to the last stage of the Tiu Vallis flood [Early Amonzian; 1]. In the postflood period, the area has been subjected primarily to aeolian processes and associated plains resurfacing. Images from Mars Pathfinder (IMP) and Sojourner cameras show evidence of modern aeolian resurfacing in the area of the Mars Pathfinder Landing site (MPF; 2,3). Consequently, an understanding of the general geologic history of the region requires knowledge of the aeolian processes and their relation to the formation of the micro- and meso-scale features. Our study compared the local and regional aeolian geomorphology at the MPF site using MPF data and part of a high resolution Mars Orbiter Camera image (MOC image 577743128.25603, 6.6 m/pixel). All azimuths reported here are for downwind directions.

Observations: Aeolian features at the MPF site include wind depositional (ripplelike patterns, drift deposits and duneforms), erosional (wind tails, moats around rocks, lag deposits) and abrasional (ventifacts flutes, pits and grooves on the rocks) features [3,4]. Analysis of IMP images [2,4] shows that the main orientation (azimuth 171-260°) of both depositional and erosional features at the site correlate with the strongest winds in the northern hemisphere winter (from NE to SW), predicted from the NASA-Ames General Circulation Model [5]. They also correlate with the orientations (azimuth 202-225°) of wind streak, seen on Viking Orbiters (VO) images [6].

Analysis of the MOC image shows that the surface of the former fluvial plain within the MPF area is complicated by several types of landforms which could be primary aeolian features and those which were modified by wind processes. The MOC image shows few distinctive features related with fluvial processes, other than faint lineations oriented with Tiu Vallis [7]. The dominant relief of the surface (other than craters) consists of bright parallel to sinuous ridges ranging in length from tens to several hundreds of meters. Ridge spacing ranges from 25 - 60 m and they are 7 - 20 m wide. The ridge morphology is consistent with transverse dunes seen on MOC images in other regions [8]. They occur in sets oriented in a NW-SE trend and their orthogonal azimuth of 206-213° is consistent with the orientation of wind tails and small dunes at the MPF site and with the wind streaks seen on VO images. The ridges could be fluvial, formed in association with the Ares Vallis flood [9], or through aeolian processes [10]. For example, they could have formed in the final stage of the Tiu Vallis flood, similar to the giant ripples marks in the Channeled Scabland [11], although other fluvial features such as braided channels and bar deposits are absent. Moreover, stratigraphic relationships suggest that the ridges post-date the flood episodes. Rather, several lines of evidence suggest that the bright ridges are relatively recent aeolian features. For example, bright ridges cross the rims and drape over the slopes of large craters, which post-date the flooding. The ridges also drape over the flanks of older surfaces, such as North Knob, Twin Peaks, and Big Crater, and are oriented with winter winds predicted by the GCM. IMP images [12] show that the eastern slopes and the saddle of Twin Peaks (mainly South Twin) are crossed by bright strips which also are identified on the MOC image as part of two parallel bright ridges.

Small isolated areas (several hundreds meters across) of the surface lack the bright ridges and have a homogeneous roughness. These areas are distributed randomly across the plain and show faint hillocks and lineations. Such areas occur near North Knob and around some craters in both the windward and leeward sides. We suspect that these areas represent predominantly deflationary surfaces, and might be represented by the MPF site, which is considered to be predominately deflationary (18).

Bright patches of inferred aeolian origin are seen within some small craters (60 to 300 m in diameter), predominately on the SW part of the crater floor. In several cases, bright streaks emerge from the craters and are oriented to the SW.

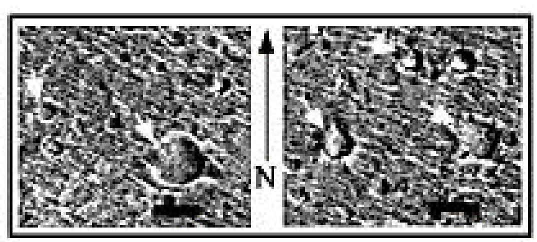

Fig.1. Examples of the modified craters rim at MPF site. The fragments of the image MOC 25603. The bars are equal to 250m.

Ventifacts are present on many of the rocks at the MPF site [2,13]. Recent studies [4,14] show that the orientation of the ventifact flutes (azimuth 250-330°) are indicative of ESE to WNW winds, distinctly different from the current prevailing winds (NE-SW) and suggesting a significant change in the wind regime [13,14]. Wind shifts could occur periodically in association with the current 125,000 year obliquity oscillation cycle, when the equinoxes occur at perihelion position on the orbit with a 51,000 year cycle [15]. Evidence for a paleowind regime is also suggested by the morphology of small (60-300 m in diameter), mostly secondary craters seen from orbit. Most of the craters have degraded rims and appear to be partly filled with deposits of wind origin. 80% of the 103 mapped craters have the W-NW sectors of the rim degraded or removed (Fig. 1). The average azimuth for the eroded part of the crater rims is 294° (for a range of 253-317°), consistent with the azimuths for the ventifacts flutes (Fig. 2), and different from the orientation of the wind tails and streaks. In addition, a set of faint ridges is seen about 1 km east of the MPF site. The ridges are several tens of meters wide and range in length from several hundred meters to > 1 km, oriented mainly S-N. These are superposed by the narrow bright ridges and might also represent paleowinds from the east.

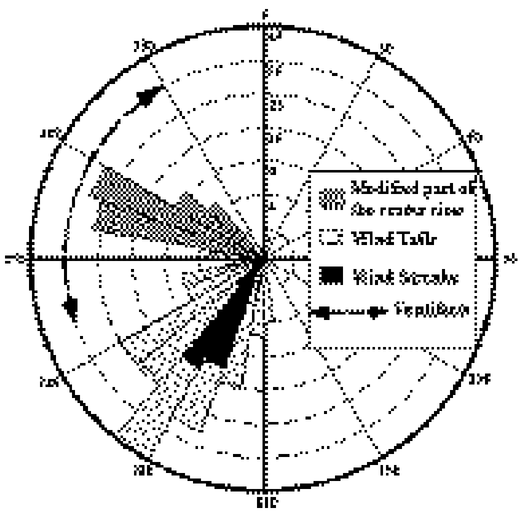

Fig.2. Rose diagram showing the location azimuths of modified part of crater rims, wind tails azimuths at the MPF site and bright wind streaks on Viking Orbiter images of the area.

Discussion: Geological analyses of the MPF site suggests that the bright ridge systems, the intracrater deposits, and crater streaks (all seen from orbit), represent a relatively recent aeolian regime that correlate with the winds responsible for the drifts and small dunes at MPF [2,16]. This regime reflects prevailing winter winds. The ventifacts seen at MPF and the degraded crater rims seen from orbit suggest a different wind regime, possibly reflecting a paleoenvironment. We suggest that the processes responsible for the modification of the W-NW sectors of the crater rims involved unidirectional winds from the east. These winds were sufficient to transport sand-sized grains which cut ventifacts on the rock surfaces at MPF. Comparable to Earth [17-18], ventifact formation is common in environments involving large fluxes of saltating grains under strong winds. Such environments on the Earth are usually found in deserts and near glaciers [17,18]. Most modern ventifacts on Earth were formed during the drier, middle Holocene period from 8 to 5 ka [18] and serve as "fossil' forms indicative for paleowind regime. Similarly, at the MPF site the source of sand-size grains is probably fluvial deposits from the flood activity of Ares and Tiu Valles, 1.8 billion years ago [14]. The faint ridges located east of the site may represent the remnants of relict duneforms, which could be a source for sand material involved in paleowind fluxes and the formation of ventifacts.

References: [1]Tanaka, 1997, *J. Geophys. Res., 102*, 4131; [2]Smith et al., 1997, *Science, 279,* 1758; [3]Greeley et al., *EOS,* F395; [4]Greeley et al., 1999, *J. Geophys. Res.*, in press; [5]Pollack et al., 1979, *J. Geophys. Res., 84,* 2929; [6]Greeley et al., 1992, in *Mars,* Univ. of Ariz., 730; [7]Parker, 1995, *LPI Tech. Rep. 95-01, Part 1,* 23; [8]Malin et al., 1998, *Science, 278*, 1681; [9]Parker and Rice, 1997, *J. Geophys. Res., 102*, 25,641; [10]Kuzmin et al., 1995, *LPI Tech. Rep. 95-01, Part 1*, 20; [11]Baker, 1985, *Quaternary Science Rev., 4*, 1-41; [12]Parker, 1998, *LPSC, XXIX*; [13]Bridges et al., 1998, *LPSC, XXIX*; [14]Bridges et al., 1999, *J. Geophys. Res.*, in press; [15]Kieffer et al., 1992, in *Mars,* Univ. of Ariz., 1180; [16]Moore et al., 1997, *Science, 278*, 1765; [17]Sharp, 1949, *J. Geology, 57,* 173; [18]Greeley, 1999, this conf.