AEOLIAN GEOLOGY OF THE MARS PATHFINDER SITE. Ronald Greeley, Michael Kraft, Gregory Wilson (Arizona State University); Robert Sullivan (Cornell University); Ruslan Kuzmin (Vernadsky Institute, Russian Academy of Sciences); Michael Malin (Malin Space Science Systems); Nathan Bridges, Kenneth Herkenhoff, Matthew Golombek (Jet Propulsion Laboratory); Peter Smith (University of Arizona).

Introduction

The Mars Pathfinder landing site contains abundant features attributed to aeolian, or wind, processes. These include wind tails, drift deposits, duneforms of various types, ripplelike features, and ventifacts (the first seen on Mars). Many of these features are consistent with formation involving sand-size particles. Although some features, such as the barchan dunes, could develop from saltating sand-size aggregates of finer grains, the discovery of ventifact flutes cut in rocks strongly suggests that at least some of the grains are crystalline, rather than aggregates. Excluding the ventifacts, the orientations of the wind-related features correlate well with the orientations of bright wind streaks seen on Viking Orbiter images in the general area. They also correlate with wind direction predictions from the NASA-Ames General Circulation Model (GCM) which show that the strongest winds in the area occur in the northern hemisphere winter and are directed toward 209 degrees.

Background

The present environment on Mars precludes liquid water on the surface; and, while active volcanism and tectonic events cannot be excluded, there is no evidence for either of these processes operating today. Consequently, wind is the dominant activity shaping the surface of Mars today. Numerous wind related features have been observed from Earth (1), from orbit (2), and the Martian surface (3) attributed to aeolian activity. Mars Pathfinder landed July 4, 1997 on outwash plains from Ares and Tiu Valles in the northern hemisphere (4). Pictures from the imaging experiment (5) and Sojourner (the rover, 6), show a wide variety of wind related features which provide insight into the aeolian and general geological history of the area (7).

Observations and interpretations

Aeolian features include those formed by both depositional and erosional processes which seem to occur simultaneously at the site. Deposits are considered to include sand (60 to 2000 microns in diameter) and dust. Most Martian dust appears to be a few microns in diameter) in the form of 1) wind tails, 2) drift deposits, 3) ripplelike deposits, duneforms of several types, and 4) material on the tops of some rocks and spacecraft components, presumably settled from atmospheric suspension.

Wind-tails are found in association with many rocks. Typically they taper to a point away from the rock in the inferred downwind direction (at the time of their formation). They range in length from a cm to nearly a meter and are bright red. Drift deposits are also bright red, but occur as patches, only some of which are associated with rocks. Wind- tails and drift deposits have a sculpted appearance and are similar to those seen at the Viking lander sites (3).

Dunelike structures occur as transverse, barchanoid, and classic barchan forms. All are small (a few m across) and of low height (less than a few tens of cm). *Mermaid* is one of two transverse forms. It has an albedo lower than the background soils. Mermaid was traversed by the rover, and its composition analyzed by the a-p-x spectrometer; results show a similarity to the Viking soils (8). When its surface was disturbed by the rover wheels, the soils were compacted (suggesting the presence of some dust) and show as a dark red deposit (5). Sojourner imaged the area near the Rock Garden not visible from the lander and revealed several bright dunes of the classic barchan form with prominent 'horns' and possible slip faces.

Knobby and ripplelike patterns are seen in several soil areas. These patterns include alternating bright and dark bands with spacings of a few cm, and the suggestion of ridge-trough morphologies. It is likely that these patterns result from saltation impact. The patterns and the differences in brightness seen on the duneforms and ripplelike surfaces are interpreted to result from the development of a lag deposit which could be only one grain deep in thickness. The grains could consist of either larger size or higher density than the underlying soils; for example, the dark appearance of the undisturbed surface of Mermaid could result from a lag deposit of basaltic grains.

Wind erosional features include deflated surfaces, "perched" rocks and ventifacts. Deflated surfaces included the possible lag deposits described above and erosional moats around rocks 10 to 30 cm across. Analysis of stereo images (e.g., RF 21093/LF 21091 for Soufle) obtained by Sojourner suggests that dark deposits in some "moats" contain ~mm-sized grains. These could represent material weathered free and/or abraded from the rocks and trapped in the moats. The rock, *Flat-top*, and other nearby rocks show a change in albedo 5 to 8 cm above the soil level within which the rocks are set. The boundary forms a generally horizontal line that can be correlated from one rock to the next. This is interpreted to represent a former level of the soil which has been subsequently deflated.

Sojourner images provide the first positive identification of ventifacts on Mars, which include flute-shaped grooves (9). Most of the flutes are seen on the upper surfaces of the rocks and range in length up to about 8 cm. Although ventifact flutes can form by the abrasion of windblown dust, saltating sand grains are more efficient and are considered to be the primary agents of abrasion to form the features seen at the MPF site.

Orientations of the wind-tails and the duneforms were determined and compared with the orientations of bright wind streaks seen on Viking Orbiter images for the area northeast of the MPF site. The orientations of these aeolian features have an average azimuth of 217 degrees and suggest formative winds from the northeast. The NASA-Ames General Circulation Model (10) was also assessed for wind patterns in the area as a function of Martian season. Strongest winds occur in the Martian northern hemisphere winter and are oriented 209 degrees suggesting the time of year for their formation. The orientation of the ventifact flutes have azimuths of 230-300 degrees (wind blowing from east to west, 9) suggestive of formation by a different wind regime than the other aeolian features.

Summary

Except for the ventifacts, most of the aeolian features at the MPF site probably formed by winds dominantly from the northeast which occur in the northern hemisphere winter. The presence of barchan dunes and ventifact flutes signal the presence of saltating grains which are likely to be crystalline. Finer-grained material (i.e., dust) is also present. The drifts, duneforms, and possible former soil horizon suggest that the level of soil was higher in the past, and that soils have been deflated. No changes in the drift material were observed during the 3-month operation of MPF, but wind speeds were generally below threshold.

References:

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