EPSC Abstracts
Vol. 6, EPSC-DPS2011-793-1, 2011
EPSC-DPS Joint Meeting 2011

Measurement of High Martian Sand Fluxes: Implications for Landscape Modification

N. Bridges (1), F. Ayoub (2), J-P. Avouac (2) and S. Leprince (2)
(1) Applied Physics Laboratory, Maryland, USA, (2) California Institute of Technology, California, USA
(Nathan.Bridges@jhuapl.edu / Fax: (443) 778-8939)

Abstract

By quantifying the displacement of ripples on Martian dunes, migration rate is found to linearly correlate to elevation on a given dune, showing that the dunes are near steady state and allowing a determination of dune migration rate and sand flux. Fluxes at the dune crests are comparable to values in Victoria Valley, Antarctica. This shows that rates of landscape modification in sand-rich and gusty areas on Mars are similar to those on Earth.

1. Introduction

Mars lacks liquid water, meaning that wind, and sand entrained within it, is the primary agent of landscape modification in the current climate. However, sand-transporting winds have been considered rare in Mars' low density atmosphere [1], such that the presence of abundant dunes on the planet has been a long standing mystery. Only recently has movement on dunes been verified in point measurements from high resolution images [2-4]. Migration rates and associated sand flux can be determined from the precise registration and correlation of optical images and Digital Elevation Model (DEM) extraction [5]. Methodological improvements in this field have been implemented in the software package Co-registration of Optically Sensed Images and Correlation (COSI-Corr) [6]. With the advent of data from the High Resolution Imaging Science Experiment (HiRISE) on the Mars Reconnaissance Orbiter and digital elevation models (DEMs), such measurements are now possible on Mars.

We chose the Nili Patera dunes (8.8°N, 67.3°E) where changes in superposed ripples have previously been identified using traditional techniques [2]. Four HiRISE images were used, two for quantifying changes in the interval between their acquisition and another two to construct a stereo-derived DEM upon which the images were orthorectified and co-registered.

2. Dune Velocities

The COSI-Corr output generated a continuous velocity distribution throughout the entire dune field . Ripple displacement is linearly correlated to elevation on the dune at any point on the stoss slope. This linear relation is consistent with the constriction of flow lines over the dune topography, with sand flux increasing is relation to rising wind shear stress [7].

3. Martian Sand Fluxes and Implications for Landscape Modification

Our results show that the Nili dunes have fluxes comparable to dunes in Victoria Valley, Antarctica [8]. This is possible considering the conditions controlling aeolian physics in the Martian environment. Once initiated, the sand splash resulting from grain impacts is the major contributor to the particle flux. Because of the significantly higher and longer grain trajectories on Mars [1], this "impact threshold" condition requires friction speeds ~1/10 that needed for fluid threshold, equivalent in magnitude to that on Earth [9]. Therefore, once gusts exceed the fluid threshold, even if rare, significant sand fluxes can be maintained as the wind speed decreases. Therefore, over long time periods, it may be that much or all of Mars has been subjected to large sand fluxes, with associated erosional modification of the landscape.

References

[1] Almedia, M.P. et al. (2008). *Proc. Nat. Acad. Sci., 105*, 6222–6226, doi:10.1073/pnas.0800202105.
[2] Silvestro, S., et al. (2010), *Geophys. Res. Lett. 37*,

doi:10.1029/2010GL044743.
[3] Chojnacki, M., *et al*.,(2011) *J. Geophys. Res., in press*.
[4] Hansen, C.J. *et al*. (2011), *Science, 331*, 575-578.
[5] Vermeesch, P. and N. Drake (2008), *Geophys. Res. Lett., 35*, doi:10.1029/2008GL035921 (2008).
[6] S. Leprince, S. Barbot, F. Ayoub and J. P. Avouac, (2007), *Geosci. Rem Sens., 45*
[7] Claudin, P. and B. Andreotti (2006), *Earth Plan. Sci. Lett., 252*, 30-44.
[8] Bourke, M.C., et al., (2009), *Geomorphology*, *109*, 148-160.
[9] Kok, J.F. (2010), *Phys. Rev. Lett, 104*, 074502.