EPSC Abstracts
Vol. 5, EPSC2010-82, 2010
European Planetary Science Congress 2010

Wind Erosion

J. P. Merrison, H. P. Gunnlaugsson, C. Holstein-Rathlou, S. Knak Jensen, P. Nørnberg and K.R. Rasmussen Mars Simulation Laboratory, University of Aarhus, DK-8000 Aarhus C, Denmark (merrison@phys.au.dk/ Fax: +45-86120740)

Abstract

All planets/moons with an atmosphere can generate surface winds which can lead to the transport of material and generate surface erosion, producing sand and sand form, forming dust and generating atmospheric dust aerosols. These processes actively restructure the planetary surface and can change its mineralogy. Although the physical processes are basic, there are wide variations in the transport/erosion rates, the spatial scales and the impact on climate. The work presented here covers various aspects of wind driven particulate transport specifically on Mars and Earth, from missions and laboratory work.

1. Sand and Dust Transport

The standard model for the Aeolian entrainment and transport of dust on earth involves first the activation of sand transport (saltation), followed by the mechanical ejection of finer dust particulates. This is not consistent with observations from Mars or laboratory studies. Instead dust transport appears to involve the formation of loosely bound dust aggregates. These aggregates have similar size to solid sand grains, but their low mass density allows them to be removed at lower wind speeds [1].

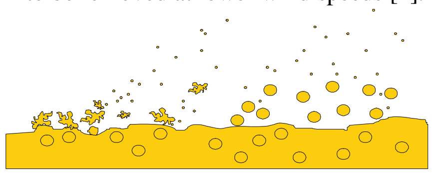

Figure: 1 Dust aggregates being entrained and liberating dust below the saltation threshold

The process of wind induced detachment can occur when the torque and lift forces of the wind dominate over the adhesive and gravitational forces holding particulates to a surface. By performing laboratory (wind tunnel) simulations the gravitational term (mass density) and shear stress (wind speed, fluid density) can be varied and simulate different planetary conditions

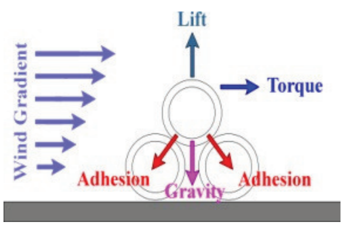

Figure: 2 Wind induced grain detachment model showing the relevant forces.

This simple force balance equation may be applied to any planet.

$$\rho u_*^2 \approx \frac{\frac{\pi}{6} g \rho_g d^3 + C_{adh} \cdot d}{C_L \cdot d^2 + C_T \cdot d^3} \quad (1)$$

For Mars it explains the paradoxical transport of dust without sand movement and agrees with observations and global circulation models.

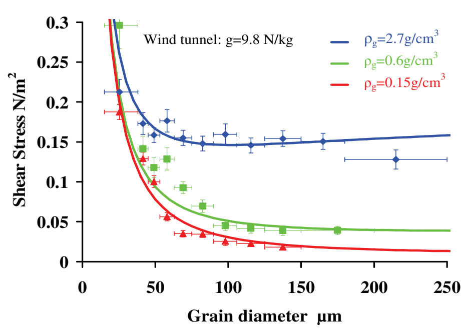

Figure: 3 Grain detachment by wind shear for different simulated mass density/gravity

2. Electrification and Electric Fields

When different materials contact/separate they become electrified, electrification also occurs when particles of the same material and different size or shape contact/separate. These processes are described by various models (contact electrification, tribo-electrification, frictional electrification etc.) though none can be generally applied. Grain electrification is seen practically everywhere granular material is transported and also generates intense electric fields in nature e.g storm clouds, volcanic plumes, dust devils, dust/sand storms etc. Laboratory simulations have shown that dust electrification and aggregation is crucial to the transport of dust on Mars (and Earth) through the formation of dust aggregates [2,3].

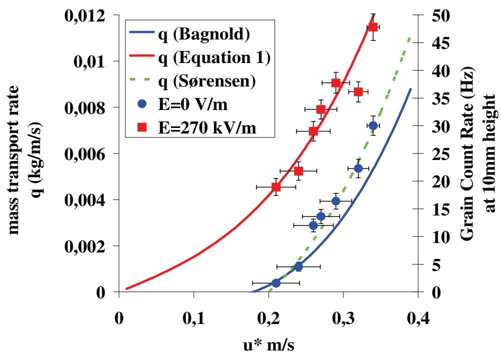

Figure: 4 Increased wind driven Sand transport rate seen in an electric field.

These (naturally) generated electric fields can also affect the transport of particulates and cause increased sand transport or may induce aggregation and/or lofting [4].

3. Wind Erosion and Mineralogy:

Wind tunnel simulators have been used to study various wind erosion and transport effects, however simulating months-years of wind induced erosion is impractical.

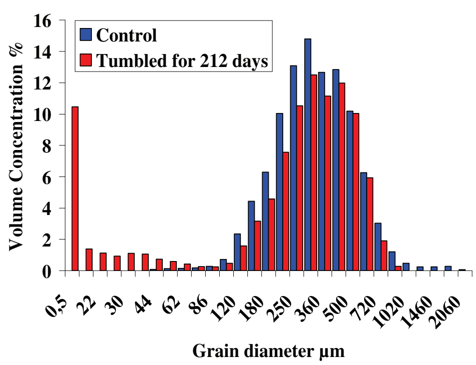

Figure: 5 Grain size distribution measured before (blue) and after (red) simulated sand erosion

A novel new technique of hermetic encapsulation and gentle mechanical agitation (tumbling) of samples has been developed to simulate sand erosion. Quartz sand (>125µm) tumbled for 7 months (10million rotations) leads to a drastic reduction in grain size and the formation of silt [5]. As well as leading to the formation of dust, sand (saltation) erosion appears also to lead to mineral change through mechanical activation of (freshly cleaved) surfaces. This process may have led to the oxidization of iron oxides (magnetite) in the Martian dust and to its reddish hue as demonstrated in laboratory erosion of quartz together with magnetite and the formation of (red) hematite. The mineralogy here is apparently complex, involving nano-phase iron oxides. Some minerals can be eroded in just a few days, in this case also showing signs of sulphate generation.

Figure: 6 Iron pyrite (left; before and right after) tumbling for 12 days generating a coating resembling desert varnish.

The mechanical activation of quartz (SiO_2) has been suggested as a possible source for the oxidizing nature of the Martian regolith.

4. Conclusions

Wind driven particulate transport is a major erosion process and climatic factor affecting the atmosphere (and surface) of planets. In all its complexity it is not well understood. It requires a combination of comparative study on planets/moons and laboratory simulation/modelling.

References:

[1] J.P. Merrison et al., Icarus **191**, 568 (2007)

[2] J.P. Merrison et al., *Planet. Space. Sci.* **56**, 426 (2008)

[3] J.P. Merrison et al., *Planet. Space. Sci.* **54**, 1065 (2006)

[4] K.R. Rasmussen et al., *Planet. Space. Sci.* **57**, 804 (2009)

[5] J.P. Merrison et al., Icarus, **205**, 716 (2010)