FORMATION AND PROPERTIES OF THE MARTIAN DUST AEROSOL.

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Introduction: Mars is a test bed for the study of dust aerosols since, lacking the active circulation of water through the atmosphere (as seen on earth), dust transport has become the dominant process for both atmospheric contamination and the dynamics of the surface. Presently the transport of fine, dust-like granular material is the most active process affecting the Martian surface. The suspension of this dust in the Martian atmosphere is also a major factor affecting the planets climate. Despite the widespread observation of other wind induced erosion features on Mars, for example sand forms, generally sand appears to be presently transported only at a at a low rate. The physical processes at work here are being actively studied both at the Martian surface and in laboratory simulators.

A discussion will be made of the current level of understanding of mineral grain transport on Mars and some of the technology involved in this research will be presented. This includes past, present and future Martian surface sensors and also the techniques and analogues used in reproducing the Martian environment in a laboratory.

Laboratory Simulations: At Aarhus University (AU) dust aerosols can be recreated under Mars simulation conditions in an environmental wind tunnel facility. Here the low pressure and temperature conditions can be reproduced in a large chamber (3m*1m) within which a re-circulating wind tunnel is housed. Mars analogue dust can be injected and studies of bot dust deposition and re-entrainment can be performed as well as Aeolian sand transport. [1].

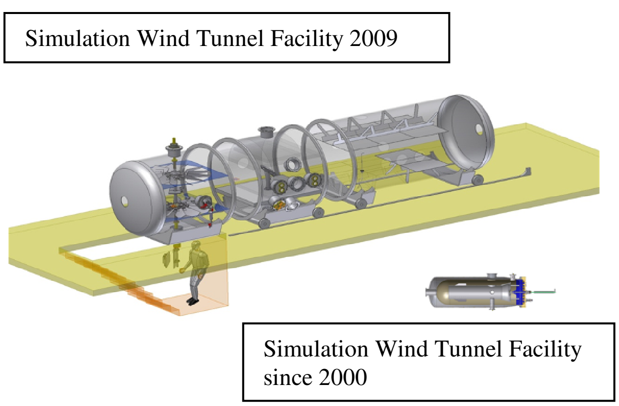

Figure 1 Mars Simulation Wind/Dust facilities at AU.

A more extensive european Simulation facility is under completion at AU, it is 10m long with a cross section around 2m x 1m, it will have superior temperature, wind and dust control as well as an advanced solar simulator allowing a wide range of atmospheric and aerosol studies.

Instrument development: Laser based instrumentation has been developed at AU which is both routinely used as an analytical tool in the laboratory simulators, but is also being developed as flight hardware for forthcoming missions (LAMDA)[2].

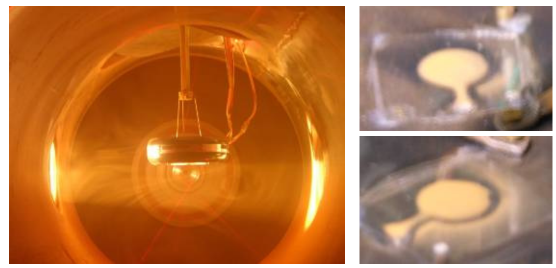

Figure 2 Laser based wind/dust sensor (left) with electrodes capturing suspended electrified dust.

The instrumentation has several functionalities specifically as an anemometer measuring suspended particulate velocities and therefore wind speed and direction, also by monitoring the counted grains passing the suspended dust concentration can (for the first time on Mars) be directly measured. The amount of scattered light at the surface of the instrument can also be detected optically and therefore the dust deposition rate measured. By applying an electric field (of the order 10V/mm) electrified dust grains are attracted to transparent electrodes. The increased dust deposition can be optically measured and used to determine the electrification (and sign) on the grains given the wind flow, concentration and grain size [2,3]. These technologies have potential application on earth, the moon and other solar system environments where granular material may be transported.

Granular Electrification: Electrification of particulates of differing size, composition or morphology is well known and described, if not well understood physically. Such electrification is responsible for a wide range of electrical phenomena in nature and often dominates the dynamics of fine grained materials. Laboratory simulations have shown that dust electrification and aggregation is crucial to the transport of dust on Mars through the formation (electroststic self assembly) of dust aggregates[4]. The standard model for the Aeolian entrainment and transport of dust on earth involves first the activation of sand transport (saltation) followed by these (larger grains) then mechanically ejecting dust particulates (figure 3). This is not consistent with observations from Mars where dust transport is active below the wind shear threshold for activating saltation and that dust is removed from sand forms without disturbing the sand.

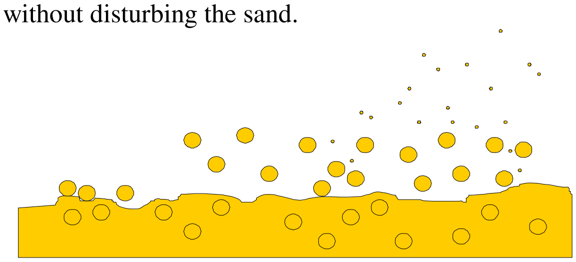

Figure 3 Standard model of saltation induced dust entrainment

Instead in laboratory studies dust is observed to be entrained at wind speeds (wind shear) below the threshold at which solid sand grains are removed. This 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 (see figure 4)

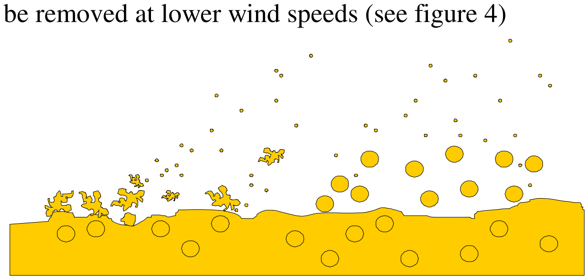

Figure 4 Dust aggregates being entrained and liberating dust below the saltation threshold

Dust cycling appears to consists of sand sized dust aggregates fragmenting into electrified dust which reform by electrostatic attraction. Dust aggregate formation and transport by wind has been seen in the laboratory (figure 5, right) and on Mars [5].

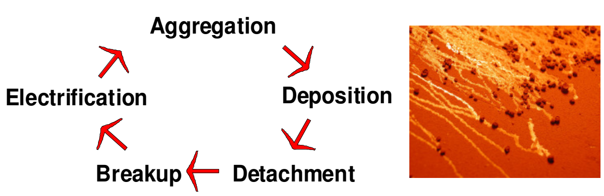

Figure 5 Dust transport cycle suggested for Mars (left) and a picture of dust aggregates in the laboratory (right).

Transport Theory

Simulation of dust aggregate transport by wind shear has been performed using hollow glass spheres; here the surface properties (adhesion) are maintained while the mass density (weight) can be varied.

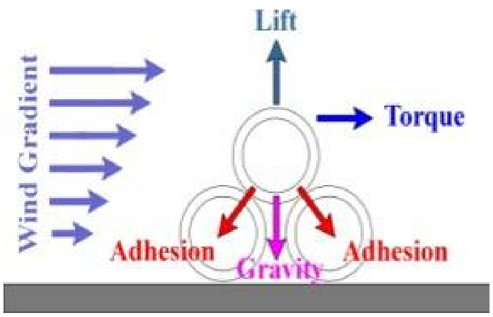

Figure 6 Wind induced grain detachment model showing the relevant forces.

A simple force balance equation has been applied in which the effects of gravity, adhesion and wind induced lift and torque are included.

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

The results agree with wind tunnel studies and observations of dust/sand removal on Mars. This model also agrees with the surface shear stress required by global circulation models for which prediction of dust entrainment (dust storm occurrence).

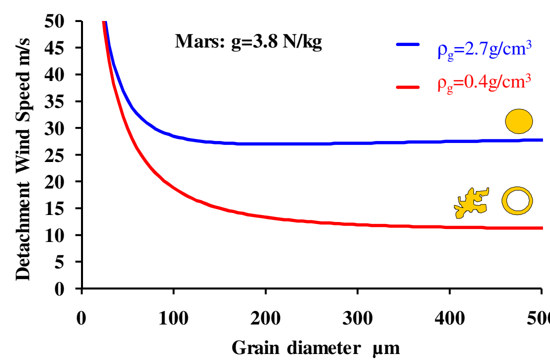

Figure 7 Wind speeds predicted for Mars (Viking landing site) based on equation 1.

In addition to continuation of laboratory simulations granular electrification should be studied at the surface of Mars [2], such research is now also being undertaken under terrestrial conditions [6].

References: [1] J.P. Merrison et al., *Planet. Space. Sci.* **56**, 426 (2008), [2] J.P. Merrison et al., *Planet. Space. Sci.* **54**, 1065 (2006), [3] J.P. Merrison et al., *Planet. Space. Sci.*, **52**, 279 (2004), [4] J.P. Merrison et al., Icarus **191**, 568 (2007), [5] Sullivan R.J. et al., J. Geophys. Res. 113, E06S07 (2008) [6] K.R. Rasmussen et al., *Planet. Space. Sci.* **57**, 804 (2009).