EPSC Abstracts
Vol. 7 EPSC2012-98 2012
European Planetary Science Congress 2012

Wind driven erosion and the effects of particulate electrification

J. P. Merrison, E. Bak, K. Finster, 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

Several related aspects of Aeolian activity are presently being studied in the laboratory, the most recent advances in this field will be presented. These include simulating wind driven erosion in the laboratory, quantifying erosion rates and the study of mineral change due to mechanical activation. Also advances in our understanding of the electrification of sand/dust particles is being made and how this phenomenon affects their behavior.

1. Motivation

The interaction between an atmosphere (wind) and a planetary surface leads to the generation and transport of granular material, this constitutes an important environmental/climatic factor on terrestrial like bodies mainly through the process of erosion. Determination of the rate of erosion, the process taking place and the chemical/mineralogical consequences are only now being fully understood. Similarly the electrification of grains and the generation of intense electric fields is a natural consequence of particulate transport and again is far from being understood in depth, recent studies have extended our knowledge here.

2. Erosion Simulation

A unique technique has been employed in order to simulate erosion in the laboratory. It involves gentle mechanical agitation (tumbling) of granular samples typically sand (>125µm), for periods of around 7 months (10million rotations). This leads to a drastic reduction in grain size and the formation of silt [4].
The process however is unlike milling in which larger grains are severely fractured (cleaved). In the case of saltation (and tumbling) it appears that the low velocity impacts lead to tiny localised chipping and the expulsion of micrometer (and even sub-micrometer) fragments.

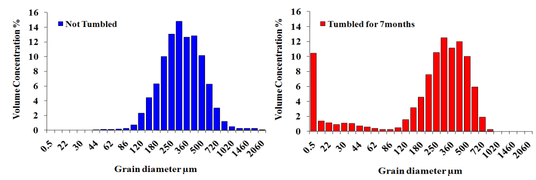

Figure 1 Grain size distribution measured before (blue) and after (red) simulated sand erosion and photograph showing a pitted quartz grain.

Interestingly the silt generated by the simulated sand erosion becomes cemented into well cohered agglomerates which appear as white spheres. This cementation may be a further result of the mechanical surface activation.

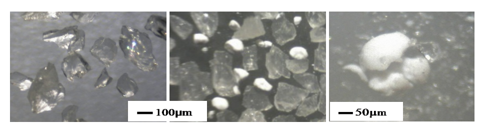

Figure 2 quartz grains before (left) and after (center) simulated erosion showing cemented quartz silt (right).

Recent work has involved performing erosion simulations using a broad range of minerals (including various silicates). This work indicates that the dependence of erosion rate on mineralogy has an (intuitively) unexpected, though physically meaningful, behaviour.

3. Wind Erosion and Chemistry

It is well documented that mechanical fracturing of silicates forms activated surfaces. This so called mechanical activation can lead to an oxidizing behaviour, presumably due to dangling oxygen bonds.

In previous laboratory simulations of (quartz, SiO_2) sand saltation, significant erosion was seen which lead to mechanical activation and allowed the quartz to become oxidizing. This was seen to be capable of oxidizing iron oxide and has been suggested as a mechanism by which the Martian dust became reddish (Hematite rich) [4].
In addition to the oxidized nature of the Martian dust, erosion induced chemistry may also explain several other surprising characteristics of this planet, specifically the presence of an unidentified oxidizing agent in the soil (observed by the NASA Viking landers) and the presence of chlorate (seen by the NASA Phoenix lander). Such processes may also be relevant to arid regions on Earth.

Figure 3 erosion simulations showing varying degrees of silt formation.

In the most recent erosion studies the effects of different atmospheric composition have been investigated. It has been seen that the chemistry involved is not simple and not limited to solid phase interactions. It seems likely that this may lead to new mechanisms for atmospheric chemical alteration through interaction with (activated) surface material.

4. Electrification and Electric Fields

Terrestrial studies show that the generation of electric fields by granular transport is a widespread and important phenomenon (for example in sand/dust storms, volcanic activity and ice/snow transport) and that intense electric fields can then consequently affect the transport of granular material [1,2].
In laboratory studies of the effects of electric fields on sand and dust transport have focussed on levitation, reduced detachment threshold and enhanced transport. They have been based on the application of simple models in which the sand bed is assumed to be conductive. Recent work shows that this assumption is in many cases not valid [3] and that in the case of a poorly conducting/insulating surface, an applied electric fields in fact leads to dielectric attraction and increased surface attraction i.e. reduced aeolian transport.

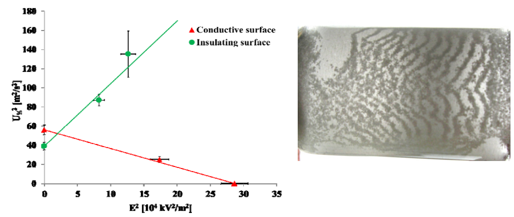

Figure: 4 An electric field increasing/decreasing wind driven sand detachment depending on surface conductivity (left). Dielectric chain formation (right).

Wind tunnel simulations have been performed which show that under arid (Mars like) conditions the effects of applied external electric fields are significantly more complicated than previously speculated and that the combined roles of granular electrification and electric field induced interaction require a far more detailed treatment to be properly accounted for.

5. Conclusions

It is becoming clear that wind driven particulate transport is not simply a method for planetary surface erosion, but may lead to a wide variety of chemical/mineralogical alteration. Similarly electrification of grains during transport affects transport and grain structure and may also be involved in chemical alteration processes in addition to those relating to electrical discharge/lightning.

References:

[1] J.P. Merrison et al., Icarus **191**, 568 (2007)
[2] J.P. Merrison et al., *Planet. Space. Sci.* **56**, 426 (2008)
[3] K.R. Rasmussen et al., *Planet. Space. Sci.* **57**, 804 (2009)
[4] J.P. Merrison et al., Icarus, **205**, 716 (2010)
[3] J.P. Merrison, et al., Planet. Space. Sci., 60, 328-335 (2012)
[4] J.P. Merrison,, Aeolian Research. 4, 1–16 (2012)
[5] C. Holstein-Rathlou, , Icarus, accepted 2012 (DOI 10.1016/j.icarus.2012.04.011)