Dust devils on Mars: Effects of surface roughness on particle threshold

Conference or Workshop Item

DUST DEVILS ON MARS: EFFECTS OF SURFACE ROUGHNESS ON PARTICLE THRESHOLD

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Introduction. Dust devils have been proposed as effective mechanisms for lofting large quantities of dust into the martian atmosphere. Previous work [1] showed that vortices lift dust more easily than simple boundary layer winds. The aim of this study is to determine experimentally the effects of non-erodable roughness elements on vortex particle threshold through laboratory simulations of natural surfaces.

Approach and Methods. Building on previous work [1], we investigated how dust devils behave when they pass over rough terrains. We employed similar techniques outlined in [1] for determining threshold using the *Arizona State University Vortex Generator* (ASUVG). Roughness element targets were added to the test bed and several sediment types were analyzed. In each experimental run, dust or sand was sieved over the roughness target and the vortex generator then was run at increasing speeds to determine the point at which particle movement begins.

Sediments tested include silica sand (90-106 μm, 106-125 μm, 125-212μm, 212-350μm, 500-700μm in diameter) and walnut shells (< 60 μm, 60-250 μm, 425-600μm, 590-1410μm in diameter). The lower-density walnut shells are used to simulate the lower gravity of Mars.

The roughness targets consisted of three 1.22 x 1.22 m boards with cylindrical, wooden roughness elements attached in regular arrays with centers spaced 5.08 cm apart. The three sizes of roughness elements used in this study include diameters 0.64, 1.91, and 2.54 cm with respective heights of 0.64, 1.59, and 2.54 cm. Each target had 529 roughness elements evenly spaced over its surface.

Roughness can be described by simple ratios of element height to their spacing (H/D). For the three targets used in this study H/D ratios include 0.13, 0.5, and 1.0 – showing an increase in the overall surface roughness with increasing values.

Preliminary Results. Initial results show that for the tested sediments, increasing surface roughness increases the velocity needed to lift particles from the test bed (Figure 1). Little or no difference existed between the lowest roughness target and no roughness. However, in some instances, the lowest roughness target allowed particles to be lifted at lower velocities than with no roughness. This result suggests that there could be an optimal roughness for particle threshold (Figure 2).

The potential existence of optimal roughness curves could be useful in determining the amount of sediment in dust devils seen over terrains of known roughnesses on both Earth and Mars. This could be useful from a remote sensing perspective to yield better estimates of the dust devil dust concentration in cases such as the dust devils seen at the *Mars Pathfinder* site [4].

Future Work. Based on this preliminary work, threshold curves as a function of roughness will be completed for a larger variety of sediment types and sizes. Also, increasing the range in ambient atmospheric conditions will prove useful in comparing terrestrial and martian conditions, and ultimately aid in the understanding of the role that dust devils play in the global dust cycle on Mars. Combining surface roughness results with other vortex sediment flux studies such as [5] and [6] should yield estimates of the potential sediment capacity of a dust devil on Mars, if the surface roughness is known. Addition of estimates from studies such as [7] (martian dust devil track densities and variability) could also lead to information about which regions on Mars are most likely to contribute significantly to the global atmospheric dust cycle.

References. [1] Greeley et al. (2003) *J. Geophys. Res.*, *108(E5)*, 5041. [2] Pye (1983) *Aeolian Dust and Dust Deposits,* 30-43. [3] MacDonald et al. (1997) *Atmos. Envir.*, *31(6)*, 783-795. [4] Metzger et al. (1999) *Geophys. Res. Let.*, *26(18)*, 2781-2784. [5] Neakrase et al. (2004) *LPSC XXXV*, #1395 (Abstract). [6] Neakrase et al. (2004) *AGU Fall Mtg.*, #P31-0982 (Abstract). [7] Balme et al., (2003) *Geophys. Res. Let.*, *30(16)*, 1830.

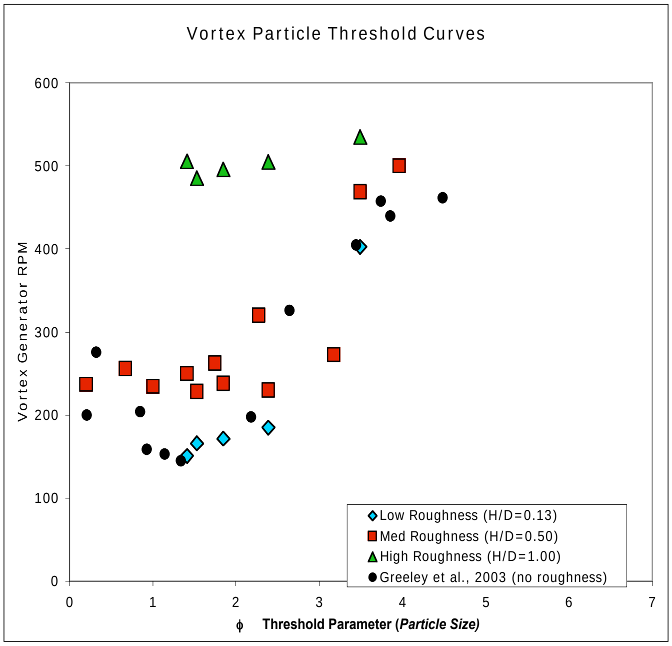

Figure 1. A plot of the preliminary data showing vortex particle threshold curves for a range in particle sizes. Particle sizes and densities are represented by a dimensionless term, ϕ, (Threshold Parameter) which relates the particle's density and diameter to the surface gravitational acceleration and mean air density (After [1]). Vortex generator RPM is roughly analogous to tangential velocity of the vortex. Blue points show the low roughness target (H/D = 0.13), which is roughly similar to the "no roughness" curve of the Greeley et al., 2003 data. Red points show an elevated threshold curve for the medium roughness target (H/D = 0.50). Green points show an elevated curve for the high roughness target (H/D = 1.00)

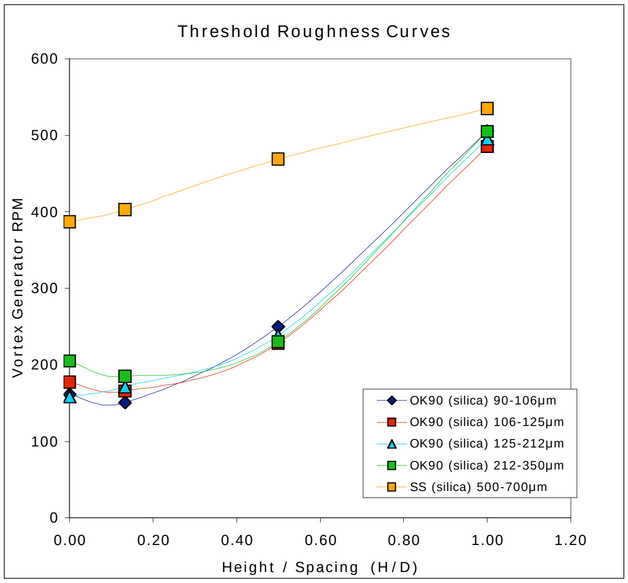

Figure 2. A plot of roughness curves for silica sands tested in this study. The height/spacing ratio (H/D) is a measure of the surface roughness where increasing values correspond to increasing roughness. Vortex generator RPM is roughly analogous to tangential velocity of the vortex.