FLUX AND BEDFORMS OF WINDBLOWN MATERIAL ON VENUS

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Aeolian activity may be important on Venus, particularly in the absence of liquid water. Surface winds have been measured up to 1.3 m/sec (1) which, combined with the high-density carbon-dioxide atmosphere, are probably sufficient to cause erosion and transportation of loose surface materials (2). Assessing the characteristics of aeolian processes will allow greater understanding of venusian sedimentary budgets on both local and global scales.

The objective of this study was to use the Venus Wind Tunnel (VWT) (3) to measure the flux of windblown particles and relate the flux to various bedforms for a range of atmospheric pressures (densities), particle sizes, and wind velocities. At ambient temperatures, the scaled venusian atmospheric pressure in VWT is 30 bars. The lower operational limit of VWT is 2 bars which was used to approximate terrestrial conditions. Measurements were obtained for a range of: 1) particle sizes--including 61μ to 88μ quartz sands, which are the easiest to move (3) under venusian conditions; a range of 2) velocities; and, 3) atmospheric pressures (2 to 40 bars). The total flux (Q = gm/cm/sec) was measured by collecting and weighing the amount of material blown over the edge of the test plate per unit time. Under terrestrial conditions, this would be somewhat analogous to measuring the flux of an entire dune field rather than just the flux of saltating particles. Therefore, it was important to measure and observe the bedforms produced in the wind tunnel throughout the experiments before interpreting the flux results.

The bedforms produced under venusian conditions were approximately the size of ripples on Earth. However, they behaved much like terrestrial dunes: the bedforms developed slip faces with concommitant separation of airflow from the crest and the path lengths of saltating particles were short in relation to the bedforms. At a velocity 20% above threshold, the bedforms were small, asymmetric ridges about 1 cm high and 10 cm long. The average height-to-length ratio (1:13) was consistent with ratios for terrestrial dunes (4). Path lengths of saltating particles were short in relation to the bedforms and particles were not observed to saltate from one bedform to the next. The bedforms migrated at a constant velocity of 0.045 cm/sec, continually burying and re-exposing material.

Flux under venusian conditions showed short term oscillations, which is a reflection of the migration of the bedforms. Maximum flux (0.028 gm/cm/sec) corresponded to the dune crests; minimum flux (0.004 gm/cm/sec) corresponded to dune troughs. In ~Earthlike conditions the bedforms were small, symmetric ripples 0.3 cm high and 3 cm long. However, at this low pressure (2 bars) it is doubtful that a fully developed, turbulent boundary layer evolved and the results may be anomalous. Total flux was 0.023 to 0.047 gm/cm/sec and was steady, unlike the oscillatory pattern observed for the venusian runs. Saltation trajectories were high and particles saltated from one bedform to the next downwind, typical for terrestrial ripples.

At high atmospheric pressures (40 bars) and a velocity twice that of threshold, bedforms were low, asymmetric ridges 0.4 cm high and 10 cm long. The saltation path lengths were longer than those observed under simulated venusian conditions and particles saltated from one bedform to the next, much like terrestrial ripples. Nevertheless, each bedform developed a small, well-defined slip face very similar to the venusian "dunes." These experiments show that dune-like bedforms develop within a certain regime of atmospheric pressure, wind velocity, and particle size. Preliminary results indicate that "dunes" are less well developed when velocities exceed twice the threshold velocity or when particle size is much greater than 88 μm. No bedforms developed at venusian pressures for winds greater than ~2.3 above threshold.

Observations in the VWT indicate that flux of windblown particles on Venus is dependent on grains moving by rolling, traction, and saltation and by movement of material in dune-like bedforms. Saltation and traction appear to be pressure dependent, with traction becoming more important at high pressures. Future work will define a pressure/velocity/particle size matrix for bedform development for the complete atmospheric-density spectrum for terrestrial, martian, and venusian conditions; additional studies of the venusian bedforms will focus on particle-size grading and internal structure and the results will be applied to the analysis of Venera images.

References

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