THE ORIGIN OF REGIONAL DUST DEPOSITS ON MARS

Philip R. Christensen, Department of Geology, Arizona State University, Tempe Az, 85287.

There are three distinct regions on Mars characterized by very low thermal inertia (1) and high albedo (2). These regions, located around Tharsis (-15° to 45° N, 60° to 200° W), Arabia (0° to 30° N, 300° to 360° W), and Elysium (15° to 30° N, 210° to 230° W), cover a total of nearly 24 x 10^6 km^2 of the surface and represent an important class of surface deposit. The thermal properties indicate that these regions are covered by at least 3 to 5 cm of very fine (~ 50 μm) dust and their origin from duststorm fallout has been suggested by several investigators (1,3,4). However, their age, history, and the dynamical processes that have led to their formation remain uncertain.

Recently, additional evidence has been derived from the Viking Infrared Thermal Mapper (IRTM) observations that allows a more complete model for the formation of these regions to be proposed. The first observation is that dust appears to be currently accumulating in the low-inertia regions (4). Following each global dust storm a thin layer of dust is deposited globally, as evidenced by an increase in surface albedo seen from orbit (2,5) and from the Viking Lander sites (6). During the period following the storm, the bright dust fallout is subsequently removed from low albedo regions, as indicated by the post-storm darkening of these surfaces (5) and by an increase in the atmospheric dust content over dark regions relative to the bright, low-inertia regions (4). Thus, the fine duststorm material is removed from dark regions but not from the bright regions, resulting in a net accumulation within the birght, low-inertia regions. Once deposition has begun, the covering of exposed rocks and sand and the accumulation of fine material on the surface make removal of material increasingly difficult, thereby enhancing the likelyhood that material will accumulate within the low-inertia regions.

A second result concerning the origin of the low-inertia regions is the observation that these areas have fewer rocks exposed at the surface than found elsewhere, indicating that some degree of dust mantling has taken place (4). There is, however, good evidence for the occurrence of some rocks at the surface (4,7), implying that the mantling is incomplete and has therefore been extremely slow or has begun relatively recently.

The minimum thickness of fine material required to produce a low-inertia surface is approximately 3 to 5 cm. Assuming that the global dust load of the 1977 storm was uniformly deposited over the surface gives a sedimentation rate of 10^{-3} cm $year^{-1}$ (8). This rate is probably an upper limit because the 1977 storm was unusually large and the dust may be preferentially deposited in the polar regions (8). However, at this rate only 5 x 10^3 years would be required to deposit the minimum amount of dust. An upper limit on the amount of dust present can only be inferred, but the occurrence of some rocks on the surface suggests that the mantle may only be several meters thick. A deposit of this thickness would only require 10^5 to 10^6 years to accumulate at the present rate.

Finally, localized deposits of coarse material have been observed within numerous craters on Mars, but these intracrater deposits are absent within the cores of the low-inertia regions. They do, however, occur around the edges of these regions (9). One possible explanation is that these deposits were once exposed on the surface in low-inertia regions, but have since been buried, providing additional evidence for mantling in these regions. Their existence around the perimeter, together with the occurence of active deposition, suggests that the low-inertia regions may be expanding, with the mantle

© Lunar and Planetary Institute • Provided by the NASA Astrophysics Data System

thickness deep enough in the center to completely bury coarse deposits, and thinner at the margins.

The explanation proposed for the origin of the low-inertia regions, which occur predominately in the northern hemisphere, is that they represent cyclic oscillations in dust depostion and removal. In this model, these regions would have formed during the most recent cycle of the 10^5 to 10^6 year north-to-south oscillation of the insolation maximums (10). In this case, fine material would currently be removed from the southern hemisphere, where wind velocities are presently the highest, and redeposited in the north. When the insolation maximum occurs in the north, the opposite may be true. This mechanism could therefore account for the observed active depostion, the occurrence of fines on the surface and for the incomplete mantling of the surface rocks and deposits of coarse material because the mantling has only recently begun.

In summary, the low-inertia, bright regions on Mars represent major deposits whose origins provide important information on the dynamics and history of martian sedimentary cycles. Results derived primarily from the IRTM data provide important constraints on the surface characteristics of these regions and allow a model for their formation to be developed. In this model, dust is preferentially deposited in the low-inertia regions, with postive feedback mechanisms acting to increase deposition once it has been initiated. Deposition is actively occurring and these regions appear to be expanding at the present time. The current accumulation of fine material, however, probably represents only the most recent cycle of deposition and erosion associated with the cyclical variations in insolation and the resulting changes in wind patterns and velocity.

References

1.) Palluconi, F.D., and H.H. Kieffer (1981) Icarus, 45, 415-426.
2.) Pleskot, L.K., and E.D. Miner (1981) Icarus, 45, 179-201.
3.) Zimbleman, J.R., and H.H. Kieffer (1979) J. Geophys. Res., 84, 8239-8251.
4.) Christensen, P.R. (1982) J. Geophys. Res., 87, 9985-9998.
5.) Pleskot, L.K., and E.D. Miner (1981) Third Intern. Colloq. on Mars.
6.) Guinness, E.A., C.E. Leff, and R.E. Arvidson (1982) J. Geophys. Res., 87, 10,051-10058.
7.) Thorpe, T.E. (1982) Icarus, 49, 398-415.
8.) Pollack, J.B., D.S. Colburn, F.M. Flasar, R. Kahn, C.E. Carlston, and D. Pidek (1979) J. Geophys. Res., 84, 2929-2945.
9.) Christensen, P.R. (1984) Icarus, in press.
10.) Ward, W.R. (1974) J. Geophys. Res., 79, 3375-3386.

© Lunar and Planetary Institute • Provided by the NASA Astrophysics Data System