514-91
150668

N89-10794

MARS LOW ALBEDO REGIONS: POSSIBLE MAP OF NEAR-SURFACE H_2O; R.L. Huguenin, Geology/Geography, University of Massachusetts, Amherst, MA 01003.

It has been proposed that dust storms on Mars that develop during pre-dawn hours may be triggered by a freeze/thaw dust injection process (1). The model was based on a phenomenon that was observed during the Viking Gas Exchange experiments on Mars, in which adsorbed gas was catastrophically desorbed from soil samples when exposed to humidification at $\sim 5^0C$. Similar conditions may develop at mid-latitude locations on Mars near perihelion, and a similar humidification-driven desorption process might occur in the soil column. If soils are dampened during humidification, desorbed gases in confined pore spaces could possibly reach 8.6 bar. Diurnal freezing may cause H_2O to crystallize within the pores, producing cohesive soil failure, release of the trapped gas, and explosive injection of freeze-dried powdery overburden dust into the atmospheric column. The process could potentially occur at 5-20 cm depth, and the freeze/thaw dust injection event may initiate after 10:00 p local time (20^0S latitude). Dust would be injected at velocities approaching 450 m/s and it would remain in the atmosphere for at least several hours before settling out. The plumes could potentially regenerate diurnally until the growing atmospheric dust load produced sufficient dampening of the diurnal thermal wave to prevent freeze/thaw. Seasonal replenishment of H_2O could potentially occur by upward migration from depth during the period between 150 sols and 475 sols after perihelion. The model was experimentally tested and the results were in good agreement with predictions, although a factor of 14 times more gas evolved from the laboratory samples than from the Viking samples. Most of the characteristics of the pre-dawn major storms could be adequately explained by the freeze/thaw injection model, including 1) pre-dawn onsets; 2) post-perihelion seasonal occurrence; 3) daily recurrence during the initial phases of the storms; and 4) generation of blue clouds (H_2O ice) at the storm sites (1).

While the proposed mechanism specifically addressed the large pre-dawn storms which initiated in Solis Lacus, Noachis-Hellespontus, and the Syrtis Major border regions (1), the process may be more widespread. The storms at those sites were the most spectacular events, expanding to global proportions. Large numbers of smaller events occur during the season of maximum local soil temperature at a variety of low-latitude locations, however. Many of these storms could possibly be the result of freeze/thaw dust injection, due to the presence of H_2O ice in the near-surface soil column.

H_2O ice is probably not restricted to Solis Lacus, Noachis-Hellespontus, and the Syrtis Major border regions. Although perhaps it may be more abundant in those regions, H_2O ice may be relatively widespread in the near layer. At the Utopia Viking lander site there was evidence for greater H_2O abundance than at the Chryse site, and within the sampling area at Utopia there was more H_2O under rocks than in the exposed soils (2,3). The concentration under rocks supports the possibility of upward migration/condensation of H_2O from a subsurface source, and the source could possibly be widespread (4).

It was argued by Farmer and Doms (5) that during the colder portions of the year H_2O ice would be stable in the regolith at latitudes poleward of +30 and -35^0, and that during the warmer times of the year some of the H_2O would tend to sublime away. At lower latitudes H_2O ice would be unstable at all times of the year, and it would continually tend to sublime away. If there were subsurface sources of H_2O such as described by Clifford (4), it would be possible that significant tempofrost deposits could accumulate seasonally poleward of $+30^0$ and -35^0 and extend close to the surface. With expected heterogeneities in regolith thermophysical properties, it is possible that the edge of the tempofrost zone could deviate somewhat from $+30^0$ and -35^0 latitude. In locales where thermal cycles are more extreme, it is reasonable that the tempofrost zone could possibly extend equatorward to $\pm 15^0$ or more, since water vapor abundances over these latitude bands could be seasonally at saturation levels with only a few degrees drop from the modeled regolith temperatures. With the latitude of maximum solar insolation extending close to the latitude of seasonal tempofrost emplacement, it is possible that conditions for the freeze/thaw dust injection process could thus be widespread along the $+15^0$ to $+30^0$ and -15^0 to -35^0 latitude belts.

Although it is not proposed here that the freeze/thaw dust injection process is the only mechanism for generation of the mid-latitude storms, most non-polar plumes occur in the southern hemisphere in a latitude band between -15^0 to -35^0 (e.g., 6). This is the latitude band into which the edge of the zone of seasonal ground ice accumulation (tempofrost) may extend, and it is the zone of maximum solar insolation during the dust cloud events. In the northern mid-latitudes the sites of most frequent occurrence were the Syrtis Major border regions, Cerberus, and Chryse. Again, these regions were in the $+15^0$ to $+30^0$ latitude band of the proposed edge of seasonal ground ice accumulation. Consequently, many of the mid-latitude local storms may possibly occur under conditions that are favorable for the freeze/thaw dust injection process, and the process could possibly be relatively widespread in these latitude bands.

If the humidification-induced dust injection process is widespread in the mid-latitude bands during the period of maximum insolation, these latitude bands would be zones of preferential seasonal dust entrainment. If true, then this latitude band may possibly be subjected to preferential removal of dust by wind transport, since the transport of dust in the rarefied Mars atmosphere should be rate-limited by the entrainment processes. This would suggest that the regions of preferential humidification-induced dust injection could possibly have relatively lower abundance of dust than regions of minimal entrainment. By contrast, the regions of minimum dust injection activity might, neglecting other entrainment processes, be possible sites of preferential dust deposition. If true this would suggest the possibility that the regions where humidification-induced entrainment occurs may have lower albedo than other regions, since the mobile dust component is apparently higher in albedo than the more coarse-grained rocks and soils (7). If the differences in dust content are sufficient, the zones of preferential dust removal could also have higher thermal intertia, since the unconsolidated fine-grained dust would have relatively low thermal intertia (8). Indeed, the regions of preferential dust cloud occurrence have moderate-to-high thermal intertia and moderate-to-low albedo. Dust clouds rarely originate in regions of high albedo and low thermal intertia (6), which is consistent with the predictions.

The latitude band which is predicted to have the maximum freeze/thaw dust entrainment activity, i.e., 15^0-35^0S latitude, contains most of the permanent low albedo regions of the planet. If the model proposed here is viable, the dark areas within this latitude band may correspond to areas of seasonal ice emplacement and humidification-induced dust entrainment activity. Low albedo regions in the northern mid-latitudes may have similar origin.

One aspect of the proposed model for formation and preservation of the low-albedo features that might appear inconsistent is the fact that the sites of dust clouds are sites of proposed minimum dust deposits. Associated with this is the apparent possible inconsistency that the dust injection event is proposed to occur within 5-20 cm deposits of fines in regions that are supposed to be relatively dust-free. These observations are not necessarily inconsistent, however, the dust plumes probably contain at most a few millimeters equivalent of dust in the atmospheric column (e.g., 6). If the dust originated from cracks, voids, and other fine-scale topographic traps, most of the surface could be dust-free.

Several-centimeter-thick layers of dust could potentially be injected from only a few percent of the surface area to produce the inferred atmospheric dust loads within the plumes. Turbulence from the injection event and regional winds could potentially combine to keep the exposed surface rocks relatively free from settled dust deposits, confining the dust primarily to the cracks and other traps and potentially preserving the low albedo.

Another aspect of the model that might appear inconsistent with the observations is the lack of water vapor anomalies at the sites of proposed freeze/thaw injection. This was discussed in detail by Huguenin and Clifford (9), where it was shown that the amount of vapor that would be injected would have been undetectable by the Viking Mars Atmospheric Water Detector Experiment. The vapor would be injected during the predawn hours, form ice, and slowly sublime, producing negligible additions to the background vapor abundances. Abundant ice fogs and frosts were observed, however, after each of the major predawn storms, consistent with the release of ~ 1 mg/cm^{-2} of H_2O from the fines (9). Clouds and fogs are the most sensitive indicators of H_2O vapor anomalies in the Mars environment, and there are preferential occurrences of the clouds and fogs in the low albedo regions (9).

The origin and preservation of low albedo markings has been a subject of considerable interest since the time that Mars was first studied, and it continues to be a focus of study at the present (10). The fact that dust storms and blue cloud activity were more frequent in the dark areas has also been of considerable interest (9). The model proposed here that the low albedo markings in the mid-latitude belts are the possible result of seasonally emplaced ground ice and humidification-induced dust entrainment may possibly provide a reasonable explanation for many of the characteristics of these features.

Acknowledgement. This research was supported by NASA Grants NSG7405 and NAGW570 to the University of Massachusetts.

References.

1 Huguenin, R.L., Harris, S.L., and Carter, R. (1986) Icarus, in press.
2 Biemann, K., et al (1977) J. Geophys. Res., 82, p.4641-4658.
3 Oyama, V.I. and Berdahl, B.J. (1977) J. Geophys. Res., 82, p.4669-4671.
4 Clifford, S.M. (1984) Ph.D. Dissertation, U Massachusetts.
5 Farmer, C.B., and Doms, F.E. (1979) J. Geophys. Res., 84, p.2881-2888.
6 Peterfreund, A.R. (1985) Ph.D Dissertation, Arizona State University.
7 Singer, R.B., McCord, T.B., Clark, R.N., Adams, J.B., and Huguenin, R.L., (1979) J. Geophys. Res., 84, p.8415-8426.
8 Kieffer, H.H., Martin, T.Z., Peterfreund, A.R., Jakosky, B.M., Miner, E.D., and Palluconi, F.D. (1977) J. Geophys. Res., 82, p.4249-4291.
9 Huguenin, R.L. and Clifford, S.M. (1982) J. Geophys. Res., 87, p.10227-10251.
10 Mutch, T.A., Arvidson, R.E., Head, J.W. III, Jones, K.L., and Saunders, R.S. (1976) The Geology of Mars, Princeton Univ. Press, Princeton, NJ, Chapter 1.