N92-10940

PLANETARY GEOMORPHOLOGY RESEARCH: FY 1990-1991

M. C. Malin, Department of Geology, Arizona State University, Tempe, AZ 85287-1404

Progress in research supported by NAGW-1 included completion of the dissertation of Jeffrey Moore (volatile ice sublimation in simulated martian polar environment), continuation of research of Robert Sullivan (hillslope processes on Mars), and completion of a global syntheses of venusian tectonics (M. Malin with R. Phillips and R. Grimm of Southern Methodist University). Work also continued on completing papers summarizing nearly a decade of field studies of eolian processes in cold volcanic deserts (M. Malin) and on a new model for interpretation of martian sediment distribution using Viking observations (M. Malin with P. Christensen, ASU).

Moore's dissertation research examined the effects of non-volatile mantling materials on the sublimation rate of water ice under simulated martian conditions. Using the Mars Environment Simulator chamber described in previous progress reports, Moore examined the effects of single layers of either "dust" (silt ~10 microns in diameter) or "sand" (modal size ~125 microns) on the rate of sublimation of water ice granules at 3 mb 95% CO_2 and 5% Earth atmosphere (i.e., 4% N_2, 0.6% O_2, 0.25% Ar, etc.). In order to observe effects within the timescale available for experiments, temperatures were elevated with respect to martian conditions, and results then scaled to Mars. Moore was also able to examine the effect on sublimation of atmospheric vapor transport using as a circulation pump. The principal variable examined was mantle thickness, which was increased from 1 mm to 5 cm in roughly logarithmic increments.

Three major conclusions can be drawn from the first set of experiments performed. First, the rate of mantle-free ice sublimation was nearly an order of magnitude smaller than that predicted by Ingersoll's 1970 model, which has served as the basis for most subsequent treatments. More recent models (but not yet published, e.g., that by Haberle and Clow) appear more in concert with the experimental results. Second, atmospheric transport of even a small amount of latent heat and water vapor can play an important role in ice sublimation when ice is exposed or mantled by thin layers of sand. Differences between the effects of dust and sand mantles on "wind-induced" sublimation were observed and are interpreted to arise from the control of diffusion rate by pore size and partial pressure. Third, variations in sublimation rates resulting both from mantle thickness and from mantle particle size were investigated--in general, mantles greater in thickness than 5 cm, of either grain-size material, effectively insulated the underlying ice from sublimation. This result can be used to understand the role non-volatile mantles play in the evolution of the martian polar deposits.

The work of Sullivan will be reported at a later date by Sullivan and Jonathan Fink, who is now Sullivan's research and thesis advisor.

In an attempt to balance the "plate"-oriented view of venusian tectonics espoused by J. Head and co-workers over the past five years, R. Phillips, R. Grimm, and M. Malin prepared a synthesis of the SMU/ASU research for publication in *Science* (3 May 1991 issue). This "pre-Magellan" work outlines a vertical tectonics model wherein venusian hot spots create plateaus of uplifted and underplated crust that evolve into *tesserae* with time. Deformation is distributed both laterally and vertically (as opposed to occurring in specific, narrow zones). The model provides an integrated view of venusian structure and geophysics.

A synthesis of results of a 4-year study of eolian processes in the cold volcanic desert of central Iceland was completed for publication. By judicious choice of study sites, information on a broad range of topics pertaining to eolian abrasion by basaltic materials was gathered. Material properties as a function of height vary dramatically, both in composition and caliber, depending on wind speed and surface configuration. Only the simplest surface (one composed entirely of well-sorted eolian sand) appears to be successfully represented by present analytical and numerical models. Sand transport as a function of time is highly episodic. Flux measurements suggest that periods of sand transport were relatively short and separated by long periods of little or no transport. Abrasion appears to have occurred during periods of wind speeds demonstrably higher than those necessary to initiate and sustain motion. Together, these observations suggest that eolian processes may be relatively catastrophic, reflecting brief, intense winds. For rocks protruding above the surface by only a few centimeters, abrasion is very low because particle impact speeds are small. Some evidence suggests it increases rapidly to a maximum, and then decreases with increasing height. However, this pattern appears sensitive to many factors, and the stochastic nature of air flow and particle motion greatly affect what happens at a given location. Combined with effects associated with the physical properties of the target rock material itself, including variations in the properties on the scale of individual sand grains, it is unlikely that a simple model of rock abrasion with height can be applied to more than an arbitrarily small and hence unrepresentative number of cases. The implications for Mars of these and other observations were also considered. They can, for example, be used to support the conclusion that infrequent winds of sufficient magnitude to cause major abrasion is the primary cause of the apparent lack of abrasion of martian rocks as seen in the Viking Orbiter images.

Finally, a model for the interpreting the clastic sediment distribution on Mars has been developed with P. Christensen. This model is based on three major assumptions: 1) surface albedo is proportional to the fraction of the surface covered by a thin deposit of high albedo dust, 2) thermal inertia, in particular the "fine-component" inertia (average minus rock contribution), reflects the effective "mean" particle size of wind-transportable fine particles, and 3) "rock fraction" is directly related to the thickness of the mantle of fine particles as they fill-in and cover non-wind-transportable materials. The model is used to investigate sediment transport and depositional patterns in both regional and global context. It is found, for example, that the global mean thickness of transportable fines, averaged over 1 degree square areas (3600 km^2) is about 35 cm, and that the thickest deposit on that scale is less than a meter thick. It is thus possible, using this model, to reconcile thermophysical interpretations of major martian surface features (e.g., the low inertia of the Tharsis volcanos) with photogeological analyses.

Owing to funding limitations in FY 1990, no funds were available after October 1990 to support research other than for student stipends. FY 1991 funds have not been received as of this date (22 May 1991), and owing to the change in location of the Principal Investigator, the prognosis for funding in the near future is poor. Future work in Planetary Geomorphology, contingent upon receiving funding, and following recommendations of the LGPRP, will focus on examining the thermophysical properties of deposits of non-volatile particulates using the Mars Environmental Simulator Chamber to which most of the funding derived from NAGW-1 has been devoted the past three years. The results of this study will be used to develop observational strategies and predictive tests for remote sensing observations of Mars using the Mars Observer Thermal Emission Spectrometer, on which the proposer is Co-Investigator.