WIND EROSION ON MARS: AN ESTIMATE OF THE RATE OF ABRASION.

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Preliminary estimates of aeolian abrasion rates on Mars have been reported previously (1), and the general procedures and approach are presented by Krinsley et al. (2). Earth based observations and the global dust storm seen by Mariner 9 led Sagan (3) to predict extremely large aeolian abrasion and deflation rates, based on saltation physics and some assumptions of martian environmental conditions. This rapid rate is at odds with constraints placed upon it by observations of surface features made from Viking images (4,5). Refinement of Sagan's calculation was made based on laboratory studies and Viking data resulting in an aeolian abrasion rate more compatible with observations of the surface (1). However, values for the parameters in the calculation are open to question, and have led to additional work using a different approach, as reported here.

The mass rate of aeolian abrasion is the product of three basic parameters:

1) S_A The susceptibility of a given material to abrasion measured in grams target lost per grams impacting mass.
2) q The mass flux of impacting material on the target, measured in grams impacting per square centimeter of target per second; q is a function of wind speed and height above a surface roughness.
3) f The frequence of winds of saltation-strength.

Mass rate of abrasion = $S_A \cdot q \cdot f$; units: gm cm^{-2} sec^{-1}

The first parameter, S_A, is measured in the laboratory using abrasion devices that simulate natural abrasion under martian conditions (6). The second parameter, q, can be measured for terrestrial environmental conditions in the field and in wind tunnels. An extrapolation of q thus determined to martian conditions is possible using equations developed by White (7) and can be compared to q measured under simulated martian conditions in MARSWIT, a low pressure wind tunnel at NASA-Ames Research Center. An estimate of the third parameter can be made from Viking meteorological observations. The only other input required for the rate calculation is the relationship between wind velocity and sand velocity in a saltation cloud.

The values for all three parameters are currently being refined; however, a first-order estimate of the abrasion rate on Mars can be made, based on the following assumptions:

1) Impactors are quartz sand similar to those used in the abrasion devices.
2) There is sufficient sand on the martian surface to allow a full saltation curtain to develop, as in wind tunnel experiments.
3) Rocks on Mars have similar abrasion susceptibilities as those on Earth of assumed similar composition and texture.
4) The present meteorological conditions as measured the the Viking Lander on Mars are similar to those in the past.

Values for these parameters can be estimated as follows:

Parameter	Typical Value	Source	Reference
S_A	10^{-4}	Abrasion machines	1,8
q	0.1	Earth wind tunnel extrapolated to Mars	7,9
f	A maximum of 10^{-2}, more likely 10^{-3}	Viking observation	10

Mass Rate of Abrasion = $(10^{-4})(10^{-1})(10^{-3}) = 10^{-8}$ gm cm^{-2} sec^{-1}

Depth Rate of Abrasion = $\frac{\text{mass rate}}{\text{target density}} = \sim 4 \cdot 10^{-9}$ cm sec^{-1}

The results in an abrasion rate of 0.1 centimeters per year (1000 meters per million years). Refinement of the measurements of S_A, q and f will increase the accuracy of this rate, however, most of the values are within order of magnitude and yet results are greatly at variance with the observations of the surface that allow an abrasion rate of approximately 10^{-3} meters per million years (4). Thus either the observation is faulty, or the assumptions upon which the calculation is based must be in error to explain the large apparent discrepancy. We consider first that the impacting material may not be quartz (11); although any other "solid" material would also result in high abrasion rates. In many areas of Mars, the sediment supply may be limited, so that q is much smaller than wind tunnel tests at that wind speed would indicate. Perhaps the assumption having the greatest effect is the size of the impacting particle. Sagan et al. (12) suggested that sand sized material would quickly self destruct into micron-sized particles due to high energy saltation impacts. Observations of atmospheric dust (13,14) and spectral reflectance information (15) support the idea that there is a large amount of material in the martian surface environment on the order of a micron in diameter. It has been suggested by Greeley (16) that this fine sediment forms aggregates bound in part by electrostatic forces. These aggregates may be strong enough to saltate and form dunes and drifts, but would disintegrate upon impact rather than abrade surface rocks. The efficiency of abrading targets by such aggregates is currently under investigation.

In summary, sufficient laboratory work has been done on the martian abrasion problem to show that there is a major difference between the calculated rate of aeolian abrasion and the limits placed on that rate by the observation of surface features at the Viking landing sites. Further work is being done to investigate this discrepancy, but it is quite likely that it is due, at least in part, to the existance of aggregates of fine particles rather than sand size particles on the martian surface.

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