INFLUENCE OF ROCK COATINGS ON SAND ABRASION AT THE MARS PATHFINDER LANDING SITE.

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Introduction

Many of the images returned during the Mars Pathfinder mission, especially pictures taken by the Rover forward cameras, show evidence of wind abrasion. Abrasion of rocks at the Pathfinder landing site has produced fluted, grooved, and pitted surfaces which are characteristic ventifact morphologies [1]. Ventifact features occur on rocks ranging in size from small, 2-3 cm tall cobbles to large boulders ~0.5 m high. Although it has been suggested that dust can abrade rock [2], because of the style of abrasion observed (large flutes and grooves rather than fine rilles) the ventifacts at the Pathfinder site are interpreted to have formed from abrasion by wind-blown sand [3]. The morphology and color of rocks as viewed in IMP images reveal that few rock surfaces are pristine; many rocks have coatings. Soils or crusts mantle some rocks surfaces [3] and weathering rinds are interpreted to have formed on other rocks [4]. Highly reflective surfaces of certain rocks could be the result of wind polishing but, alternatively, may be varnished surfaces [5]. While not all rocks observed at the landing site have such coherent coatings, dust cover, however thin, is pervasive and nearly ubiquitous to all surfaces. Because of the evidence of rock coating and mantling along with obvious ventifaction, it is important to understand the mechanical interaction of such coatings with saltating sand. The susceptibility to abrasion (S_A) of clean rock surfaces is fairly well understood [6,7] but the interference by rock coverings could substantially alter the rate at which a particular rock might abrade while under attack by windblown sand. Preliminary results of S_A for rock varnish have been experimentally determined to be about 2×10^{-9} grams of varnish removed per impacting particle of 120 μm quartz sand. This value is about an order of magnitude higher than S_A for fresh basalt [7]. If the values of S_A for rock coatings are consistently higher than S_A for rocks, abrasion rates for landing sites can be better constrained.

Method

Abrasion experiments are being conducted using the Martian Rotating Erosion Device (MRED). In the device, samples are mounted at the end of a rotational arm that “slings” the abrading material (sand) into the target sample. The angle of impact can be set for each sample and abraded by different grain size material and varying speed and pressure. The initial experiments have been run to determine S_A for rock varnish. Varnished dacite was chosen to abrade because (1) there is good color contrast between the rock and varnish; (2) dacite is an aphanitic volcanic rock to which varnish presumably adheres similarly as it does with basalt; and (3) availability. The experiments were run at martian pressure (5.6 mbar) using an abrading sand the size of which is roughly that most easily transported by wind under martian surface conditions [7].

Results

Preliminary results of S_A for rock varnish have been calculated for abrasion by 120 μm quartz sand accelerated to a velocity of 25 m/s. Values differ as a function of the angle of impact; 90°, 60° and 30° impact angles were used in this experiment. Calculated values of S_A are shown below (Table 1) first as grams of sample removed by abrasion per grams of impacting sand and second as grams of sample abraded per number of impacting 120 μm grains, assuming spherical particles.

TABLE 1. Susceptibility to abrasion (S_A) for rock varnish.

Impact Angle (deg)	S_A (10^{-4} g/g)[a]	S_A (10^{-9} g/i)[b]
90	9.33	2.25
60	7.36	1.78
30	16.2	3.91

[a] Susceptibility to abrasion given in grams of material removed per grams impacting

[b] Susceptibility to abrasion given in grams of material removed per number of impacting grains

Discussion

Preliminary results of the susceptibility to abrasion calculated for rock varnish are about an order of magnitude greater than those calculated for rock, including basalt (2-6 x 10^{-10} g/i) [7], but show a similar trend in that there is a lower S_A at a 60° impact than at 30° or 90°. Varnish, then, appears to be more easily abraded than rock but mechanically behaves in a similar manner. If the same is true of other rock coatings, finding rocks with weathering rinds, crust and soil mantling, and possibly varnish implies a very low rate of abrasion for rocks at the Pathfinder landing site. If rock coatings have consistently higher value for S_A than rock materials the rate of abrasion will be better constrained.

References Cited: [1] Sharp (1959), *J. Geol*., 57, 175. [2] Whitney and Dietrich (1973), *GSA Bulletin*, 84, 2561. [3] Smith et al. (1997), *Science*, 278, 1758. [4] Rieder et al. (1997), *Science*, 278, 1771. [5] Guinness et al. (1996) *LPSC XXVIII*, 491. [6] Williams (1981), Calculated and inferred aeolian abrasion rates: Earth and Mars, Thesis, Ariz. St. Univ. [7] Greeley et al. (1982), *JGR*, 87, 10009.