EOLIAN SALTATION ON MARS

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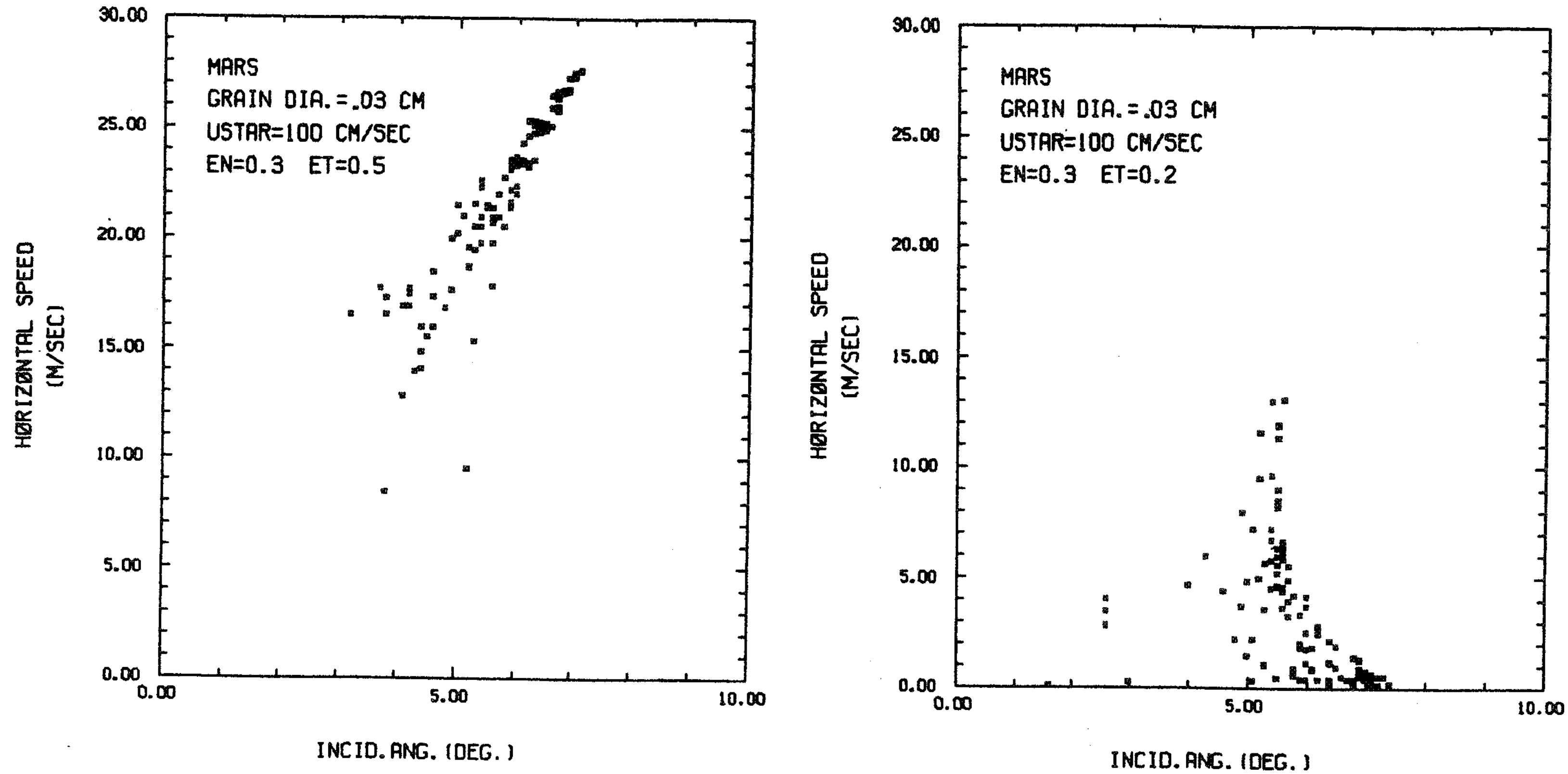
At the high wind speeds necessary for saltation on Mars, individual sand grains assume relatively long low angle trajectories compared with those on the Earth. Williams and Greeley [1] argued that saltating grains on Mars do not transmit sufficient momentum to the surface for entrainment of secondary grains, and they concluded that the Martian saltation cloud has a low number density and the sediment flux is weak. I have developed a computer model in order to examine the effects of both the wind field and surface collisions on the Martian saltation cloud; results are summarized here.

Grain trajectories were derived by numerical solution of the exact two-dimensional equations of motion for a spherical sand grain embedded in an arbitrary wind field [2]. The saltating grain collides with an individual surface grain at a randomly chosen point within a collision cross section defined by the colliding grain and the surface grains. The surface grains lie in mutual contact on a horizontal plane. This collision model [3] does not account for entrainment of secondary grains; it focuses only on the primary saltating grain whose behavior dominates the saltation cloud [4]. The horizontal and vertical speeds of a saltating grain just after collison are restored to a fraction of the speeds before collision in proportion to two coefficients of restitution, EN and ET (Figure 1). The vertical wind speed is zero and the horizontal wind speed varies with height according to a logarithmic distribution [5] as scaled by the wind-shear speed.

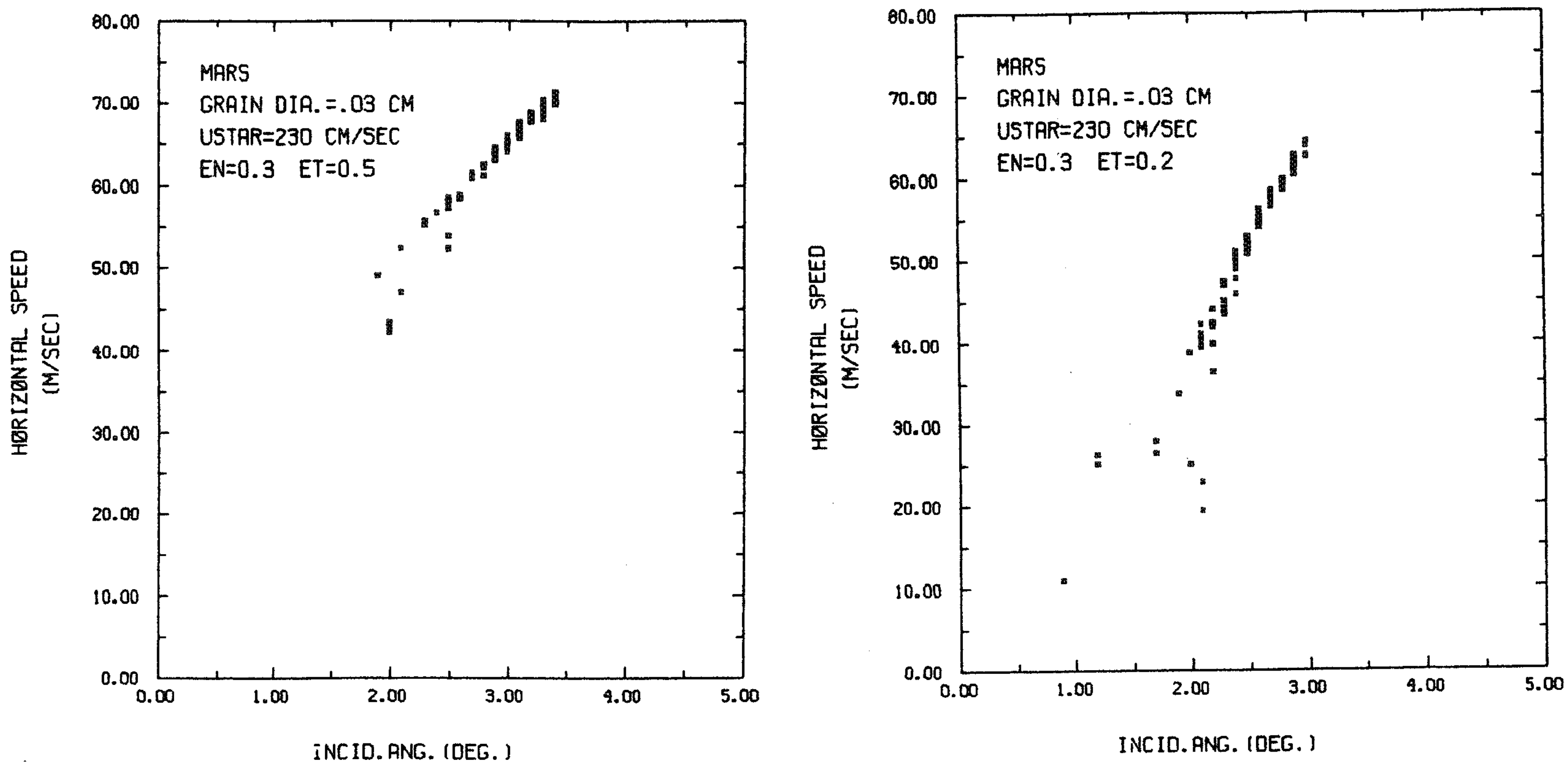
The horizontal speed versus incidence angle for a single saltating grain just before each of 100 successive, random collisions with a surface of similar-size grains is shown in Figures 1 and 2. The distribution of incidence speeds and angles assumed by one grain in this model characterizes reasonably well the quantitative physical processes in the saltation cloud. Saltating grains (Figure 1a) that transfer small fractions of their horizontal momentum to the surface (ET=0.5) attain higher speeds, rise higher above the surface, and achieve longer trajectories than do saltating grains (Figure 1b) that transfer larger amounts of momentum (ET=0.2); relatively small differences in the coefficients of restitution yield significant differences in the saltation cloud. These conclusions remain valid for wind-shear speeds at the saltation threshold (Figure 2). As shown in Figure 2b, grains can both assume long trajectories and transfer large amounts of momentum to the surface for the rapid development of the saltation cloud. Nevertheless, because the surface-collision parameters of saltating Martian sediments are unknown, the development and effectiveness of the saltation cloud remain uncertain. Surface-collision parameters for spherical sand grains on Mars could be more accurately characterized by scaled laboratory experiments.

References: [1] Williams, S.H., and R. Greeley, 1986, Abs. Lun. Planet. Sci. Conf., 17th, p. 952-953; [2] White, B.R. et al., 1975, NASA TM X-62463, 200 p; [3] MacKinnon, D.J., 1986, NASA TM 88383, p. 254-256, [4] Mitha, S. et al., 1985, Brown bag preprint series in basic and applied sciences, Calif. Inst. Tech., BB-36, 25 p; [5] Bagnold, R., 1941, The physics of blown sand and desert dunes: London, Chapman and Hall, 264 p



(a) (b)

Figure 1 - Horizontal speed vs. incident angle (the angle between the grain trajectory and the horizontal) of a saltating spherical sand grain immediately before 100 successive, random collisions with a surface of similar-size sand grains. Data points are derived for a wind-shear speed (USTAR) less than the saltation threshold for 0.03-cm-diameter sand grains on Mars. EN is the fraction of speed restored along the line of centers between the colliding grain and the surface grain in question; ET is the fraction restored perpendicular to the line of centers. Except for the difference in ET, components of (a) and (b) are the same.



(a) (b)

Figure 2 - Same as Figure 1 except that the wind-shear speed (USTAR) is set equal to the threshold wind-shear speed for the saltating grain.