BEHAVIOR OF WINDBLOWN SAND ON MARS: RESULTS FROM SINGLE-PARTICLE EXPERIMENTS; J.R. Marshall[1], J. Borucki[2], and C. Sagan[3], [1]SETI Institute/NASA Ames, MS 239-12, Moffett Field, CA 94035, [2]NASA Ames, [3]Cornell University

Experiments are investigating the behavior of individual sand grains in the high-energy martian aeolian regime. Energy partitioning during impact of a saltating grain determines grain longevity, but it also influences the way in which the bed becomes mobilized by reptation. When single grains of sand are fired into loose beds, the bed can absorb up to 90% of the impact energy by momentum transfer to other grains; it has been discovered that the impacting grains cause circular craters even at low impact angles. Hundreds of grains can be splashed by a single high-velocity (100 m/s) impact causing more bed disturbance through reptation than previously thought. The research is supported by NASA's PG & G Program.

Because the martian aeolian environment is both high energy and of long duration, the most mobile fractions of windblown sand should have eradicated themselves by attrition, unless sand supply has kept pace with destruction. It is therefore important to understand the rate of grain attrition in order to make sense of the existence of vast dune fields on Mars. Attrition has been addressed in other studies, but precise data for a single saltating grain striking a loose bed of sand have not been acquired -- the quintessential case to be understood for dunes on Mars.

To acquire these data, we are employing a compound crossbow which has the bolt-firing mechanism replaced with a pneumatically-automated sabot system. The sabot can launch individual grains of sand of any size between several millimeters and ~ 50 microns, at velocities up to 100 m/s. This is around the maximum velocity expected for saltating grains on Mars. The sabot sled is equipped with photoelectric sensors for measuring sabot velocity. Baffling of the grain's exit orifice has enabled projection of single grains without significant aerodynamic effects from the sabot. Grains are fired into loose beds of sand at about 15 degrees from the horizontal (typical saltation trajectory at impact) while being filmed on high-speed video. High-intensity pulse illumination for the grains is triggering by the solenoid-operated bow trigger. A 45 degree mirror over the impact site provides simultaneous horizontal and vertical images of the impact on each video frame. UV fluorescence is enabling grain and grain-fragment recovery.

At 100 m/s, grains of all sizes shatter into many fragments when the sand is replaced with a solid target. Kinetic energy of grains at this velocity exceeds the critical energy for catastrophic failure of minerals. Although probably exceptional as a grain speed, it suggests that conditions on Mars might elevate materials into an attrition regime not encountered on other planets; individual grains blown across rock pavements on Mars will have short lifespans. When experimental grains impact loose (dune) sand, much, if not most of the kinetic energy is converted into momentum of other grains. Using the high-speed filming, the energy involved in splashing grains at the impact site can be derived from the size of the crater, the speed of the splashed grains, and the rebound speed of the impactor. The amount of energy partitioned into material failure (as opposed to momentum) is too small a fraction of the total to be calculated under these circumstances. This does not necessarily mean that little damage occurs to the grains (the full extend of the damage has yet to be determined) because only a small fraction of impact energy is required for inducing brittle fracture. Damage is orders of magnitude less than during impact against solid surfaces.

In the process of video-imaging the impact of single grains into sand, it was found that impact craters were always symmetrical (no elongation in the direction of impact). This is surprising for 15 degree trajectories, and distinctly reminiscent of (but not analogous to) meteorite craters. Many hundreds of grains are injected into the air by one single high-velocity grain; the ejecta blanket covers several square centimeters even with the impact of a 100 micron particle. Every grain can trigger the entrainment of a significant portion of the bed, enough material in fact, to account for much of the grain population at the base of a saltation cloud.