THE FORMATION OF CRATER-RELATED BLAST WIND STREAKS ON MARS. S. N. Quintana[1] and P. H. Schultz[1], [1]Brown University, Department of Geological Sciences, 324 Brook Street, Providence, RI.

Introduction: Cater-related permanent wind streaks are observed around some craters on Mars. Such wind streaks are different from the "typical" wind streaks that commonly occur on Mars. Traditional wind streaks can be light or dark features [1], but they are non-permanent features that can change length and orientation over time. Additionally, traditional wind streaks are often considered to be depositional features based on their appearance and thermal properties [1, 2]. Conversely, crater-related permanent wind streaks do not change length or orientation over time. Hence, these streaks are proposed to be formed by impact-generated winds [3].

Crater-related permanent wind streaks, hereafter referred to as "blast-wind" streaks, are nearly invisible unless imaged in the nighttime thermal infrared. At these wavelengths at night, the blast-wind streaks appear bright, and radiate away from a central crater. Existing topography, such as preexisting craters, leads to double wind streak tails, indicative of scouring by strong, sustained winds and vortices [4] (Fig. 1).

Here we propose that impact vapor coupled to the atmospheric shock wave produce the blast-wind streaks. The blast wind, which is similar to the blast wave from a strong volcanic eruption like Mt. Saint Helens [5, 6], can travel at hundreds of meters per second on Mars. This wind is therefore capable of entraining material to cause scouring and preconditioning of the surface.

The implications of blast wind scouring on Mars are numerous. Wind streak extent and morphology provide clues to the velocity, intensity, and duration of the blast in the conditions of the atmosphere at the time of the impact. The expressions of the winds streaks are dependent on: (1) the geologic setting, such as whether an abundance of wind-sensitive surface material existed at the time of impact; (2) the history of active resurfacing from high-latitude mantling deposits, for example; and (3) impactor variables, including velocity and composition. Thus, blast-wind streaks also have implications for regional surface lithology and climate.

Approach: Both computational modeling and laboratory experiments are used to assess the formation blast-wind streaks. We will test the hypothesis that the streaks are caused by impact-generated winds following vapor expansion and atmospheric coupling.

Computational Experiments. Computational experiments are performed using the CTH shock physics analysis package developed at Sandia National Laboratories [7]. A suite of simulations were performed to test a formation mechanism for the blast wind streaks. In all simulations, a 1.5 km diameter projectile impacted at 45° and 12 km/s into a basalt target. In each simulation, an obstacle was emplaced at a distance from the impact point to test the effect of existing topography, such as preexisting craters. Simulations were run under current Mars surface pressure and temperature conditions, as well as a higher surface pressure condition of 35 millibars. Three simulations were run for each of these conditions: (1) a dunite projectile directly impacted the basaltic target; (2) a dunite projectile impacted a basaltic target overlain by 500 m of porous water-ice; and (3) a solid water-ice projectile impacted the basaltic target.

Laboratory Experiments. In addition to providing a benchmark for the CTH models, laboratory experiments allow us to explore controlling processes in impacts. The first in a series of laboratory experiments was performed at the NASA Ames Vertical Gun Range (AVGR) in Mountain View, CA. The AVGR can reach impact velocities of about 7 km/s; however, some non-porous materials of interest will not vaporize at this velocity. The goal of these experiments is to study the vapor component of impact and vapor coupling to the atmosphere, so easily vaporized powdered dolomite was used [8]. The experiments documented the expanding vapor plume and evolution of the resulting atmospheric shock wave. Various tracer methods were employed to record evidence of vapor expansion, and high-speed digital imaging cameras recorded the process.

Results: As expected, a layer of porous ice enhanced vaporization in simulations [9]. The vapor blast interacted with the surface while travelling radially from the impact site with speeds of hundreds of meters per second (Fig. 2). Laboratory experiments documented both the initial vapor blast and sustained trailing winds, revealed by entrained Styrofoam pearl tracers. These tracers were first lifted off the surface before being mobilized outward. As a result, they rarely scoured the surface, indicative of entrainment in turbulence at the surface. Experiments performed without an atmosphere did not mobilize the tracers (except very near the impact); hence, the blast-wind required an atmosphere in order to induce outward flow on the surface. Moreover, obstacles placed on the surface disrupted the boundary flow layer and induced enhanced mobilization on the lee side. Lower impact angles (<45°) resulted in asymmetric effects with minimal mobilization uprange (along with surface scouring) and enhanced mobilization downrange (Fig. 3).

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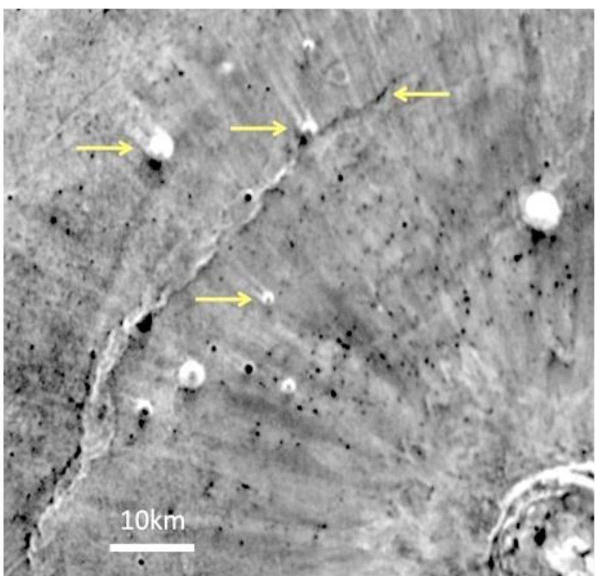

Figure 1 - THEMIS nighttime infrared image of Santa Fe crater in Chryse Planitia from Schultz and Quintana [3]. Arrows point to bright, double wind streak tails from preexisting craters. These wind streaks suggest that the blast was strong and sustained.

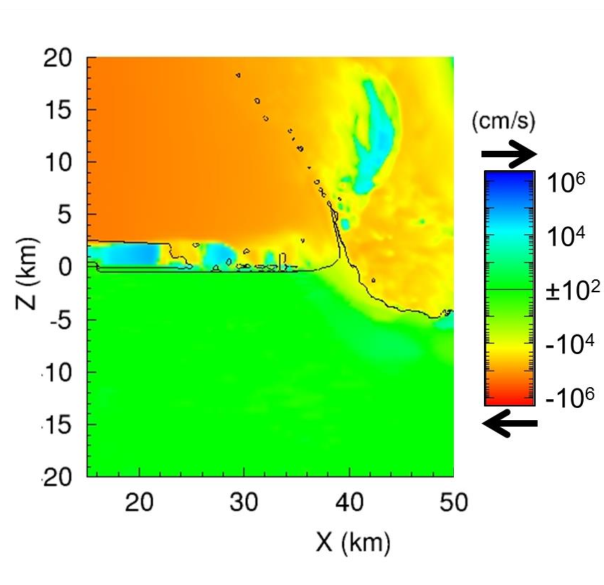

Figure 2 - CTH x-velocity plot of a 3D calculation at 18 s into the calculation. Plot shows the impact of a 1.5 km diameter dunite projectile into a basaltic target overlain by 500 m of porous water-ice. The projectile impacted from right to left at 45° and 12 km/s. Note the color and direction legend on the right. Blast-wind velocities reach at least 100 m/s. Vortices begin forming downrange at the surface with tornadic intensity prior to arrival of ejecta.

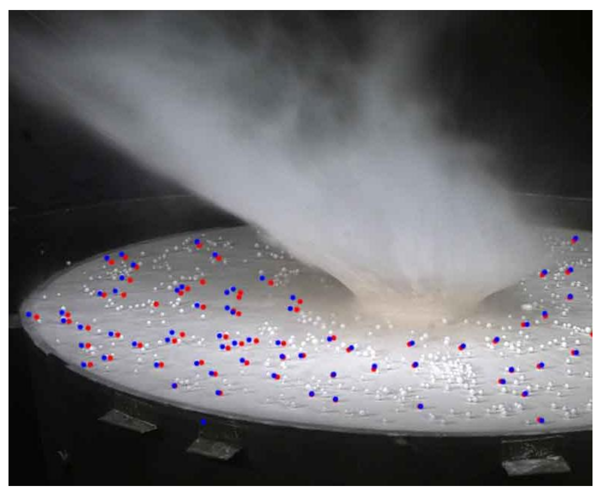

Figure 3 - Laboratory experiment of a 0.25 inch Pyrex projectile impacting dolomite at 45° (from the right) and approximately 5 km/s. Red dots indicate the initial position of some of the Styrofoam pearl tracers. Blue dots indicate the position of the tracers at 1935 μs into the impact. Impact vapor expansion interacting with the ambient atmosphere mobilizes the tracers to meter per second velocities.