MARTIAN DUST DEVIL TRACKS: INFERRED DIRECTIONS OF MOVEMENT.

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Overview. Inferred dust devil tracks are seen in many parts of Mars, including the floor of Gusev crater, the landing site for the *Mars Exploration Rover, Spirit*. In most cases, the directions of motion of the dust devils that formed the tracks are not known. Wind tunnel experiments simulating dust devil processes reveal a distinctive "scalloping" pattern on the surface left by some tracks that enable the direction of movement to be determined. The pattern consists of a series of overlapping (and progressively superposed) circular patches that result from the clearing of particles beneath the dust devil vortex core, and partial deposition over the previously-cleared patch as the dust devil moves forward. Similar patterns are seen in some dust devils tracks on Mars, including those in the Argyre Planitia and Hellas Basin regions.

Introduction. Linear, curvilinear, meandering, and looping albedo patterns are seen in many parts of Mars and are considered to represent the pathways of vortices (1) or dust devils (2). Most of these inferred *dust devil tracks* are dark and are thought to represent the removal of dust by the dust devil to expose a darker substrate. Analysis of dust devil tracks in Hellas and Argyre show that the tracks fade with time, presumably as a result of dust settling from the atmosphere (3. Although some active dust devils and their tracks have been "captured" by imaging in the process of formation (2) and the direction of motion thus can be determined, for most tracks the direction of motion is not known. Such determinations are important for comparisons with models of winds in the lower atmosphere and for understanding the processes that modify the surface.

Laboratory simulations. An apparatus to simulate the physical processes of particle entrainment by dust devils was recently put into operation (4). Termed the *Arizona State University Vortex Generator* (ASUVG), the apparatus produces "table-top" dust devils as large as 40 cm in diameter and 150 cm high. Although the cylinder that generates the vortex is fixed above the table, the test-table can be moved laterally in order to simulate the movement of the dust devil across the terrain. Previous experiments demonstrated that the fundamental morphology of the vortex and the atmospheric pressure distribution on the surface beneath the dust devil vortex are comparable to natural dust devils on Earth and on Mars (4). As true of full-scale vortexes, the core of the simulated dust devil also 'wobbles' and its position tends to meander over the surface of the test bed. Measurements in the field and laboratory show that there is a decrease in surface pressure beneath the core, such that dust devils act as local 'vacuum cleaners' to lift sand and dust from the surface. Coarser particles, such as sand, tend to be ejected from the dust devil core, forming a cloud-like 'skirt' of debris that returns to the surface, rather than being carried upward into suspension, as is the case with most of the dust component (fig. 1).

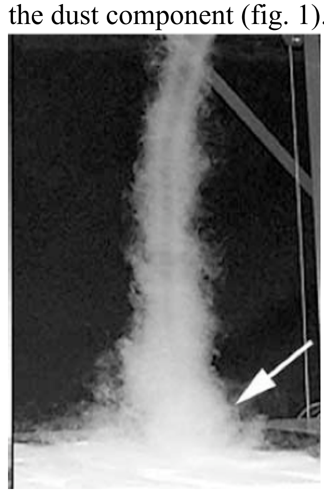

Figure 1: A Laboratory simulated dust devil using the ASUVG.

ASUVG experiments were assessed to determine potential characteristics of the dust devil tracks that would enable the direction of movement to be determined. The experiment test bed was covered with a 1 mm-thick layer of sand grains 0.02 mm in diameter. The bare test bed was black, which provided a contrast with the white sand. The ASUVG was 'spun-up' to form a vortex sufficient to lift the particles (exposing the bare test bed) and the test bed was moved laterally to simulate the passage of a dust devil over the surface. The resulting tracks left by the vortices consisted of a zone from which the sand was cleared that is 2 to 4 times the diameter of the vortex, exposing the dark test bed floor. However, as shown in figures 2 and 3**,** the sands were ejected from the path of the vortex and re-deposited in an annular pattern around the core. As the table moved beneath the vortex (simulating the passage of the dust devil) the vortex re-mobilized the sand at the leading edge and re-deposited it in the lee of the core.

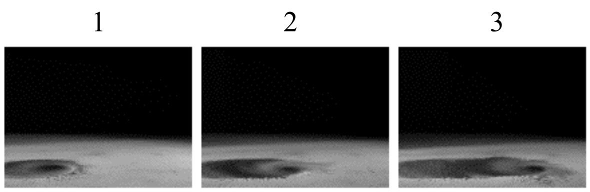

Figure 2: Oblique view of the ASUVG test table showing "scalloped" track. Apparent motion of vortex is left to right, and is ~50cm in traverse.

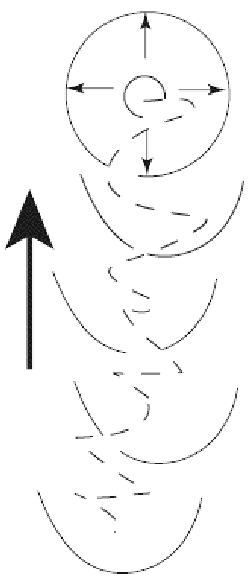

Figure 3: A diagram of a "scalloped" track produced in the lab. Large arrow indicates direction of propagation. The concentric circles show relative size of vortex core in relation to the "scalloping" in the track.

Martian examples. The pattern observed in the laboratory experiments is seen in many places on Mars. For example, figure 4 shows terrain east of the Hellas basin in which several dozen inferred dust devil tracks occur.

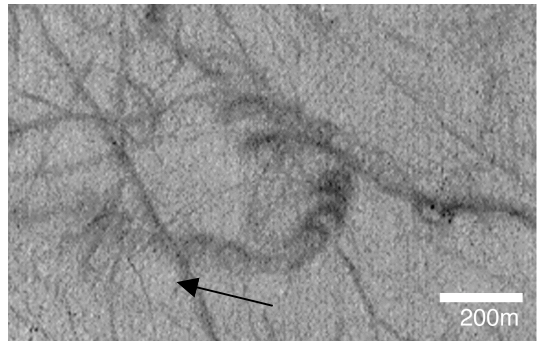

Figure 4: A scalloped dust devil track found to the west of Hellas Basin; arrow indicates inferred direction of motion. Image a portion of M10-03516, courtesy of MSSS.

Although most are linear or curvi-linear dark features about 20 m or smaller in width, some features are larger, the most prominent of which is a looping pattern about 65 m wide and 650 m long. This suggests that it was formed by a larger dust devil than those responsible for the narrower dark streaks. The series of overlapping circles suggests that the direction of movement was initially toward the south, with a shift toward the west. Similar patterns are found within the Hellas and Argyre basins, and elsewhere on Mars.

Conclusion. Laboratory experiments reveal a distinctive pattern of erosion and deposition associated with the passage of vortices across a surface. The pattern consists of a series of overlapping circular zones that are cleared of loose particles; the direction of movement is indicated by the superposition of the circular zones.

References: **1]**. Grant and Schultz, (1987) Science, v. 237, 883-885. **2]**. Edgett K.S. and Malin M.C. (2000) LPS XXXI, Abstract #1073. **3]**. Balme et al., (2003) JGR 108, 5086-5094. **4]**. Greeley et al., (2003) JGR 108, 5041-5052.