THE BIRTH AND DEATH OF TRANSVERSE AEOLIAN RIDGES ON MARS. P.E. Geissler, Center for Astrogeology, U.S. Geological Survey, Flagstaff, AZ 86001 USA (pgeissler@usgs.gov).

Introduction: The small bright crescents that are common on Mars were dubbed "transverse aeolian ridges" or TARs precisely because their origin is unknown [1]. The non-genetic term was chosen because it did not convey an interpretation as to whether the features were ripples or dunes or something else entirely. First seen in Viking [2,3] and MOC [4,5] images, the origin of the features remains a mystery today.

We propose that the TARs are indurated dust deposits, primary depositional bedforms that formed in place and were subsequently indurated and eroded to their current states by eons of sandblasting. We point out examples of dust drifts and dune-like features that appear to have been recently formed by dust accumulating directly onto the surface from the windblown dust suspended in the atmosphere. We show how these pristine dust deposits could evolve to explain the range of morphologies of the TARs.

Birth of TARs: Syria Planum is an area that is known from orbital monitoring to be a region of frequent albedo changes and a corridor for transportation of dust from Tharsis into Solis Planum [6]. Bright wind streaks are clearly visible against the dark surface, showing that modern winds blow downslope, towards the south and southeast. HiRISE images show isolated dust drifts in this region that accumulated behind boulders and other topographic obstacles. Nighttime THEMIS images of Syria show conspicuous cold spots, tens of km across, that are cold during the daytime because they are bright at visible wavelengths. These cold spots are much cooler at night than the thick, settled dust deposits nearby that have similar albedo. This suggests that the cold spots have a lower thermal inertia than the settled dust deposits, consistent with freshly deposited dust.

Figure 1 shows a close-up of one of these cold spots. The dust deposits here are organized into sets of parallel ridges spaced 30 to 70 m apart that are oriented transverse to the wind direction. These "bright dune-like features" are clearly not dunes because their steeper sides face upwind, just the opposite of dune slip faces. The bright dune-like features resemble TARs in size and spacing, but they differ markedly in morphology. The ridges end abruptly with blunt edges, in contrast to the gradually tapering terminations of TARs. They are asymmetric in cross-section, with slightly steeper planar surfaces upwind and irregular surfaces trailing downwind, in contrast to the symmetry of TARs. The crests of the ridges are crenulated, unlike the smooth crests of TARs.

Upwind and downwind of the bright dune-like features are found isolated triangular dust deposits that are shaped like inverted Deltas. These pyramid-shaped "deltoids" are frequently formed in pairs or triplets that create shorter ridges similar to the bright dune-like features. Individual deltoids typically measure 15 to 20 m across their upwind edges with tails that extend 20 to 30 m downwind. From their spatial relationship, we infer that the bright dune-like features formed from rows of aligned deltoids. Deltoids are found intermingled with the dust drifts spotted in this region [6] but unlike dust drifts, the deltoids do not appear to require topographic obstacles in order to form. Similar relationships between dust drifts, deltoids, and bright dune-like features are seen in nearby images of other cold spots (ESP_032735_1680, ESP_013582_1895).

We propose that the dust drifts, deltoids and bright dune-like features are original primary bedforms, deposited by dust that was suspended in the wind. The precise mechanisms are unclear, but the fact that the deposition ignored negative topography shows that the sediment was carried in suspension, not saltation. The morphology of the bedforms suggests that the dust is sticky, collecting behind obstacles and accumulating on surfaces that are already dust coated, perhaps indicating that the dust particles are cohesive.

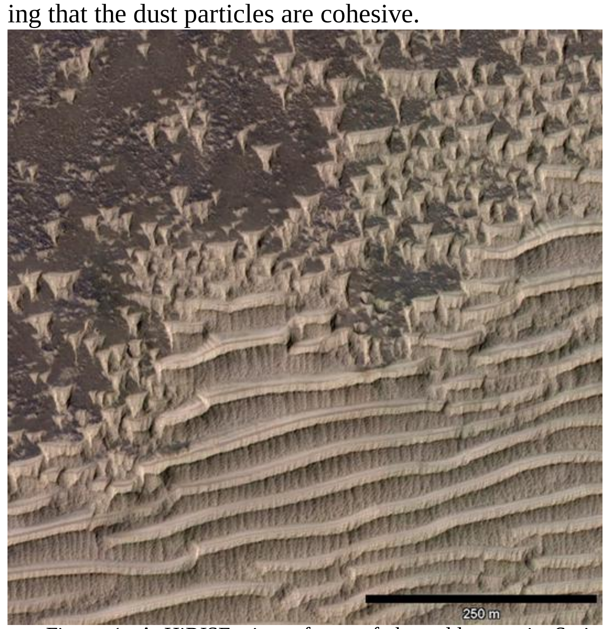

Figure 1. A HiRISE view of one of the cold spots in Syria Planum shows examples of pristine dust deposits that we infer to be the ancestors of TARs. Upwind, towards the top of the image, are found pyramidal deposits that resemble inverted Delta characters and are nicknamed "deltoids". Towards the bottom of the image, rows of aligned deltoids apparently merged to form "bright dune-like features" with semi-regular spacing of ~50 m. Unlike dunes, they have their steep faces upwind (PSP_009448_1670; 254.15°E 12.86°S).

Death of TARs: If we presume that the features in Syria Planum represent the ancestors of TARs elsewhere on Mars, it is easy to see how they subsequently evolved. TARs are resistant to erosion, suggesting that the dust may have been physically or chemically indurated after it settled, but there is no doubt that sand beats up on the TARs nowadays. Active sand dunes that often dwarf the TARs are seen overriding TARs in many places, including Endeavor crater where the MER rover Opportunity monitors the advance of the sand dunes. We suggest that sandblasting over millions of years has eroded the TARs, reducing their sizes and erasing small craters from their surfaces. This would account for the puzzling observation that the TARs that are battered by sand dunes have lower crater retention ages than TARs that are far from sand dunes [7]. This suggests that the TARs are relatively soft, compared to bedrock.

Sandblasting should also erode dust deposits, reducing their sizes and changing their shapes. This is the process that we believe is responsible for morphing the strangely shaped deltoids and bright dune-like features into TARs. The crenulated crests of the dust deposits are worn down by erosion, the blunt ends of the ridges are smoothed into tapers, and the slopes are evened out by sandblasting that preferentially erodes the upwind slopes and winds that alternate on diurnal and seasonal time scales. Sandblasting causes the shapes of dust deposits to evolve into the familiar forms of TARs today (Figure 2). Of course, the war is ultimately won by sand, and the death of TARs occurs when they are eroded entirely. The TARs that survive the longest will be those that are sheltered from the wind, tucked away in channels and crater interiors where they are seen today.

Discussion: The significance of TARs is that they tell us what the weather was like on Mars millions of years ago. Nowadays, sustained wind speeds of 40 m per second and a rich supply of dust are required for TARs to actively form. These conditions are met in only a few places on Mars today, on the Tharsis Rise and the giant volcanoes, where topographic variations are extreme. The widespread distribution of TARs tells us that such conditions must have been pervasive in the past, when stronger winds and a dustier atmosphere caused by the higher axial obliquity produced dust deposits all over Mars that would later be indurated and eroded to form the TARs that we see today.

References: [1] Bourke, M et al. LPSC 34, 2003 [2] Thomas, P et al. Icarus, 45, 124–153, 1981; [3] Zimbelman, J., Icarus 71, 257-267, 1987 [4] Thomas, P et al. Nature 397, 592-594, 1999; [5] Malin, M and Edgett, K, J. Geophys. Res., 106, 23429, 2001 [6] Geissler, P et al., LPSC 43, 2012 [7] Berman, D et al. Icarus 213, 116-130, 2011.

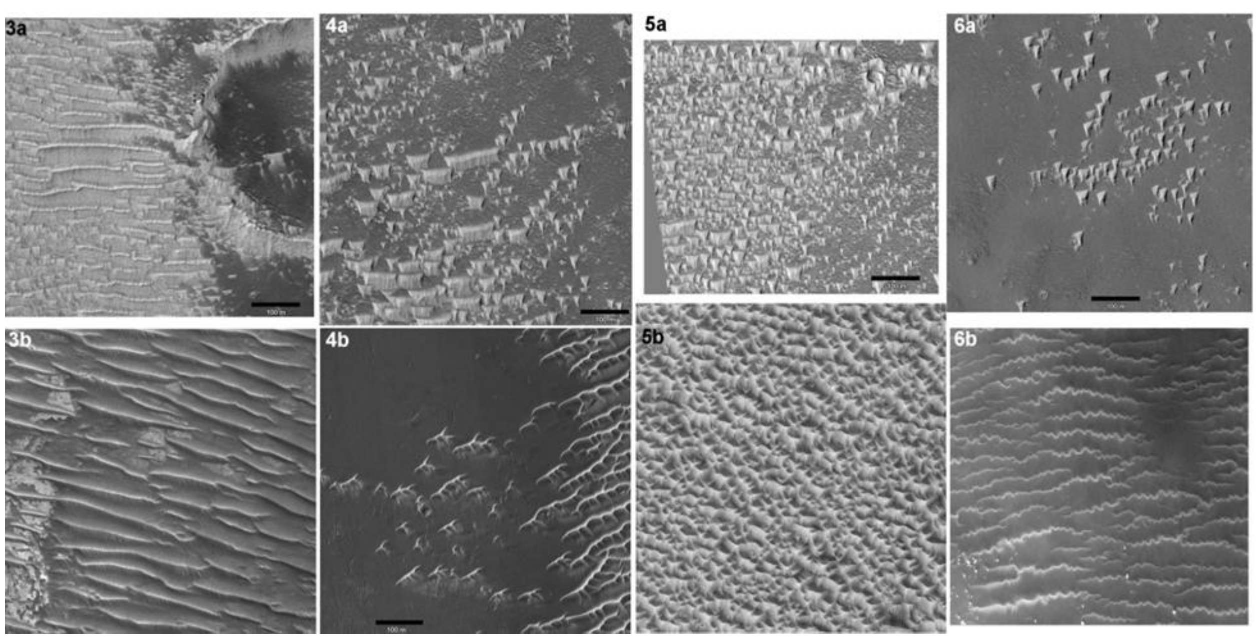

Figure 2. Morphological Evolution of Dust Drifts. Here we compare the shapes and sizes of modern day dust drifts in Syria Planum (a) with those of TARs elsewhere on Mars (b). All images are shown at the same resolution; the TARs that lack 100m scale bars have been rotated to match the geometry of the dust drifts. 3a: misaligned rows of deltoids. 3b: forked TARs in the Valles Marineris. 4a: short rows of deltoids along with deltoid pairs and triplets. 4b: Sanskrit TARs in Endeavor crater. 5a: unaligned deltoids. 5b: barchan-like TARs in Meriani Planum. 6a: staggered row of deltoids. 6b: sinuous TARs in the Southern Highlands.