PRELIMINARY RESULTS FROM A NEW STUDY OF TRANSVERSE AEOLIAN RIDGES (TARS) ON MARS.

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Introduction: Fields of small-scale, ripple-like aeolian duneforms display many similarities in morphology to low albedo dunefields in which dune wavelengths and individual duneforms are an order of magnitude larger. Both show complex structure and secondary modification of primary bedforms. Also, there is some evidence that the smaller bedforms show thermal signatures consistent with their being formed from finer-grained material than the large, dark dunes.

Introduction: On Mars, large dark dunes (LDDs) with wavelengths 100s to a few 1000s of meters and low albedo (typically < 0.15 [1]) are found in circumpolar and intracrater dunefields. The are likely formed from basaltic sand of particle size 500-1000mm [2]. However, high resolution Viking [3] and Mars Orbiter Camera Narrow Angle (MOC NA, [4]) images have revealed another distinct population of aeolian duneforms (termed "Transverse Aeolian Ridges"; TARs [5]) that are smaller and generally brighter than (or of similar albedo to) the surrounding terrain. Why are these duneforms different in albedo and size to LDDs? Does this reflect differences in particle size, composition, wind regime or sediment supply?

Many LDDs superpose TARs [4] but there are also examples of TARs superposing dark dunes [2, 4] and of TAR orientation being influenced by LDDs [2]. Also, crater counts on TARs in Nirgal Vallis [6] indicate that they ceased to be active 1.4 to 0.3 Myr ago. It seems, therefore, that some TARs formed recently, while others are relict, and that a temporal separation of TAR and LDD formation is unlikely.

The thin atmospheric and low gravity on Mars suggest that saltating grains have long trajectories and high kinetic energies [7]. Thus the spacing of TARS might be consistent with their being either extremely large ripples, or small transverse dunes. On Earth large ripples often have coarse particles size at their crests (thus often called "granule ripples" [8]), these particles being transported by reptation rather than saltation. Such a difference in formation style might explain the difference in scale and morphology between LDDs and TARs and it is this hypothesis that we test here.

Results: Possible criteria to distinguish ripples from dunes include: size (ripples tend to be smaller), morphology (ripples generally have neither complex/compound structure nor steep avalanche faces) and particle size (large ripples on Earth frequently have coarse particle sizes on the surface). While we accept that ripple sizes on Mars might be different, we note that barchanoid ridges with similar sizes to TARs do occur on Earth [9]. We have begun a new Study of TARS and testing our preliminary observations using these criteria has yielded interesting results:

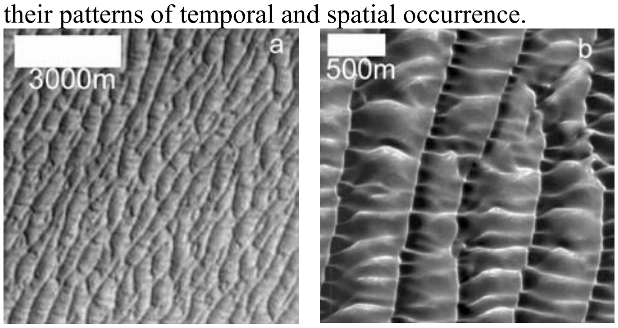
1) Scale invariance in morphology. Fig. 1a shows a THEMIS image of a field of LDDs from the north-polar sand sea that have simple barchanoid ridge structure. However, MOC NA imaging (fig. 1b) shows transverse structures within the interdune areas. TARs show similar structures but at much smaller scale (fig. 1c). At even higher spatial resolution, the MER Spirit Rover descent camera revealed what appeared to be simple TAR-like forms on the floor of endurance crater (fig. 2a) but Rover observations from the surface (fig. 2b) again reveal superposed network patterns. On Earth, complex structure is rarely observed on ripples, suggesting that these examples are small dunes.

2) Thermal properties and particle size. Using co-registered MOC NA and THEMIS IR images we have compared the thermal properties of TARs and LDDs. Fig. 3a shows TARS forming within channels adjacent to dark material containing barchan duneforms. Fig. 3b shows the same scene in THEMIS night-time images with the extent of the TAR and LDD material outlined. In the night-time image, areas covered by TARs are consistently slightly brighter than areas covered by dark dune material, suggesting that TAR material has thermal properties distinct from LDD material. The "low" thermal inertia of TARs has been noted before, but either using low resolution TES measurements [2] or not compared directly with LDDs [10, 11].

These results suggest that TAR material in this example has a smaller grain size than LDD material. Other explanations might be that the TARs have cm-scale dust cover, as suggested by [12] (although the surrounding terrain in our example does not show thermal signatures of such mantling) or that the 'interdune' areas and/or interiors of the duneforms are very fine grained but the surficial dune crests have large particle size, thus averaging out to the observed thermal properties. However, the simplest explanation is that TARs have lower thermal inertia than LDDs and are thus composed of finer graded, or perhaps compositionally distinct, material.

Conclusion: This preliminary study supports the idea that TARs are dunes rather than granule ripples. Interestingly, the thermal signature of TARs in fig. 3 suggests they are made up of finer material than LDDs and so should be more easily mobilized by wind, yet the superposition relations described above suggest that LDDs are generally more active. A wider study of LDD and TARs is necessary to identify whether thermal and superposition relations can be correlated.

Future research directions: We plan to perform crater counts on TAR fields; to search for duneforms with sizes intermediate between TARs and LDDs; to map spatial distribution and azimuthal orientations of TARs to compare with GCM wind regimes and to compare TAR and LDD particle size/superposition relations. Thus we hope to explain why TARs are distinct in size, morphology and albedo from LDDs and constrain their patterns of temporal and spatial occurrence.



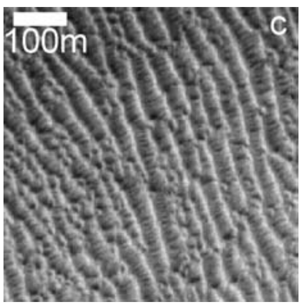


Fig. 1. Observations of TARs and LDDs. 1a (LDDs) is from THEMIS Visible V0435500, 1b (LDDs) from MOC NA E02-01879, 1c (TARs) from MOC NA R09-02119. Increasing transverse structure is visible as resolution is improved from 1a to 1b. Both TARs and LDDs show this structure.

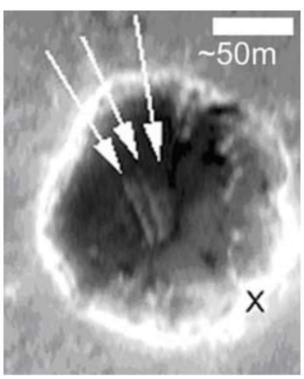


Fig. 2. Endurance crater. Arrows show possible TARS. X shows position of MER-B Rover when image shown in fig. 3 was taken. Image from MER-B descent imaging camera, NASA Planetary Photojournal image PIA05146.

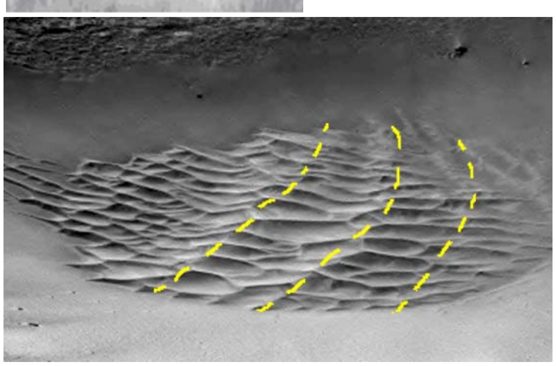


Fig. 3. Endurance crater duneforms from MER-B NavCam, sol 116. Dashes mark structures visible in fig. 2. Again, increase in resolution reveals transverse (network) structure.

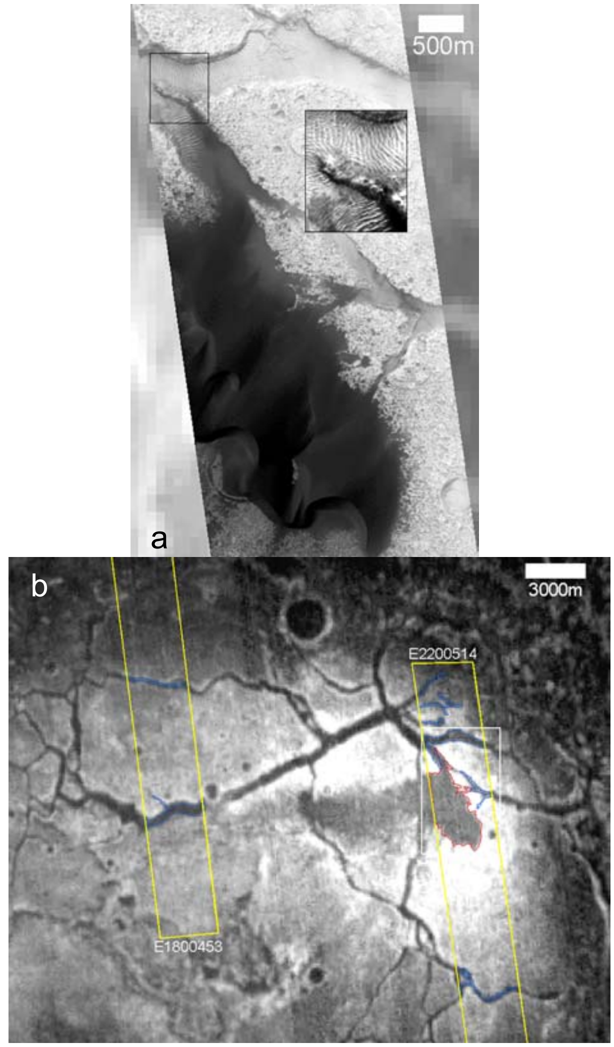


Fig. 4. Fig 4a shows a section of MOC NA image R09-02119. The dark material to the south contains barchan like slip faces and is presumably LDD material. The channel floor to the north is covered with TARs (see magnified inset). Fig 4b shows sections of THEMIS night-time IR images I05687011, I07547014, and I11104010. The area covered in 4a is outlined in white. TAR coverage from mapping using MOC NA images is outlined in red, LDD material is outlined in blue. Note the LDD material shows lighter tones than the TARs in the night-time IR image.

References: [1] Thomas, P. & C. Weitz (1989), Icarus 81, 185-215. [2] Fenton et al. (2003), JGR 108 (E12). [3] Zimbelman, J.R. (1987), Icarus, 71, 257-267. [4] Malin, M.C. & K. S. Edgett (2001), JGR 106, (E10). [5] Bourke, M.A. et al. (2003), LPS XXXIII, Abs. #2090. [6] Reiss, D. S. et al. (2004), JGR 109 (E06). [7] White, B. (1979), *JGR 84 (B9)*, 4643-4651. [8] Sharp, R.P. (1963), JGR *71*, 617-636. [9] Breed, C.S., & T. Grow (1979), in McKee, E.D. (ed.), USGS Professional Paper #1052. [10] Zimbelman, J.R., (2003), 6th Int. Conf. Mars, Abs. #3028. [11] Fergason, R.L. & P.R. Christensen (2004), LPS XXXV, Abs. #1710. [12] Fenton, L. K. & Fergason, R.L. (2004), LPS XXXV, Abstr #1974.