CROSS-SECTIONAL PROFILES OF RIPPLES, MEGARIPPLES, AND DUNES: A METHOD FOR DISCRIMINATING BETWEEN FORMATIONAL MECHANISMS.

J. R. Zimbelman[1], S. H. Williams[2], and A. K. Johnston[1], [1]CEPS/NASM MRC 315, Smithsonian Institution, Washington, D.C. 20013-7012, zimbelmanj@si.edu, [2]Ed. Div., NASM, MRC 310, Smithsonian Institution, Washington, D.C. 20013-7012.

Introduction: The distinction between ripples and dunes, two very common aeolian landforms in desert environments, is a consequence of differing processes active in the generation and propagation of both features. Here we present topographic profiles of sand ripples, megaripples, and small sand dunes, measured perpendicular to the crest of each feature. This information provides a useful method for discriminating between ripples and dunes for transverse aeolian bedforms observed on other planets.

Methodology: Several procedures were used to measure topography for features whose dimensions range over more than three orders of magnitude. A simple but elegant procedure for generating detailed profiles of sand ripples [1] was used to document active sand ripples with wavelengths of ~10 cm at Great Sand Dunes National Park and Preserve (GSDNPP) in central Colorado (Fig. 1). Megaripples, with wavelengths up to several meters, were measured relative to a laser line projected above the feature (Fig. 2); we measured megaripple profiles at GSDNPP and several locations throughout the Mojave Desert region in the southwestern U.S. [2-7]. For sand dunes, we used Differential Global Positioning System (DGPS) [8, 9] surveys to measure profiles across active (Fig. 3) and stabilized (Fig. 4) transverse dunes throughout the western U.S. [7]. Precision varies with each method but in general, the shadow measurement technique [1] provides horizontal and vertical locations to better than ~0.2 mm, the laser profiling technique provides horizontal and vertical locations to better than ~0.5 cm, and the DGPS points are reproducible to <2 cm horizontal and <4 cm vertical [8, 9].

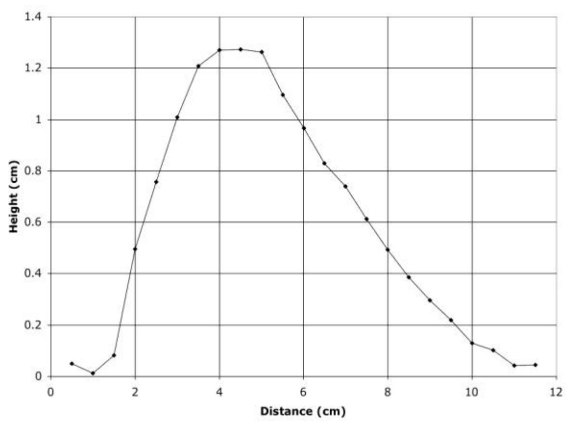

Figure 1. Profile across a sand ripple at GSDNPP, 9/18/03. Wind from the right. V.E. = 6.0X.

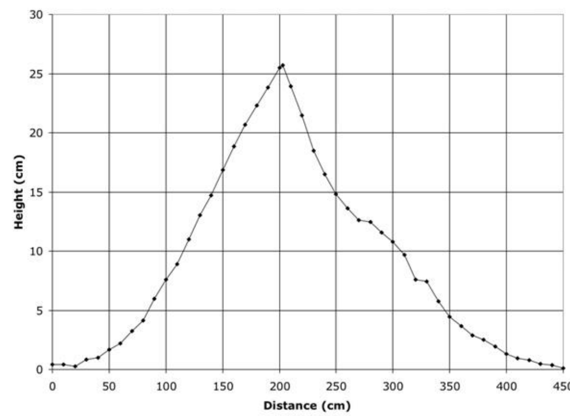

Figure 2. Profile across a megaripple coated with very course sand, GSDNPP, 9/20/02. Wind from the left. V.E. = 10.5X.

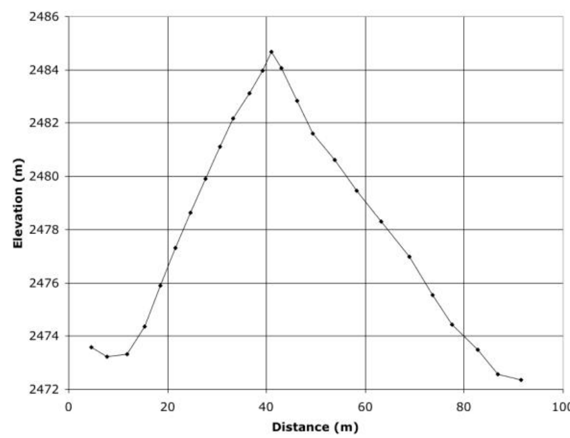

Figure 3. Profile across an active reversing sand dune, GSDNPP, 7/30/09. V.E. = 5.4X.

Results: The measured cross-sectional profiles show interesting similarities and differences between sand ripples, megaripples, and dunes. When all profiles (both distance and height scales) are normalized by the width of the feature (defined to be the breaks in slope at the base of either side of the feature crest), the shape of each profile is preserved while allowing for comparison of features of greatly different scale [10]. Sand ripples have a much broader, more rounded profile than profiles of either megaripples or dunes. The scaled height of megaripples is half that of either sand

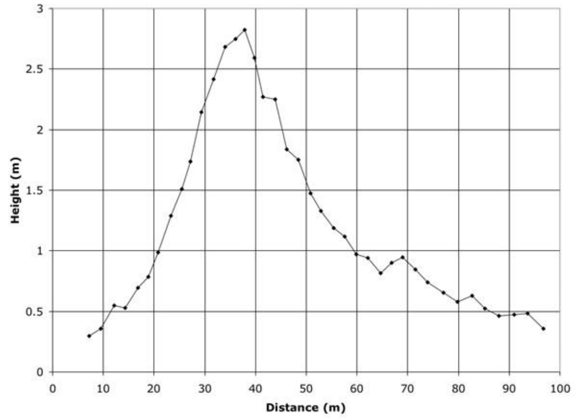

Figure 4. Profile across a stabilized transverse sand dune near Parker, AZ, 2/19/03. Wind from the left. V.E. = 24X.

ripples or dunes, and the megaripple profiles tend to be more symmetric than the profiles of either ripples or dunes (with the exception noted below). Dunes can have diverse profiles depending on the type of dune being studied; transverse dunes tend to have rounded overall shapes, stabilized transverse dunes have scaled heights that are half that of megaripples (and a quarter that of sand ripples or other dunes), and reversing dunes are the only dune type that yields profiles as symmetric as the profiles of megaripples.

Application to Mars: Measured field profiles were compared to profiles obtained through photoclinometry along transects from HiRISE images [10, 11] using the same width-scaling procedure described above [10] (Fig. 5). The HiRISE data reveals that Martian trans

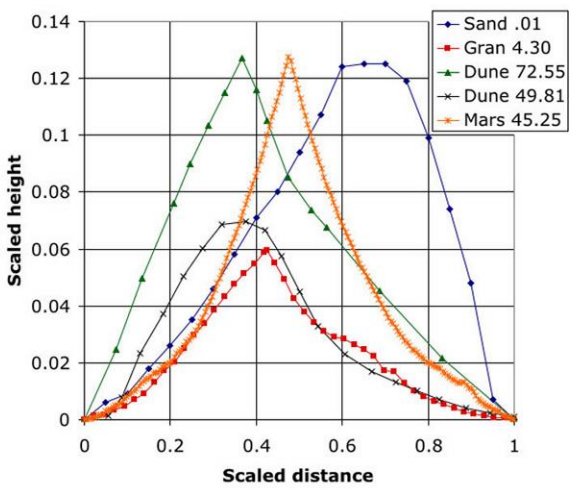

Figure 5. Profiles scaled by the width of the feature (widths, in m, indicated in inset box). 'Sand' is a sand ripple, 'Gran' is a granule-coated megaripple, 'Dune' (green) is a reversing dune, 'Dune (black) is an active transverse dune, 'Mars' is a TAR on Mars [10].

verse aeolian ridges (TARs) have incredibly symmetric profiles [10, 11]. TARs with (unscaled) heights <0.5 m most closely match the profiles of megaripples, while TARs with (unscaled) heights >1 m are closely matched to profiles of reversing dunes [10, 11]. Additional measurements of TARs from HiRISE images are underway [12], and it is hoped that the additional data will help to clarify where large megaripples and small reversing dunes may be distinguished on Mars.

Conclusions: Measurements of the cross-sectional profiles of sand ripples, megaripples, and small sand dunes provides a useful tool for attempting to discriminate between formation by ripple and dune processes. HiRISE images of Mars are sufficiently detailed that it now seems likely that most TARs on Mars can be distinguished as either megaripples or reversing dunes.

References: [1] Werner B.T. et al. (1986) Geology 14, 743-745. [2] Williams S.H. et al. (2002) LPS 33, Abs. 1508. [3] Wilson S.A. et al. (2003) LPS 34, Abs. 1862. [4] Zimbelman J.R. and Williams S.H. (2005) Spring AGU, Abs. P32A-4, JA363. [5] Zimbelman J.R. and Williams S.H. (2006) LPS 37, Abs. 2047. [6] Zimbelman J.R. and Williams S.H. (2007) GSA Aba Prog. 39(6), Abs. 218-5. [7] Zimbelman J.R. and Williams S.H. (2007) in The Geology of Mars (M. Chapman, Ed.), Cambridge Univ. Press, 232-264. [8] Zimbelman J.R. and Johnston A.K. (2001) in Volcanology in New Mexico, NM Mus. Nat. Hist. Sci. Bull. 18 (L.S. Crumpler and S.G. Lucas, Eds.), 131-136. [9] Zimbelman J.R. and Johnston A.K. (2002) NM Geol. Soc. Guidebook, 53rd Field Conf., 121-127. [10] Zimbelman J.R. (2009) 7th Int. Conf. Geomorphology, Melbourne, Aust., \Papers\236.pdf. [11] Zimbelman J.R. (in press), Geomorphology, doi: 10.1016/j.geomorph.2009.05 .012. [12] Shockey K.M. and Zimbelman J.R. (this volume).

[Supported by NASA MDAP grants NNG04GN88G and NNX08AK90G]