

**LARGE AEOLIAN RIPPLES: EXTRAPOLATIONS FROM EARTH TO MARS.** S. A. Wilson<sup>1</sup>, J. R. Zimbelman<sup>1</sup> and S. H. Williams<sup>2</sup>, <sup>1</sup>CEPS/NASM MRC 315, Smithsonian Institution, P.O. Box 37012, Washington, DC 20013-7012, wilsons@nasm.si.edu, jrj@nasm.si.edu, <sup>2</sup>Educational Services, NASM, MRC 305, P.O. Box 37012, Washington, DC 20013-7012, williamss@nasm.si.edu.

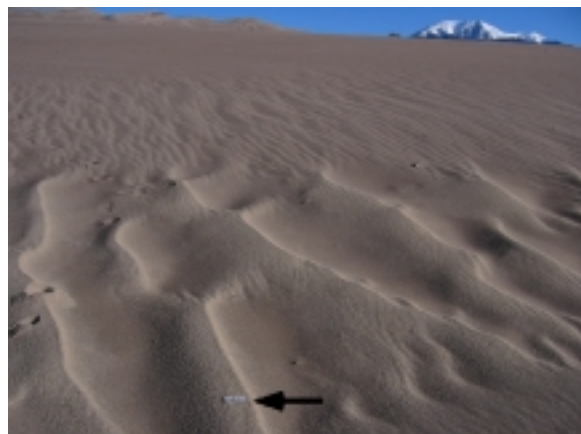
**Introduction:** The shapes produced on terrestrial surfaces that are continually subject to aeolian processes range in size from tiny ripples to giant dunes [1]. The physical mechanism of the formation of ripples, the smallest of aeolian bedforms, is intimately related to saltation and reptation processes. Sand and granule ripples are typically tens of reptation path lengths wide and do not alter the flow of wind that passes over them. Dunes are greater than tens of saltation path lengths wide, large enough to affect the local wind regime, and typically exhibit avalanche-generated slip faces on their lee side. On Earth, the differences between aeolian ripples and dunes are quite apparent and distinct [e.g., 1]. On Mars, however, the thin atmosphere leads to greatly increased saltation path lengths for sand-sized particles [2], which may cause the physical dimensions of large ripples and small dunes to overlap despite their unique formation mechanism [3, 4, 5]. Since bedforms intermediate between ripples and dunes are rare in terrestrial aeolian environments, the largest terrestrial granule-covered ripples are used as analogues for ripple-like bedforms on Mars as imaged by the Mars Orbiter Camera (MOC). Comparing the physical characteristics of granule ripples on Earth to ripple-like bedforms on Mars is useful to further the understanding of large ripple formation on both planets.

**Large Ripples on Earth:** Large terrestrial granular ripples vary with grain size and have wavelengths that range from ~1 m up to 20 m. We have documented several granule or pebble-covered ripples with wavelengths between 1 m and 10 m in the southwestern United States and at Great Sand Dunes National Monument (GSDNM) in Colorado. The ripples at all scales have a fairly consistent index (height/wavelength) that agrees with the 1/15 value given by Sharp [6], whereas the dunes at Parker, AZ, have a significantly different index (1/51), as compared to the ripples. Laser profiling of ripples (Figure 1) was conducted perpendicular to the crest axis to measure the wavelength, height and shape of granule ripples at GSDNM. Figure 2 depicts a field site where granule ripples were measured, and Figure 3 shows the resulting profile of distance versus height.

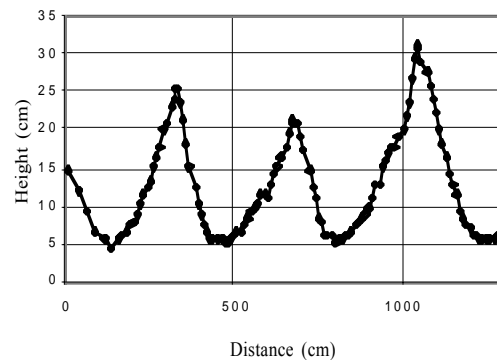
**Ripple-like Bedforms on Mars:** With its increased surface resolution, MOC has provided the detail necessary to document and examine ripple-like bedforms on Mars. These common bedforms are found in topographic depressions such as troughs and



**Figure 1.** Laser profiling of granule ripples at Great Sand Dunes National Monument.

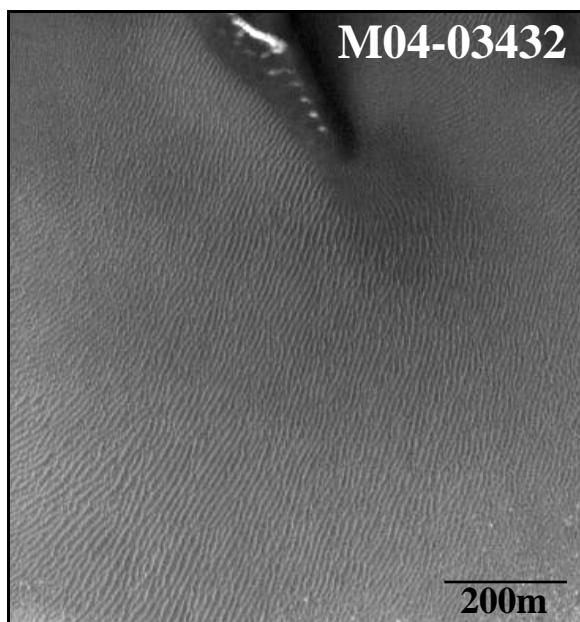


**Figure 2.** Site of laser profile in Figure 3 at Great Sand Dunes National Monument. Card is 10 cm (arrow).

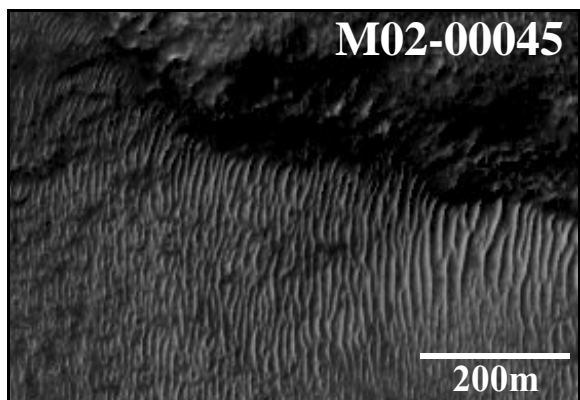


**Figure 3.** Profile of granule ripples (slope removed) in Figure 2 at Great Sand Dunes National Monument.

craters as well as around obstacles [7] and on flat plains. These aeolian features exhibit symmetric lee and stoss slopes and are commonly brighter than their surrounding, but some can also be dark toned or the same albedo as the surrounding material [7]. The majority of ripple-like bedforms in Sytris Major, Noachis, Phaethontis and Memnonia exhibit wavelengths between  $\sim 10$  m and 60 m although some exceed 100 m [8]. The majority of the ripple-like features on Mars have wavelengths too large to be aerodynamic (impact) ripples but are smaller than dunes and appear to lack slip faces. Figures 4 and 5 show typical ripple-like bedforms on Mars with wavelengths of 12 m and 13 m, respectively.



**Figure 4.** Ripple-like bedform on Mars with  $\sim 12$  m wavelengths, 2.77 meters/pixel, near  $52.36^{\circ}\text{S}$ ,  $326.92^{\circ}\text{W}$ . NASA/JPL/MSSS.



**Figure 5.** Ripple-like bedform on Mars with  $\sim 13$  m wavelengths, 2.78 meters/pixel, near  $40.35^{\circ}\text{S}$ ,  $320.73^{\circ}\text{W}$ . NASA/JPL/MSSS.

**Predicting Ripple Profiles on Mars:** Profiles of terrestrial ripples from GSDNM and Edwards as well as stabilized dunes at Parker, AZ, with wavelengths ranging from a few tens of centimeters to several meters, have been extrapolated up to 10 m (assuming linear horizontal and vertical scaling) to predict the cross-sectional aspect of ripple-like bedforms on Mars (Table 1). While current data are not easily amenable to measurement of cross-sectional aspect, the extrapolations produced here should prove useful for anticipated data from future missions to Mars.

Location	Wavelength	Height	Scaled Height
GSDNM	0.59 m	4.3 cm	73 cm
GSDNM	3.7 m	25 cm	68 cm
Edwards	9.7 m	60 cm	62 cm
Parker	128 m	2.5 m	20 cm

**Table 1.** Linear extrapolation between wavelength and height, scaled to 10 meters.

**Summary:** Large aeolian ripples on Earth are potential analogs to ripple-like features on Mars. The terrestrial ripple surfaces are covered by particles larger than medium sand (usually granules or small pebbles), raising the possibility that the Martian features also involve a bimodal distribution of particles. Extrapolation of large terrestrial ripples and small linear dunes provide potential quantitative parameters for evaluating whether the Martian ripple-like bedforms are more similar to either ripples or dunes.

**References:** [1] Wilson, I. G. (1972) *Sedimentology*, 19, 173-210. [2] White, B. (1979) *JGR*, 84 (B9), 4643-4651. [3] Bagnold, R. A. (1941) *The physics of blown sand and desert dunes*, Chapman and Hall, London. [4] Anderson, R. S. (1987) *Sedimentology*, 34, 943-956. [5] Anderson, R. S. and P. K. Haff (1988) *Science*, 241, 820-823. [6] Sharp, R. P. (1963) *J. Geology*, 71, 617-636. [7] Malin, M. C. and Edgett, K. S. (2001) *JGR*, 106 (E10), 23,496-23,499. [8] Wilson, S. A., and Zimbelman, J. R. (2002) *Geol. Soc. Am. Abstr. Programs*, Abstract 77-8.