LARGE RIPPLES ON EARTH AND MARS. S. H. Williams[1], J. R. Zimbelman[2], and A. W. Ward[3], [1]2035 Rockhurst Blvd, Colorado Springs, CO 80918, dr_swilliams@hotmail.com; [2]CEPS/NASM MRC 315, Smithsonian Institution, Washington, D.C. 20560-0315, jrz@ceps.nasm.edu; [3]Astrogeology Program, U.S. Geological Survey, 2255 N. Gemini Drive, Flagstaff, Arizona, 86001, wward@usgs.gov.

Introduction: Persistent alteration of the shape of a terrestrial surface undergoing active aeolian processes is documented on three different size scales: ripples, dunes, and draa [1]. The size of ripples, the smallest aeolian bedform, are in some way related to the distance sand grains saltate (bounce) along the surface under high wind conditions. The periodic forms of dunes and draa on Earth are much larger than the lengths associated with saltation. Bedforms intermediate in size between ripples and dunes occur rarely in terrestrial aeolian environments but are more common under water. Formation mechanisms are not clearly understood. Recent MOC images of Mars show that intermediate bedforms are very common. Comparative planetology can be used to learn more about the process of large ripple formation in general, and by analogy to the Martian surface environment.

Brief Background: Initial studies of ripples considered them to be directly related in size to the average distance a sand grain travels on a saltation hop, although with differing mechanisms for determining the saltation path length [2,3]. Anderson [4,5] makes the case that the key dimension linked to ripple wavelength is not the saltation length , but rather the displacement distance when grains are dislodged from the surface by a nearby impacting grain. Ripples larger in wavelength than that commonly found in fine sand (~15 to 25 cm) have been called a variety to names, but for simplicity we will use "large" to refer to ripples (on Earth) of wavelength >50 cm. Large aeolian ripples on Earth have been described at the Kelso Dunes and in Coachella Valley in southern California [3], at Rogers Dry Lake on Edwards AFB [6, 7], in the Libyan Desert [2], Namibia [8], Iceland [9], and the Algerian Sahara [10]. Next we summarize some of the attributes of large ripples on Earth, as described in the literature, and from our own observations.

Some Observations: Sharp [3] described 'granule' (particles 2 to 4 mm) ripples at Kelso with wavelengths of 0.25 to 2 m, a ripple index (RI, wavelenght/height) of 15, and the"upper part of a granule ripple has a prominent internal structure of well-developed foreset beds." Sharp [3] also described granule ripples in Coachella as somewhat larger than those at Kelso but with a comparable RI, consisting of granules 2 to 5+ mm in diameter at the crest but "beneath the surface (crown of granules) is a considerable admixture of normal wind-blown sand." Bagnold [2] describes 'ridges' with "wavelengths exceeding 20 meters and heights of over 60 cm" as being common in some parts of the Libyan Desert. At Great Sand Dunes National Monument (GSDNM) in Colorado, we observed granule (1-2 mm) ripples were present only where granules collected on aeolian sand near the stream source, ripple wavelengths up to 2 m with heights of up to 9 cm, granules veneer the ripple form but the ripple cores consist of unstratified sand, and granule motion by traction (rolling) without the aid of saltating sand was observed over a wet sand base during a strong front passage. At Edwards, ripples range from granule ripples like those at GSDNM to ripples of up to 9.7 m wavelength (Fig. 1). Much like at GSDNM, the ripples consist of a veneer of coarse particles over a core of fine sand and silt typical of the nearby playa surface. Beneath the coarse particle veneer the fine core is indurated; this resistant surface also is exposed in the flat areas between ripple crests (Fig. 2).

Figure 1. Large ripple at Edwards AFB. Wavelength is 9.7 m; ripple height is 60 cm. JRZ, 10/26/01.

Figure 2. Oblique view of Edwards large ripples over an indurated subsurface. Card is 20 cm. JRZ, 10/26/01.

We have combined our preliminary field results from GSDNM and Edwards AFB in the following summary plots, where there is a clear correlation between wavelength and height (Fig. 3), and also between wavelength and maximum particle size (Fig. 4).

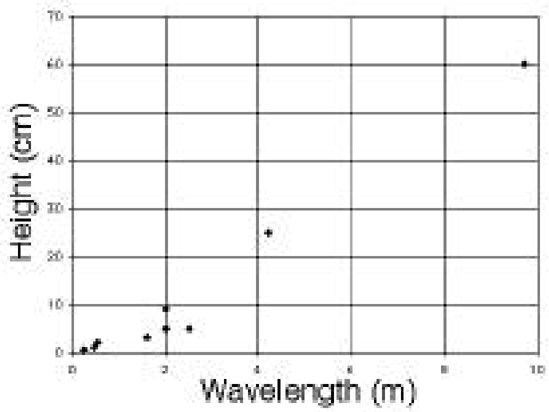

Figure 3. Ripple height as a function of wavelength. The slope of the plot corresponds to RI, giving a value of ~15, similar to the results of Sharp [3].

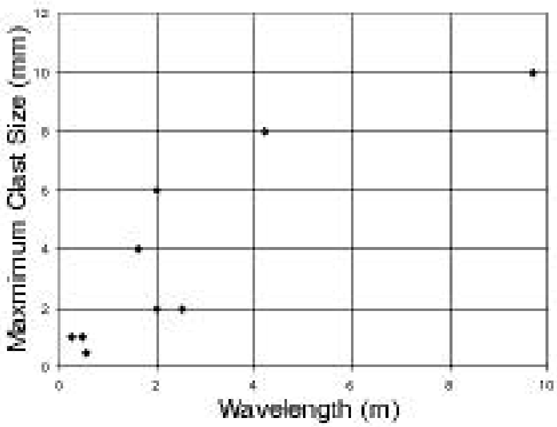

Figure 4. Ripple maximum clast size as a function of wavelength. From same ripples shown in Fig. 3.

Significance for Mars: Viking images revealed considerable evidence of dune fields and other aeolian features [e.g. 8], including hints of bedforms similar in size and form to large ripples on Earth [e.g. 11, 12]. MGS and MOC have greatly increased our ability to see meter to decameter-scale aeolian features [e.g. 13], including wonderful views of large ripple-like features [14, 15; Fig. 5]. The wavelength of the Martian ripples is up to many tens of meters, which is considerably longer than the scale of typical saltation path lengths on Mars [16]. Martian ripples veneered by coarse particles over a fine-grained core should be considered.

Prediction: Our results to date lead us to be confident that the THEMIS instrument on the Mars Odyssey spacecraft will be able to test whether ripple-like features on Mars follow the same physical relationships as

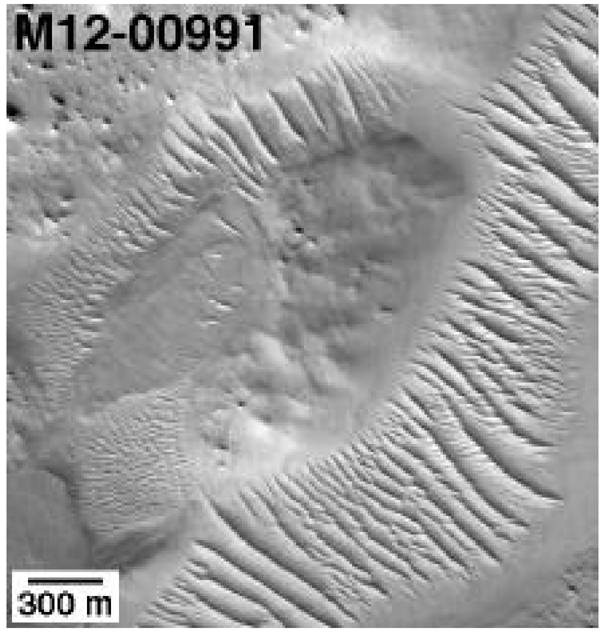

Figure 5. Large ripples on Mars, after Fig. 45A of [14]. Several wavelength scales are present at this location. MOC image M12-00991, 4.54 m/pixel, near 29.3°N, 299.8°W. NASA/JPL/MSSS.

large ripples on Earth (Figs. 3 and 4). Once Odyssey is in its mapping orbit, THEMIS will be able to make thermal infrared measurements with ~20 m spatial resolution. THEMIS images of ripple locations (e.g. Fig. 5) taken during Martian night should be able to determine, with a single thermal measurement, if there is a direct relationship between surface particle size and bedform wavelength.

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