GEOLOGIC ASPECTS AND RELATIONS OF SMALL EOLIAN DUNES AND LARGE RIPPLES ON MARS.

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Introduction: Large ripple-like and small dune-like eolian bedforms were observed to occur on the floors of troughs, impact craters, and other depressions in some of the highest spatial resolution images acquired by the Viking orbiters. Similar features were seen in pictures of the Viking 1, Viking 2, and Mars Pathfinder landing sites. Since the earliest Mars Global Surveyor Mars Orbiter Camera (MOC) narrow angle views (1.5–20 m/pixel) of September 1997 (*e.g.*, AB1-00406 [1]), a plethora of meter- and decameter-scale bedforms have been observed in thousands of images. As of January 2001, new pictures are obtained daily by MOC, and nearly 80,000 total have been acquired. The bedforms occur in a range of settings from the summits of the highest volcanoes to the floors of the deepest basins; they come in a variety of relative tones and shapes; many are found in a state of partial burial or exhumation; some have superimposed impact craters; and all are providing as-yet-undeciphered clues regarding the geologically-recent history of Mars.

General Features: Figure 1 shows the general nature of the "small eolian bedforms" on Mars. Fig. 1A shows bedforms in Auqakuh Vallis (M12-00991, 29.2N, 299.6W), Fig. 1B shows light-toned ripple-like bedforms surrounding knobs and in the shallow craters of Isidis Planitia (M10-02671, 18.1N, 272.4W). In both cases, the ripple-like forms surround local topographic highs in a pattern radial to their slopes, indicating local topographic control and, ultimately, an eolian origin for the landforms. The sharp crests and steep slopes of bedforms in Fig. 1A and the patterns reflective of local topography in Fig. 1B are reminiscent of terrestrial "granule ripples" [2] and/or "megaripples" [3]. Terrestrial granule and megaripples are typically composed of granules and sometimes very fine to fine pebbles, and they form largely via saltation impact/traction in areas of eolian deflation.

Distinct from Large Dunes: The small ripple-like bedforms are distinct from the larger eolian dunes that have been known since Mariner 9. All large martian dunes and dune fields have relatively low albedos (*i.e.*, <0.15) and no light-toned or high albedo (*i.e.*, >0.20) large dunes have ever been observed. In contrast, many of the small eolian bedforms have lighter-tones [4]. Indeed, in places where the two types of bedforms occur together, it is often observed that the larger, dark-toned dunes are over-riding the smaller, lighter, ripple-like bedforms [5]. Figures 2A and 2B show examples (arrows), the first is in the Nili Patera caldera (M10-01512, 9.1N, 293.0W), the second in northeastern Syrtis Major (M11-01038, 17.1N, 282.3W). Granule ripples superposed on the eroding portions of some large dunes are also observed, as seen in Fig. 2C amid springtime retreating frost on dark-toned dunes in Hellespontus near 47.6S, 326.2W (M02-01818).

Relative Albedo: As noted, small eolian bedforms, or ripple-like (or dune-like) bedforms occur in a variety of settings, from the tops of the highest martian volcanoes [6] to the bottoms of the deepest basins. Unlike the larger dunes known since Mariner 9, these smaller bedforms can have relatively high albedos (*i.e.*, as high as ~0.30 [4]) but may come in a range of relative and absolute albedos that may be reflective of mineral composition, particle size, or both. Figure 3 shows the three basic relative tones—Fig. 3A shows light-toned bedforms on a dark-toned substrate (Terra Sabaea, M02-03360, 6.6S, 343.3W), Fig. 3B shows dark-toned bedforms on a lighter-toned substrate (NE Hellas, M00-01300, 27.5S, 282.6W), and Fig. 3C exhibits bedforms of an albedo that is indistinguishable from the adjacent and surrounding terrain (Tractus Catena, SP1-26703, 26.0N, 101.3W). The latter is, like many similar examples in the greater Tharsis region, mantled by more than a meter of fine-grained material apparently settled from suspension.

Exhumation and Cratering: Many of the small bedforms found today at the martian surface may be relatively old and inactive. Those that are over-ridden by larger, dark dunes (Figs. 2A, 2B) suggest that they are less-active than the dark dunes. Still others, as at the arrows in Figs. 4A (M19-01045, 6.1S, 228.0W) and 4B (M19-01839, 13.0S, 160.8W) are in various states of being exhumed from beneath a meters-thick mantle (in Fig. 4A, arrow 1 indicates bedforms completely mantled, arrow 2 shows the underlying bedforms have a light tone, and arrows 3 show several that are emergent from beneath the mantle). The relative age of some small eolian bedforms are also indicated by cratering. Those shown in Figs. 4C (M19-02044, 5.5S, 83.9W) and 4D (M22-02408, 13.4N, 202.6W) have small (10s of meters) impact craters superposed upon them (arrows).

References: [1] Malin M. C. and Edgett K. S. (2000) *LPS XXXI*, No. 1069. [2] Sharp R. P. (1963) *J. Geol., 71*, 617–636. [3] Greeley R. and Iversen J. D. (1985) *Wind As A Geological Process*, Cambridge Univ. Press, New York. [4] Thomas P. C. *et al.* (1999) *Nature, 397*, 592-594. [5] Edgett K. S. and Malin M. C. (2000) *J. Geophys. Res., 105*, 1623-1650. [6] Edgett K. S. and Malin M. C. (2000) *LPS XXXI*, No. 1072.

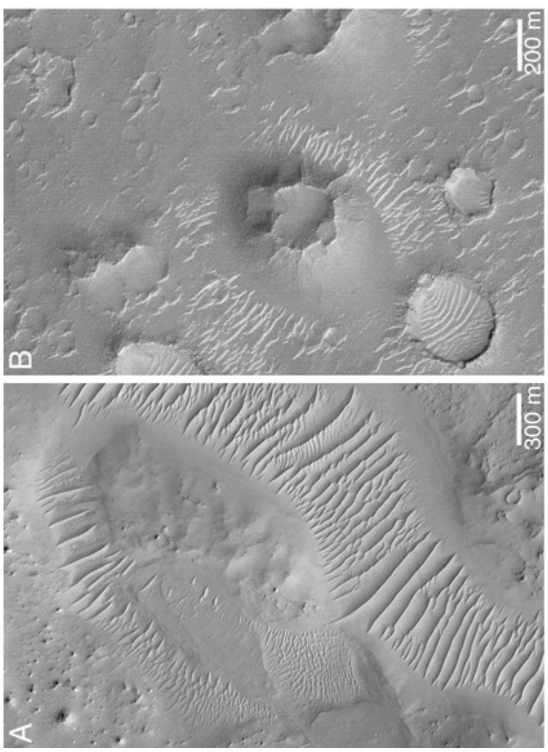

Figure 1

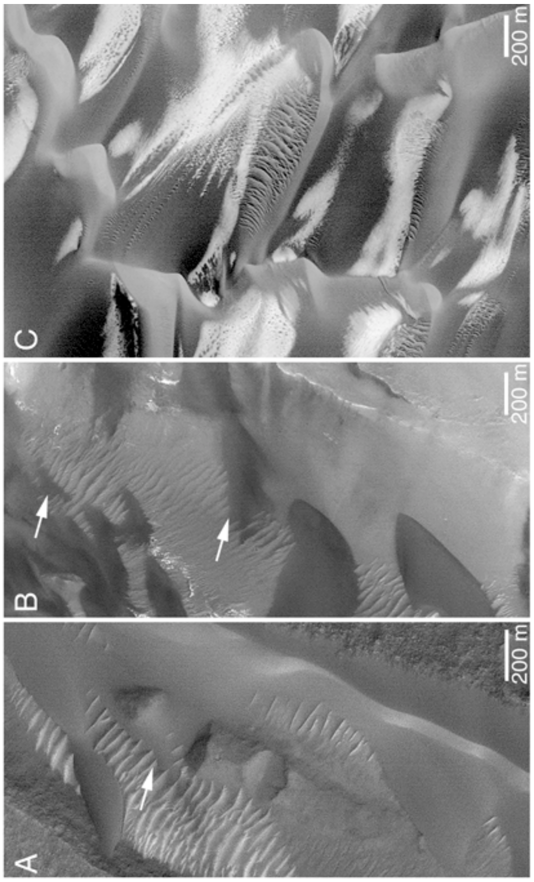

Figure 2

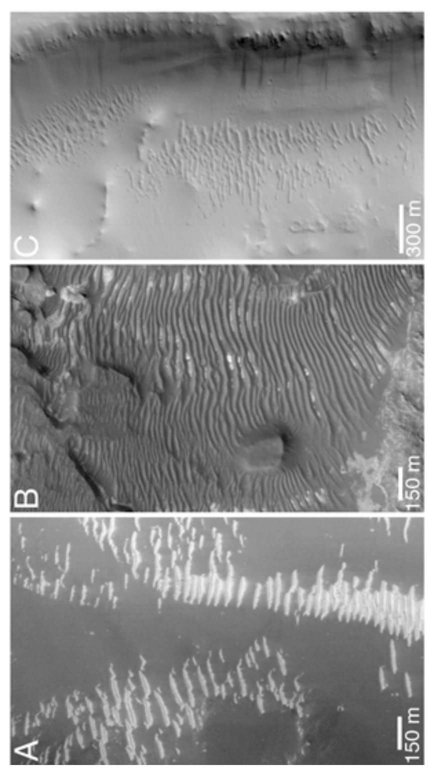

Figure 3

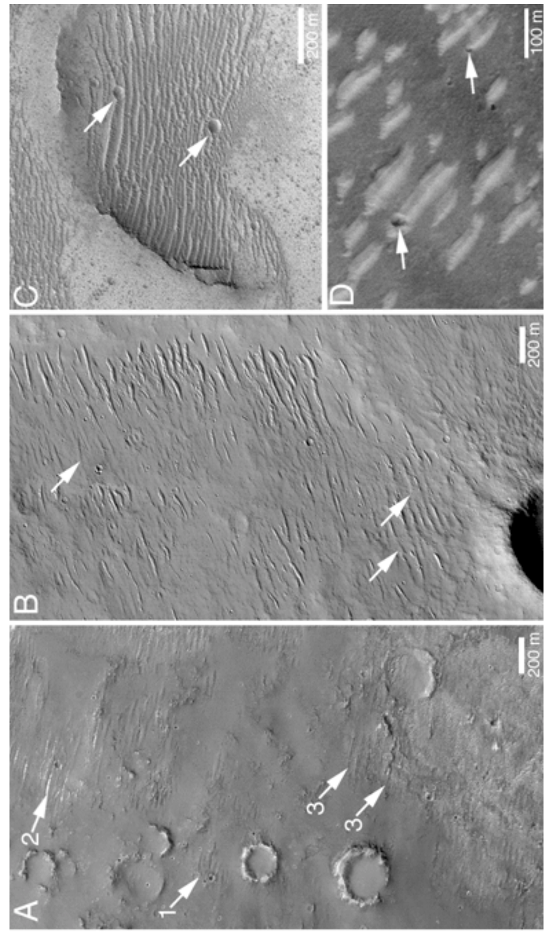

Figure 4