

Sinuuous Longitudinal Large Ripples on Barchanoid Bedforms, Herschel Crater, Mars. E. Visick¹ and M.W.Telfer²

¹ University of Plymouth, Drake Circus, Plymouth, Devon, UK (elizabeth.visick@plymouth.ac.uk), ² University of Plymouth, Drake Circus, Plymouth, Devon, (matt.telfer@plymouth.ac.uk).

Introduction: Images from the Mars Global Surveyor (MGS) Mars Orbital Camera (MOC) provided a step-change in resolution of Mars remote sensing, and over a nine-year (1997-2006) period, provided relatively high-resolution (<12 m/pixel) coverage of ~5% of the surface of Mars [1]. Although many of the science highlights related to the evidence of the presence of past surface water, many aeolian bedforms were observed, and many were repeatedly observed to search for evidence of dune migration [2]. Despite the improved resolution of the sensor, relatively little evidence of aeolian movement was observed, and most of the attention of dune ‘activity’ focused on gullying [3]. Indeed, one of the principle conclusions drawn from these investigations was that some of the dunes appeared to be affected by subsequent aeolian erosion, inferring that the dunes had become indurated to such an extent that they were prone to subsequent erosion, effectively becoming superimposed with yardangs [3,4,5].

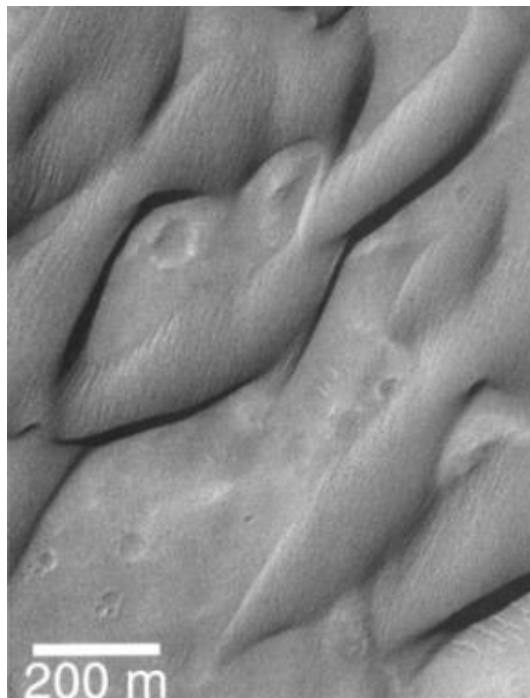


Fig. 1. Cropped detail of figure 22 from Edgett and Malin (2000); (MOC image M00-03222), illustrating apparently grooved surfaces of the dunes, interpreted as post depositional erosion of now-indurated dunes.

Barchans (some highly asymmetric) and barchanoid ridges of Herschel Crater (around 15.34°S, 228.19°W) were typically cited to exemplify these indurated dunes, with MOC M00-03222 in particular used repeatedly to highlight these bedforms. Such intact, indurated and subsequently eroded dunes would be almost without a terrestrial analogue.

Background - Improved resolutions and a reinterpretation: The general narrative that modern-day aeolian dune activity on Mars was very limited, and that the dunes appeared largely relic bedforms, was challenged by the order-of-magnitude improvement (~0.25 m/pixel) in spatial resolution brought along with the High Resolution Imaging Science Experiment (HiRISE) sensor on the Mars Reconnaissance Orbiter (MRO), entering orbit in 2006 [6]. The implied aeolian dynamism of the landscape was quickly recognized [7], though it was not until four years later than the first quantified observations of (large) ripple migration were made [8]. Closer inspection of the surface of the ‘indurated dunes’ of Herschel Crater, however, revealed that they were not erosional textures, but a lower order of depositional bedform, oriented predominantly parallel to the direction of the winds that can be inferred as forming the dunes (roughly NNE to SSW) [7]. More recently, a barchan dunefield in western Herschel Crater has been observed in repeated HiRISE imagery, and migration rates for the (large) ripples calculated [9]. However, the site originally identified as appearing unusual in the MOC images has not been reinvestigated in detail with the benefit of the improved resolution of HiRISE imagery; this study aims to address this, by exploring HiRISE data from central Herschel crater to explore the occurrence, and possible formative mechanisms, of the unusual bedforms that once led to the interpretation of erosional features on the surface of these dunes.

Methods: We use modified versions of an automatic crest detection algorithm [10] to map the crest-lines of large ripples on the surface of dunes in central Herschel crater, and analyzed within a GIS framework using ESRI ArcGIS Pro. Analysis is being conducted on HiRISE images, collected from 2010-2017. A primary question for analysis is why the apparently grooved texture was evident on these dunes, near the

middle of Herschel crater, and not other, similar dunes in the same region.

Results and Discussion: Preliminary analysis of the data confirms the existence of two sets of metre-decametre scale ripples, nearly orthogonal to each other, with (large) arcuate/sinusoidal ripples, oriented approximately parallel (longitudinal) to the NNE-SSW orientation of the dune, abundant on the upon back of the dune on which they sit (Fig 2). On the dune flanks, straight, simple (large) ripples are oriented parallel to the dip of the topography, and near transverse to the winds implied by the orientation of the dune, suggesting that here, topography is the dominant control on orientation [9]. Both are observed to move during the interval of observation (2010-2017).

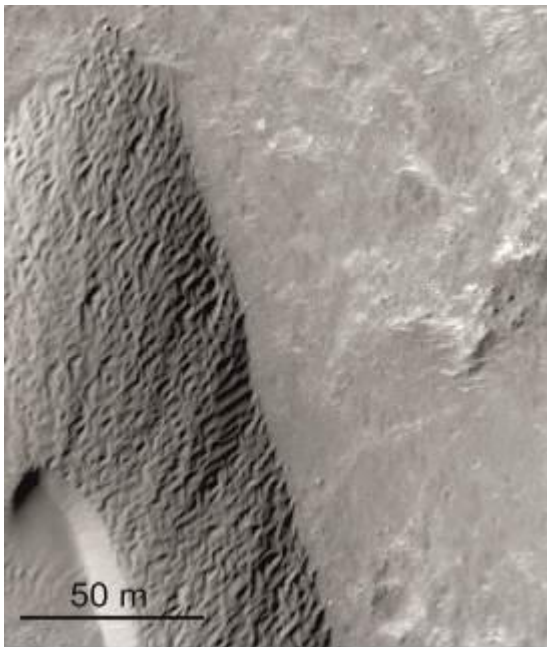


Fig 2. Detail of the snout of an asymmetric barchan, oriented approximately N-S. Note N-S oriented sinuous large ripples on the dune back, and E-W oriented ripples on the flank (ESP_016916 Image: NASA/JPL/University of Arizona).

Preliminary quantitative analysis of crest detection demonstrates the potential for successful mapping, but highlights the likely need for independent applications of the algorithm for transverse and longitudinal bedforms (Fig 3). Such mapping will be used to quantify ripple migration.

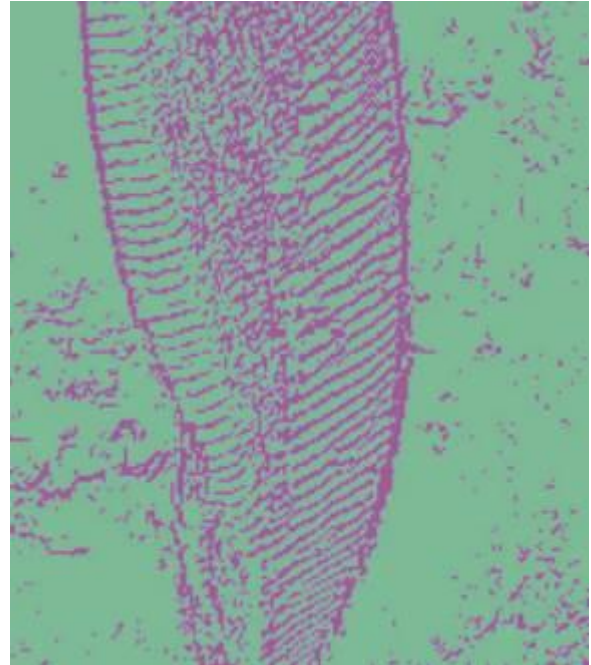


Fig 3. Preliminary automated mapping of transverse bedforms on the dune flank. Note that bedforms on the dune back are poorly delineated here due to the directional filters, but can be refined by adjusting these filters.

Preliminary conclusions: Dune textures once suggested to represent erosional surfaces have, since the availability of HiRISE data, been recognized as depositional bedforms, yet have lacked further analysis. Initial analysis of the bedforms suggests that the patterning is largely dominated by approximately longitudinal, sinuous large ripples, with the flanks dominated by bedforms with slope-determined orientation. Further analysis will focus on identifying why these dunes exhibit the pronounced sinuous longitudinal ripples on their surface.

References:

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