Do Large Dunes on Mars Migrate? Ripple and Dune Movement in Coprates Chasma, Valles Marineris.

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Introduction

For this study, we have measured and compared the rate of ripple migration on the stoss side of some of the largest dunes on Mars to the crest movement over a 7-year time period, measuring both long term movement aswell as seasonal change.

Study Site

The study site is a large 111km² dune field in Southern Coprates Chasma, situated in the eastern part of Valles Marineris.
The dune field is interesting for two main reasons:

first the dune field has a potential source region located 35km west of the dune field, offering an insight into source to sink systems and erosion rates on Mars.

Second, the dune field contains barchan, barchanoid and longitudinal dunes with mean heights of ~100m, with the largest dunes reaching ~250m.

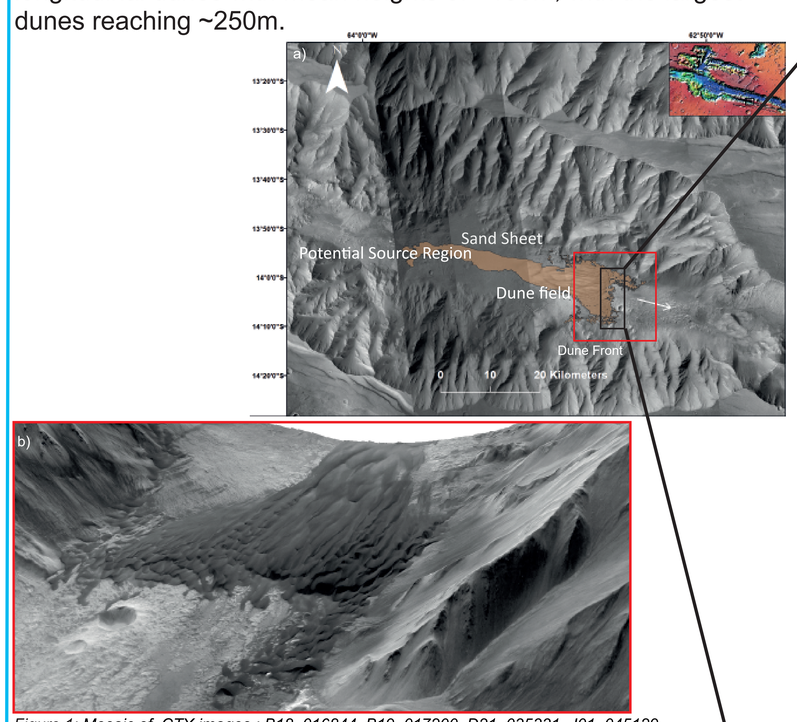

Figure 1: Mosaic of CTX images : B18_016844, B19_017200, D21_035331, J01_045129, B22_018123, P08_004067 and D08_030439, credit: NASA/JPL/University of Arizona.The context image shows the location of the dune field within Valles Marineris highlighted by the black square. The black box over the dune field shows the location of figure 3.The red box shows the location of b. b) The dune field within Coprates Chasma showing the steep slopes of the valley.

Ripple Displacement

The displacement of the ripples range from 0.7 to 18.3m over the full 7 years with a mean and standard error of 6m ± 1m.

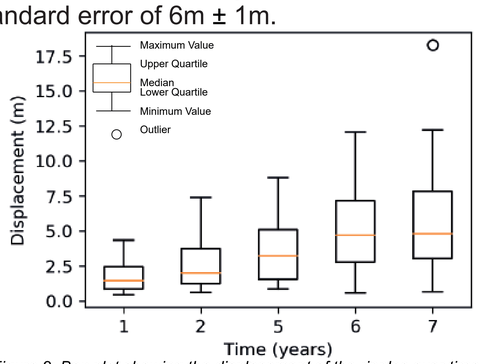

Figure 2: Box plot showing the displacement of the ripples over time. The ripples have migrated larger distances over time as expected.

Dunes 2,10 and 18 consistently show higher displacement, which may be due to the winds present. These dunes are in the centre of the valley, where there could be a channeling of the winds, leading to higher and more frequent winds and greater displacement of the ripples.

The ripple flux was calculated for each dune for each time period. Minimum flux calculated was 0.04 and maximum flux 1.74m²yr⁻¹ with a mean of 0.45m²yr⁻¹.

Methods

Ripple displacement has been measured by using subpixel correlation of images from the High resolution Imaging science experiment Camera (HiRISE 25 cm/pixel [1]) with the co-registration of optically sensed images and Correlation (COSI-Corr) software package [2]. Stacked profiles over 21 dunes at the dune front have been averaged to give a ripple displacement rate.

Dune crests: Dune crest movement has been tracked and analysed by manually mapping out the crest shape of the dunes over the same time period as the ripple migration.

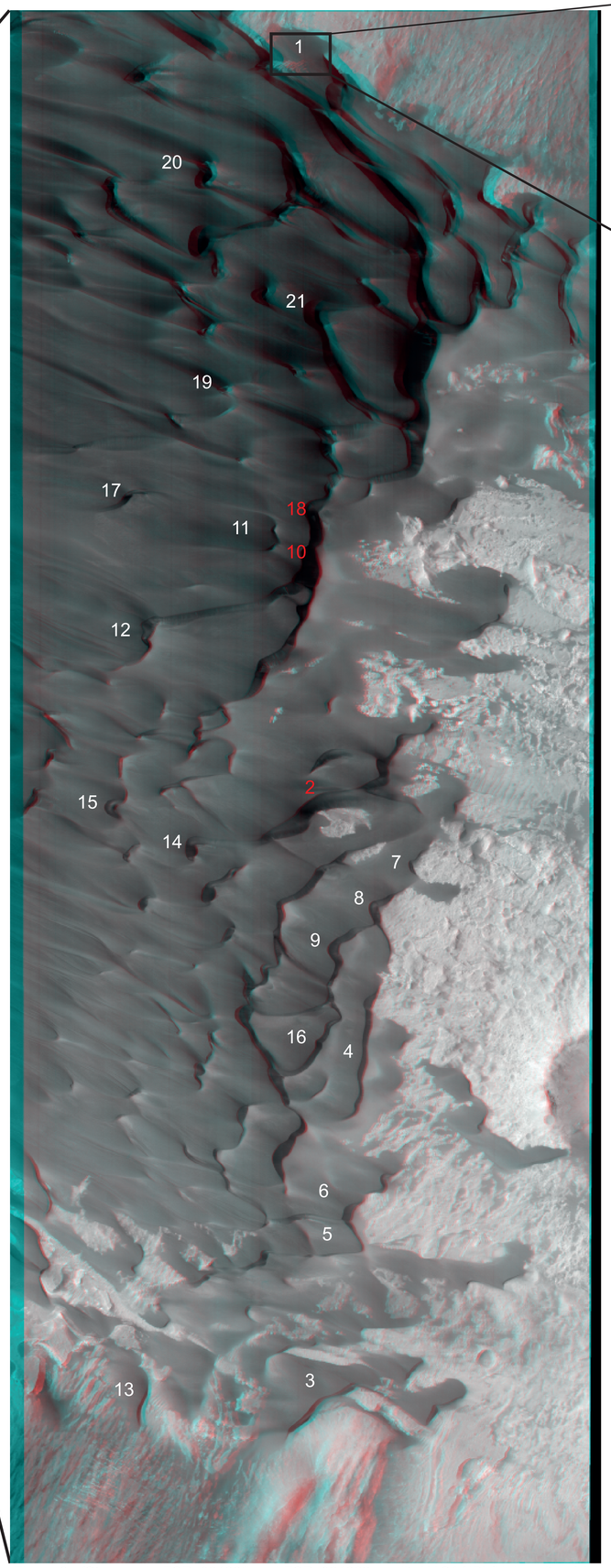

Figure 3: (Stereopair: ESP_031995 and ESP_031929 credit: NASA/JPL/University of Arizona) 3D image of the dune front where both ripple and dune crest measurements were taken across the 21 dunes labelled.

Dune Crest Displacement

The dune crest displacement varies much more widely over time as the crest morphology changes with time. The co-registration error has been calculated as 0.09m, which is less than a pixel (25cm).

The displacement of the dunes ranges, -2 to 4.6m over the full 7 years with an average of 0.06 ± 2.2m.

Dune 1 has a higher displacement for all time periods than the other dunes, likely to be due to slope winds and katabatic winds travelling down the valley walls.

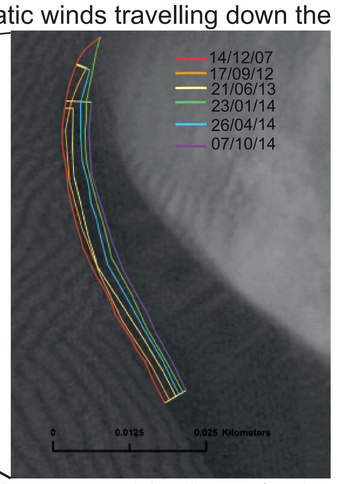

Figure 4: Dune crests traced along the crest of the dune for each time period. HiRISE image credit: NASA/JPL/University of Arizona

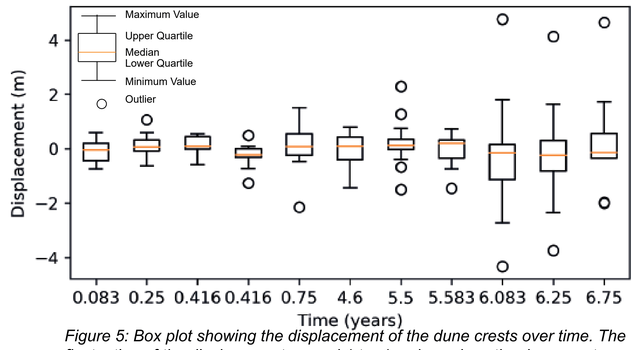

Figure 5: Box plot showing the displacement of the dune crests over time. The fluctuation of the displacement around 1 to -1m shows how the dune crest morphology has changed over time. There are several outliers seen, most of which are displacement values from dune 1.

Dune crest flux was calculated for each of the dunes for each time period.

Minimum flux calculated was 0.04m²yr⁻¹ and maximum flux was 1409m²yr⁻¹ with a mean of 35m²yr⁻¹.

Comparison of Ripple Displacement to Dune Crest Displacement

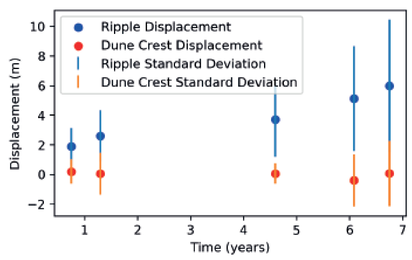

Figure 6: Scatter plot showing the average displacement and standard deviation of both the ripples and the dunes over time.

The dune crest displacement is much smaller than the ripple displacement, this is due to the size of the dunes being larger than the ripples and therefore the volume of sand moving is much greater, explaining the larger crest flux. Both the ripple displacement and the dune displacement was greater in the centre of the valley suggesting a channeling of winds down the valley.

References and Acknowledgements:
[1] McEwen,A.S.,et al,J.Geophys.Res.E: Planets, 112, E05S02,2007. [2] Leprince, S., et al, IEEE J. Geosci. Rem. Sens. 45, 1529–1558, 2007.
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