EPSC Abstracts
Vol. 13, EPSC-DPS2019-721-1, 2019
EPSC-DPS Joint Meeting 2019

EPSC
EPSC-DPS Joint Meeting 2019
15–20 September 2019 | Geneva, Switzerland

Variably dusty yardangs in Mars' Olympus Maculae

Kirby Runyon (1), Kim Seelos (1) and Charlene Detelich (2)
(1) Johns Hopkins APL, Laurel, MD, USA, (2) Department of Marine, Earth, and Atmospheric Sciences, North Carolina State University, Raleigh, NC, USA, USA. (kirby.runyon@jhuapl.edu)

Abstract

The low-dust Olympus Maculae are a geologic window to the local volcanic and aeolian stratigraphy. They display dust-cover changes associated with the 2018 global dust storm and dust devils, which are confined to the maculae. Local yardangs indicate cyclic erosion and deposition and thus strong wind, and yet we have not observed ripple movement within dark sand deposits.

1. Introduction

The Olympus Maculae are a series of discrete, generally low albedo km-scale patches along a section of the western Olympus Mons aureole deposit within the Medusae Fossae Formation (MFF; Figure 1; [1]), interpreted as an aeolian-modified volcanic ignimbrite [e.g., 2]. In nighttime infrared THEMIS observations, they appear brighter than their surroundings, indicating qualitatively higher thermal inertia, and show other evidences of having anomalously low dust cover. They are spatially associated with an aeolian-dominated terrain consisting of yardangs, sand patches, and low- and high-dust areas, including dust devil tracks. Here, we report on a dust and sand change detection campaign using high resolution orbital imagery that both pre- and post-dates the 2018 global dust storm. We also describe apparent repeated formation and degradation of yardangs.

2. Methods

We analyzed High Resolution Imaging Science Experiment (HiRISE; [3]) and Context Camera (CTX) images of the Olympus Maculae to characterize the geomorphology and search for aeolian changes between repeated images acquired at multiple locations. We used the full pixel scale of HiRISE (0.25-0.5 m/px) to search for sand ripple changes and the browse images (~6 m/px) to characterize more general changes in dust covering. We constructed "false orthoimages" of the browse images by slaving later-acquired images to the dimensions and aspects of an earlier image using the Auto-Align Layers feature in Adobe Photoshop along with manual adjustments. This alignment of time-series images allowed semi-quantitative identification of changes.

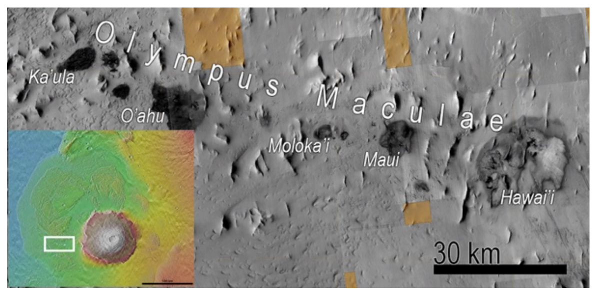

Figure 1: Location and visible appearance of the Olympus Maculae on the aureole deposit of Olympus Mons (CTX and High Resolution Stereo Camera data). Inset basemap: MOLA and THEMIS data; scale bar is 500 km. Individual names are informal nicknames after the Hawaiian Islands. Images from CTX, HRSC, MOLA, and THEMIS. Mosaicked in JMARS and Google Earth. Credit: NASA, ESA.

3. Results

HiRISE images taken after the 2018 global dust storm show that the maculae shrank and the borders became more diffuse. Cross bedding in the underlying lithology became less apparent due to increased dust cover following the dust storm. Dark, subparallel ~100 m long streaks interpreted to be dust devil tracks (trending WNW to ESE) appeared following the dust storm (Fig. 2). One active dust devil and its shadow were spotted within a macula. No dust devil tracks are visible beyond the macula borders.

Dark sand patches are scattered throughout the area, though no dunes are present. Aeolian sand ripples with meter to decameter wavelengths superpose all the sand patches. No detectable ripple movement occurred in time series spanning over 10 Earth years, which includes pre- and post-dust storm as well as sand patches with recent dust devil tracks.

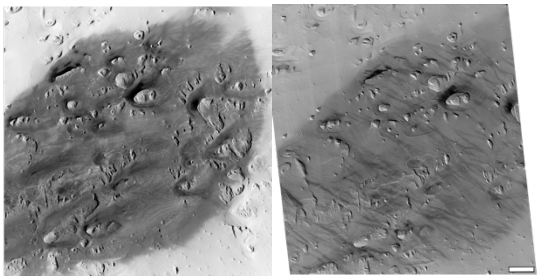

Figure 2. Dust changes in the macula Ka'ula include boundary position, sharpness, banding visibility, and dust devil tracks. Dust devils appear confined to the macula. 500 m scale bar. HiRISE PSP_009502_1980 (2009; left) & ESP_058213_1980 (2018; right); Credit: NASA/UA.

Most yardangs interior and exterior to the maculae are composed of pronounced U-shaped moats upwind of each streamlined outcrop. However, various morphologies are interpreted to capture different stages of formation and degradation (Fig. 3) and can be partially filled, display cross bedding, have concentric moats; have various dust coverings, etc.

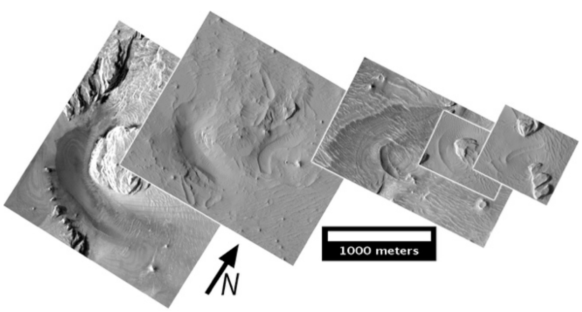

Figure 3. Examples of yardangs and windward erosional moats in O'ahu macula. The morphology progresses from well-defined to very degraded, left to right. Dark sand and cross bedded layering is evident in low-dust areas. Subframes from HiRISE PSP_003450_1975; Credit: NASA/UA.

4. Discussion

The aeolian ripples are stationary on terrestrial decade timescales, yet changes in dust deposition and dust devil tracks reveal windy conditions at the present; yardangs and a paucity of superposing craters show extensive aeolian activity in the very recent past. Elsewhere on Mars, ripples are seen to move substantially on month-long timescales [4,5]. This surprising lack of sand movement may be analogous to the El Dorado ripples explored by the Spirit rover, and proposed by Sullivan et al. [6] to be as a result of ripple induration and clumped dust aggregates that inhibit migration.

5. Summary and Conclusions

The anomalously low-dust Olympus Maculae have changed pre- to post-2018 dust storm and are strongly affected by intensely localized dust devil activity. Local yardangs reveal multiple, cyclic episodes of aeolian erosion and burial. Future work will model the origin, evolution, and overall persistence of the low-dust maculae.

Acknowledgements

Support acknowledged from NASA MDAP grant 80NSSC17K0451 and the Oak Ridge Institute for Science and Education.

References

[1] Detelich, C.E., Runyon, K.D., and Seelos, K.D.: Characterizing anomalous wind eroded terrain on Mars: the Olympus Maculae, LPSC, Houston, USA, Abstract #1861, 2019.

[2] Mandt, K.E., de Silva, S.L., Zimbelman, J.R., and Crowbn, D.A.: Origin of the Medussae Fossae Formation, Mars: Insights from a synoptic approach, JGR, 113, doi:10.1029/2008JE003076, 2008.

[3] McEwen, A.S., et al., Mars Reconnaissance Orbiter's High Resolution Imaging Science Experiment (HiRISE), JGR 112, doi:10.1029/2005JE002605, 2007.

[4] Bridges, N.T., Ayoub, F., Avouac, J-P., Leprince, S., Lucas, A., and Mattson, S., Earth-like sand fluxes on Mars, Nature, 485, doi:10.1038/nature11022, 2012.

[5] Runyon, K.D., Bridges, N.T., Newman, C.E., Martian sand sheet characterization and implications for formation: A case study, Aeolian Research, 29, doi: 10.1016/j.aeolia.2017.09.001, 2017.

[6] Sullivan, R., et al.: Wind-driven particle mobility on Mars: Insights from Mars Exploration Rover observations at ''El Dorado'' and surroundings at Gusev Crater, JGR, 113, doi:10.1029/2008JE003101.