Spatial analysis of the 2018 global dust storm on Mars in the Valles Marineris region using ArcGIS

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Abstract

During the 2018 Mars opposition a global dust storm developed in the period from May to July and declined again in September. Interestingly, when the storm vanished an accumulation of dust could be detected at several locations, e.g. the Valles Marineris region. In order to correlate local topographic features with the distribution of dust we have investigated the nature of the terrain in the Valles Marineris region using ArcGIS software and detailed elevation data of Mars. Spatial analysis using ArcGIS seems to be a useful tool to obtain more insight in dynamic features on Mars and other planets.

1. Introduction

Mars was imaged during the 2018 apparition using a C8 Schmidt-Cassegrain Telescope (E.S., Curaçao) and a C14 (J.S., Houten, The Netherlands), respectively. Since the altitude of Mars was the highest on Curaçao (54° as compared to 14° in The Netherlands) and this Caribbean island has often excellent seeing conditions, the most detailed information was collected on Curaçao.

Starting at the end of May a big dust storm developed in the Northern hemisphere in the Moab region. At the end of June, the dust storm covered almost the entire Martian surface and at the end of September the storm had almost completely vanished again. The initiation of the 2018 storm in the Northern hemisphere is remarkable, since all known global dust storms so far (1909, 1925, 1956, 1971, 1973, 1975, 1977, 1982, 2001 and 2007) originated in the Southern hemisphere [1]. A short communication of our observation of the 2018 Mars opposition is in press [2].

2. Dust in the Valles Marineris region

On 2018 August 1 we did an interesting observation. Whereas under normal conditions the eastern end of Valles Marineris can often hardly been traced, in images of that date the complex canyon system popped up very distinctly as compared to in the images of September 5 (Fig. 1). A similar phenomenon occurred during a regional storm in November 2005 (see https://britastro.org/node/11534). Our observation prompted us to study the presence of dust in the Valles Marineris region in more detail.

To correlate the albedo features in our Mars images with real three-dimensional geological structures on Mars we have used ArcGIS software (http://www.arcgis.com/index.html). This Geographic Information System (GIS) software is frequently used for geo-spatial analysis for a whole range of applications, e.g. crime analysis, environmental studies, geology, mapping, 3D analyses, utility companies, transportation etc. Using ArcGIS and the USGS Mars Orbiter Laser Altimeter (MOLA) Elevation data of Mars (https://astrogeology.usgs.gov/search/map/Docs/Globes/i2782_sh1) albedo features in our Mars images could be correlated with the elevation and topographic features at specific sites (Fig. 2). We have investigated whether there is a correlation between the accumulation of dust and the local nature of the terrain. We have checked whether there is a preference of dust accumulation in valleys. In particular, the distribution of dust in the Valles Marineris region has been investigated (Fig. 2 and 3).

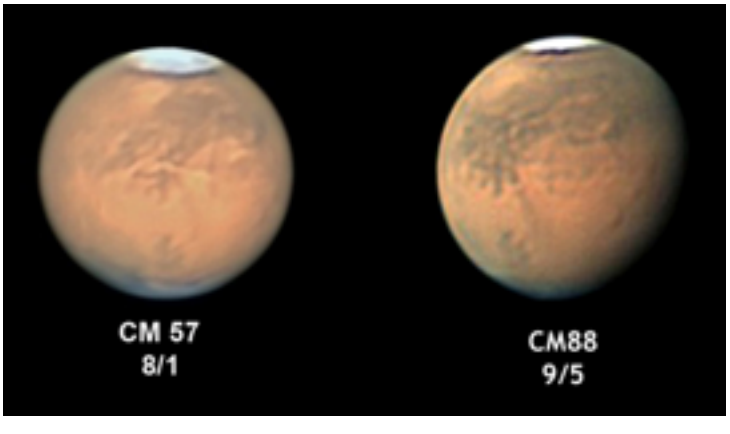

Figure 1: Dust in Valles Marineris on 2018 August 1. As a comparison the September 5 image is shown. South up

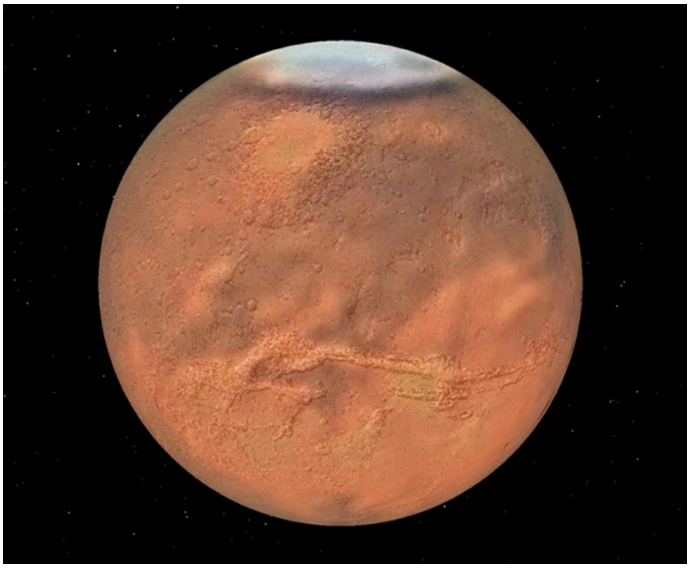

Figure 2: Mars of 2018 August 1 image superimposed on the MOLA USGS map using ArcGIS. South up.

Fig. 3 clearly illustrates the accumulation of dust in the Valles Marineris canyon complex. In September the course of the canyon can hardly be traced in our images. In contrast on August 1 the course of the canyon can easily be detected as a bright channel of dust following the Valles Marineris borders.

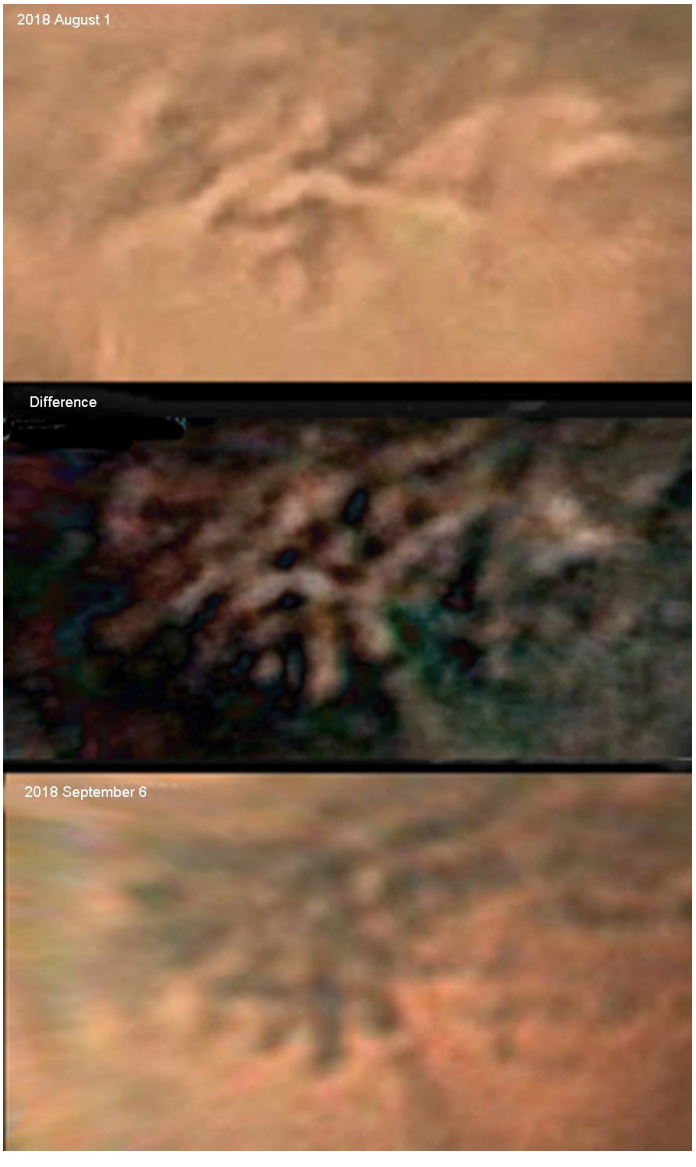

Figure 3: Dust distribution in the Valles Marineris on 2018 August 1(top) compared to 2018 September 6 (bottom). The difference between the two images is shown in the middle panel. South up.

By subtracting the image of 2018 September 6 from the image of 2018 August 1 a difference image is obtained in which the location of dust in the

region can easily been detected (Fig. 3, middle panel). Most of the dust is located in the complex canyon system, but accumulation of dust is also detected in other regions, in particular in Sinai Planum (Fig.4).

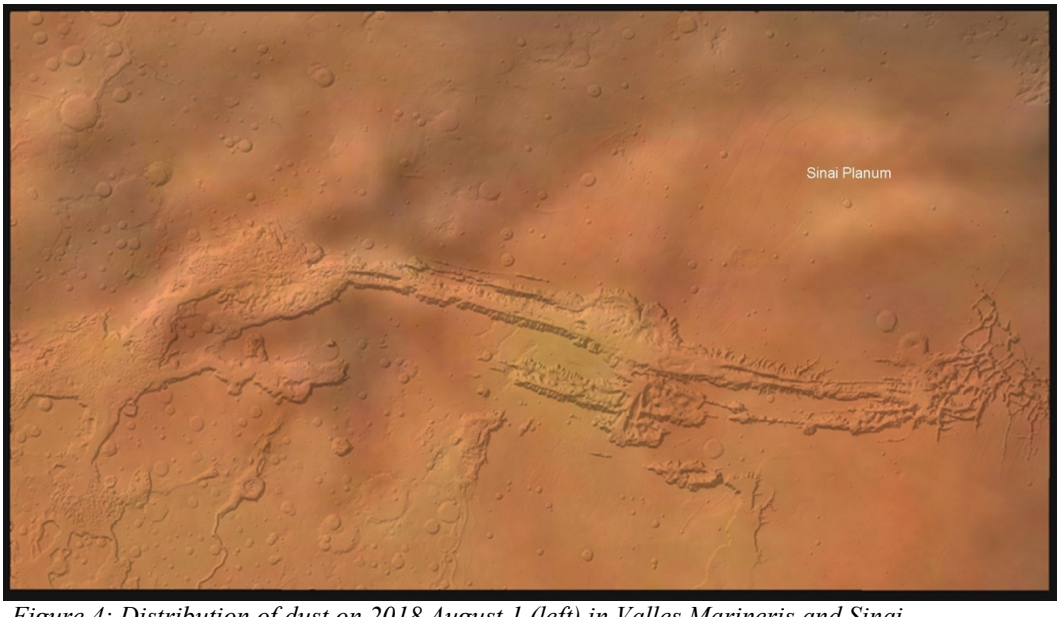

Figure 4: Distribution of dust on 2018 August 1 (left) in Valles Marineris and Sinai Planum

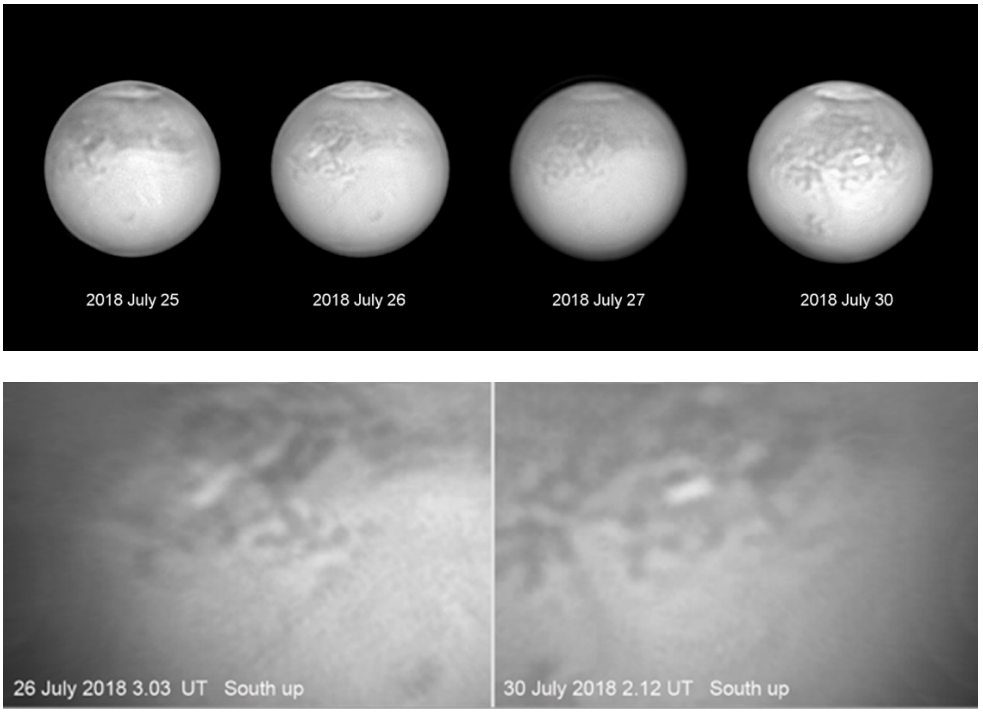

Figure 5: Dust accumulation in Sinai Planum on 2016 August 1 (IR). South up.

In this region, close to Valles Marineris, we also detected short-lived dust storms on 26 and 30 July, respectively (Fig. 5). On 2018 July 25 and 27 no local dust storm could be found. Analysis by McKim of all dust storms recorded over the years revealed that in the region south of Valles Marineris more often dust storms have developed (1879, 1926, 1946, 1973 and 1984) [1].

To investigate the local conditions using ArcGIS we have made cross sections of Valles Marineris and Sinai Planum using the MOLA Elevation Map of Mars (Fig. 6). Elevation profiles of the dust storm in Valles Marineris nicely show the deep canyons present in Valles Marineris. The observation that dust accumulates in the Valles suggest that it is captured between the mountain walls of the canyon systems. As for the dust in Sinai Planum, a profile of this region in the MOLA Elevation Map shows that this dust accumulation is positioned on an inclination with a flat slope. Investigation of the geological situation of the dust at Sinai Planum (Fig. 7) indicates that

the dust in Sinai Planum is located at the transition of two geological structures (colored regions in Fig. 8): a younger region (pink) with distinct lava flows (red arrows in Fig. 8) and an older region (brown) with many wrinkles (black lines with dots in Fig. 8).

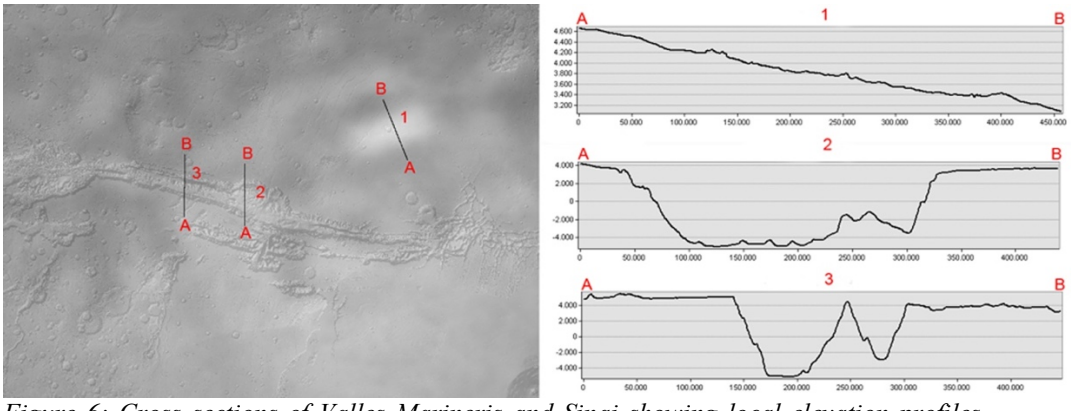

Figure 6: Cross sections of Valles Marineris and Sinai showing local elevation profiles (2018 July 30). South up.

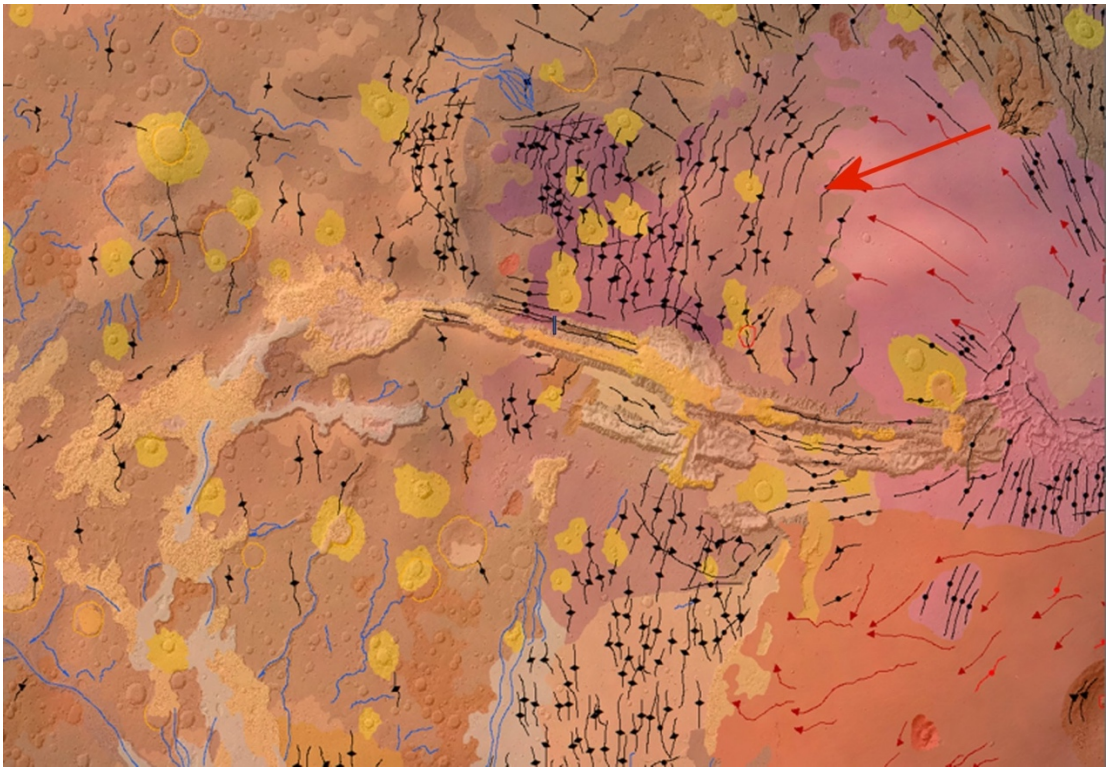

Figure 7: Geological data of the region of Fig. 7 superimposed on a map with geological data. Colored regions indicate distinct geological era and the red arrows and black lines with dots indicate different lava flows and wrinkles, respectively. The red arrow indicates the dust accumulation in the Sinai Planum. Source: https://astrogeology.usgs.gov/search/map/Mars/Geology/Mars_SIM-1083_Mariner_9_GIS

3. Discussion

The distinct accumulation of dust in Valles Marineris during the global dust storm in 2018 June and July prompted us to investigate in more detail the local geological conditions. For that purpose we have applied ArcGIS software and detailed Mars maps collected with the Mars Global Surveyor. We have shown before in a study of the Great Red Spot of Jupiter in different spectral bands that this software is a useful tool to get more insight in cloud structure [3].

Elevation profiles of Valles Marineris obtained with ArcGIS demonstrate the canyon-like structure of this region. Obviously, dust easily accumulates

between the mountain walls of the canyon system facilitating the detection of the Valles in amateur images. Interestingly, there is a region south of Valles, in Sinai Planum, where also dust accumulates. Elevation profiles of that region reveal that at this site a shallow inclination is found; no distinct craters or canyons are present. To get more insight of this location we collected data about the local geological conditions. It appears that the dust is located at the border of two distinct geological structures: a younger region with lava flows collapses against an older region with many twisted wrinkles. This might lead to unequal heat absorption of the local surface facilitating dust storm formation. Clearly, further studies are required to understand the meaning of this phenomenon. We have demonstrated that ArcGIS software is a useful tool for amateur astrophotographers to better understand the features in their images and might even lead to a better insight of the Mars surface and meteorology

4. Acknowledgements

We acknowledge the USGS (Unites States Geological Survey) for publishing the MOLA Elevation dataset in ArcGIS format.

5. References

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https://drive.google.com/file/d/1xr6pefXooah6dn_eJoxY1nxxqwgc3nnU/view