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Northern and southern seepages on Mars and their astrobiological consequences

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Introduction

Behaviour of the annual frost on Mars points to the characteristics of climate and soil type [1, 2, 3] and to the presence of water ice [4, 5, 6] and even the possibility of ephemeral melting [7]. In our previous works [8, 9] we showed that on both hemispheres of Mars seepage-like features are present at high latitude, which could be the result of interfacial water [10] driven seepages. Here we compare southern and northern ones.

Methods

Our group analysed the Martian polar dunes and seepage-like features on MGS MOC, MEX HRSC and MRO HiRISE images. Topographic data were acquired from MGS MOLA and MEX HRSC DTMs, and temperature data from MGS TES observations.

Discussion

The seepage-like features on the southern [8, 11, 12] and northern [13, 14] (**Fig. 1.**) dunes of the polar region show characteristic branching morphology, somewhere pond-like accumulating feature at their lower end. They possibly formed by the action of interfacial water [15, 16] as we have shown recently [17]. To gain more information on the astrobiology potential of these dunes, we started a detailed comparison of the seepages at the northern and southern hemispheres. It is known, that the atmospheric water vapour content is higher, and the maximal daytime temperature is lower at north. At north a continuous water ice layer is present in the lower part of the seasonal cap [18, 19, 20, 21], while at south only patches were found [22, 23, 24]. We observed the following similarities and differences between the seepage-features at south versus north:

Seepage-features

- are present on relatively steep slopes of dunes,
- follow the small-scale dune ripples during their movement,
- the average growth speed is 0.6-2.0 m/sol, although at north there are higher values,
- during the movement of seepages the average temperature on 3 km scale is lower at north (160-180 K) than at south (160-220),
- re-brightening was observed at north probably by re-condensation during the movement of seepages,
- after a certain Ls value seepage features appear all along the steep slopes at north, while no similar phenomena was observed at south,
- there is no correlation between the temperature and the flow speed of seepages,
- more ponds are present at south, although this may arise form the difference in the dune topography,
- are in contact with spiders in some places at south, but spiders were not found at north.

Sequence of seepage changes

Based on our observations the seepage features and their source spots show the following changes as the season passes by:

1. emergence of a Dark Dune Spot at the top of the dune's slope with wind-blown structures,

2. start of seepages from spots, and at north the emergence of a bright elevated ring at the spot,

3. growth of seepages in downward direction, while the slope's upper section may become bright again with some refreezing process,

4. at north the upper section of slope may darken with the appearance of many seepage features,

It is difficult to elucidate, if did observable movement happen on the dune material during the movement or did not. The resolution is still not enough, and there can be overlapping structures with different ages. Based on the detailed analysis of HiRISE images, after the total disappearance of the frost at some locations the dark seepage features disappear. Probably the previously moved dark grains rolled into the trenches of the bright polygonal terrain surrounding the dunes.

Based on model computations [25] interfacial water and salts are present on Mars, which help the formation of liquid water. Observations show water ice lags behind the receding seasonal cap, the growing seepages together with theoretical background suggest interfacial water is present on the observed spots. Therefore in the images of this

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paper liquid water lubricated mass wasting of dune grains, or the seep of liquid water is probable.

There are various signs of ice and even melt water related features on dunes [26, 27]. Even when frost cover does not cover the surface any more, physically bond ice is still present inside the dunes [28] or present in the shallow subsurface kept there by chemical bonds too [29] H_2O ice may serve as source of H_2O molecules to diffuse outward from the dunes' interior.

The possibility of liquid water on Mars is of high importance regarding its astrobiological consequences, as we analysed in detail previously [11, 30, 31], and it is possible, that interfacial water can be used by microorganisms [32].

Conclusions for astrobiology

Based on our recent work, shallow subsurface micro-environments are ideal for possible living organisms on Mars, because of the UV shielding, and available H_2O. During the movement of seepages the temperatures were between 160-180 K at north, and 160-220 K at south on 3 km spatial resolution. The spots and seepages are probably warmer at north and at south also than their surroundings.

Our results show that water activity is high for water uptake in the case of a hypothetical microorganism during nighttime. Temperature for metabolism may be good daytime. The best period where these two factors overlap are morning hours or around noon, if the pore spaces are densely packed to slow down the diffusion of H_2O out from the shallow subsurface. In principle the outward diffusing water vapour may also be useful for hypothetical microorganisms [11, 31, 33].

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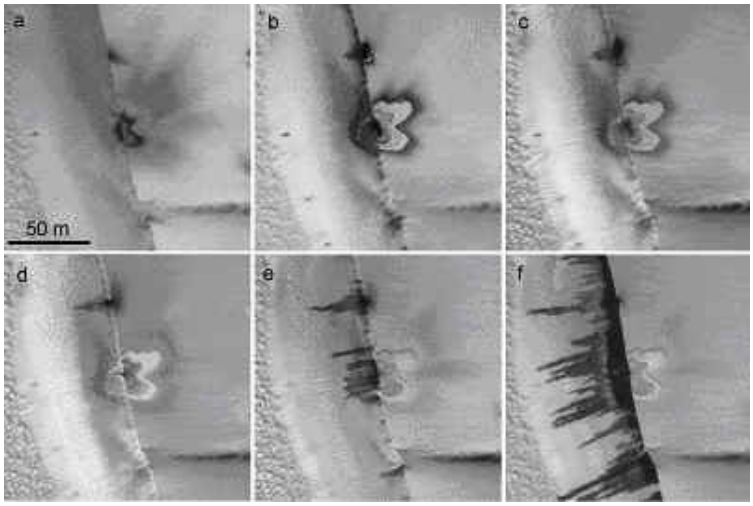

Fig. 1. Changes of a large spot and seepage-features emanate from it at 85N 1E on HiRISE images no. 7043, 7531, 7676, 7887, 8032 8230, acquired at Ls=23.4, 40.8, 45.8, 53.1, 58.1, 64.9 respectively. The higher part of the terrain is to the right and the slope is tilted to the left. Different phases are visible: a) wind blown streaks, b) c) bright and dark ring formation, d) e) first seepages, f) seepages all along the slopes' top edge