POSSIBLE LIQUID-LIKE WATER PRODUCED SEEPAGE FEATURES ON MARS.

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Introduction: Various polar albedo features appear on Mars in springtime, like spiders [1, 2, 3, 4], dark spots [5, 6], Dalmatian spots [7], and Dark Dune Spots (***DDS***s) [8]. Some of them formed probably by CO_2 jets [9] others possibly by flow-like process [8, 10, 11]. The seasonal behavior of polar frost may give insight into the type of ice on the cap [12], characteristics of waterice annulus [13], frost outliers [14], and even into the climate changes [15]. We studied the seasonal behavior of the flow-like process at the DDS-seepages [10, 11, 16]. In our previous works we analyzed the possible interfacial water related seepage-like features at south [17], then our team [18] and other groups [19] investigated their northern counterparts.

Methods: We used MOC (MGS), HiRISE (MRO), HRSC (MEX) images, topographic data from MGS MOLA PEDR dataset with processing version L [18], and from HRSC DTM [19]. Temperature data from TES (MGS) measurements was also used [20] with the "vanilla" software. Temperature data were derived for daytime around 2 pm, and have spatial resolution around 3 km.

We analyzed the following locations and images: 1) 84N 233E (HiRISE **7193**-2640, **7404**-2640, **7905**-2640, **8248**-2640), 2) 77.5N 300.1E (HiRISE **7468**-2575, **7758**-2575, **7903**-2575, **8114**-2575) 3) Russell crater (54S 12E), 4) Richardson crater (72S 180E), 5) unnamed crater (68S 2E).

Discussion: Two groups of dark spots are present at the two northern locations, we simply called them "large" and "small" groups, see details in *Table 1*. The large ones resemble to "classical" DDSs [4], which are 6-10 times fewer than the group of small spots.

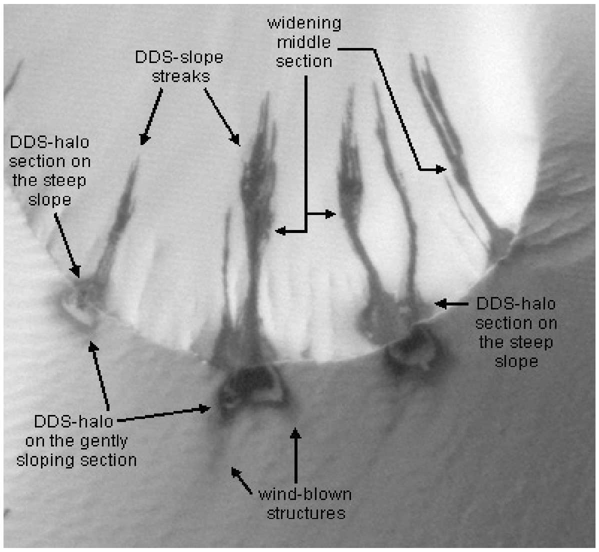

Fig. 1. ***Morphology of large spots with slope streaks on a 100x100 m section of HiRISE image 7193 (84°N, 233°E)***

characteristics	"large" DDSs	"small" DDSs
diameter	5-25 m	<5 m
morphology	Dark interior, diffuse ring-like halo on horizontal plains, and slope streaks on steep surfaces	Simple spots, rarely with slope streaks and ring-like halo
location	Only at the top edge of steep slopes	Gently and steeper slopes, as welll as on horizontal surfaces
changes in time	Slowly growing, above all slope streak lengthening	Growing above all in number

Table 1. ***Basic characteristics of "large" and "small" spots***

The seepage-like structures emanate from the observed "large" spots have the following characteristics:

- Most of them show a widening around half of their length (*Fig. 1.*).
- The central dark part of the spot gives rise to wide and long, while the halo-like outer ring gives rise to narrow and short flow-like streaks.
- They show average daily movement of 1-7 m/day at 77.5° N *Fig. 2.* and 0.3-0.8 m/day at 84°N (*Fig. 3.*).
- During the movement of these slope streaks the average surface temperature is around 165K, and at the dark streaks could be higher.
- Larger spots give rise to wider and longer streaks.

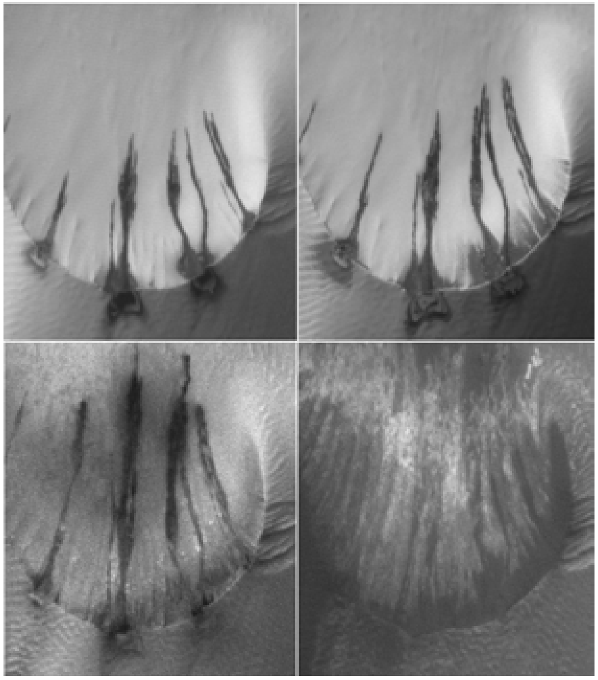

Fig.2. ***As the season (spring) advances the seepage-like features on 110x105 m on HiRISE images (7193, 7404, 7905, 8248, dt ~ 3 month; 84°N, 233.4°E)***

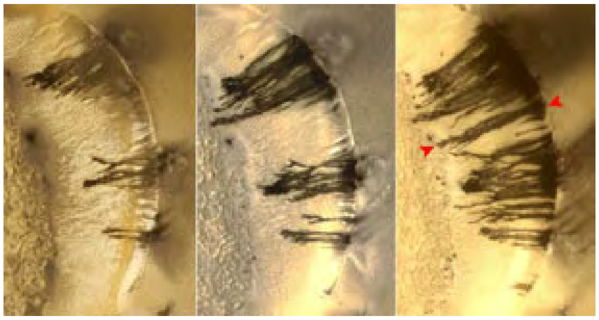

Fig. 3. ***Growing of seepage-like features as the season passes by on 100x150 m HiRISE images at 77.5°N, 300.1°E (dt=22 and 12 Earthly days;7468, 7758 and 7903 [18]). Arrows show the longest growth in the seepage form***

Fig. 4. shows the annual average temperature curve of the terrain number. 2. The observed temperature values based on 3 km resolution, the three arrows mark the date of HiRISE images with seepage-like features. Based on the temperature there have to be CO_2 free terrains, which are the mentioned dark spots based on their low albedo.

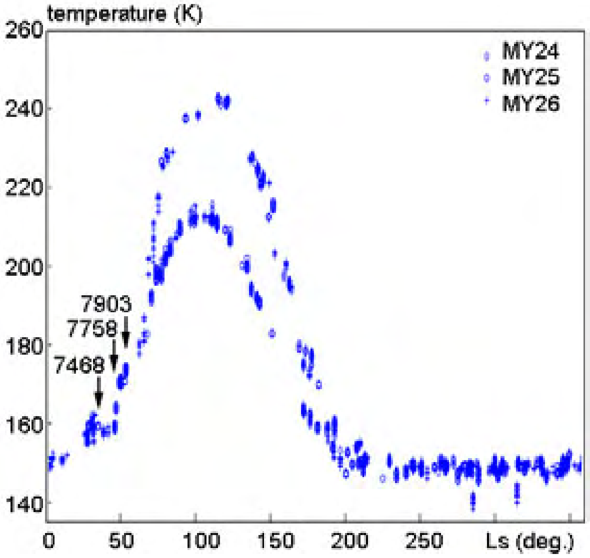

Fig. 4. Annual temperature distribution of the analyzed northern terrain number 2)

In our previous works we analyzed resembling southern slope structures [11, 17, 24]. The basic similarities and differences between the northern and southern features (*Fig. 5.*) are: 1) the width of the seepage-like features depends on the slope angle. Prompt stopping of the slope means sharp change in the slope angle. This fact results in accumulation (at the southern seepages it can be frequently observed); 2) gentle diminishing of the slope angle results in a little widening of the seepage-like "stream". This can be observed in the northern seepage-like objects.

Conclusion: We analyzed different models for the possible origin of southern slope structures [11], and the liquid water related model interpreted best their morphology. Based on computations, interfacial water must be formed on Mars at suitable temperature and in the presence of water ice [23], and at tilted surfaces the dune grains lubricated by waterfilm may move downward [24]. Northern seepage-like features emanate from DDSs related also be to interfacial water-driven movement of dune grains. Such local wet environments may have astrobiological importance as well [25].

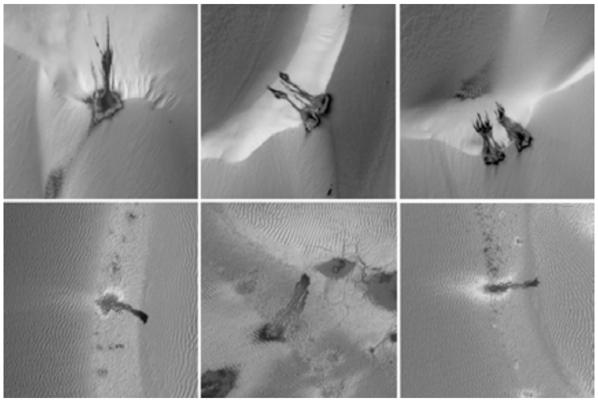

Fig. 5. ***Comparison of northern (top, HiRISE 7193) and southern (bottom, HiRISE 3386) seepage-like structures on 200x200 m image subsets***

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References: [1] Kieffer et al. (2000) *JGR*, 105, 9653. [2] Ness and Orme (2002) *JBIS*, 55, 85. [2] Piqueux et al. (2003) *JGR*, 108, 5084. [4] Christensen et al. (2005) *AGU*, #P23C-04. [5] Malin et al. (1998) *Science* 279, 1681. [6] Zuber (2003) *Science* 302. 1694. [7] Kossacki and Kopystynski, (2004) *Icarus* 168, 201. [8] Horváth et al. (2001) 32th *LPSC* #1543. [9] Kieffer et al. (2006) *Nature*, 442, 793. [10] Gánti el al. (2003) *OLEB* 33, 515. [11] Horváth et al. (2009) *Astrobiology*, accepted. [12] Calvin, Titus (2008) *Planetary and Space Science* 56, 212–226. [13] Schmitt et al. (2006) 4th *Int. Conf. Mars Polar Sci. Exp.*, #1323. [14] Kuti (2009) 40th *LPSC,* #1006. [15] Head et al. (2003) *Nature,* 426, 797. [16] Horváth et al. (2002) 33th *LPSC* #1109. [17] Kereszturi et al. (2008) 39th *LPSC* #1555. [18] Kereszturi et al. (2008) 37th *COSPAR* Montreal, Canada, #1497. [19] Russel P. et al. (2008) *GRL*, 35. No.23 ID L23204. [20] Smith et al. (1999) *NASA Planetary Data System*, Washington Univ., St. Louis, Mo. [21] Heipke et al. (2007) *Planetary and Space Science*, 55, 2173. [22] Christensen et al. (1992) *JGR*, 97, 7719-7734. [23] Möhlmann (2008) *Icarus* 195, 131-139. [24] Kereszturi et al. (2008) *Icarus* submitted. [25] Szathmáry et al. (2007) in *Planetary Systems and the Origin of Life*, ed. Ralph Pudritz, Paul Higgs, Jonathan Stone, Cambridge Astrobiology Series III., Cambridge University Press 241-262.