MORPHOLOGICAL ANALYSIS OF THE DARK DUNE SPOTS ON MARS: NEW ASPECTS IN BIOLOGICAL INTERPRETATION.

***A. Horváth*[1,2], *T. Gánti*[3], *Sz. Bérczi*[4], *A. Gesztesi*[1], *E. Szathmáry*[3,5]** [1]Budapest Planetarium, H-1476, Pf. 47, [2]Konkoly Observatory, H-1525 Budapest Pf. 67, [3]Collegium Budapest (Institute for Advanced Study), 2 Szentháromság, H-1014 Budapest, [4]Eötvös University, Dept. G. Physics, H-1117 Budapest, Pázmány 1/a., Hungary, [5]Eötvös University, Dept. of Plant Taxonomy and Ecology, H-1117 Budapest, Pázmány 1/a. Hungary (planet@mail.datanet.hu)

Abstract: We analyzed the *Dark Dune Spots (**DDS**s)* of the southern polar region of Mars on MGS MOC images. Studies of MOC images revealed the shape, the pattern and the morphological dynamics of these spots. Here we show that the formation of DDS begins from the bottom of the frost layer, at the frost/soil boundary. DDSs appear when the spotting process advances and holes are produced in the frost layer. The time sequence of DDSs was interpreted as resulting from possible biological activity on Mars **[1, 2]**.

Introduction: Dark dune spots (**Fig. 1**) occur as ephemeral objects on the *dark dune (**DD**)* fields, which are fine-grained, dark blue **[3]**, low-albedo, sand-sized eolian sediments, mainly of dense basaltic sand **[4]**.

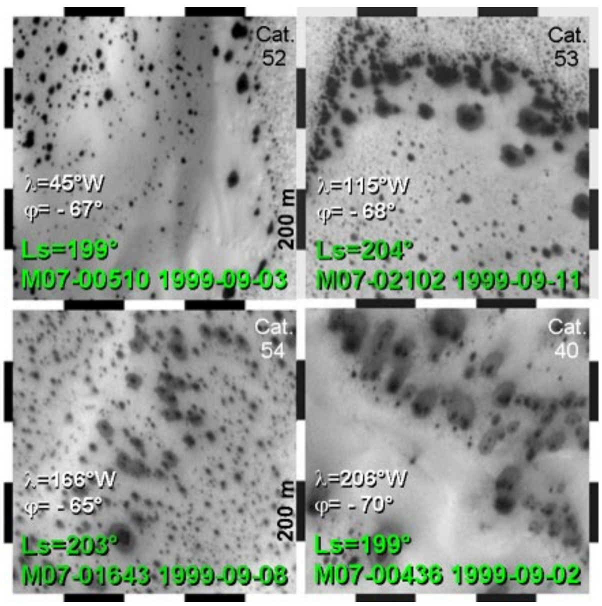

Figure 1. Typical circular dark dune spots (DDSs) on different frosted intra-crater DD fields early spring of the southern polar region of Mars. Sun illuminated from upper left and north is up at these MOC images.

The size of DD regions is in the range from a few kilometers to some dozens of kms, their thickness varies from 10 m (**Fig. 2**) to 200 m **[5]** in average. DD fields are the first surfaces to frost in the fall and they are the first to defrost during late winter and early spring, although frost may persist (**Fig. 3**) on them until early summer **[6]**.

DDSs begin to appear during late winter and spring on the ice cover of intracrater dark sand sheets. In their analysis Malin and Edgett modeled DDS dynamics as a complex process of CO_2 and H_2O sublimation and re-precipitation. They distinguished three explanations: a) thermophysical properties of the sand, b) the dunes "breathe" water vapor, c) the microstructure of dune surface (rough at 100 m scale), which contributes to the formation and persistence of the frost on the dark dune sheets **[7]**.

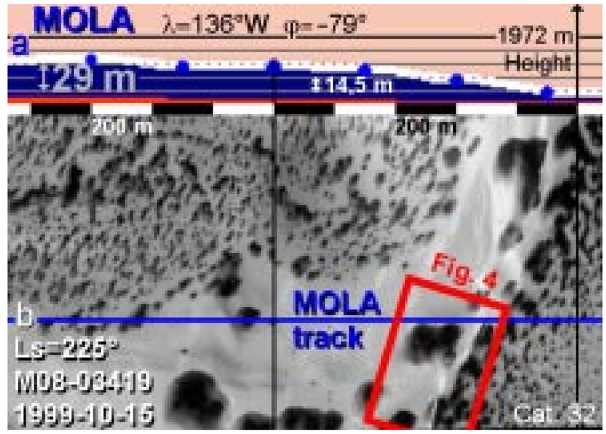

Figure 2. We estimated the thickness of DD field and the depth of DDSs holes in the frost (bottom) from MGS MOLA measurements (**a**). Detail of MOC image (**b**) in the frame is enlarged in Fig. 4. Sun illuminated from upper right, north is in the right lower corner (**b**).

MGS MOC materials and methods: We have analyzed ca. 200 MGS MOC pre-processed narrow angle images covering areas bw. 58°S – 82°S latitudes. The South Polar Region was chosen for this study of DDSs, because MGS MOC image coverage was better in this region, than in the northern one. We used MOC images made between May 1999 and May 2000 (from winter to summer of the southern hemisphere). Enlargement, contrast and brightness improvements were made by Paint Shop Pro 6 software.

Morphological characteristics of DDSs: The diameter of DDSs varies between a few dozen and a few hundred meters. The majority of the early DDSs are circular (Fig. 1, 3). An important observation is the relationship between the fine-scale topography and this circular shape.

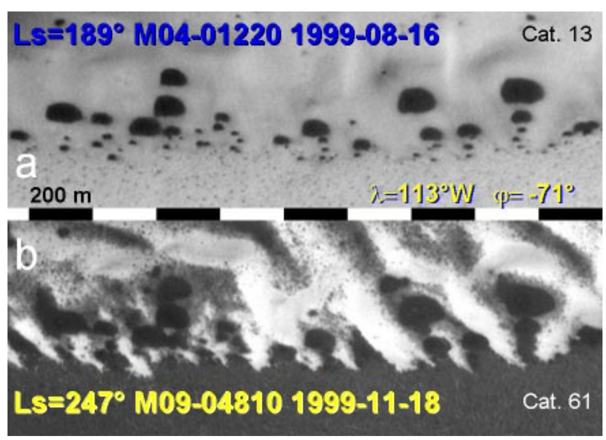

Figure 3. On the edge of these DD fields early spring DDSs appear as crater-like holes in the frost layer (**a**). Even late spring the ice cover (together with the DDS-holes) survived on these same parts of DD, while the surrounding crater floor has been already defrosted (**b**).

MORPHOLOGY OF DDSs ON MARS: A. Horváth, T. Gánti, Sz. Bérczi, A Gesztesi, E. Szathmáry

Circular shapes of DDSs are superimposed on (so they are independent of) the local small-scale topography (**Fig. 4**). The most important new observation is that the ***DDSs are crater-like holes*** in the frosted layer (Fig. 2, 3). The central region of DDS is dark because it is deep, exhibiting the bare dark dune surface. The existence of the DDS-holes in the frosted layer is important evidence that the process of ***DDS formation begins from the bottom***, because the effect of defrosting by sublimation acting always on the top of the frost is uniform.

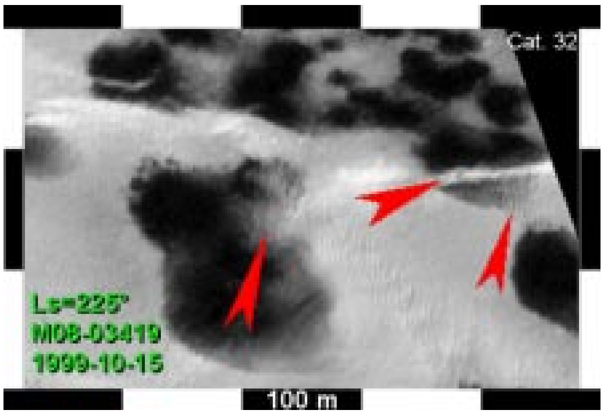

Figure 4. Here we can recognize DDS-holes and white frosted grooves above the grey spots (arrows). From these is we conclude that spotting process begins at the bottom of the ice cover, as suggested by the DDS-MSO model. Sun illuminated from upper left, north is up.

The surrounding gray annulus is the slope of the central hole and this annulus is gradually gray because of the gradually thinner frosted precipitation layer (snow and ice).

On slopes of the dark dunes the spots are elongated or fan shaped downwards, depending on the steepness of the slope, indicating gravitational effects in spot morphogenesis. From some spots extensions emanate, indicating some downward seepage or flow, i.e. transport of a fluid phase, probably brine, which occurs below frost cover (**Fig. 5**).

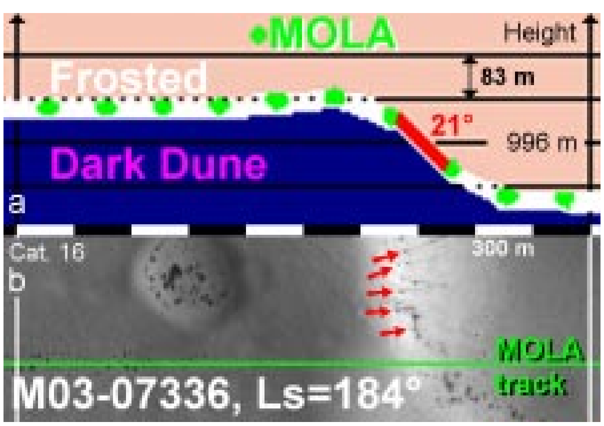

Figure 5. Creek-like flows or seepage originate from these DDSs (arrows in **b**) on steeper slopes (21°) of dark dunes in the Lyell crater (MGS MOC image: M03-07336, 1999-08-07, φ= –70°, λ=15°W). Steepness was determined on MGS MOLA data (**a**). Sun illuminated from upper right, north is in the right lower corner on MOC images (**b**).

Time sequence of the morphological changes of DDSs: We fitted a tentative time sequence of the morphological changes of DDSs on the basis of the time coverage of the MOC images. Initially gray fuzzy spots or fields of spots appear. The boundary of the gray fuzzy spot gradually becomes sharper and grayer**;** then it turns dark. Finally, when all frost sublimated from the surface of DD (summer), a light gray patch remains at the site of its origin **[5]**.

Conclusion and biological interpretation of DDSs: We found that the circular shape of DDSs is independent from local small-scale topographic variation. Fig. 4 shows surface pattern of grooves on the top of the ice coverage, which remained untouched while gray and dark spotting had been advancing beneath them. This observation and existence of DDS-holes may be interpreted so that the development of the DDSs begins from the bottom of the frosted ice-snow layer. This may imply that the melting/evaporation process "eats up" the frosted layer from the bottom where the DDS centers develop, which become the dark holes of the DDSs.

The bulk radial symmetry, the flowing (seepage) patterns and the defrosting beginning from bottom of DDSs suggested us a biological interpretation of the all DDS phenomena. Therefore we proposed that for interpreting these complex seasonal phenomena the sublimation processes should be combined with some kind of biological activity [1, 2]. Under Martian circumstances the only possible solvent is liquid water with some salt component.

We interpreted the sequence of DDS formation and changes as a biomarker **[8]**. If ***Martian Surface Organisms (MSOs)*** exist, they could dwell below the surface ice, which is heated up by their absorption of sunlight. Later they grow and reproduce through photosynthesis and they can generate their own living conditions. Not only liquid water, but even water vapor can sustain this form of life. Water vapor can migrate in the soil below the CO_2 frost cover supporting the life conditions for endolithic type communities and this activity enhances the defrosting/melting process on the top of the dark dune surface (**Fig. 6**).

Figure 6. DDS-MSO model: dynamics of biogenic spot morphogenesis. The ice cover first disappears in the center, where the melting started bottom. When water evaporates, then the organisms (MSOs) desiccate.

Acknowledgments: Authors thank for the use of MGS MOC images of NASA, JPL and Malin Space Science Systems, for discussions with A. Chicarro, E. Illés and for MOLA data **[9]** to A. Sik.

References: **[1]** Horváth A., Gánti T., Gesztesi A., Bérczi Sz., Szathmáry E. (2001a) *LPS XXXII*, #1543. **[2]** Horváth A. at al. (2001b) in *Proc. RAS*, in print. **[3]** Thomas at al. (1992) in *MARS*, Univ. of Ariz.Press 767-795. **[4]** Edgett K. & Malin M. (1999) *LPSC XXX*, #1029. **[5]** Horváth A. at al. (2002b) *LPS XXXIII*, #1109. **[6]** Malin M. & Edgett K. (2000) *LPSC XXXI*, #1056. **[7]** Malin M. & Edgett K. (2001) *J. Geophys. Res.* ***106***. *E10*, p, 23429. **[8]** Gánti T. at al. (2002) *LPS XXXIII*, #1221. **[9]** NASA, JPL, Planetary Image Atlas Website.