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Circumpolar water ice patches as possible microhabitats on Mars

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Abstract

Transient water ice layers in the polar regions of Mars produce such combination and interaction of materials, which contribute to the formation of possible microhabitats. These microhabitats may resemble to those terrestrial counterparts where extremophiles could survive sometimes freezing, salty and arid conditions. Here we outline local climatic, temperature, and salty issues that also help circumpolar microhabitat formation on Mars.

1. Introduction

In the circumpolar regions on Mars 20-100 m diameter water ice rich ring-like features are present [1] at the shrinking seasonal cap. These so called Dark Dune Spots (DDSs) hold the H_2O ice there for extended period and provide favorable conditions for astrobiology. The basic parameters to this so-called DDS-MSO model is summarized in our previous publication [2], here only the latest results: presence of water ice, consequence of microporosity, brine formation and grain movement are summarized.

2. Morphology of slope streaks

Dark slope streaks emanate from springtime formed DDSs [3] with meter/sol movement of the confined (and not the wind blown) dark material, possibly by brines or interfacial water on Mars [4].

Beside liquid H_2O temperature is also important factor for astrobiological issues. During the movement of slope streaks the temperature on km scale spatial resolution (from TES data) is around 180-230 K. This value is below the threshold limit of metabolism of extremophiles on the Earth, but the real temperature could be higher because of bad spatial resolution. If the movement is produced solely by rolling dark dune grains [5], these features are still important as locations the solar heated grains are in physical contact with water ice, as visible in Fig. 1.

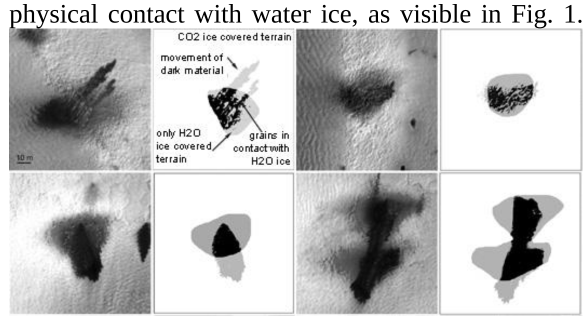

Fig. 1. Examples where dark streak material is direct contact with water ice in Richardson crater

3. Available water at the spots

At the outer, ring-like area of these Dark Dune Spots water ice lags behind the disappearance of CO_2 cover.

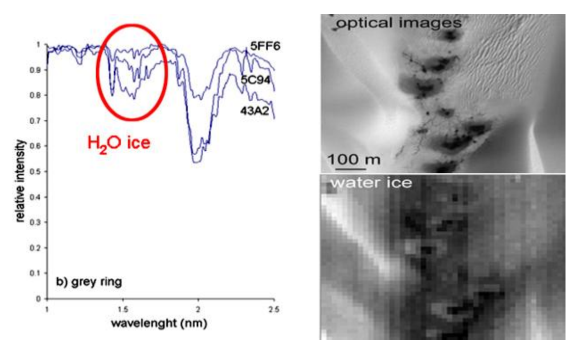

Fig. 2. Identification of water ice in DDSs: CRISM spectra (left), optical and BD1500 images (right) of spots

The access of water ice there is still difficult for any hypothetical organism. Two issues might help to have elevated temperature and available H_2O together there: **1.** Phoenix lander showed that temperature above -40 °C and relative humidity above 0.5 are nearly present together at 1.2 meter high in the northern circumpolar region twice a day. Inside inter granular pores of surface regolith these values could be even higher (and this favorable period longer) as the grains are warmer and between them the H_2O diffuses at a slower rate (Fig. 3.)

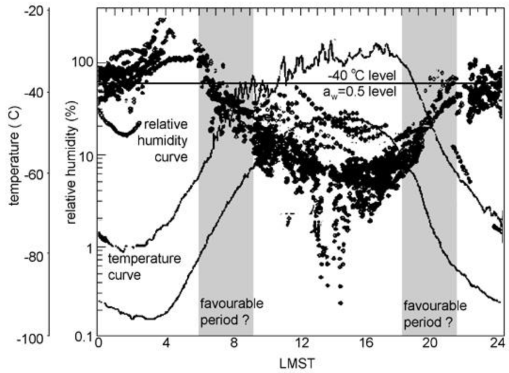

Fig. 3. Daily temperature (solid) and water activity (dotted) curves at the Phoenix lander. Gray columns mark interesting periods with elevated T and Rh [6]

2. In theory if the Martian water ice at the bottom of CO_2 ice accumulated earlier from falling snowflakes, vapor migration inside this H_2O layer might enlarge pore spaces at the bottom and closing them at the top [7] increasing the vapor concentration below (Fig. 4.).

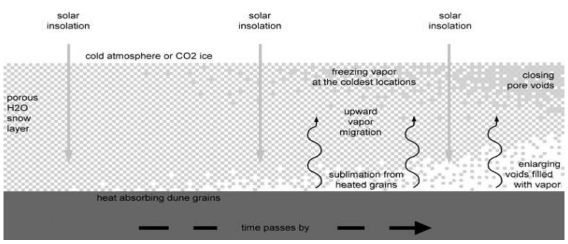

Fig. 4. Hypothetical time sequence of the process inside porous snow-like H_2O layer forming a heat insulator shield

Along the grains thin interfacial water film is present, although it is unknown are various microscopic scale water types useful for organisms or not on Earth [8].

4. Effects of microporosity

Microscopic pores slow down the diffusion of water vapor, and enhance over saturation and liquid formation. Using laboratory experiments around the lower temperature limit of metabolic activity brines evaporate in the open air at the order of 0.1 mm/h on Mars [9], under porous layer at an even slower rate. Analyzing potential analogs in Atacama desert the primary producers are located in hygroscopic saline crust. Inside halite pores deliquescence produces briny solutions inside at relative humidity well below atmospheric condensation level, [10] and adsorption, evaporation, condensation cycles produce dynamic wet micro-oasis.

5. Summary and conclusion

Water ice has occasionally direct contact with solar heated dune grains around or above the melting temperature of certain brines in DDSs. Although elevated temperature and high water activity are not present together on Mars in general, but based on observations and Earth analogs over saturation and liquid brine formation could be present at low relative humidity. This increases the astrobiological consequence of circumpolar shallow subsurface locations at DDSs (Fig. 5.). As thin mineral layer shields against strong UV radiation and the interfacial water possibly in springtime may decompose aggressive oxidants, the possibility of life at these circumpolar regions could not be excluded yet if organism there could improve survival strategies beyond that is observed on Earth [11].

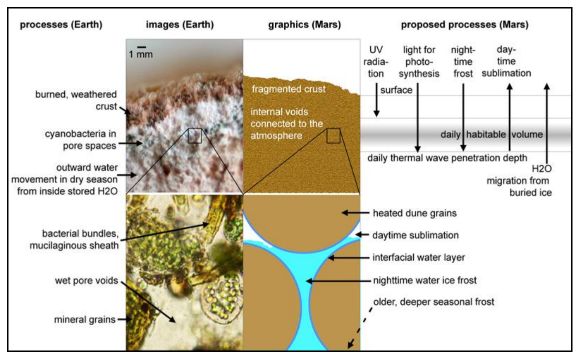

Fig 4. Summary of benefits of cryptobiotic crust on Earth (left), and proposed conditions on Mars (right)

Acknowledgements

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References

[1] Kereszturi et al. (2010) Planetary and Space Science 59, 26-42. [2] Szathmary et al. (2007) Life in the dark dune spots of Mars: a testable hypothesis - in Planetary Systems and the Origin of Life, ed. Pudritz, Higgs, Stone, Cambridge Astrobiology Series III., 241-261. [3] Horváth et al. (2009) Astrobiology 9(1) 90-103. [4] Möhlmann, Kereszturi (2010) Icarus 207, 654-658. [5] Hansen et al. Science 331:575-578. [6] Hudson et al. (2009) 40th LPSC #1109. [7] Horvath et al. 38th COSPAR Scientific Assembly F34-0022-10. [8] Möhlmann, D. (2009) Cryobiology 58:256-261. [9] Altheide et al. (2009) Earth Planet. Sci. Lett. 282:69-78. [10] Wierzchos et al. EGU 2011 abstract EGU2011-1968-1. [11] Pócs (2009) Acta Botanica Hungarica 51(1-2) 147-178.