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CRYOLITOZONE OF MARS – AS THE CLIMATIC INDICATOR OF THE MARTIAN RELICT OCEAN (ACTIVE-PASSIVE MICROWAVE REMOTE SENSING OF MARTIAN SALT PERMAFROST AND SUBSURFACE SALT PORE WATER)

Yu. Ozorovich[1], Alain Fournier-Sicre[2], V. M.Linkin[1] , A.S,Kosov[1] D.P. Skulachev[1], S. Gorbatov[1] , A.Ivanov[3], Essam Heggy[4]

[1] Space Research Institute, Russian Academy of Sciences, 84/32 Profsoyuznaya st.,Moscow, 117810,Russia (interecos@gmail.com),
[2] **FAST-ER, France.**
[3]Swiss Space Center, Swiss
[4]JPL, USA

The existance of a large Martian cryolitozone consisting of different cryogenic formations both on the surface- polar caps ice and in subsurface layer (and probably overcooled salt solutions in lower horizons) is conditioned mostly by the planet's geological history and atmosphere evolution. The very structure of the cryolitozone with its strongly pronounced zone character owing to drying up of 0 to 200 m thick surface layer in the equatorial latitudes ranging from + 30 to - 30$_0$ was formed in the course of long-periodic climatic variations and at present is distincly heterogeneous both depthward and in latitudinal and longtudinal dimensions.
The dryed up region of Martian frozen rocks is estimated to have been developing during more than 3.5 bln years, so the upper layer boundary of permafrost can serve as a sort of indicator reflecting the course of Martian climatic evolution.
Since the emount of surface moisture and its distribition character are conditioned by the cryolitozone scale structure its investigation is considered to be an important aspect of the forthcoming Martian projects.
In order to create Martian climate and atmosphere circulation models the whole complex information on surface provided by optical and infrared ranges observations, regional albedo surface measurements, ground layer thermal flow investigations, etc. must be carefully studed.
The investigation of permafrost formation global distribution and their appearance in h ≤ 1 m thick subsurface layer may be provided successfully by using active-passive microwave remote sensing techniques [1].
Along with optical and infrared observations the method of orbital panoramic microwave radiometry in centi- and decimeter ranges would contribute to the mapping of the cryolitozone global surface distribution.
This proposal discusses methodical and experimental possibilities of this global observation of Martian cryolitozone as the additional way for investigation subsurface of Mars.

The main idea of this approach is – the salt component of subsurface is the global geolectrical marker of the Martian relict ocean in the past.

Mars' observations by means of ground and onboard instruments are known to have been conducted in recent years. These observations provided information on Mars' surface mean temperature values and their seasonal variations. Radar measurements allowed to estimate dielectric constant and soil upper layer density values.
Mars' surface radiation measurements by a 3,4 cm radiometer aboard Mars-3 and 5 automatic interplanetary stations (1971-1973) proved to be more informative. Radio brightness temperature variations were registered along the flight route. As a result surface temperature latitudinal distribution estimates in a spatial resolution element, were obtained as well as more precise values of dielectric constant and soil density of centimeter fractions this surface layer.

No more experiments using microwave radiometers were conducted since.

The only way to obtain information about Mars surface mezoscale structure is to use a high spatial resolution panoramic equipment on-board. Mars' surface radio images would allow to identify regions differing in ice percentage content in cryogenic surface structures or in mineralized solutions of negative temperature and to estimate relative quantity of cryogenic formations - permafrost fractions as well as to measure the soil looseness or porosity degree.
In addition it would be possible to restore various regions' average vertical temperature, humidity and porosity profiles of less than 1 m thick surface layer. These dependencies combined with the results of depth inductive sounding (0.5 km) and magnitotelluric (1- 5 km) sensing would provide new and more detailed information on Martian crust structure and character and its cryolitozone, necessary to create a more reliable paleoclimatic model of the planet.

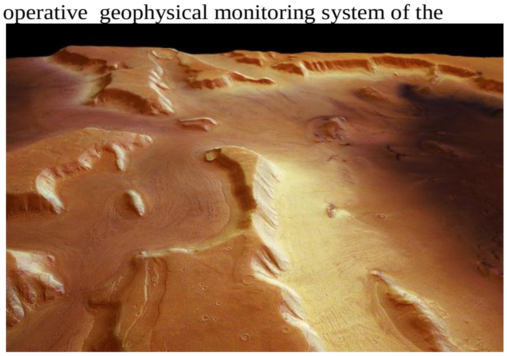
Experiment equipment and methods

Space experiment is conducted to obtain maps of temperature and humidity global distribution of Martian cryolitozone upper layer by means of radiothermal images of the surface. Analysis of the available data produces estimates of the soil integral content, degree of salt solutions mineralization and porosity.
Regions of permafrost and ice formations are identified as well. One could possibly estimate average profiles of temperature, humidity and porosity of a 0,5-1 m thick surface layer. For that purpose one should apply observations by a two channel scanning radiometer of centimetre and decimetre ranges.
Fluctuational sensitivity of each channel is ~ 0,1$_0$ K, time constant of integration is 1 s. The two channels share an antenna, an inflatable or self-opening one with a mechanically scanning beam; aperture is about 3-4 m in size; directivity diagram - 3$_0$. Spatial

resolution element (pixel) is about 20 km, observation belt is of 200 - 400 km depending on the orbit parameters. Restoration accuracy of the radiobrighness temperature absolute values is of order of 2-3$_0$K. Microwave block dimensions are up to 500x500x300 mm; weight is ~ 10 kg.
An optimal frequency range for Martian radiometric measurements is 8-18 or 21 cm. Suggested radiometer presents a synthetic aperture microwave radiometer-imager. An optimal frequency range for Martian radiometric measurements is 8 -18 or 21 cm. It employs an interferometric technique to synthesize high resolutions from small antennas. This radiometer can be build, for example as analog of Electronically Steerable Thinned Array Radiometer (ESTAR). ESTAR operates at 1.4 GHz and has been deployed on the C-130 and P-3 aircrafts. It was used by NASA to measure soil moisture and to assess the potential to measure ocean surface salinity.
Antenna fastening and joint to microwave block are hard. Registering system is a digit tape-recorder. Information stream is up to 1 kb/s. Power consumption is up to 50W/27V. Radiometer observations are conducted along the route of the Martian orbital station in accordance with the experiment general program. Observation angle is $\theta \sim 0\text{-}30_0$; polarization is vertical. Frequency of the radiometer calibration is not less that once in 24 hours. Radiometer scale calibration and measurement of antenna-feeder unit transition coefficient can be carried out against standard sources as well as the relict radiation (~ 3$_0$K) with the antenna proper orientation.
Generally it is desirable to match the radiometer system observation zone with that of optical and TV systems and infrared radiometer as well. Martian surface radio images should be geographically identified. Data processing and temperature and humidity maps drawing is performed by processor system back on Ground.
On the base space- technology platform
- the small satellite CHIBIS, also will planning to create prototype of Martian instrumentation for the operative geophysical monitoring system of the natural ecosystem for remote sensing in the range of 18-21 cm and 8-13 mkm.
This is allowed to realize preliminary testing and calibration of the prototype of the Martian instrument in the Earth's condition.
One of the areas of future studies on the surface of Mars are providing the measurements in situ in the local geophysical martian polygon by different geophysical instruments, including: radar measurements in the range of 0.5 – 50 Mhz, low-frequency sounding by MARSES - TDEM instruments, MTS (magneto –telluric sounding) with depth of sounding until 1 km, in the frame work of the rover survey of the different areas of Martian surface .
Additional information about MARSES-Active experiment on
www.iki.rssi.ru/MARSES/english/info.htm

[1] Ozorovich Yu.R., Raizer V.Yu., Microwave remote sensing of Martian cryolitozone, Preprint IKI, No.1768, 1991:
https://www.researchgate.net/publication/275266762_Microwave_remote_sensing_of_Martian_cryolitozone)

[2] ACTIVE-PASSIVE MICROWAVE REMOTE SENSING OF MARTIAN PERMAFROST AND SUBSURFACE WATER.
V.Raizer[2], V. M.Linkin[1] , Y. R. Ozorovich[1], W.D. Smythe,B[3]. Zoubkov[1], F. Babkin[1]
[1] Space Research Institute,Russian Academy of Sciences, 84/32 Profsoyuznaya st.,Moscow, 117810,Russia
(yozorovi@iki.rssi.ru),
2 STC,Fairfax, VA 22031-1748,USA
(Vraizer@aol.com),
3 JPL/NASA,4800 Oak Grove Drive,Pasadena,CA 91109,USA
(wsmyth@spluvs.jpl.nasa.gov).
http://www.lpi.usra.edu/meetings/lpsc2000/pdf/1258.pdf



These glaciers have been hiding in plain sight whole time, under a blanketing of dust. There's so much ice, in fact , that if the glaciers were spread uniformly over the entire surface of the world, Mars would be covered in one meter of ice. Mars' dusty cover is doing more than hiding the glaciers from evaporation in the thin, radiation-prone atmosphere of Mars/
(*Credit: ESA/DLR/FU Berlin,Copengahen University*)