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Geophysical aspects and opportunities of e/m sounding subsurface cryolitozone of Mars

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Abstract

The main goal of the science-technology project MARSES TDEM is the adaptation space technology for geophysical searching frozen roks on the Earth and during of the future space missions on Mars and Moon.

1. Introduction

There are many evidences that water once was abundant on Mars. There are stream lined islands formed by flowing water,flow patterns reminiscent of wadis in Earth deserts, and outflow channels thought to have been formed by sudden out-rush of subterranean water. The secondary task is to measure the soil properties of the subsurface of Mars, which include porosity, electrical resistance of the liquid phase,thermal conductivity, temperature dependence. A main task of the MARSES system is to examine changes in subsurface properties of local areas regolith on the martian surface, and to relate them to optical images and other remote sensing data in order to understand the nature of different terrain forms. The dryed up regions of Martian frozen rocks is considered to have been developing during more than 3.5 bln years, so the upper layer boundary of permafrost can serve as an indicator reflecting the course of martian paleoclimate evolution [1, 2].

2. Subsurface Science

Analysis of the ground-based geophysical cryolithozone related to electromagnetic studies, which takes into account characteristics of the preliminary electrodynamics model of martian cryolitozone. This model based on the current geological concepts of the cryolithozone structure, on the estimations of the ice containing material or wet fraction of subsurface horizons at negative temperatures, on physicalchemical transitions in the solutions of KCl , NaCl, CaCl2 with the martian regolith and so on. All of them show the potential possibilities of the Mars electromagnetic sounding in the depth range up to one kilometer both the planetary surface or satellite orbit.The presence of the low conductivity screens in the cross section structure and bad grounding conditions decrease the efficiency of the traditional (or so called vertical methods of electric sounding or VES) contact sounding methods. But such a screen is not a barrier for magnetic field and in these conditions an inductive sounding with controlled source is The usefulness of different methods of the inductive sounding (frequency modulation or impulsed one) in cryolithozone studies is defined by the following factors:
- cryolithozone is characterized by the relatively low conductivity of permafrost soil of weak contrast of geoelectric section;
- the season variations of phase state of upper and deep layers of martian surface may exit;
- the high and low conductivity screens at the surface and in the depth of permafrost soil may also exit.
These aspects can limit the possibilities of the high frequency sounding (HFS) method for Mars cryolithozone structure studies. The experience in experimental studies of permafrost clay formation in the earth conditions, which are similar to martian permafrost soil, shows that the depth limit of HFS methods is about 50 m.
Martian soils and subsurface geoelectrical structures are substantially different according to their properties in comparison with the pure surface ices and gletcher ices on the Earth. The relative magnetic susceptibility of the Earth soils is close to 1, but Martian soils may have much more higher values of magnetic susceptibility. Estimations show that the attenuation in this environment could be several orders of magnetitude higher than in ice. Therefore even in martian equatorial regions (from -300 to +300 latitude) with several hundred of meters palagonites or montmorillonites layers the HFS method could not give an information about cryolitozone structure up to the depth of

500 m, which is upper border of icebearing layer. In the middle latitude region (from 300 to 500) the depth of upper border of permafrost layer should be equal to 100-150 m and though at high latitudes it might be even at the surface and in this case HFS method allows one to measure the depth of permafrost[3, 4].
The difficulties of the estimation of attenuation (which is in its turn the sounding depth) require the comparative studies in the natural earth conditions close to martian ones.

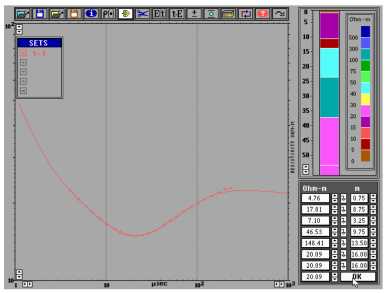

Figure 1: This is the example of the geoelectrical section in the field testing by MARSES TDEM on the geological deposit Centralnoe in winter time under -25C

3. Comparative investigation of martian and Earth's frozen rocks

The goals of the MARSES Experiment based on the TDEM instrument is comparative investigation of martian and Earth cryolithozone (possible investigation of subsurface relics of martian life) and the interpretation of geophysical data of subsurface soil structure [5, 6], including:
- the theoretical development of comparative models of subsurface frozen structure for typical rocks which formed martian cryolithozone in the mixture of poligonites and montmorillonites;
- the development of the software package for detailed analysis of subsurface martian structure, porosity, electrical resistance of liquid phase, thermal conductivity, temperature dependence, which are in agreement with the interpretation of data obtained in the field testing and laboratory supporting measurements;
-the estimation of maximum depth of sounding and resolution of the MARSES instrument in the conditions of rocks close to martian subsurface soil;
- possibility to study subsurface frozen water component using TDEM instruments and induced polarization (IP) device in several areas which are close to martian conditions: Antarctic, Iceland, Hawaii (volcanic area);
- improvements of hardware and software on the base of the field studies in order to use in the earth conditions, including environmental and geophysical application, and future space experiments on the martian surface.
Choosing right methods and instruments for Mars' cryolitozone structure research is the present day task for future missions on Mars. Data analysis of Mars' near-surface element composition (Mossbauer spectrums from Mars Exploration Rovers) shows magnetic materials presence on the surface. In some extent it confirm the "theory of meteoriteMars' upper crust evaporating". At the same time crust structure will develop under any frequency or time-domain sounding methods in additional induced polarization effects.

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