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Project "EXOMARS-Sounding": Experimental possibilities for complex sounding of the subsurface geo-electrical structure of Mars.

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Abstract

The primary goal of the "EXOMARS-Sounding " experiment is an investigation of the martian cryosphere and particularly its internal structure. These studies are based on the following measurements which are performed by various instruments carried by the lander scientifical instruments:

- Low frequency sounding by TDEM method and instrument;
- magnetic (3 components) and electric (2 components) field fluctuations in the frequency range from 3 to 20000 Hz which allows to determine an impedance on a surface of the Mars (magnetotelluric sounding) and to investigate electrodynamic properties of subsurface martian rocks;

1. Introduction

Theory of meteorite Mars upper crust evaporating.

One of the most probably mechanism of Mars upper crust saturation by stable magnetic materials is mechanism of meteorite evaporating during long-continued geological history of Mars.

As a result of thin atmosphere Mars surface was exposed by the quite intensive meteorite impacting. The very specific upper crust consisting of large percentage of magnetic materials has been composed as a result of such meteorite impacting.

Composing upper Mars layer with magnetic powder fractions of maghemite particles.

Stable maghemite particles was composed as a result of meteorite treatment of Fe_2O_3 under high temperatures and transform in Fe_3O_4 - stable maghemit, that was an additional factor of drying upper layer and Mars water loss in the subsurface which under high temperature transforms to vapor and creation of upper super-paramagnetic layer on the Mars.

As an Earth's example: Popigai crater (Yakutia), 35 million years ago, crater's diameter is 130 km.

The main factor that determines remote sounding possibility is presence of Fe_3O_4 layer on the Mars surface that has essential magnetic anisotropy properties that is certainly a serious difficulty for remote sounding results' interpretation if there is a frequency dispersion of return signal including magnetotelluric sounding.

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 physical-chemical transitions in the solutions of KCl , NaCl, $CaCl_2$ 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 more useful.

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 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 [E.Heggy, JPL NASA].

Therefore even in martian equatorial regions (from -30^0 to $+30^0$ 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 ice-bearing layer. In the middle latitude region (from 30^0 to 50^0) 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.

1.1 Comparative investigation of martian and Earth's frozen rocks

The goals of the MARSES Experiment based on the TDEM instrument and MT sounding is the 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 [1,2] , 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 3-D 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;

- improvements of the new generation of the 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.

Summary and Conclusions

Moreover, **there is a possibility of joint measurements with the magnetometer of the rover (ESA) and Marses-MT (IKI RAS) for the magnetotelluric profiling in the place of lander for simultaneous measurements of components of the magnetic and electric fields [5].**

For the first time, there is the possibility of experimental probing of the subsurface structure of Mars by various joint experimental methods and instrumentation for lander and rover project EXOMARS [6].

The complex sounding of the Mars provides not only the information about its cryosphere structure but also an outstanding experience of sounding at surface of celestial bodies. This experience is of particular importance for further investigation of subsurface structures of Mars and its paleoclimatic history which will be carried out in the future space missions.

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