POSSIBILITY OF THE SEASONAL EXISTENCE OF SALT SOLUTION IN THE MARTIAN SURFACE REGOLITH AND THEIR MORPHOLOGICAL EFFECT. Kuzmin R.O. and E.V. Zabalueva -Vernadsky Institute of Geochemistry and Analitical Chemistry, Russian Academy of Sciences, Kosygin st.19, Moscow, 117975 Russia, rok@geokhi.ru

INTRODUCTION. The presence of the water-soluble salts in the Martian regolith [1, 2, 3] may influence on the phase state of the ice-containing regolith in the areas where the ice in the regolith is stable on the surface. In the modern climate of Mars such conditions might be only on the latitudes above 40-45°[4, 5]. The salts presence in the ice-containing frozen soil of Mars may be responsible for the liquid water phase appearance in the regolith surface layer (seasonally) in a broad range of negative temperatures. In this paper, we examine the seasonal effect of the melting-freezing process in the near-surface layer of Mars caused by the achievement of the ground temperature equal to the eutectic points of the several salt solutions considered most probable on the planet [6, 7]. The process may serve as major factor in smoothing over of the original topographic roughness of the Martian surface due to the surface material on the slopes will undergo liquefaction and acquire the capability to flow.

POSSIBILITY OF SALT SOLUTION EXISTENCE IN THE MARTIAN REGOLITH. The substantial enrichment of the Martian soil with chlorine and sulfur discovered at the Viking 1 and 2 and Mars Pathfinder landing sites [1, 3] makes it more probable that the water-soluble salts (as chlorides and sulfates) may exist on Mars surface [6]. Such salts as NaCl, $MgCl_2$, and $CaCl_2$ are considered as the most probable candidates for salts contained in the Martian regolith [2, 6]. The solutions of the salts have eutectic points (or temperature of total solution freezing) at 252, 238, and 218 K respectively [7, 8]. If the Martian regolith contain multi-component salt solutions, their eutectic point is lower and will attain 210 K [7]. The zone of the temporal existence of the solutions in the surface regolith may be associated directly with the layer of seasonal temperature variation within the ice-containing regolith. When the temperatures in the layer are higher (seasonally) than the freezing point of the eutectic mixtures (ice + salt), an appearance of the liquid phase in the soil is becoming possible. The ultimate amount of the liquid phase will depend on the amount of ice and salts in the regolith. The quasi-periodic axial-obliquity changes (from minimal to maximal over a period of 125 kyr [9, 10]) are one of the chief factors responsible for time-dependent changes of the ground ice stability on the Martian surface as the function of the latitude. To estimate the depth range of the surface regolith where the appearance of the salt solution in the regolith may be available we performed an analysis of the annual thermal field dynamics within the surface layer. The dynamics was computed for any latitude during the entire Martian year both for its present climatic conditions (corresponding to a 25.2° axial obliquity) and for the paleoclimatic conditions (corresponding to maximal obliquity value 45°), using the MARSTERM program [11]. The parameters of an average model of the Martian surface regolith were used for the calculations (thermal inertia $I=6.5x10^{-3}$cal/ cm^2 $s^{1/2}K$, albedo A=0.25, soil density $\rho=1.66g/cm^3$). The results of the calculations shows that appearance of the potential zones with the seasonal salt solution within the surface layer in both hemispheres of Mars are remarkably different both for the case with the present obliquity value and for one with maximum obliquity value (see fig.1 and 2).

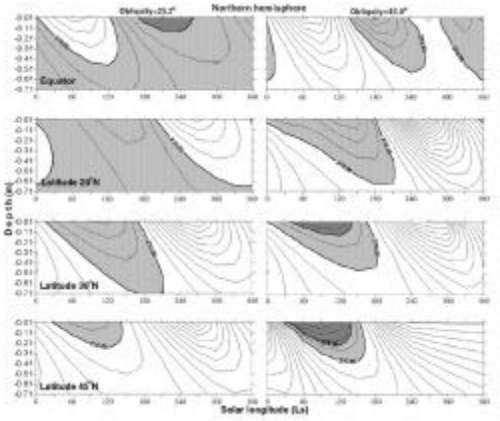

Fig.1. *Dynamics of the temperature field in the layer of seasonal temperature variation in surface regolith in the North hemisphere of Mars. Shaded are zones of potential appearance of salt solution with eutectic points 210-218K.*

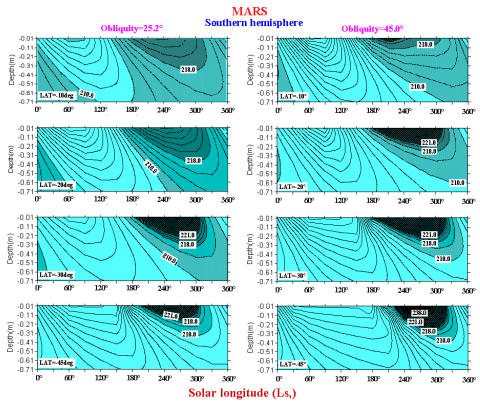

Fig.2. *Dynamics of the temperature field in the layer of seasonal temperature variation in surface regolith in South hemisphere of Mars. Shaded are the zones of potential appearance of salt solutions with eutectic points 210 – 238K.*

At that, it is seen the asymmetry of the potential zone appearance as function of the latitude. As shown on the fig.1 and 2, the salt solutions in the regolith on the middle latitudes of the southern hemisphere may appear with wider range of the eutectic points (210-238K) than on the latitudes in north hemisphere (210-218K). At the present climate conditions the salt solutions is much less probable to be revealed in the thinner subsurface layer (or are still arising?) on the latitude above 30°. While in the north hemisphere the presence of only the multi-component solutions with a eutectic point at 210K may be possible, in the south hemisphere the solutions may appear on with wider range of the eutectic points (210-221K). In a paleoclimatic conditions (obliquity 45°) the salt solutions with wide range of the eutectic points might appear in the surface layer up to equatorial zone of Mars, because in the period the ice in the surface regolith may be stable even in the low latitudes zone [10]. It is probable that appearance of the salt solutions in the regolith on the equator zone (during paleoclimate conditions) could be responsible for a duricrust layers formation. In the climate corresponding to minimal obliquity values (13°) the seasonal existence of salt solutions in the regolith seems to be unlike, since under the conditions the process of the significant regolith desiccation (to depths of tens of meters) embrace the largest latitude range (±60°). If the salt solutions took place within the surface regolith seasonaly (even on the scale of film waters) it may be considered as the analogue to the seasonal process melting-freezing, which operates in the permafrost regions of Earth.Indirect evidence of freezing-melting
process activity on Mars (in the summer time) would seem to be provided by a specific landscapes with intensive planation of the heavily crater terrains on a latitudes above 30°. The type of the landscapes is named “terrain softening” and there is the suggestion that such terrains were formed (and, possibly, continues to be formed) due to a slow creep processes of the upper layers of the ice-saturated regolith [12]. The type of terrain is common only within the 30°-60° latitude belts, i.e., where the ice in the surface soil is stable and where the conditions for the seasonal appearance of salt solutions in the surface soil are most probable. While sharing such origin of the “terrain softening”, we suggest that the process of of salt solutions appearance within the surface regolith itself is important factor in the formation of the subdued relief. The presence of ice in the soil noticeably increases the slipping of slope material, especially at temperatures close to 0 C, at which the amount of unfrozen water in the ice-soil system increases [13, 14]. As result, the surface material, losing a stability to shear, will undergo liquefaction and acquir the capability to flow. This is typical picture for the solifluction processes in the permafrost regions on the Earth and may be possible on the Mars due to the salt solutions appearance in the surface regolith.

CONCLUSION. The analysis carried out thus makes it quite probable that, in the course of the cyclical and long-term changes of the physical conditions on Mars (due to the periodic changes of the axial obliquity with a cycle of 125 kyr) conditions would arise for the seasonal appearance of salt solutions in the surface regolith . The process would occur in a limited range of middle latitudes in in periods with obliquity value equaled or exceeded its presenr value. Apparently, it was during these periods that the processes of the cryogenic planation of the Martian terrain (due to a solifluction-like process) were most active within the middle latitudes.

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