SLOPE STREAKS ON MARS – SIGNS OF WATER, FLOWING IN THE NEARSURFACE CAVITIES

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Introduction: Now the distant studies with the orbital equipment seriously support the water hypothesis of the Martian slope streak origin. In the low latitudes of the planet with the low thermal inertia of the ground the presence of the surface ice – the source of water – is eliminated. The slope streaks which are observed there are not connected with the surface water flow. This is confirmed by the absence of the visible material movement. At the same time any undersurface water must be effectively absorbed by the fine-grained soil, the characteristic size of its fractions is of several microns, i.e. instead of streaks there should form the isometric spots of the humid soil. Therefore the slope streak formation is possible under condition of the presence of channels through which the water moves down the slope sufficiently fast before it is fully absorbed by the capillaries.

Hypothesis: The slope streak is the superficial capillary display of the flowing water in the sublimation cavities under a layer of an upper ground. The slope streak development represents the consecutive distribution of the ice melting process downhill as a result of the mineralized water wave passing along the cavities at the ice surface, formed by the previous sublimation. The chain development of this process occurs only on slopes where the water can flow under the force of gravity. Meanwhile any essential lateral energy and substance transferring does not occur in the course of the slope streak formation. The water is soaked up in the ground pores, fixes in the form of the ground ice, which sublimates for a long time after this. After the sublimation of the new formed ice in the upper ground there remain the arid salts and the sublimation of the bed-rock ice, and formation of the cavities renew. It is supposed that the dotted origin of the slope streak occurs in such closed cavity as a result of the water steam condensation in the point of the maximal cooling or as a result of dehydration of the crystalline hydrates while heating.

Discussion: A priori we accept one condition: the presence of the saline ice under a layer of an upper ground. It is known, that the slope steaks form rather quickly Proceeding from the fact of the low heat conductivity of a ground it is possible to consider that at least at some centimeters in depth it is composed of the fractions of the same size as and at the surface – about several microns. The calculations show impossibility of the fast water filtration movement in the porous space of such ground. The terrestrial rock with the essential content of such fractions has the filtration factor smaller than 0,05 m/day. The filtration speed in a fine-grained ground submits to Darcy's law and can be defined from a ratio:

$$V = K^* I / n, \text{ where:}$$

V – the filtration speed, m/s; K – the filtration factor, m/s; I – the stream gradient, decimal fraction; n – porosity, decimal fraction. In the conditions of Mars the filtration factor of the ground, that is similar in the fractional structure to the terrestrial one, owing to the smaller gravity (0,38 of terrestrial), will be proportionally smaller. The porosity of the disperse Martian ground having the low thermal inertia and presumably the friable structure is reasonable to accept 0,3-0,5. The real inclination of the surface at the areas of the slope streak development is from 7 to 35^0, that corresponds to the stream gradient of 0,1-0,7. The rated speed of the water filtration will make < (0,004-0,044) m/day. It is clear, that at the filtration speeds even by two orders of magnitude greater the capillary absorption in the fine-dispersed dry ground should dominate and the process of wetting on the surface will be revealed in the isometric stains. At the same time we really see that the slope streaks are always subordinated to the action of the relatively weak Martian gravitation. Hence the filtration environment should be much more permeable rather than it is possible to expect in case of the fine-grained grounds. The supposed capillary penetration of water in the subsurface layers should be the process that is secondary and limited in time, i.e. be formed in the wake of rather quickly passing wave of the liquid water. The hypothesis about the local melting of the subsurface ice owing to the dissolution of the crystalline hydrates which are directly at a surface of this ice – in the channels that formed as a result of the previous sublimation of ice (see Fig.1) – can satisfy these conditions. The ground with the low thermal inertia should have the considerable temperature gradients with depth that at the change of the seasons should create the conditions for rather better migration of the moisture with a variable direction upwards and downwards. At the same time the subsurface fine-grained ground, as we see, is not blown off by a wind, i.e., being cohesive, creates the conditions of the good isolation from the atmosphere. As a result of the slow subsurface sublimation the ice surface can come off a layer of the rigid frozen together ground. It is logical to assume that in the formed cavities, that are parallel to the surface, the water steam will circulate, transferring the moisture and energy (see Fig.1a). The interaction of steam and the ground salts in such closed cavities can lead to the slow formation of the crystalline

hydrates of sulphates, chlorides (including ferrous chloride), perchlorides, and other salts.

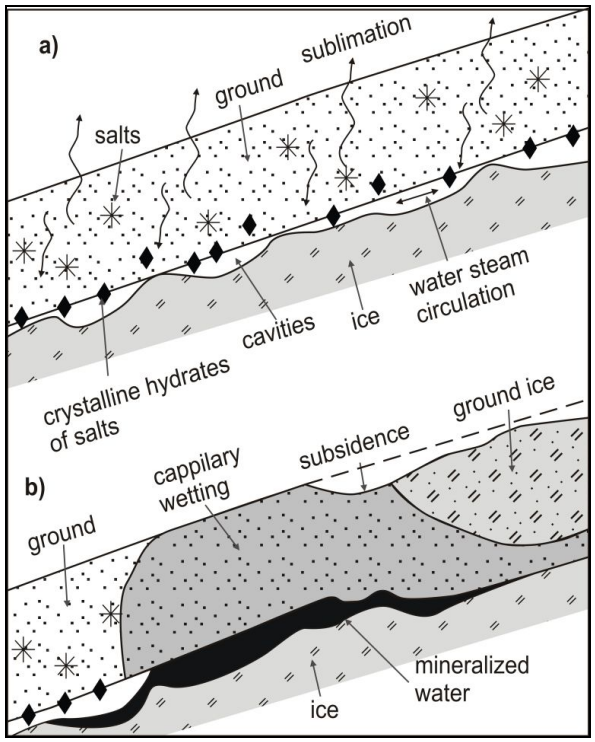

Fig.1. The scheme of the hypothetical formation of the cavities: (a) and the mineralized water wave passage through them (b).

As the occurrence of the liquid water under the conditions at the Martian surface demands exceptional conditions, then the mechanisms providing occurrence of the limited quantity of the liquid mineralized water in the closed volume i.e. under the ground surface first of all can apply for universality in such conditions. Following our hypothesis about the emptiness formation at the surface of the sublimating ice, it is possible to assume the prior condensation of the water steam (while cooling) and the possible occurrence of the first drops of water at the surfaces of the grains of the hydrophilic crystalline hydrate (while heating). The acceleration of this mechanism can be caused by the abnormal cooling or heating in the point of the suddenly reduced capacity of the isolating ground, for example, as a result of a stone blow the formation of the subsurface crack, the removal of a ground layer by a tornado, etc. The watertightness of the cavities before watering and slump of the soil is the essential circumstance. The system closure, the liquid and vaporous water presence, the smoothed temperature regime, the isolation from the rigid radiation create relatively favorable conditions for the life support. The potential comprehensiveness of the cavities in which the living organism metabolism is possible suggests the possible source of the suddenly burst methane in the Mars atmosphere.

The floods are not formed where the stream stops therefore it is possible to assert that all the slope streak water is fixed in the capillaries of the upper ground. Thereby it is also possible to expect that the ground wetting is accompanied by its subsidence (Fig. 1b): the ground fractions can lose the connections caused by the previous dry condition of the ground as it is observed in the terrestrial loessial soils cemented by the carbonates. In the Martian soils it can be other salts – sulphates, chlorides, etc.

Thus, the process of the slope streak formation develops increasingly at the expense of the local resource of energy and salts, but the initiation in the form of a portion of water comes from the adjacent site situated higher. It gives the slope streak the visual effect of the stream.

The most interesting and hard to explain observable phenomenon is overcoming by the slope streak the opposite slopes – the rims of the small craters and other roughness. It is possible to explain by the effect of the capillary forces. The ground, with the prevalence of the particles in size of some microns, in the terrestrial conditions theoretically provides lifting of the capillary water at height of 3-12 m, and at the counteraction of the capillary forces to the Martian gravity which is 0,38 from terrestrial, the lifting can make correspondingly to 7,9 -31,6 m. Visually the capillary forces are revealed by "the fringe" at the ends of the slope streak and by the smooth expansion of the slope streak downhill as a result of the water slowdown while decreasing of the flow inclination. The author's conception of the ice nature of the underlying slope streak massif is based on the following. The subsurface melting of the frozen rocks without the removal of the melted layer should lead to the termination of this process because of the capacity increase of the thermo-isolating layer. At the same time we do not observe any ground accumulation at the slope streak bottom. Other argument in favor of the ice prevalence in the slope streak bottom is the smoothed form of the slopes and the smooth outlines of the streaks themselves. If the massif consisted of the mixture of the rock and ice mix then while melting the smoothed surface would not be formed – the rock fragments would create more chaotic picture. It is logical to assume that the melting subsurface massif consists at least mainly of the ice.

The basic conclusions: 1. As a result of the subsurface ice sublimation at the foot of the pulverescent upper grounds in the low latitudes of Mars the closed cavities, where water steam can circulate, are formed transferring moisture and energy. 2. The development of the slope streaks from the initial point represents the consecutive distribution of the subsurface ice melting downhill as a result of the mineralized water wave passing along the cavities without the essential lateral energy and substance transferring. 3. In near surface conditions of Mars the watered closed cavities are the best environment for search of the present life.