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ELECTRICAL PROPERTIES OF FROZEN ROCKS

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The paper considers the location which is covered by permafrost. The site under the study is called Sandibinsk deposit. Such geophysical method as vertical electrical sounding was used to explore electric properties of frozen rocks in the site. The graphs of low temperature and electrical resistivity were produced on the basis of the received data. The further analysis comprises the comparison of the obtained graph with the same graph from the reference book.

The internal waters of Russia represent not only clusters of liquid water, but water in a solid state, forming the inland, mountain and underground glaciations. Underground glaciations areas are called cryolithozone.

Cryolithozone is the upper layer of the earth’s crust, characterized by negative temperatures of rocks and the presence (or possible existence) of ground ice. It is composed of permafrost, ground ice and unfrozen-horizons of highly mineralized groundwater.

Permafrost region in Russia is about 11 million km2, accounting for nearly 65% of the country’s territory (Fig. 1).

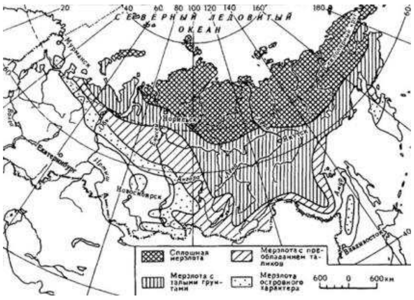

Fig. 1 Permafrost on the territory of Russia

The possibility to use geophysical methods for exploration of perennial permafrost is brought about due to the relationships existing between these characteristics and geophysical properties.

Both direct current electrical prospecting and low-frequency electromagnetic methods are commonly applied to determine the geotechnical characteristics of the permafrost. With respect to survey targets and measurement technique the methods of direct and low-frequency alternating current electrical prospecting are divided into electric profiling, vertical electrical sounding (VES) and well logging.

VES is used to detect the rock sequence in a section of horizontal and steeply dipping layers, their thickness and electrical resistivity (SER). SER is the basic electrical parameter which gives information on the composition, structure and state of frozen ground and ice. With VES it is possible to accomplish the following tasks:

- to distinguish layers of different lithology in a section and determine their occurrence elements;
- to detect vertical alternation of thawed and frozen soils as well as to define frozen soil thickness;
- to study changes in the composition, moisture (ice content), cryogenic temperature and texture of frozen soils in a vertical sequence.

SER of frozen water-saturated rocks with a low concentration of the pore solution dramatically increases with temperature decreasing up to the crystallization point of free water, i.e. when the spatial cryogenic crystallization structure is formed.

Frozen rocks SER can range from a few to 10^6 Om • m according to the temperature, lithologic features, moisture and degree of pore solution mineralization.

If a rock contains only bound water, the resistivity gradually doubles or increases just threefold (low ice content) with the temperature decrease, and when all the pore water is tightly bound, the electrical resistivity of rocks remains practically unchanged during the transition to a negative temperature. Increasing salinity of pore water lowers the rock freezing temperature and its resistivity; this affects cryogenic structure type of freezing rocks and spatial distribution features of ice and unfrozen water, structure and composition of boundary zones, as well as ice inclusions [1].

The analysis considers the results of surveys carried out on one of the planned Sandybinskoye field well sites where drilling, thermometry and DC vertical electrical sounding were conducted. The section of the site reveals from two to four geoelectric layers which differentiate grounds varying in composition and occurrence.

The frozen rocks have a temperature close to zero, ranging from 0 to -4 ° C. Electrical properties of frozen rocks which occur at this temperature range were given little consideration and the data presented in reference literature and scientific articles are too general and not specific.

The electrical properties of frozen loams that are most informative were subjected to a detailed analysis. Using the graph of the temperature distribution of the soil at various depths in a well section and resistivity data (results of VES), a set of resistivity versus temperature cross-plots for eight wells was produced. An averaged resistivity versus temperature curve for loams was compiled on the basis of the obtained plots. A trend line was imposed on the chart (Fig. 3). The resulting trend line was further compared with the scheduled resistivity versus temperature changes for loam, presented in “Recommendations for the application of geophysical methods to frozen soils” [2] and with the chart presented in the reference literature (Fig. 2) [3].

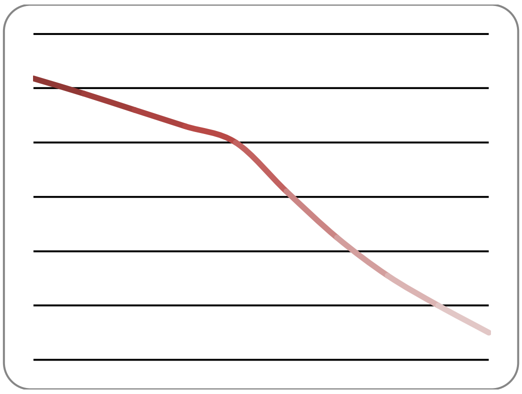

Fig. 2 Reference resistivity versus temperature cross-plot

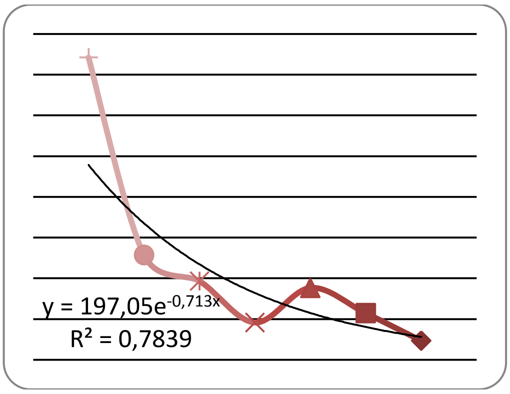

Fig. 3 Experimental resistivity versus temperature cross-plot

Finally, the comparison of the reference chart and the plot proposed as a result of the present analysis reveals their incomplete correspondence. These graphs coincide in shape within the sections which refer to temperature ranging from 0 to -2 ° C; the shape of the graph in this segment is an exponent. Proceeding to t = - 4 ° C the produced chart is also an exponent, while the corresponding section of the reference chart with the temperature t = - 2 ° presents a straight line. The freezing point of free water is the temperature at which regular relationships between the resistivity and temperature change. The freezing point depends on the degree of salinity. The investigated site has an average salinity, and it is 0.1 - 0.083 g / l. The proportion of free and bound water in loams has a great influence on the resistivity and the freezing point. The resistivity versus temperature graph, which was obtained in the described analysis, represents a graph which is intermediate in shape between the resistivity versus temperature cross-plot for ice of varying salinity and the resistivity versus temperature cross-plot for loams (Fig. 4).

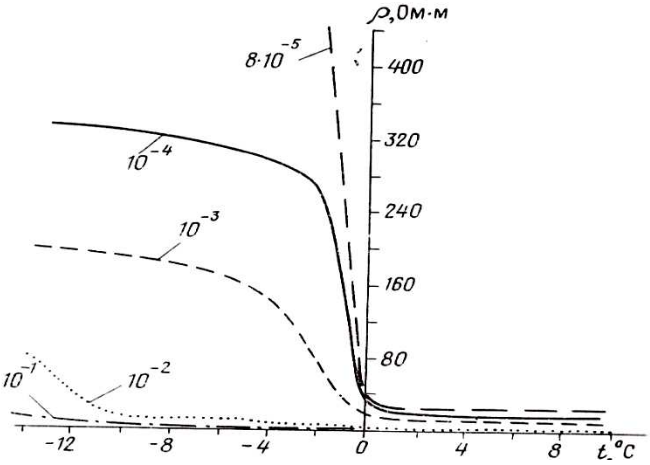

Fig. 4 Dependence of ice resistivity on KCl concentration and temperature (by A. Smirnov)

As a result of the work carried out in the investigation, resistivity versus temperature dependence within the temperature range of 0 to (-3,5) ÷ (-4) ° C, that varies according to an exponential law ($y = 197{,}05{*}e^{-0{,}713x}$) with mineralization 0.1 g / l, was obtained. By contrast, the similar chart from the reference literature changes exponentially within the segment that corresponds to the temperature reaching -2 ° C, and then it changes linearly. Evidently, this may be due to the peculiarities of free water freezing and changes in the proportions of water and ice inclusions in the pore waters. Resistivity values growth proceeds slower in the frozen loam soils with decreasing temperature, when they occur naturally in a sequence, compared with the process observed while taking measurements on samples in the laboratory.

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THE APLLYING OF MATHEMATICAL MODELLING METHOD FOR CONTROL OF THE CATALYTIC REFORMING INSTALLATION OF ACHINSK OIL–REFINING FACTORY

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Nowadays catalytic reforming is the one of the most important oil-refining processes. According to experience, optimal operation of a catalysis allows it to be used more effectively. Platinum catalysts, which is used in reforming, are very expensive, and in order to prolong the work period of the catalysts, it is necessary to research how effectively they are being used on oil-refining factories. The solution of this scientific task can only be performed by applying mathematical modelling.

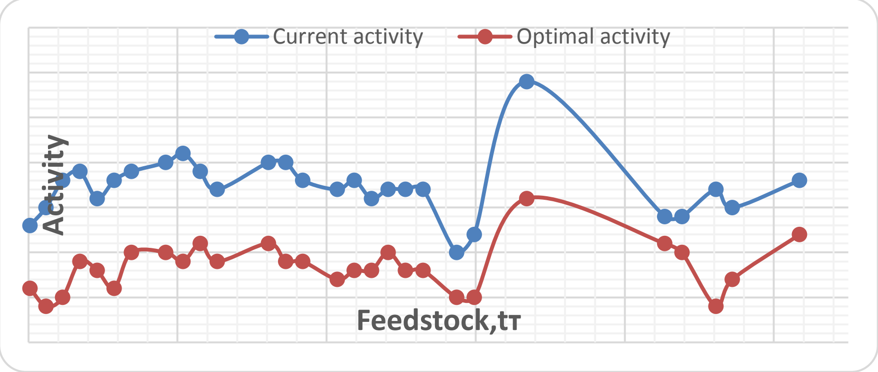

Fig. 1 The comparison of current and optimal activities of the catalyst

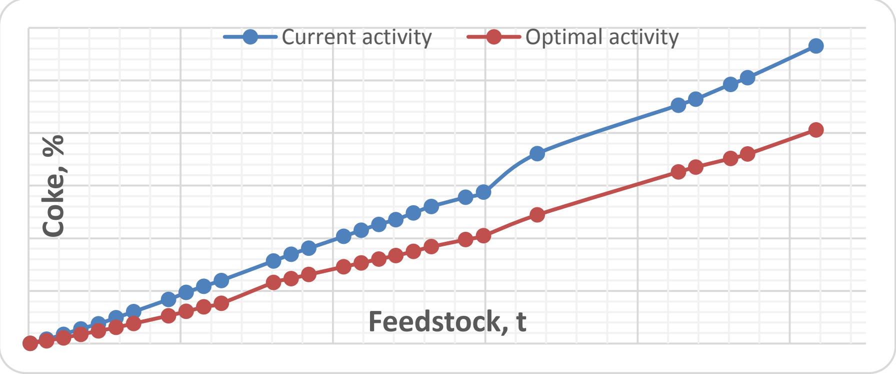

Fig. 2 The accumulation of coke

The goal of this is to determine the operating efficiency of the catalyst used at an oil-refining plant. To achieve this goal, the computer-based modeling system "Catalyst's Control" created at the Department of Chemical Technology of Fuel and Chemical Cybernetics was used. The system is based on the mathematical model of the benzene catalytic reforming, which takes both the physical and chemical mechanisms of hydrocarbon conversion reaction mixture as well as the catalyst deactivation into account. In assessing the effectiveness of the catalyst, the current and the optimal activity of the catalyst during its fifth work period were calculated using the program.

The results, which are shown on Figure 1, indicate that the amount of current activity during this work period is 0.8-0.85 points. However, a deviation from the optimal activity on 2.5 points in total can be observed. This deviation influences on the accumulation of coke (Fig. 2). For example, the total amount of coke in the catalysis is 34.92 % higher