Experimental research of joint influence of salinization and petroleum pollution on thermal capacity of frozen ground

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ABSTRACT
The majority of gas and petroleum fields are situated in permafrost zones, some of them – on saline territories. Oil pollution of soils can occur in various ways: during the extraction, processing and storage, and there is a danger of leakage during transportation of oil and petroleum products. With oil producing pollution and salinization of soil often occurs at the same time. The sources of salts in this case are the formation fluid, commercial waste water, the contents of the granaries and other geochemically active substances used for the extraction and desalting crude oil. In addition, joint salinization and contamination can occur during rupture of oil on the saline areas, where the there are ways of oil transportation.
Nowadays there are researches on properties of saline soils and on properties of soils polluted with petroleum. Currently there is no studies that describe changes of ground properties with joint pollution of salt and petroleum.

RÉSUMÉ
Actuellement, la plupart des gisements de pétrole et de gaz sont situés dans les régions froides, beaucoup d'eux - dans la diffusion des roches salines. La pollution des sols peut se produire de diverses manières: lors de l'extraction, de la transformation et du stockage, et il a le risque de fuite lors du transport de pétrole et des produits pétroliers. Lorsque la production de pétrole il ya souvent les cas où la pollution et en même temps la salinisation des sols se passe. Les sources de sels dans ce cas sont les fluides de formation, les eaux usées commerciales, le contenu des greniers et d'autres substances géochimique actives utilisées pour l'extraction et le dessalage du pétrole brut. En outre, la salinisation et la pollution commune peut se produire à la rupture de l'huile dans la distribution des sols salins, où il y a le transport routier de pétrole.
Insertions dans les sols de différentes solutions et produits modifie considérablement leurs propriétés. Il y a des articles consacrés à l'étude des propriétés des roches salines, aussi que à étude des propriétés des roches, contaminés avec de l'huile. Toutefois, à ce jour il n'existe aucune étude qui réponde à la question quelle sont les propriétés du sol sous l'influence combinée sur eux de la salinité et de pollution pétrolière.

1 INTRODUCTION

To predict the interaction of engineering structures with the geological environment and making technical decisions on the use of certain types of structures and facilities engineering protection of the territory it is necessary to carry out thermal calculations, which use thermal characteristics. In this way it is necessary a detailed study of thermal properties of soils, to carry out their spatial variability, as well as factors affecting the performance of these properties. It is also necessary to explore the phase composition of water in a frozen ground as it determines the course of geological processes in the permafrost and the specificity of basic physical and mechanical properties of a frozen ground, including thermal ones.

We had for an object a research of joint influence of salinization and petroleum pollution on thermal characteristics of thawed and frozen grounds, particularly on thermal capacity.

2 THE OBJECT OF RESEARCH AND EXPERIMENTAL METHODS

For experimental research was chosen the loam lake-alluvial (la IV), light gray selected on Bovanenkovo field. Its humidity is 20%. Soil refers to light loam (classification V. Okhotin) by granulometric composition. Salinity of D_s is 0,02%. According to the gradation of salinity it is a non-saline soil (GOST 25100-95). Humidity lower limit of plasticity is 32%, humidity the upper limit of plasticity - 43%, a plasticity - 0.11, the density of the solid components is 2,7 g/cm^3.

We carried out tests on pastes with different gradations of salinization (Ds=0%, Ds=1,0%, Ds=2,0%) and oil pollution (z=0%, z=2,5%, z=10%).

The quantity of salinization and oil pollution was calculated with formulas:

$$D_s = (m_z/(m_{ск}+m_z))*100, \quad [1]$$

where D_s - salinization of soil,% m_{ck} - weight of the soil skeleton, m_z - weight of salts contained in the soil [SNIP II-18-76];

$$C_{ps} = D_s / (D_s + W_{tot}), \quad [2]$$

where the C_{ps} – the concentration of pore solution, p.; W_{tot} – total soil moisture, p. [SNIP 2.02.04-88].

Adding oil was carried out after moistening the soil and mixing it thoroughly.

It was a complex study of the freezing point of soil, phase composition of pore moisture, heat capacity and thermal conductivity.

Experimental investigation of thermal characteristics were conducted using gauge ITS-λC-10, which gives the continuous dependence of thermophysical parameters on temperature. In the experiment temperatures of the glass and the central zone of the sample they are recorded as a function of time. Thermocouple or thermopile are used as the temperature sensors.

3 RESULTS

3.1 Influence of salinization on the freezing point.

Figure 1, Figure 2 and Figure 3 shows the melting thermograms for loam. In pure clay loam (Figure 1) in saline 0% and 0% contamination, the freezing point is -0,2 °C.

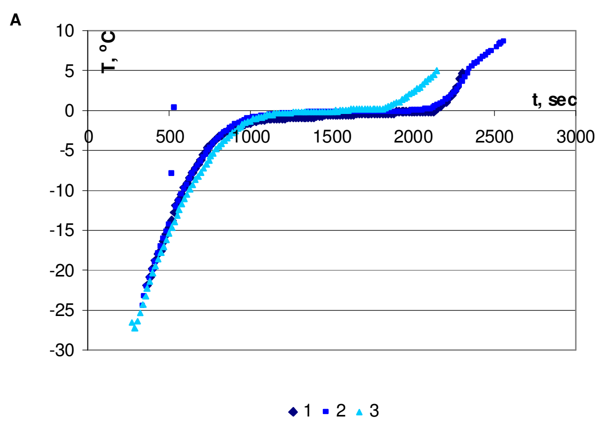

Figure 1. Thermograms of loam thawing: D_s=0%, 1 – z=0%, 2 – z=2,5%, 3 – z=10%

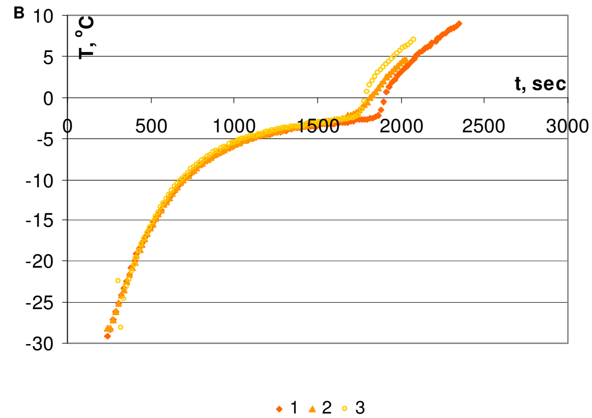

Figure 2. Thermograms of loam thawing: D_s=1%, 1 – z=0%, 2 – z=2,5%, 3 – z=10%

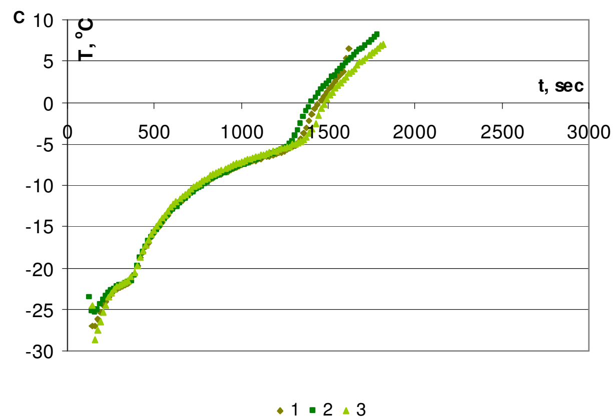

Figure 3. Thermograms of loam thawing: D_s=2%; 1 – z=0%, 2 – z=2,5%, 3 – z=10%

These graphs (Figure 1, Figure 2, Figure 3) shows that the range of temperatures where intensive transition phase happen changes, also the time of phase transitions reduces. In addition, during the temperature range from -21 to -23 °C for samples with salinization of 2% one more transition phase is recorded. It is due to the formation of sodium chloride cryohydrate. Terms and conditions of its formation are the solution concentration 0,23 DE and temperature -21,2 °C. The fact that the inflection on the graph is connected with the formation of cryohydrate is confirmed by calculating the concentration of pore solution C_{ps} at a temperature of -22 °C.

3.2 Joint influence of salinization and oil pollution on the freezing point

Figure 1 shows that while adding 2,5% of oil in the ground, thawing thermogram does not change. However, for non-saline clay loam with 10% of oil pollution thawing thermogram differs, which may be connected with the peculiarities of the experiment and a large quantity of ice in the sample. However, to confirm this fact it is necessary to carry out an additional research. In saline soil samples (Figure 2, Figure 3), addition of oil pollution 2,5% and 10% does not influence the kinetics of thawing process.

3.3 Influence of salinization on thermal capacity

While adding 1% salinization to pure ground heat capacity of light loam in the frozen state increases to 1400 J / kg * K and there are no changes in the unfrozen state.

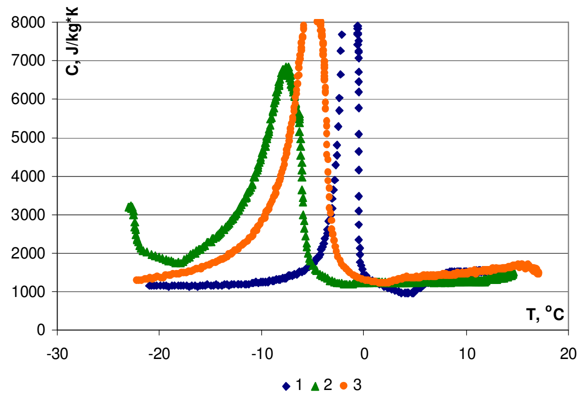

Figure 4. The dependence of the heat capacity in light loam on temperature: 1 - D_s = 0% 2- D_s = 1%, 3- D_s = 2%.

Increasing of heat capacity with increasing of salineization happens due to the substantial increase in the number of unfrozen water, as there is melting of more ice.

Figure 4 shows the influence of salinization on the occurrence of transitions phase in the ground. When the ice thaw heat capacity tends to infinity. In clean soil, this peak reaches 17000 J / kg * K. In the soil with 1% salinization, this peak shifts to the left, as the temperature of soil freezing is reducing. Moreover heat capacity up is 9000 J / kg * K that is associated with less ice, which moves in the water. Furthermore, this peak has a different form, in contrast to the one that is recorded for non-saline soils.

This is connected with the fact that the transitions phase of the solution in saline soil occur in the temperatures spectrum. The peak on the graph falls on the intensive phase transitions, which are held for non-saline soil in a temperature range from -0.2 to -7 °C, in saline 1% - from -3 to -17 °C. The higher salinization the more unfrozen water in the soil and the greater temperature range in which the phase transition happens. In the temperature range from -21 °C to -24 peak of the heat capacity of soils with 2% salinization is recorded, the graphs because there is a significant increase in the heat.

Consider Figure 5, which shows the variation of heat capacity of light loam on temperature with different values of salinization and oil pollution. Figure 3 shows that the oil addition either to a net, or to a saline soil has almost no effect on the values of heat capacity. Also, there is no influence on the form of dependence, that's mean to the process of change in heat capacity while temperature changing.

4 CONCLUSION

Figure The research of the freezing point of light loam is carried out. These data are correspondent to the studies for saline and oil polluted grounds, carried out before. The study of joint saline and contaminated samples shows that the combined effect of salinization and oil pollution is virtually nonexistent, and the temperature of freezing start is determined mainly by the value of salinization. Meanwhile the oil addition does not significantly alter either the value of the freezing temperature or thawing kinetics of the process.

The study of heat capacity of light loam depending on temperature, salinization, and oil pollution is carried out. Experimental data show that an increase of salinization increases the heat capacity of frozen soil due to the fact that with increasing of salinization the quantity of unfrozen water also increases. Moreover it is revealed that the contamination almost have no influence on the nature of the specific heat dependence on temperature, and even addition of even 10% oil is not a significant contribution to the total heat capacity of the soil.

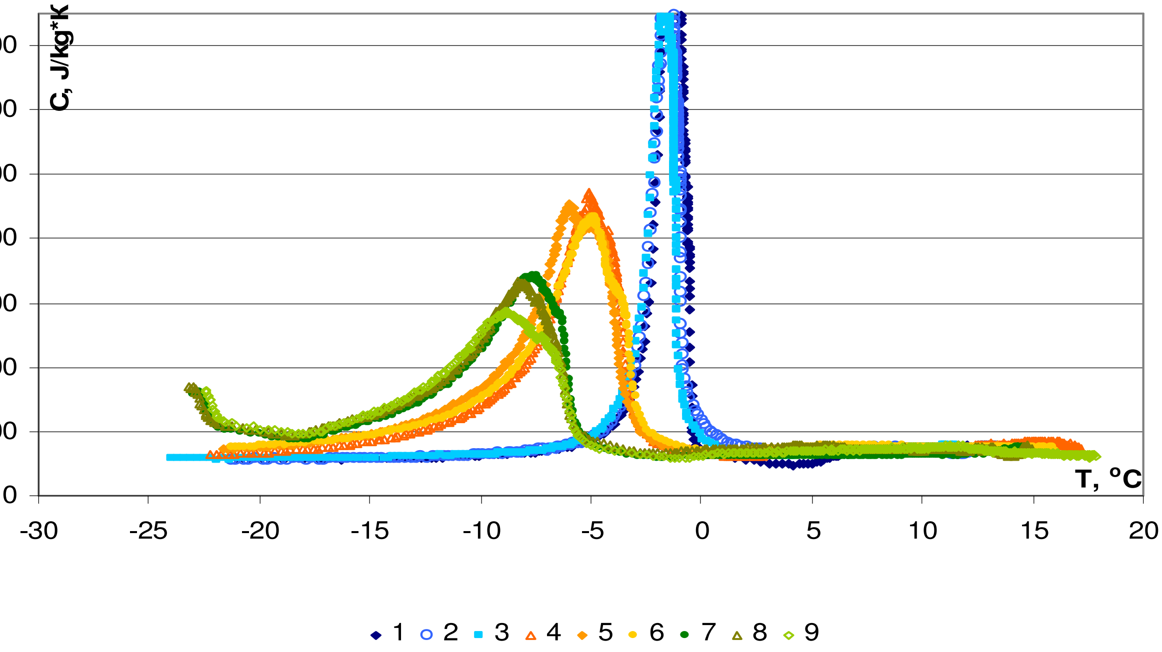

Figure 5. The dependence of the heat capacity of light loam on temperature, salinization and oil pollution: 1 – D_s= 0%, z=0%; 2 - D_s= 0%, z=2,5%; 3 - D_s= 0%, z=10%; 4 - D_s= 1%, z=0%; 5 - D_s= 1%, z=2,5%; 6 - D_s= 1%, z=10%; 7 - D_s= 2%, z=0%; 8 - D_s= 2%, z=2,5%; 9 - D_s= 2%, z=10%

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