A Brief Comment on the Change in the Content of Unfrozen Water in Frozen Soils with Increasing Temperature

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Commentary

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DESCRIPTION

An increase in the negative temperature of permafrost in the Arctic region as a result of climate change may lead to an increase in the content of unfrozen water in the permafrost. This entails a change in the soil properties and additional risks of reducing their bearing capacity, which previously fully ensured the stability of engineering structures and their safe operation. Many other factors, including technogenic ones, such as the thermal impact of various buildings and engineering structures during their construction and operation, well drilling, etc., can also lead to an increase in the content of unfrozen water in frozen soils. Therefore, today it is relevant to develop new promising methods for determining the content of unfrozen water in frozen soils.

The article briefly considers the history of the development of methods for determining the phase composition of moisture in frozen soils and proposes their author's systematization. Particular attention is paid to one of the promising methods-water potential method, which allows one to quickly measure the content of unfrozen water with high productivity. The data on the use of the water potential method to estimate the amount of unfrozen pore water both on model soil samples in a wide range of negative temperatures (up to -15°C) and on samples that were collected during engineering surveys in the north of Western Siberia are presented. The conducted studies showed good convergence when comparing the results with data obtained by other methods, in particular with NMR, as well as with the contact method, which is the most popular in Russia [1].

Pore water potential measurement by the water potential method can be carried out on WP4 instruments developed by the METER group (formerly Decagon Devices). To obtain the dependence of the content of unfrozen water in frozen soil on its temperature using this method, a series of successive single measurements is required at various total moisture values, which is determined by weighing the soil samples on analytical scales. For each sample moisture value, the pore water potential (ψ) is initially measured on WP4 devices, and then the values of the pore water activity (a) are calculated, which are subsequently recalculated into the equilibrium (equivalent) temperature (teq, oC), which actually represents freezing temperature at a given value of soil sample moisture. The theoretical foundations of the method are also described in detail in articles [2,3]. The time of one measurement on the WP4 device (time required for soil moisture and vapor-bearing air in the sample chamber to reach full equilibrium) is usually no more than 30 minutes. Only for some clay soils with low moisture content it can reach 1 hour, which is very fast and productive compared to the performance of other traditional methods for determining the content of unfrozen water.

Using the described method, it is shown how an increase in the temperature of natural frozen soils affects an increase in the content of unfrozen water in them. As an example, data are given for natural samples of saline and organic rich soil widespread in the north of Western Siberia.

The article also discusses changes in air temperature and permafrost and under the influence of climate change over the past 50 years according to monitoring data at various points in the western sector of the Russian Arctic. On the example of one of the permafrost sections typical for the north of Western Siberia (Yamal Peninsula), a forecast is proposed for a possible change in the phase state of permafrost due to an increase in the temperature of the upper permafrost horizons caused by climate warming.

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