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Geophysical methods of monitoring of permafrost on the objects of economic activity

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Abstract

Hydro units are natural laboratory for the study the interactions between climate-permafrost-aquafer. Our geophysical observations, including long-term temperature measurements, near hydro units focused on the study of seepage processes. The aim of the study is to use geophisical information for constructing reliable numerical model of interaction of human impact (hydro units) on the system "permafrost-climate-aquafer". Another part of our work is spatial electric monitoring of the permafrost state near injection wells on oil fields in Western Siberia. We present an experience of such monitoring at a multiple-well platform of an oil field. Changes of permafrost physical state near the injection well investigated using radio wave methods of cross well surveys.

Keywords: hydro unit, permafrost, seepage, geophysical monitoring, cross well survey, modelling

Introduction

The Yedoma permafrost is significant source of greenhouse gases. Increasing thawing of permafrost may have positive feedback for greenhouse effect when gases emitted to the atmosphere. Intensity of gases contribution mainly depends on the active layer thickness (ALT). The presence of artificial aquafer in permafrost environment gives an additional effect for deeper thawing than for active layer due to seepage development. The magnitude of thaw process evaluated by numerical modelling. We present monitoring geophysical data from Sitikan and Viluy hydro units and VNIMS testing ALT area of near Svetliy settlement in Western Yakutia. Special EM observation were performed near multiple-well platform of an oil field for detecting local thaw processes caused by intensive injection of hot fluid(up to 120°C) used for maintaining reservoir pressure. (Cherepanov, 2014).

Methods

Geophysical methods included surface and borehole observations. (Snegirev et al., 2003, Milanovskiy et al., 2008, Milanovskiy et al., 2015). Long-term temperature measurements organized in boreholes drilled in frozen coastal zone and in different elements of hydro unit's construction as well as in reservoir. Geophysical monitoring included Electrical Resistivity Tomography, Method of a Natural Field, Georadar, Seismic Profiling and Sounding. Down-hole observations included complex of logging studies (Resistance, Flow meter survey, Gamma logging, Neutron Gamma logging, Caliper measurement, Radio Wave Geo - Introscopy - RWGI). We also used RWGI method (Istratov &. Frolov, 2003) and its modifications for controlling condition of permafrost rock mass on different objects of oil and gas sector, located in Western Siberia. Electrical parameters of rocks - electrical resistivity (ϱ) and permittivity (ε) are more sensitive to changes in physical and mechanical properties of permafrost rock massif comparing with temperature data. Technology of spatial radio wave monitoring makes possible to determine geoelectric structure of the research site. We may classify the state of rocks in three main categories: 1) frozen rocks in stable condition; 2) rocks in the thawing state, when the process of phase transition "ice-

water" is going on; 3) fully thawed rocks, in which the phase transition was completed.

Numerical Model

Numerical evaluations of originating and development of talik-zones near the dam, performed for two cross-sections: normal and orthogonal to general direction of filtration flow (quasi 3D). We solve non-steady problem of heat-mass transfer in fractured-porous saturated frozen environment. Model analyzes conditions causing origin and development of talik near reservoir, such as air temperature variations, snow cover, seasonal change of water temperature in storage basin, permeability evolution in frozen soil and inner structure of frozen massif. (Milanovskiy et al., 2011).

Results

Comprehensive environmental-geophysical monitoring including long-term regime temperature measurements and complex of logging studies, electrical, seismic, acoustic methods were used for solving of various geocryological problems in the cryosphere. It is evident that a perfect system of geophysical monitoring should include real-time observation of the permafrost state. From our data, we observe that deep talik formation in permafrost environment is in a close connection with artificial aquafer providing water head for seepage in thawing strata. After beginning of filtration, seepage zone works like intensive heat source for surrounding frozen rocks. The "domino" effect works until we have driving forces - headwater from aquafer or relief. In the last case, originally frozen rocks containing ice after thawing became seepage zone. The principal interest is the very beginning of thaw process inside frozen strata containing ice. For active layer the main factor is climate impact. From our observation, maximum thaw depth is not so much (not more than 3m). From other hand, we observe seepage processes much deeper. The model shows a significant impact of artificial aquifer. The talik forms even in case of deep permeable layer location, which do not affected by surface temperature conditions. The "domino" effect (two permeable layers divided by an impermeable one) may enhance penetration of the thawed zone with time significantly. The problem of deep thawing of permafrost near aquafer (even without seepage on deep level) is important in connection with possible instability of gas hydrates under growing temperature.

The technology of spatial geoelectric monitoring for the early diagnosis of the change in the frozen state of rocks in situ, has been developed and experimentally tested. Developed algorithms and data processing programs permit to obtain 3D distribution of effective ϱ and ε of the rocks in the inter-wellbore space. We consider the experience of new technology testing in stages of engineering design, construction and production time of multiple-well platforms of oil and gas fields in Western Siberia. The development of the thawing zone around the injection well during several years demonstrated for multiple-well platform on the oil field. The development dynamics of thawing processes in space and with time have been determined for various types of soils.

References

Cherepanov, A.O., 2014. Spatial geoelectric monitoring of permafrost state near injection wells by the example of an oil field in Western Siberia. *Geophysical Research* 12: 18-24. (In Russian).

Istratov, V.A., &. Frolov, A.D. 2003. Radio wave borehole measurements to determine *in situ* the electric property distribution in a massif. *J. Geophys. Res. – Planets*, Vol. 108, No E4: 8038-8043.

Milanovskiy, S., Petrunin, A., Velikin, S., & Istratov, V., 2011. Numerical simulation of seepage processes in permafrost near a hydro unit In: *Cold Region Hydrology in a Changing Climate (Proceedings of symposium H02 held during IUGG2011 in Melbourne, Australia, July 2011)* IAHS Publ. 346: 164-170.

Milanovskiy, S., Velikin, S. & Istratov V. 2008. Geophysical study of talik zones (Western Yakutia). *Proceedings of the Ninth International Conference on Permafrost* (ed. by D. L. Kane & K. M. Hinkel) (University of Alaska, Fairbanks)

Milanovskiy, S., Velikin, S., Petrunin, A., & Istratov, V., 2015. Geophysical Monitoring of Engineering Constructions in Western Yakutia and Study of Coupled Problem of Temperature and Seepage Fields in Permafrost near Hydro Unit. *Proceedings of 68th Canadian Geotechnical Conference and 7th Canadian Permafrost Conference, GeoQuebec2015*, Quebec City, Canada, September: 20-23, 9p.

Snegirev, A.M., Velikin, S.A., Istratov, V.A., Kuchmin A.O., Skvortsov A.G., Frolov A.D. 2003. Geophysical monitoring in permafrost areas. *Proceedings of the Eighth International Conference on Permafrost*, 21–25 July 2003, Zürich, Switzerland, Phillips M., Springman S.M., Arenson L.U. (eds.) Zurich, ICOP: 1079-1084.