

Permafrost researchs report of Russia 2015

Geocryological monitoring in undisturbed condition was continued. The 2015-results were submitted in the GTN-P Database. The 298 observatories contain several boreholes or soil temperature measurements. The 61 CALM-sites present different landscape condition.

******* Earth Cryosphere Institute (ECI SB RAS) (Earth Cryosphere Institute, Siberian Branch, Russian Academy of Science, Tyumen)** publishes the journal “Earth’s Cryosphere” (“Kriosfera Zemli”): <http://www.izdatgeo.ru>

The results of the most fundamental and advanced investigations, important results on the programs of the Earth Cryosphere Institute (ECI SB RAS) and of the many others Institutes and organizations specializing on permafrost/cryosphere researches are presented in the journal “Earth’s Cryosphere” (“Kriosfera Zemli”). The abstracts of the most interesting papers are submitted for the consideration of readers.

1) **V.N. Golubev, D.M. Frolov.** Peculiarities of water vapor migration at snow cover–atmosphere and snow cover–ground boundaries

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Concentration gradient of water vapor in snow cover is determined by the presence of temperature gradient. The formation of water vapor concentration gradient on the boundaries of contacting media (snow cover–atmosphere and snow cover–underlying ground) is conditioned by the difference between water vapor content in pore spaces of snow and in boundary layers of atmosphere and ground. The result is the sublimation of ice grains and the migration of forming vapor. It has been demonstrated that the snow sublimation intensity under isothermal conditions depends on microstructure and varies from $42 \cdot 10^{-8}$ kg/(m²·s) at –8 °C for ice and $40 \cdot 10^{-8}$ kg/(m²·s) for snow with density 500 kg/m³ to $32 \cdot 10^{-8}$ kg/(m²·s) for snow with density 160 kg/m³. Water vapor content in pore space of snow amounts to 1.08 at –22 °C and 1.045 at –5 °C in regard to its concentration defined by Clapeyron–Clausius equation. Consideration of water vapor transfer on the snow-ground boundary for isothermal conditions and at the presence of temperature gradient for sand and clay models has demonstrated that flux values range (8.0–39.3)·10^{–8} kg/(m²·s) (from ground to snow) and (1.0–2.5)× 10^{–8} kg/(m²·s) (from snow to ground).

2) **S.M. Fotiev.** Genesis and mechanism of formation of the layers of the repeatedly-injective ice

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The typical features of the ice layers occurring in situ in the full sections of the marine sediments have been specified. The comparison of the mineralization and the chemical composition of the

ice of the lacustrine and marine waters have proved that the ice layers had been saturated by the lacustrine waters. It was determined that the ice layers began forming only after the full sea regression and considerably later than the perennial freezing of the surrounding deposits. It has been ascertained that thick ice layers cannot be formed during the process of segregational accumulation. The leading role of the process of injective ice accumulation during the formation of the thick layers of the ultrafresh ice inside the strata of the frozen deposits have been proved. The source “feeding” the ice layer occurred to be not inside but outside the surrounding deposits. The conditions of penetration of the lacustrine waters into the strata of the frozen deposits and the layerwise formation of the ice layers have been examined. It was revealed that the delivery of the water from lake to ice layer and its transportation to enormous distances was provided by the huge cryogenic pressure occurring during ice freezing inside the closed lake depression.

3) D.G. Shmelev. Role of cryogenese in the formation of composition of the Late Quaternary deposits in Antarctic oasis and North East Yakutia

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The pioneer data obtained by the Cryology Laboratory of the Institute of Physicochemical and Biological Issues in Soil Science from Antarctic oasis and North East Yakutia are analyzed in the paper. Two different types of cryogenic weathering have been distinguished on the basis of analyzes of current temperature regime of active layer and features of deposit composition. The detailed investigations of the Late Quaternary deposits of North East Yakutia and Larsemann Oasis (Antarctica) have ascertained the cyclic structure of cryolithogenic strata caused by the changes in the environmental conditions during sedimentation. It was established that the most favorable conditions for cryogenic weathering had occurred at the Late Pleistocene–Holocene terms for the examined regions.

4) S.S. Kutuzov, I.I. Lavrentiev, E.V. Vasilenko*, Y.Y. Macheret, D.A. Petrakov, G.V. Popov**** Estimation of the Greater Caucasus glaciers volume, using radio-echo sounding data and modelling

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The results of ice-thickness measurements and modelling of the Greater Caucasus glaciers, using radio-echo sounding data, GlabTop model and satellite imagery, are presented and discussed. Ground and airborne radioecho sounding measurements were conducted at selected Caucasus glaciers, including the biggest Bezengi glacier, reference glaciers Djankuat and Marukh as well as glaciers of the southern and eastern slopes of Mt. Elbrus in 2011–2013. The GlabTop model was calibrated using the measured ice-thickness data and ice-thickness and bedrock topography

maps were completed for 224 glaciers (13 %) which cover 719 km² or 64 % of the total glacier area in Caucasus. New dataset of the Caucasus glaciers outlines was completed using available satellite imagery. There were 1713 glaciers with the surface area of (1121 ± 30) km² in Caucasus in 2010–2013. Obtained data were used to calibrate volume-area scaling relationship and to calculate the total volume of Greater Caucasus glaciers which is (43.5 ± 5.0) km³.

5) J.B. Gorelik, P.V. Soldatov, A.A. Seleznev. Engineering and geocriological conditions of the Yamburg gas and condensate reservoir and dynamics of the ground state of boreholes

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Engineering and geocriological conditions of the Yamburg gas and condensate field are considered from the point of view of their impact on the operational reliability of the production wells and on the state of the soil near the wellhead area. The results of the previous permafrost's researches have been significantly supplemented after the drilling of special permafrost parametric wells of 250 m depth and the permafrost core examination, custom-made by NTF "Krios" in the period from 2004 to 2005 (the customer is CoLtd "Gazpromdobycha Yamburg"). According to its construction characteristics (ice content, thaw factor) the field ground occurring below than 10–15 m has a low coefficient of subsidence during thawing and is favorable for building. Nevertheless, regardless of the exploitation time of wells, disorders occur on the well pads due to the ground subsidence and atypical loss of stability of individual wells. The nature and dynamics of these disorders are discussed in the article in relation to the properties of deposit frozen ground.

6) V.P. Melnikov, A.V. Brouchkov*, A.N. Khimenkov** On the development of fundamentals of geocryology

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There is an objective requirement of further improvement of the cryolithozone formation theory. Some methodological approaches to studying of the bases of cryostratigraphy, including the development of criteria for definition of the cryostratigraphical horizons and techniques for allocation of local and territorial cryostratypes, are considered. Need for further development of the permafrost-facial analysis in relation to epigenetical permafrost offered by E.M. Katasonov is proved. The importance of studying live substance in cryolithozone is designated.

7) A.I. Kizyakov*, A.V. Sonyushkin, M.O. Leibman***, M.V. Zimin**, A.V. Khomutov***.** Geomorphological conditions of the gas-emission crater and its dynamics in Central Yamal

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This paper presents the characteristics of the relief within the area of crater formation in Central Yamal, based on the analysis of remote sensing data, including stereo-pair very high resolution data as well as field observations. Time interval of the crater formation was defined as late fall 2013. Data on the morphology of the studied area before and after the crater formation were obtained. The existence of the bulge with the base diameter 45–58 m and height of about 5–6 m in place of the crater was documented. Analysis of multi-temporal digital elevation models allowed calculating the volume of the crater and the parapet formed around it. The volume of discharged material is almost 6 times larger than the volume of material found in the parapet. The difference is due to a significant amount of ice that, according to the results of field observations, is exposed in the walls of the cylindrical portion of the crater, and, apparently, comprised a major part of bulge material that thawed after ejection. The rate of the crater increase in diameter due to melting of its ice walls and the rate of its filling with water over the summer period were determined.

8) A.S. Victorov, V.N. Kapralova, O.N. Trapeznikova. Mathematical model of the lacustrine-thermokarst plain morphostructure under the changing climatic conditions

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The aim of the paper is theoretical and empirical substantiation for a new model of developing the morphological pattern for thermokarst lacustrine plains taking into account the climatic changes. The model is based on the approach of the mathematical morphology of landscape, using the random process theory. The researches have resulted in the mathematical model for the morphological pattern of uniform thermokarst lake plains changing under climatic changes in case of isometric lakes. It has been demonstrated analytically that under the climatic changes the distribution of thermokarst lake areas should obey the lognormal distribution at any time, and their spatial distribution should obey the Poisson distribution for the different physiography and permafrost conditions. These conclusions agree with empirical testing of key areas with different physiography, geology and permafrost conditions.

9) I.D. Streletskaya^{*}, A.A.Vasiliev^{}, G.E. Oblogov^{**}, I.V. Tokarev^{***}.** Reconstruction of paleoclimate of Russian Arctic in Late Pleistocene–Holocene on the basis of isotope study of ice wedges

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Paleoclimate of the Russian Arctic has been reconstructed based on the isotope composition ($\delta^{18}\text{O}$) of ice wedges. All available data on isotope composition of syngenetic ice wedges with determined geologic age have been analyzed. Spatial distribution of $\delta^{18}\text{O}$ values has been analyzed by the present time, as well as MIS 1, MIS 2, MIS 3, and MIS 4. Trend lines of spatial distribution of $\delta^{18}\text{O}$ for different time periods are almost parallel. Based on the data on isotope

composition of ice wedges of different age, winter paleotemperatures have been reconstructed for the Russian Arctic and their spatial distribution has been characterized.

10) Yu.B. Badu. Ice content of cryogenic strata in gas-bearing structures on the Northern Yamal

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Investigation of the ice content of the ground in the cryogenic sections of the gas-bearing structures (Northern Yamal) has been carried out. The differences in salinity due to the conditions of accumulation and freezing of the sediments in Late Pleistocene have been revealed. The value of the pore water mineralization, at which ice-segregation occurs in disperse ground, has been determined.

11) G.Z. Perlshtein, G.S. Tipenko, A.V. Levashov* Prospect of the atmospheric heat utilization on permafrost territory

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Effects of the film water heater is analyzed theoretically. Calculation researches were accomplished on the basis of generally accepted design equations. Unique dependence has been established between the water heating rate and the temperature on its surface. This important conclusion allows us to significantly simplify the numerical modelling procedures. Accomplished calculations show high prospects of the simplest water heater on the Russian permafrost territory.

12) V.A. Dubrovin, L.N. Kritsuk, E.I. Polyakova* Temperature, composition and age of the Kara Sea shelf sediments in the area of the geocryological station Marre-Sale

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The results of studying the upper 20 m-thick Near-Yamal bottom shelf sediments, stripped in May 2014 by two boreholes of VSEGINGEO, have been presented. The boreholes were equipped with the loggers LPC for monitoring observations of temperature regime dynamics in the bottom sediments. This was necessary in connection with the prospective development of hydrocarbon deposits in the shelf. The results of the temperature change for three summer months of 2014 have been obtained. It has been revealed that the marine aleurolithous clays and aleurolites represent relict frozen strata subjected to cryogenic metamorphization in the subaerial conditions. The diatomic complexes of clayey soils consist exclusively of marine extinct species typical of the Early Eocene *Pyxilla gracilis* diatom zone. A complex of modern marine sublittoral diatoms has been found in the sands of the near-shore borehole upper part.

13) V.V. Olenchenko, A.I. Sinitsky*, E.Y. Antonov, I.N. Eltsov, O.N. Kushnarenko, A.E. Plotnikov, V.V. Potapov, M.I. Epov. Results of geophysical researches of the area of new geological formation “Yamal crater”

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Results of the field survey and geophysical observations on the area of the rare geological objects known as “Yamal crater” have been presented and discussed. The purpose of the research was to determine the origin of the crater. In 2014, permafrost and geomorphological observations, sampling of soil, water, geodetic and geophysical surveys were carried out. As a result, the absence of radiation anomalies has been revealed. It has been demonstrated that the crater is situated within the limits of the circular negative anomalies of the magnetic field, nearby the intersection of the linear negative anomalies of the magnetic field. It was found that the crater occurs at the junction of geoelectrical structures, and the geophysical showings of the horizon saturated with gas-hydrates have been detected at a depth of 60–80 m. It is suggested that both the abyssal migratory gas and the gas-hydrate decomposition could be the source of the gas. It was shown that the pingo existed on the place of the crater. The problem of identification of the hazardous pingo has been stated. This problem can be solved by complex investigations, including permafrost and geophysical surveys as well as drilling. Yamal crater, pingo, permafrost, gas, gas hydrate, fault, geophysical methods, geoelectric section, electrical resistivity tomography, electromagnetic sounding.

14) L.T. Shirshova, D.A. Gilichinsky, N.V. Ostroumova, A.M. Yermolayev. Application of spectrophotometry for quantification of humic substances in the permafrost sediments

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The application of spectrophotometry for determining the chromophoric humic substances content in permafrost sediments has been discussed. Strong linear correlation between the content of chromophoric humic substances and the content of organic carbon in the humic fractions isolated by the sequential resin-alkali extraction procedure has been revealed. Rapid non-destructive spectrophotometric method can be used when monitoring the state of humic substances stored in frozen strata.

15) E.A. Bondarev, I.I. Rozhin, V.V. Popov*, K.K. Argunova. Assessment of possibility of natural gas hydrates underground storage in permafrost regions

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An approach to assessment of possibility of the construction of natural gas hydrate underground storage in appropriate geological structures has been proposed. It is based on the mathematical model of multiphase real gas and water flow in porous media. The model takes into account the transformation of gas and water into hydrate at certain temperature which depends on gas flow

pressure. The dynamics of hydrate and water saturation as well as the pressure and temperature fields in a reservoir with given porosity, permeability and initial values of pressure, temperature and water saturation has been studied. An implicit finite-difference scheme is used to approximate the original boundary-value problem. The finite-difference equations have been solved using simple iteration and sweeping algorithms. Some examples of calculations corresponding to real cases are given. Calculations have revealed that the final result strongly depends on the porosity and permeability of a reservoir. Further efforts are needed to estimate the role of heat exchange with surrounding rocks.

CONFERENCE

Earth Cryosphere Institute (ECI SB RAS) in the period July 02-05, 2015 (Tyumen, Russia) has successfully held the International conference «**Arctic, Subarctic: mosaic, contrast, variability of the Cryosphere**», which was attended by 170 scientists representing the leading scientific organizations from Russia, Europe: <http://www.ikz.ru/conference2015>

******* Melnikov Permafrost Institute (MPI SB RAS) (Melnikov Permafrost Institute, Siberian Branch, Russian Academy of Science, Yakutsk)** <http://mpi.ysn.ru/index.php/en/>

1. Main research results 2015

1. Studies by the MPI Laboratory of General Geocryology and Kazakhstan Alpine Permafrost Laboratory established a new genetic type of dynamic periglacial landforms – partially thawed ice-rubble-silt rock glaciers widespread within the mountain permafrost zone of Europe and Central Asia (Fig. 1). An integrated study of the Gorodetsky glacial-periglacial complex in northern Tian-Shan, employing ERT, GPR, thermometry and meltwater isotopic analysis, has shown that this rock glacier has a thawed bed and consists of blocks of metamorphic ice separated by thaw zones of intense seepage flow.

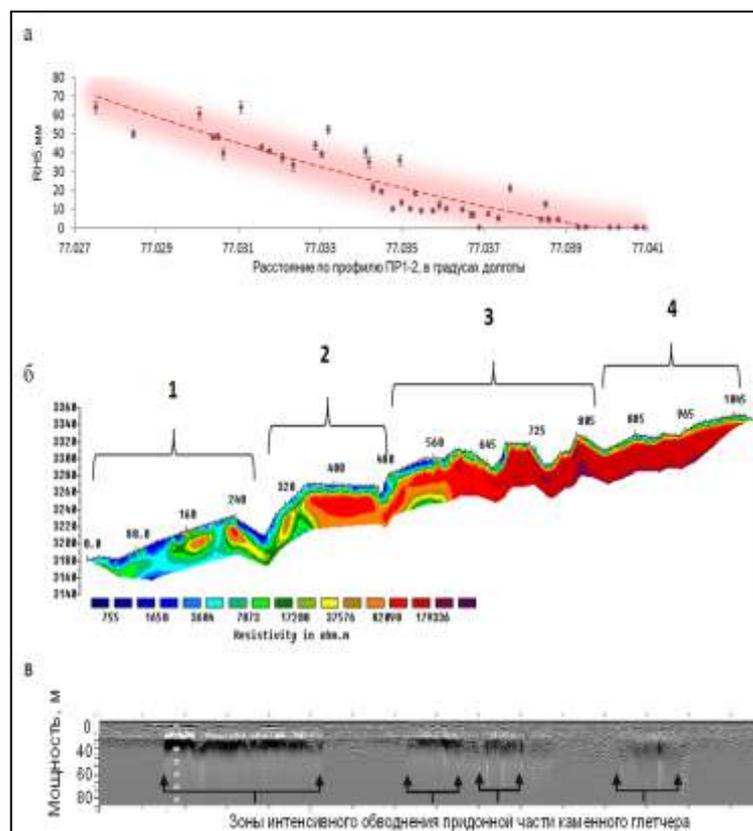
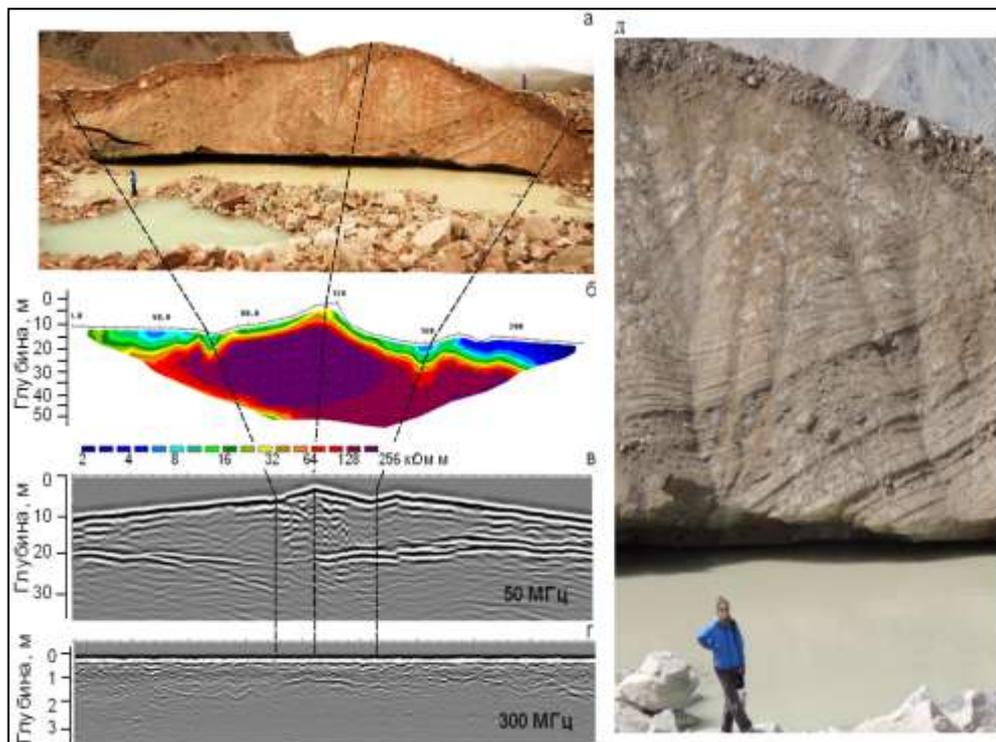


Fig. 1. Results of the Gorodetsky rock glacier study (northern Tian-Shan):

Left: a) Block of fossil metamorphic ice; b) resistivity profile; c-d) radar sections obtained at different frequencies; e) metamorphic folding of the ice block. Right: a, b, c) 1-km-long integrated profile along the rock glacier axis; a) relative age in RH5, b) resistivity (formations of different age: 1-2- active, thawed, 1-4 – passive, young); c) radar section.

2. Monitoring studies conducted by the Laboratory of General Geocryology and the Laboratory of Groundwater and Geochemistry indicate an increase in upper permafrost temperatures due to climate warming. In Yakutsk, permafrost temperatures have warmed by 3°C over the last 80 years (Fig. 2). As a result, significant changes in geocryological conditions are taking place in near-surface permafrost. The formation of multi-layered cryopegs has been observed in Yakutsk (Fig. 3). The dynamics of cryopeg levels and chemical composition suggest that frozen soils separating the cryopeg layers have transformed into a thawed state. Such transformation of the geocryological conditions in northern cities of Russia significantly reduces the bearing capacity of frozen foundations, increasing damage and accident rates.

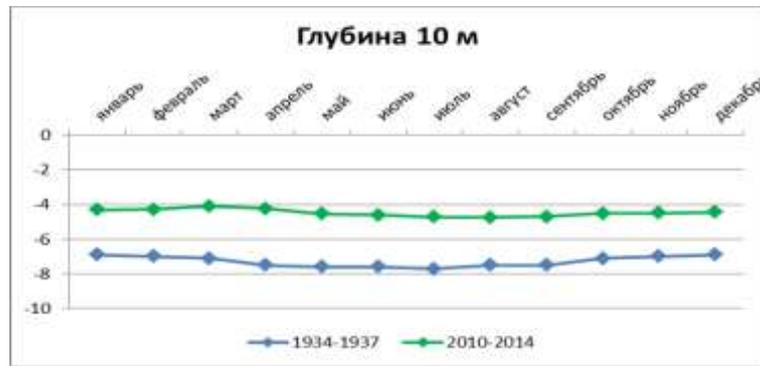


Fig. 2. Curves of permafrost temperature at 10 m depth for the periods 1934-1937 and 2010-2014 for an urban site, Yakutsk.

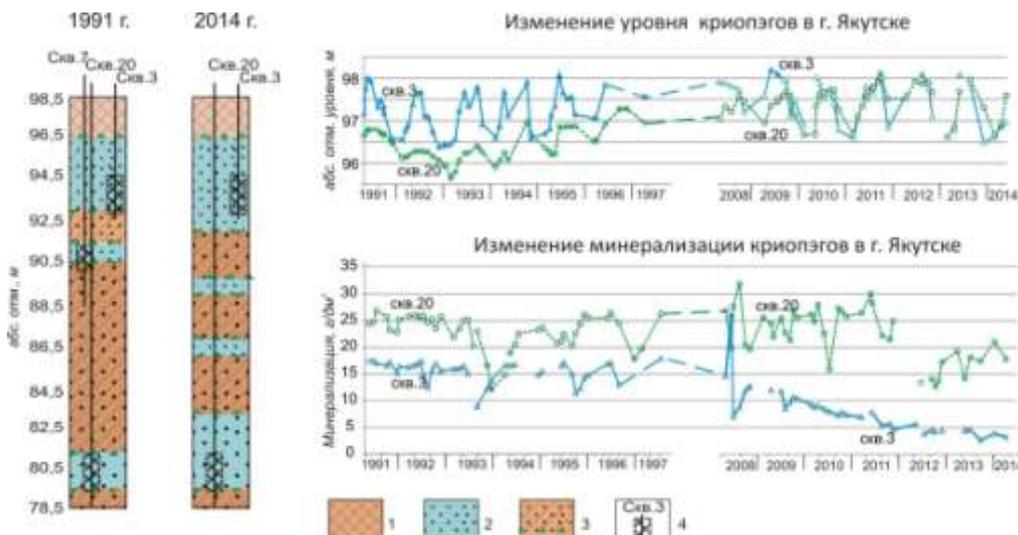


Fig. 3. Logs showing the position of cryopeg layers and curves demonstrating the dynamics of cryopeg levels and dissolved-solids content.
 1 – active layer consisting of sandy silt and silt; 2 – cryotic sands saturated with saline water (cryopegs); 3 – perennially frozen sands; 4 – observation well and filter interval.

3. Based on data about the structure of subsea permafrost in the Laptev Sea shelf, two-dimensional physical-mathematical models were developed by the Laboratory of General Geocryology simulating the geocryological conditions in the shelf for different time slices of the Late Pleistocene.

During the Late Neopleistocene and Holocene, permafrost degradation occurred mainly from below. Maximum subaerial freezing of the sediments reached 800 m, while upper permafrost temperatures were as low as -18 to -19°C (Fig. 4a).

The postglacial marine transgression caused a further reduction of permafrost thickness, by 150–200 m in its lower horizons and by 30–60 m from the top, due to increased temperatures in the near-bottom sediments and diffusion of sea salts (Fig. 4b).

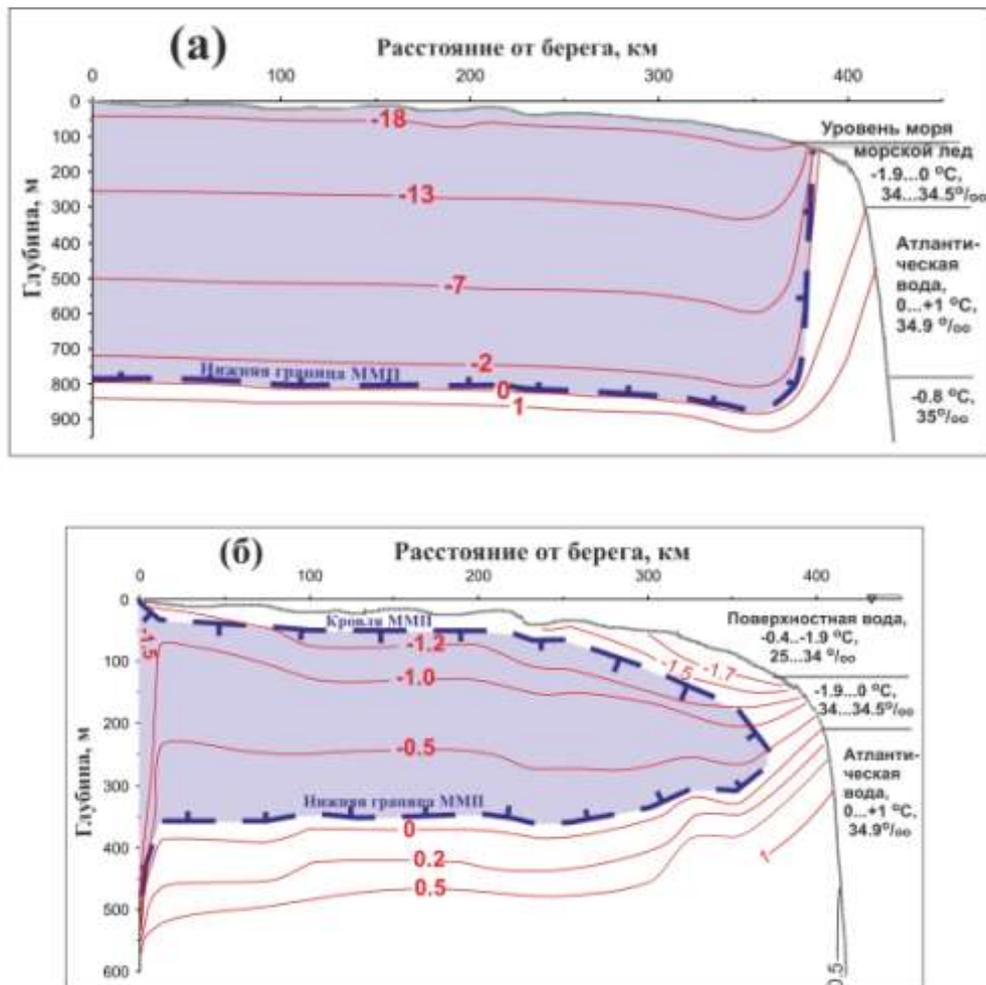


Fig. 4. Physical-mathematical models of Laptev subsea permafrost evolution

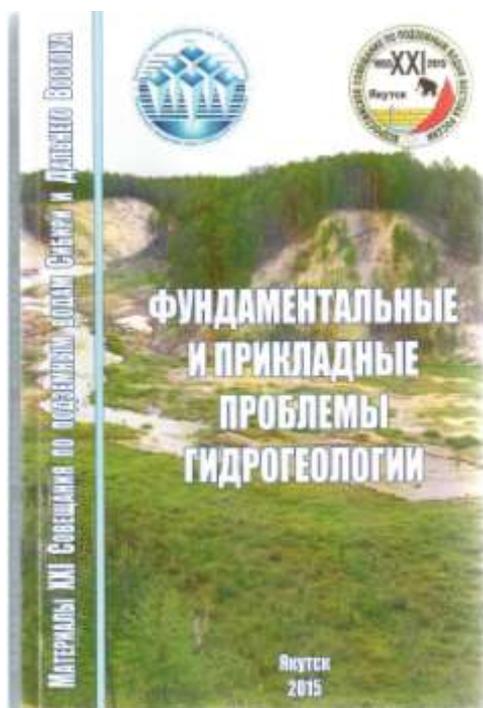
(a) – subaerial freezing stage which lasted from 117 kya to 50 kya. Permafrost conditions are shown for the end of this freezing stage; (b) – end of the last regression-transgression cycle in the Arctic basin.

2. Meetings and expeditions

1. An important event in 2015 was the XXI Conference on Groundwater in Siberia and Far East held in Yakutsk from 22-28 June. The conference hosted by MPI was organized as part of the

Federal Target Program 2010-2015: Clean Water and marked the 60th year since the first forum of Siberian hydrogeologists was organized. In all, 122 papers were submitted to the conference, authored and co-authored by 267 researchers and practitioners from St. Petersburg, Moscow, Perm, Yekaterinburg, Tyumen, Novosibirsk, Tomsk, Krasnoyarsk, Irkutsk, Chita, Khabarovsk, Vladivostok, Petropavlovsk-Kamchatsky, Anadyr, Yakutsk, Neryungri, Mirny, Khandyga, and Deputatsky. Foreign participants represented Japan, Republic of Korea, and China.

The plenary and oral sessions were attended by 120 delegates. All papers submitted to the conference were published in: Alekseev S.V. and Shepelev V.V. (eds.). 2015. *Fundamental and Applied Problems in Hydrogeology, Proceedings of the National Conference on Groundwater in Eastern Russia (XXI Conference on Groundwater in Siberia and Far East with International Participation)*, Yakutsk, June 22 – 28, 2015. Yakutsk: Melnikov Permafrost Institute SB RAS Press, 552 pp.





Plenary session, XXI Conference on Groundwater in Siberia and Far East, June 2015, Yakutsk.

2. Several field campaigns were undertaken by MPI in 2015, some of them in cooperation with foreign partners. An expedition was organized to Makhatta Tukulun, a large active dune massif on the Vilyui River, 20 km upstream from the town of Kysyl-Syr, central Yakutia. The program of the Kysyl-Syr expedition included geomorphological and landscape investigations. Twelve key sections were described and about 400 samples collected for grain-size, mineralogical, spore pollen, geochemical, radiocarbon dating and micromorphological analyses. A full-length documentary film, “Tukulans – Pleistocene Cryodeserts in Yakutia”, was shot during the expedition.



Shooting a documentary film about tukulans, July 2015, Kysyl-Syr.

3. Another highlight of the last summer season was the Fourth Forum for Young Permafrost Scientists organized by MPI from 29 June to 12 July. This event commemorated the 200th birthday of Alexander von Middendorff, a Russian naturalist and explorer who pioneered scientific research on permafrost. The Forum included a three-day conference in Yakutsk attended by early career scientists and students from Moscow, Novosibirsk, Tyumen, St. Petersburg, Vladivostok, Chernyshevsky, and Seoul. The conference was followed by a field workshop which focused on frost-related forms and processes along federal roads in Central Yakutia, with special emphasis on the causes and dynamics of slope processes at KP 450 of the Lena Federal Road.



Field workshop participants at Buluus icing, central Yakutia.

3. Publications

Theoretical, experimental and field investigations carried out by MPI researchers resulted in 280 publications, including four monographs:

- Makarov V.N. (2015). Arsenic in the Biosphere of Yakutia. Novosibirsk: Academic Publishing House “Geo”, 93 pp.
- Makarov V.N., Sedelnikova A.L. (2015). Environmental Geochemistry of Yakutsk Urban Lakes. Yakutsk: Melnikov Permafrost Institute Press, 232 pp.
- Medeu A.R., Akiianova F.Zh., Beisenova A.S., Blagoveshchenskii V.P., Kunaev M.S., Malkovskii I.M., Nurmambetov E.I. (2015). Atlas Mapping in the Republic of Kazakhstan. Almaty: Institute of Geography Press, 261 pp.
- Shesternev D.M., Verkhoturov A.G. (2015). The Geological Medium of Mineral Resources in Trans-Baikalia Under Changing Climate. Chita: Trans-Baikal University Press, 227 pp.

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In 2015 Cryolithology and Glaciology Department fundamental studies on the impact of natural and technogenic factors on cryolithozone and glaciosphere been conducted.

New approach to the analysis of mineral loess substance genetic nature was proposed. Its distribution is almost identical to the area of cryolithozone in the Pleistocene. The map of distribution of loess, loess-like minerals in modern and Pleistocene cryolithozone was made for the first time (authors – V.N. Konishchev, N.A. Koroleva).

Field and laboratory researches determined the spatial distribution of the content of O_{18} isotopes in modern and more ancient ice wedges that were formed in the Russian Arctic during MIS 1, MIS 2, MIS 3, MIS 4. The research showed that, since 60,000 years ago until the present time, features of atmospheric transfer in the north of Eurasia, in general, has not changed (I.D. Streletskaya et al.). The isotopic composition of methane and massive ice bed in Yamal clearly indicated its bacterial origins and formation in situ.

Features of cryogenic strata such as geocryological structure, thickness, temperature and ice content above gas-bearing deposits of the Yamal Peninsula (north of Western Siberia) were analyzed. Geocryological classification for these gas-bearing structures was developed for the first time (Yu.B. Badu).

Concept of geo-ecological parameters for the sustainability of permafrost landscapes to the mechanical loads was established. Map on a scale of 1: 20 000 000 called "Seasonal thawing and freezing of the territory of Russia" was compiled to assess the impact of natural factors on the geo-ecological state of cryolithozone (N.V. Tumel', L.I. Zotova, N.A. Koroleva, S.Yu. Dedyusova).

For example, the Norilsk region, one of the largest industrial region in the cryolithozone. After analyzing temperature fields of around 800 permafrost basements having cold ventilated cellars, it was found out that 55% of the basements tend to experience permafrost degradation, 25% - permafrost buildup, 20% preserved preconstruction thermal state (V.I. Grebenets). Map on a scale of 1: 15 000 000 called "Activization of dangerous engineering cryogenic processes in cities and settlements of cryolithozone of Russia" (V.I. Grebenets).

Geographic information system was developed for Kolka glacier and Karmadon Basin, where in 2002 there was a famous catastrophe with human losses and massive destruction. It was determined that from 2004 to 2014, against the background of unfavorable climate conditions (for the Caucasus glaciation), about 30 million m³ of ice accumulated in the cirque of Kolka glacier. As a result, the glacier front has advanced by 800 meters (D.A. Petrakov et al.). This is the only case of significant advance of glaciers in the Caucasus in the XXI century.

Regime investigation of the dynamics of seasonal thawing (International Program CALM – Circumpolar Active Layer Monitoring), that began in 2004, continued on the experimental site near Talnakh (south of the Taimyr peninsula) and in Lorino (settlement on Chukotka) (V.I. Grebenets, A.A. Maslakov). The data on the reaction of permafrost to a very cold but abnormally long summer of 2015 was obtained. This year average depth of soil thawing in Talnakh region will exceed by 15 % compared to the average value of many years.

In July 2015 in Igarka and Norilsk region were held regular International field student's courses on permafrost, which was attended by younglings from Russia, USA, Germany and France (courses are conducted by docent of Lomonosov Moscow State University V. Grebenets and master of The George Washington University K.E. Nyland).

******* Geocryology Department, Geology Faculty, Lomonosov Moscow State University**

Geocryology department of the Lomonosov Moscow State University in 2015 has been developing the revised digital edition of the permafrost map for Russia 1:2 500 000. The studies have been focused on the European North, Western Siberia and Yakutia. The original 3D software for thermal calculations was tested. A possibility for simultaneous numeral modeling of

heat and water flows during freezing is now considered. Arctic shelf permafrost was studied by geophysical methods for Laptev and Kara seas. A new data on underground ice on the Arctic islands have been received. Monitoring site on Baydara bay was used to study thermal mode of permafrost, coastal erosion rates and properties of frozen soils. Methane content of permafrost deposits has been studied in Western Siberia and Central Yakutia, as well as microbial communities in samples of permafrost deposits. Mechanical and thermal properties of frozen grounds was studied for major pipelined projected in the country. A new and revised edition of the Permafrost Forecast textbook (1974) has been completed for publishing. A master program in English on permafrost studies for foreigners is announced for 2016.

******* Sergeev Institute of Environmental Geoscience RAS (Moscow)**

Geocryological monitoring in undisturbed condition was continued. The 2015-year data were submitted to the GTN-P database. Sergeev Institute of Environmental Geoscience RAS supports 11 monitoring TSP-sites and 2 CALM-sites in Northern Transbaicalia Region (Chara). Also the activity of geocryological processes in Olkhon Island was estimated in cooperation with Institute of Earth Crust SB RAS, Irkutsk (Fig.1). IEG RAS participated in Moscow State University post-graduate student training combined with permafrost monitoring in Vorkuta Region (Fig. 2, 3). The cooperation with Melnikov Permafrost Institute SB RAS opened new horizons of long term permafrost investigation in Igarka (Middle Siberia).

The new program of common investigations of Arctic surface (rivers) and underground water discharge with Institute of Water Problems RAS was drawn up.

The comparative analysis of Yamal Craters formation hypotheses with future investigation plan was developed.



Fig. 1. Cryogenic landslides at Olkhon Island (Baikal Lake). The photo was taken by using the radio-control quadrocopter.



Fig. 2. Boring in Vorkuta Tundra.

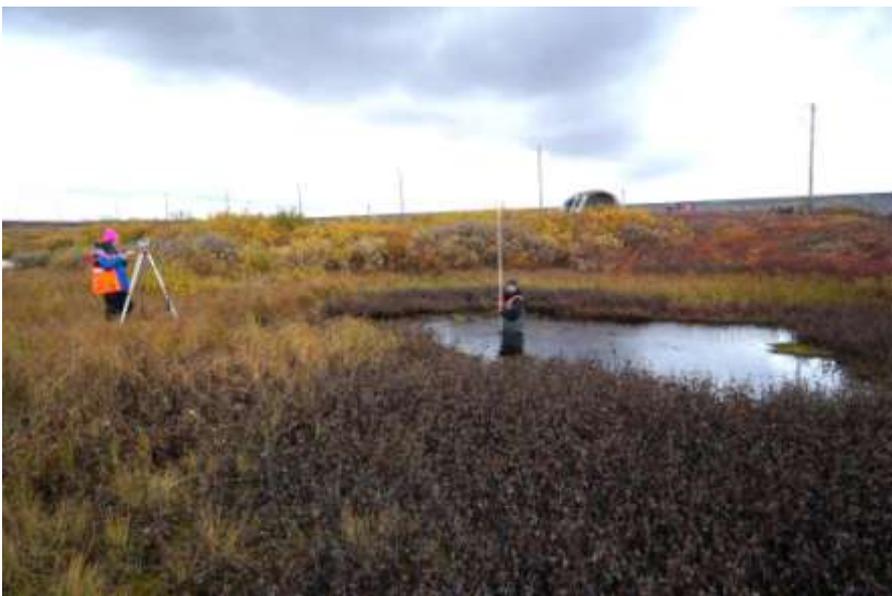


Fig. 3. Measurements of the thermokarst lake's depth in Vorkuta Tundra.

****** Institute of Physicochemical and Biological Problems in Soil Science, RAS (Soil Cryology Laboratory)(Pushchino, Russia)**

Permafrost Microbiology

1. It was announced that the *Mollivirus sibericum*, a fourth type of giant virus isolated from the permafrost sample where last year another giant virus *Pithovirus sibericum* was discovered. These four types of giant virus exhibit different virion structures, sizes (0.6–1.5 μm), genome length (0.6–2.8 Mb), and replication cycles. Their origin and mode of evolution are the subject of

conflicting hypotheses. The fact that two different viruses could be easily revived from prehistoric permafrost should be of concern in a context of global warming. This is the result of joint work of the Soil Cryology laboratory and our french colleagues from Institut de Microbiologie de la Méditerranée.

2. Viable amoeboid protists were isolated from the Arctic Late Pleistocene and Holocene permafrost sediments many of them belong to new species. The diversity of amoebae in the permafrost is rather low in comparison with that of modern tundra soils. The genus *Acanthamoeba* appears most widespread in the permafrost sediments under study. The amoebae under study are stable with reference to stressful effects; the cysts of fossil amoebae examined successfully survived under conditions of the free space. It is shown that, in the permafrost, along with viable prokaryotes, eukaryotic microorganisms are also preserved and, like remains of rigid skeletal structures, provide evidence of the existence of ancient ecosystems. Although the taxonomic diversity of amoebae in the permafrost is relatively low, they include not only new species of known genera, but also new taxa of higher rank. The resistance of cysts of protists from permafrost makes them a promising model for the study of the cryptobiosis in eukaryotic organisms and for further experiments both in the space and on the Earth.

3. We performed a result of comparative analysis of the two permafrost samples isolated from lake sediments and ice complex with utilization of metagenomic sequencing approach. We have shown that the presence of methane in one sample and its absence in the second are associated with the prevalence of the certain groups of microorganisms and their corresponding genes. The possible scenario of the development of both Yedoma and lake sediments can be proposed on the basis of these findings. Analysis of metagenome from IC4, a sample of the lake sediments, demonstrated occurrence of many physicochemical reactions such as denitrification, iron reduction and sulfate reduction, which could reduce environmental redox potential and ultimately create favorable conditions for development of methanogenic community and methanogenesis. As reflected from the composition of IC8 metagenome, the sporadic occurrence of such physicochemical reactions brought to deficiency of methanogenic activity and lack of biogenic methane in the late Pleistocene ice complex on Kolyma-Indigirka lowland. The obtained results demonstrate that the metagenomic analysis of permafrost microbial communities can represent a valuable instrument for paleo-reconstruction of conditions under which the permafrost sediments were formed in geological perspective.

Permafrost Astrobiology

4. The permanently frozen volcanic sediment is one of the most promising geological objects for searching life on Mars. On Earth, volcanic intrusions into permafrost result in formation of the unique microbial communities. We propose several terrestrial analogues of Martian polar volcanoes, such as the permanently frozen volcanic sediments on the Kamchatka peninsula and in Antarctica. The present study shows applicability of the morphometric analysis for demonstration of the morphological similarity between the terrestrial and Martian cinder cones. In the present work, the morphometric analysis of young Martian landforms is based on the assumption that the conical structures identified on digital terrain model (DTM) are volcanic cinder cones. Morphometric analysis of the studied cones showed a range of degradation. The extent of degradation may be an indicator of age based on comparison with volcanic cinder cones on Earth. A morphometric analysis of potentially young volcanic cones in the North Polar Region of Mars was performed to estimate their relative age. The 14 potential cinder cones were identified using the DTM provided by Mars Express High Resolution Stereo Camera (HRSC), allowing for the basic morphometric calculations. The majority of the cinder cones are localized in the Chasma Boreale region within the area 79°–81°N and 261°–295°E. The calculated morphometric parameters showed that the cone average steepness varied from 3.4° to 11.8°, cone height-to-width ratio varied from 0.025 to 0.12, and the ratio between surface and basal area of the cone varied from 1.005 to 1.131. The studied cinder cones were classified with respect to the morphometric ratios assuming that larger values correspond to the younger structures.

Employing the terrestrial analogy of morphometric ratios as a proxy for relative geological age, we suggest that existing microorganisms may be found in permafrost of young Martian cinder cones.

Permafrost Soil science

5. For the first time the soil mapping of 29% the ice-free area of Antarctica carried out. It was characterized the soil taxa. The leading role of the factors of area drainage, nanorelief formation, activity cryoturbation in the formation and development of the tundra CRYOSOL was found.

Conference

In the period from September 27 to October 1, 2015 Soil Cryology laboratory has successfully held the International conference «Permafrost in XXI century: basic and applied researches», which was attended by 90 scientists representing the leading scientific organizations from Russia, USA, Germany: <http://cryosol.ru/news/163-permafrost-conference-is-over.html>

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