ФЕДЕРАЛЬНОЕ АГЕНТСТВО
НАУЧНЫХ ОРГАНИЗАЦИЙ

International Conference

Permafrost in XXI Century: basic and applied researches

Pushchino, Russia, September 27 – October 1, 2015

ISBN 978-5-9905029-2-5

УДК 551.34; 624.139; 624.131.1; 551.32; 612.821; 591.51; 550.47; 579

International conference "Permafrost in XXI Century: basic and applied researches" (September 27 – October 1, 2015, Pushchino, Moscow region, Russia).

Program and Conference materials.

International conference "Permafrost in XXI Century: basic and applied researches" continues the traditions of the Pushchino Permafrost meetings that were started in the 90s under initiative of David Gilichinsky.

The main topic of the conference:

- Permafrost Response to Climate Change and Permafrost Monitoring
- Physicochemical Properties of Permafrost
- Permafrost-affected Soils
- Permafrost engineering and hazardous processes
- Permafrost hydrology
- Permafrost microbiology
- General, regional and historical geocryology

ISBN 978-5-9905029-2-5

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Federal Agency for Scientific Organizations
Russian Foundation for Basic Research
The Scientific Council on Earth Cryology RAS
Institute of Physicochemical and Biological Problems in Soil Science RAS

International Conference

Permafrost in XXI Century: basic and applied researches

PROGRAM

ABSTRACTS

Pushchino, Russia, September 27 – October 1, 2015

The International Conference «**Permafrost in XXI Century: basic and applied researches** » organized by: Federal Agency for Scientific Organizations, Russian Foundation for Basic Research, The Scientific Council on Earth Cryology RAS, Institute of Physicochemical and Biological Problems in Soil Science RAS

Conference Organizing Committees

Chairman: Vladimir Melnikov *(Academician of RAS, Chairman of Scientific Council on Earth Cryology RAS, Director of the Earth Cryosphere Institute, SB RAS)*

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Earth Cryosphere Institute SB RAS (Tyumen), ANO “Gubernskaya Academiya” (Tyumen), OAO “Fundamentproekt” (Moscow)

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	hjjk	
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ABSTRACTS

of the International Conference

Permafrost in XXI Century: basic and applied researches

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September 27 – October 1, 2015

Russian-German Cooperation in Permafrost Research Future Perspectives and IPA-CLiC Permafrost Research Priorities

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Joint projects of the Potsdam research unit of the Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research (AWI) and Russian partners started as early as in 1992. Since that time, intensive studies on permafrost related problems were carried out cooperatively between Russian and German scientists in Russia, mainly in Siberia. Starting with a first expedition to Norilsk and the Taymyr Peninsula in 1992, this vibrant cooperation continued with at least one joint field campaign organized each year to the permafrost areas of Siberia. Since 1997, the regional focus moved to the Lena Delta at the research station Samoylov, the coastal lowlands surrounding the Laptev Sea and the New Siberian Islands. Additional projects started later in central Yakutia and on the Kolyma and Indigirka lowlands.

During more than 2 decades, several research topics were investigated:

1. The study of the development of the environment during the last climatic cycles in Siberian permafrost areas.
2. The study of near surface processes in permafrost landscapes with special emphasis on the exchange and feedback of material and gases between frozen ground, active layer, atmosphere, and ocean.
3. The study of land-ocean interactions based on the experiences obtained during the IPA/IASC program "Arctic Coastal Dynamics" (ACD), and its extension to subsea permafrost and gas hydrates on the large Siberian shelves.

At the international level, many initiatives have been initiated or strengthened during the last years under the umbrella of the International Permafrost Association (IPA). These include the overhaul of the Global Terrestrial Network of Permafrost GTN-P, consisting of the Thermal State of Permafrost (TSP) and the Circum Arctic Active Layer Monitoring (CALM) program.

Several larger international projects with high amount of funding were also recently started. Under the lead of scientists of AWI Potsdam, the ESA DUE Permafrost project built up a pilot framework for coordinated and semi-operational remote sensing sensor integration and application in permafrost areas. The European Union Project PAGE21 (Permafrost and its Global Effects in the 21st Century), coordinated by AWI Potsdam, deals with the characterization and transformation of carbon, its contribution to the greenhouse gas budget and the incorporation of permafrost parameters in global models and is by far the largest permafrost project ever funded by the European Union (EU). The new Research Project „CarboPerm“, which is coordinated by Russian and German PIs was also started in 2013. Other international Programs as Defrost (Scandinavian Countries), Adapt (Canada), GrenTea (Japan) and NGEE (US) are all large scale contributions that call upon a coordinated research strategy in the Circum Arctic permafrost areas.

In order to shape and inform that coordinated research strategy, the IPA and the Climate and Cryosphere (CliC) project decided to piggyback on the existing IASC ICARPIII Program, aimed at defining research priorities for the Arctic, to establish a similar process specifically for permafrost. The IPA and CliC established a core group of experts with the aim to define research priorities for the next ten years in permafrost science and engineering. This is done by a transparent process based on the engagement of the permafrost science and engineering communities. A major feature of this process is the involvement of young permafrost scientist from the Permafrost Young Researchers Network (PYRN) who organized several meetings (for example during the EUCOP IV Conference in Evora, Portugal) in order to define their own research priorities.

In this presentation, we will report on the major results of the PAGE 21 project, the outcomes of the Permafrost Research Priorities process and the potential for future Russian-German cooperation in permafrost research.

Session 1:
Permafrost Response to Climate Change and Permafrost Monitoring

The Vulnerability of Permafrost from 1960 to 2300 Based on Simulations of the Process-Based Model GIPL2 across the Northern Hemisphere:Implications for Soil Carbon Vulnerability

Sergey Marchenko[1], Dmitry Nicolsky[1], Vladimir Romanovsky[1], David McGuire[2], Scott Rupp[3]

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Recent observations indicate a warming of permafrost in many northern regions with a resulting degradation of ice-rich and carbon-rich permafrost. In the last 30-40 years, warming in permafrost temperatures observed in Northern Eurasia, Canada, and Alaska has resulted in the thawing of permafrost in natural, undisturbed conditions in areas close to the southern boundary of the permafrost zone. The main aim of this study is to evaluate the vulnerability of permafrost under climate warming across the Permafrost Region of the Northern Hemisphere. We applied the process-based permafrost dynamics model GIPL2 (Geophysical Institute Permafrost Lab), using a historical climate forcing CRU3.1 data set for retrospective (1960-2009) and CCSM4 RCP4.5 and RCP8.5 (2009-2300) for analysis of permafrost dynamics in the future.

We estimated dynamics of the area and volume of seasonally thawed soils within the three upper meters across the entire Permafrost Domain. During the last four decades of the 20th century, the simulated total area and the volume of thawed soils with Active Layer Thickness (ALT) shallower than 3 m has been varying between 11 and 13 million km^2, and between 17.3 to 19.4 thousand km^3 respectively. Our projections according to the CCSM4 RCP4.5 climate scenario indicate that the maximum unfrozen volume of soil within three upper meters would change between 12.8 and 20.8 thousand km^3 during 2009–2300. Despite the slower rate of soil warming in peatland areas and a slower degradation of permafrost under peat soils, a considerable volume of peat (approximately 20% of the total volume of peat in the Northern Hemisphere) could be thawed by the end of the current century and 35% by 2300. The potential release of carbon and the net effect of this thawing will depend on the balance between increased productivity and respiration, and will depend on soil moisture dynamics.

Monitoring of Thermal State of Permafrost in the Nenets Autonomous Region

Galina Malkova

Tyumen state oil and gas University, Earth cryosphere Institute SB RAS, Tyumen, Russia

The report provides results of thermal state monitoring of cryogenic geosystems on geocryological stations Bolvansky, Kashin and Shapkina located in the permafrost zone in the European North (Nenets Autonomous region). There are here currently only two active monitoring sites – Bolvansky and Kashin. In 2014 they managed to examine the site Shapkina and prepare several boreholes for the continuation of temperature measurements. All sites are located in the southern tundra and in continuous permafrost zone, but favorable conditions for formation of taliks exist in local areas.

The Bolvansky site, R24 is located on the right bank of the Pechora Bay. As a result of 30 years of observations at the Bolvansky site (R24) a unique array of the actual data, allowing to study both rhythmic and trend thickness changes of the active layer and temperature of frozen soils was received. This data can be extremely useful in the study of the modern state and evolution of geosystems in the Nenets region in terms of global warming and increasing technogenesis.

Since 1983, the mean annual air temperature (MAAT) according to the weather station Bolvansky increased by 3°C, and the mean annual permafrost temperature (MAPT) in various landscapes - only by 0.2...1.0°C. At the same time the trend of MAAT is 0.07°C/year, and trend of MAPT is significantly lower- up 0.01 to 0.03°C/year.

After a few unusually warm years, average annual temperature in the active layer increased from –2... –3°C in the 1980, to 0... –0.2°C in 2011 and 2012. Significant ALT increase was recorded in summer 2012. The lower part of the active layer remained unfrozen in winter 2012/2013, due to warm weather and thick snow cover. As result, the permafrost table is lowered in local areas within of CALM-site R24. Long-term observations at site Bolvansky in the continuous permafrost zone showed that permafrost degradation and formation of closed taliks occur in cryogenic landscapes having low thermal inertia. These include tundra landscapes on the hilltops, presented by ice-poor loam with MAPT of –1…–2°C. Sites with peat on the surface even at a temperature of 0.. –1°C remain stable

Site Kashin (R24-A) is organized at the small island in the Korovinckaya bay in the outer part of the Pechora river Delta. Island Kashin is composed of the frozen sand and peat of various thickness can be found on separate sites in the upper part of the permafrost. According to geophysical data, the permafrost thickness on the island is 30-40 m. In the 2012 in the center of Kashin site two temperature boreholes (10.0 m depth) was drilled, where in the automated mode 4 times a day they did temperature measurement of air, surface and permafrost at the depths 1, 2, 3, 5, 7 and 10 m. Currently we have data for 3 years.

Preliminary results of the survey of the temperature dynamics of permafrost in the boreholes at the Shapkina site, located 100 km South from the coast of the Pechora Bay in continental conditions, within V ice-sea plains with an altitude of about 100 m. Regular geocryological studies were conducted at this site in the period from 1983 to 1993 the employees of Timanskaya geological survey dispatch, then for more than 20 years, the site was not functioning. In the summer 2014 we were able to examine a part of the boreholes at this site and to carry out temperature measurements in them. For 30-year period the permafrost temperature at the depth of 10-12 m increased significantly. The greatest changes occurred in the geosystems of hilltops and watersheds occupied by flat shrub-moss poorly drained tundra. In 1983, there was temperature of -1.7°C, and in 2014 – already only -0.6°C, i.e. there was an increase of 1.1°C. In wetland geosystems there was minimal temperature changes of 0.3°C: in 1983, the permafrost temperature at the depth of 10 m was –0.7°C, and in 2014 – only –0.4°C.

Ecosystems Impact on Thermal State of Permafrost in Alaska

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Significant declines in permafrost distribution are expected as the climate warms, but large uncertainties remain in determining the fate of permafrost under future climate scenarios. These uncertainties are driven, in large part, by vegetation and ecosystem properties that modulate the effect of climate on permafrost temperatures. Long-term monitoring of permafrost temperatures demonstrates the importance of these local conditions. Observations conducting in Alaska since eighties years of XX century show increasing of mean annual ground temperature on 1.5 to 2ºC northward from Brooks range and 0.5–0.75ºC in interior Alaska, in some places, brought it to thawing (State of climate, 2014).

Permafrost temperature is an integrated parameter and depends not only on the air temperature, but also on the heat transfer conditions at the ground surface and on the thermal properties of soils. Surface conditions play especially important role in permafrost thermal state, where ecosystem parameters can Resilience of permafrost in areas close to its latitudinal boundaries is mostly determined by the ecosystem parameters such of type of vegetation, productivity of system and topography.

The investigated region characterized by varied climate zones from a maritime (North Slope region) to a continental zone (interior Alaska). It covers different landscape zones, including mountains, boreal forest, and tundra.

Totally data from 10 observation sites were analyzed for linkages between vegetation parameters and permafrost temperature dynamics.

Our approach bases on the estimation on difference between air and surface temperature (□ts), surface and bottom of active layer temperature (□tal) and, finally, temperature at the bottom of active layer and at the depth of zero seasonal oscillation (□tpf) at the key stations. The first index (□ts) during winter time will give us information about snow influence. Comparison of □ts within spots with different vegetation during summer allows us to estimate canopy and albedo input into the surface radiation balance. Combination of □tal with measurements of soil physical properties from one side and thickness of organic layer as well as TOC in mineral soil provides the data for speculation about system bioproductivity impact. Finally based on □tpf we can estimate influence of permafrost thermal properties on the ground temperature dynamics.

Observed indexes were compared with components of subsurface heat cycles calculated using modified Kudryavtcev algorithm which include energy expenses on both sensible and latent heat within active layer and underlying permafrost.

Results of our investigation show that boreal forest has higher negative impact on ground surface temperature in comparison with tundra due to shading effect during summer and reducing of snow cover thickness in winter season, because trapping of snow on canopy. In general systems with higher bioproductivity show more resilience of permafrost thermal state. Permafrost temperature is most stable at the sites with permafrost temperature close to freezing point because significant part of heat penetrating into permafrost is spending on phase transition of soil water.

Current research was supported by National Science Foundation of USA (projects ARC-0520578, ARC-0632400, ARC-0856864 and PLR-1417908).

Response of Landscapes of the Permafrost Ecotone to Warming of Climate (on the Example of the Yenisei Siberian)

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The report emphasizes the changes in the Yenisei Siberian middle boreal (taiga) landscapes caused by climate warming. Transformation of landscapes to outer influences are analyzed on the basis of repetitive studies. The cryogenic landscapes are ranked by their susceptibility to climate warming.

In the Central Yenisei region, the modern climate change has been registered since the 1980s. Analysis indicates that all stations have observed a positive trend of changes in the annual air temperature. The annual average temperature grew by 1–2°C and greater compared with the previous period of cooling. Winter became warmer; spring and fall are longer than in 1959–1970.

The warming waves appear to be associated with increased western convection from the Atlantic (this is especially evident in the winter season due to the influx of “warm” air masses) and, accordingly, the weakening of the Asian anticyclone (its western branch, or the Voyeikov axis) because of the large loss of ice cover in the Arctic. Most of warming is during the winter period.

The permafrost landscape system changes particularly quickly in the subzones of sporadic and discontinuous permafrost. The following processes can be identified as probable responses to climate warming in the insular and discontinuous permafrost subzones: 1) increase of the active layer depth and intensification of solifluction processes; 2) local replacement of solifluction processes by landslide mass movement in the areas of active river erosion; 3) frequent falling of trees with a creeping root system. Usually it happens in the areas where the depth of viscousplastic hydromorphic clays is about 1.5 m or more; 4) existence of trees with bent trunks and vertical tops; 5) improvement of drainage on top surfaces and adjoined gentle slopes (water disappears from ruptures-windows; it is often absent in fissures ruptures); 6) increasing numbers of stone blocks in unstable positions on the surface of kurums (‘stone seas’) as well as the spread of reindeer moss patches (both in size and number); 7) discharge of ground rills under a block cover of kurums; 8) noticeable warming in underground kurum space after a decrease in water supply; 9) possible lowering of the permafrost table in kurum stows; 10) intensification of thermokarst processes; 11) wide development of long-frozen soil which can indicate recent permafrost degradation in places.

The Application of Heat Flux Measurements for Monitoring of Soil Thermo-Physical Properties

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Soils in nature are open non-equilibrium systems, which have a variable composition and structure. The effective value of their thermo-physical properties can change with time under the influence of changing environmental factors. Usually, thermo-physical properties of soils measured in situ differ from the estimates obtained in the laboratory. Presented here is a method of monitoring the temperature and heat flow to obtain data on the dynamics of effective thermal conductivity and effective heat capacity of soils in natural conditions. The use of both temperature and heat flow allows the calculation of thermo-physical coefficients using simple models that do not require a large number of constraints.

Observations are carried out at two monitoring points. The first one is located at the site of regular meteorological observations near Pushchino (the Oka river basin). The loam soil has the average annual temperature +6^{o}C. Measurements of heat flux are conducted since November 2013 here. The second monitoring point is located at the site of geocryological monitoring, Chersky village, North-Eastern Yakutia (the basin of the Kolyma River). Silty-loamy soil on the second paragraph has an average annual temperature is -7^{o}C. Measurements of heat flow were started in October 2014 at the second monitoring point. Observations for air temperature, radiation balance, precipitation, and other factors are carried out additionally to the monitoring of soil temperature and heat flux at both sites.

The heat flux sensors 0924 (Etalon LTD) and loggers 1/100 (Etalon LTD) are used to the heat flow measures. The soil temperature sensors of the UGT DL-103 weather station are used at the first monitoring site. The Campbell Scientific Inc. equipment was used at the second site.

Effective heat capacity of the soil was calculated by the equation of thermal balance of the soil layer. The heat conduction equation was used to calculate the effective thermal conductivity of the soil.

The calculated average value of the effective thermal conductivity is 1.4 W/(m*K) at the first monitoring point. The effective thermal conductivity varies from 1.1 W/(m*K) to 1.9 W/(m*K) here. Effective heat capacity averages 2.2 kJ/(kg*K) and varies from 0.3 kJ/(kg*K) to 8.1 kJ/(kg*K). Similar amplitude fluctuations of effective thermo-physical coefficients were found at the second monitoring site under the average annual soil temperature -7^{o}C.

The observed changes in effective rates of thermal conductivity and heat capacity of soils because the soil heat transfer with boundary environments occurs in non-equilibrium conditions. It is complicated phase transitions during freezing and thawing, evaporation and condensation, convection, mobile phases, heat effects of chemical reactions, interfacial interactions, biochemical transformations. In addition, temperature sensors and heat flux as a foreign body distort the temperature field in the soil and serve as barriers to convective heat and mass transfer. It should be supplemented the monitoring complex by measurements of moisture content, potential moisture and other indicators that characterize the dynamics of soil properties under natural conditions for adequate interpretation of the observed dynamics.

Influence of Modern Variations of Winter Climatic Conditions on Seasonal Ground Freezing Depth

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Snow is traditionally considered as transitional media between atmosphere and ground through which the heat transfer is going. Freshly deposited or slightly metamorphosed snow is characterized by relatively low heat conductivity therefore snow cover during the cold seasons prevents cooling of the ground. But at the periods of temperature rise to the positive values the snow cover becomes an obstacle for ground heating, i.e. thermal physic properties and thickness of snow cover as well as the thermal regime of winter season determine heat outflow and temperature of underlying ground. For calculations of thermal influence of snow V.A. Kudriavcev suggested an equation, which includes thermal diffusivity and thickness of snow cover and amplitude of yearly air temperature oscillations. Our research of seasonal freezing depth is based on trend changes and interannual variations of snow cover depth and climatic indexes of precipitation and temperature of winter seasons (November–March) 1960–2014. The maps of anomaly distribution of climatic indexes on the territory of Russia at these winter seasons and modeling of regional stratigraphic pits of snow cover were compiled on the base of data of 50 meteorological stations. On the territory of Russia the positive sign of temperature trend in 1961–2000 (+0,047ºC/year) changed in 2001–2014 to negative (–0,017ºC/year), the sum of winter precipitation grows up from 0,24 to 0,54, and snow cover thickness decreases from 0,25 to –0,32. In Subarctic belt (Narian-Mar, Salekhard, Turukhansk, Khatanga, Viliusk, Yakutsk, Verkhoyansk, Oymyakon meteorological stations) the trend of annual winter temperature season growth increased more than three times and trends of sum of winter precipitation and snow cover thickness became negative. Average values of interannual variations during this period were practically constant and equal 1.5ºC for temperature, 10 mm for precipitation and 2 cm for snow cover thickness, while maximal values reached 3ºC, 30 mm and 7 cm and more than for an order increase value of trend changes. These interannual variations assumed considerable variations of seasonal ground freezing depth, which reached in Turukhansk 25 cm/year, in Irkutsk 46 cm/year and in Barnaul 35 cm/year.

Temperature Regime of Soils in Northern Yakutia

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Temperature regime of soils in Northern Yakutia was researched in framework of International Research Programs “Circumpolar Active Layer Monitoring” and “Temperature State of Permafrost”. Temperature monitoring using data loggers has been started in 1998 in north of Kolyma Lowland. After 10 years, in 2008, the monitoring spread to adjustment regions: Yana-Indigirka Lowland (basin of Allaiha River) and Bykovskiy peninsula, located in Lena delta, Tiksi bay. In the Kolyma Lowland soil temperature regime is studied the most long time and comprehensive. Measurements are performed at 17 sites that characterize zonal and intrazonal soil conditions.

In our investigation it was found that the temperature zonal loamy soils of Northern Yakutia increases from north to south. In the same direction time of the period positive temperature and annual sum of temperatures of above 5°C increases. In the transition from tundra to the northern taiga winter temperature at a depth of 20 cm changes much more rapidly than the summer on account of jump (on 4–5°C) increasing of mean annual temperature and reducing (to 10°C) of annual amplitude. The rapidly increasing of winter soil temperature in the taiga ecosystem is caused by more stable, high and friable snow cover than in tundra ecosystems.

Sandy podburs of Khallerchinskaya tundra (north-eastern part of the Kolyma Lowland) is characterized by higher temperatures in the summer and more deep penetration of 5° C isotherm (50 cm) than in the loamy soils of the tundra and taiga. In the middle of summer in the soil profile at depth 20 cm daily mean temperature above 10°C are observed, which is not recorded for the other zonal soils. Sandy soils are the least inertia to temperature changing: maximum and minimum annual values are usually recorded in them earlier than in loamy soils.

In the research region the warmest soils are xeromorphic loamy soils of extrazonal steppe communities which studied on the banks of Panteleikha River (right tributary of Kolyma River). These soils are characterized by the highest temperatures of summer and maximum annual temperature amplitudes.

Soils of Northern Yakutia are characterized by permafrost temperature type. Based on the level of the temperature regime in the warm period subtype, all studied soils can be identified as a very cold except xeromorphic loamy soils of extrazonal steppe communities which are cold soils; the temperature regime of the cold period of tundra soils and soils of steppe areas are very cold, taiga zonal soils - the cold. The climate of zonal taiga soils by value of annual temperature amplitudes is mild, tundra soils - continental and soils of s steepificated areas - extremely continental.

Based on the dynamics of the annual sum of negative average daily temperatures of tundra and taiga soils from the end of the 1990s, the trend of soil climate warming is observed, that is allow to increasing of air and permafrost temperatures.

By the amount of the incoming heat radiation (heat supply) soils of Northern Yakutia is differ from each other about 5 times: loamy tundra cyiozems, taiga gleyzems and alluvial soils (1300-2400 kcal/m^2-year) < sandy tundra podburs (3200-4100 kcal/m^2-year) <taiga loamy cryometamorphic soils (4400-4800 kcal/m^2-year) <xeromorphic loamy soils of steepificated area (6,700 kcal/m^2-year).

Methane Emissions in the Atmosphere during Coastal Retreat near Marre-Sale Station, the Western Yamal Peninsula

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The large amount of methane is withdrawn from turnover of the Earth and preserved in permafrost. Methane is emitted in the atmosphere during the permafrost degradation on the shelf, the continent and the melting of the subsurface ice. In recent decades great attention is given to analysis of the methane content inasmuch as, according to the relevance, methane is the second greenhouse gas after the carbon dioxide, its increase in the atmosphere has a significant impact on the climate as a whole. Since the second half of the XX century, the concentration of methane in the atmosphere has been increasing annually by 1%.

The data about the concentration of methane contained in the air bubbles of the subsurface ice and frozen rocks of the cliff near the polar station Marre-Sale were obtained.

Abnormally high value of the concentration of methane in the air bubbles is set in the massive ground ice. The methane content reaches 21.5 ml/kg; it exceeds the amount of methane in the permafrost sediments and in the ice wedges.

The monitoring observation of 4 kilometers of retreat of the sea shore has showed that the shore recedes at an average rate of 1.7 meters a year. The methane concentration was measured by use of gas chromatography HPM4 (Russia) with flame-ionization analyzer IFHBP RAS (Pushchino) in the 101st gas sample of sediments and ice by Headspace method. It was rated that annually 10.3 kg or 14.3 cu m of methane is emitted in the atmosphere because of the destruction of 100 meters of seashore. 463.5 kg or 643.5 cu m of methane were emission as a result retreat of 4.5 km of seashore. The total amount of methane coming from 100 square meters of shore segment for the year is up to 0.501 kg (CH_4) year. According to Kazantsev V.S. (2013) 0.117 kg (CH_4) in a year is emitted in terms of 100 square meters of fenland march ecosystem.

Methane emissions from the retreating sea costs with underground ice are large and comparable to the emission of methane to the surface of the wetland ecosystems that need to be considered in climate models predicted.

The Influence of Climate Change on the Intensity of Ice Gouging of the Seabed by Hummocky Formations in the Baydaratskaya Bay

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Sea ice is an important zonal relief-forming factor and agent in the coastal-shelf zone of the Arctic seas. Among different kinds of direct ice impact, ice gouging is the most dangerous one for underwater engineering-hydrotechnical facilities. It includes destructive mechanical action of ice on the bottom grounds, connected with the ice cover dynamics, hummocking and formation of stamukhas under the impact of hydrometeorological factors and of the relief of the coastal and shelf area.

Within the territory of Russia, the most detailed investigations of ice gouging processes were conducted in the Baydaratskaya Bay, along the crossing of the main gas pipeline “Bovanenkovo-Ukhta”. As a result of the warming in autumn 2012, a historical minimum of sea ice area in the Northern Hemisphere since the beginning of satellite observations in 1979 was reached. The ice-free period duration, in its turn, increased.

Under the conditions of climate warming, the character and intensity of ice gouging impact on the coasts and bottom change considerably. Ice hummocking increases; the width and stability of fast ice decreases; as a result, the action of sea ice on the coasts grows. During the last decades, not only a general decrease of the ice cover was observed, but also the circulation system of sea water and ice has been changing, which leads to a redistribution of areas with thin young and thick perennial pack ice.

Among the first-year ice, clear anomalies of the ice cover thickness were observed in the last decade. A decrease of the ice thickness immediately leads to changes in the size of the hummocky ice formations, the deepening of which directly depends on the ice thickness. In this way, maximal ice thickness (up to 2 m) is observed in the East Siberian Sea, which is characterized by the largest stamukhas at the same time.

To assess the real intensity of the ice gouging impact during a given ice season, repeated sounding of the sea bottom microrelief is necessary, in order to select the ice gouging forms which were created in the period between the two consequent observations.

Field geophysical observations, including monitoring observations, were made in the Baydaratskaya Bay of the Kara Sea and within the territory of the pipeline "Bovanenkovo-Ukhta" underwater crossing in the period from 2005 to 2012, corresponding to a significant climate warming and ice decrease in the Kara Sea.

During the last two decades, the duration of the ice period in the Baydaratskaya Bay decreased almost by 1,5 months; the fast ice often breaks and can be carried away during its formation; the thickness of the ice cover decreased at least by 10-15 sm. In May 2007, for the first time since 1932 (which was also a period of warming and ice cover decrease), an iceberg was documented.

The executed investigations approve the fact that, in the conditions of climate change, the ice cover thickness, the ice hummocks' size and the fast ice width generally decrease. As a result, the zone of the most intensive ice impact moves landwards, to areas of smaller water depth. If before, the maximum number of ice gouges was observed at depths from 17 to 20 m; at present, this zone has moved to 12-16 m. Ice gouges have stopped forming in the central, deep part of the bay. Since 2005, only once gouge appeared at the depth of 20 m in winter 2009.

Based on the analysis of literature, modeling and field observations, it has been established that in the conditions of climate warming and ice cover decrease, the zone of the most intensive ice impact moves landwards, to areas of smaller water depth.

The Role of Soils and Vegetation Covers Properties in Forming Active Layer Thickness on Two CALM Sites

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Two new CALM sites (100×100m) were organized near Chara settlement in 2013. Grid nodes are spaced at 10-m intervals, yielding a regular array 121 (11×11) of data collection points. The territory is characterized by continuous permafrost, average annual air temperature –7.2°C and average ground temperature –2 to –5°C. Field tests of soils and vegetation covers properties study on these sites were executed.

First site is situated on the first Chara river terrace with elevation ranging from 729 to 730 m above sea level. Upper part of geological section is presented by sandy silts and peats, underlayed by alluvial sands. According to 121 measurements the average thickness of active layer was 0.59 m with values ranging from 0.31 to 1.28 m. Types of vegetation cover on this site varies including timberland with thick moss layer and areas with almost lacking vegetation. Second site is situated on the fluvial plain with elevation ranging from 705 to 706 m above sea level. Surface of studied area is drained. Vegetation cover on second site is presented by hummocky tundra and hummocky mire. The geological section is presented by sandy silts and peats, underlayed by alluvial sands. Obtained data (121 measurements) shown 0.55 m of average thaw depth. The smallest values (0.38m) of seasonal thaw depths were observed under sedge-moss cover near trees. The highest values (up to 0.8m) of active layer thickness were observed under sedge cover (old dirt road). As a result of fieldwork active layers thickness map and vegetation map were prepared and samples were collected for laboratory tests.

We focus investigation on first site because of high variability of conditions. High-density grid measurements, investigations of vegetation cover and properties of soils were executed for understanding active layer features on this site. Active layer thickness depends from many factors, including moisture, density and thermal properties of soils and vegetation covers. Analysis and comparison of two above maps show that smallest values (0.31m) coincide with thick moss covered timberland. The highest values (up to 1.28m) of active layer thickness were observed under old dirt road with suppressed vegetation.

Experimental soils property data were obtained during laboratory tests. Moisture of samples varied from 14 to 41% for soils and from 262 to 530% for samples of covers (peat, moss). Density varied from 1.5 to 2 g/cm^3 for soils and from 0.4 to 1.12 g/cm^3 for other samples. In general, soils under the road have higher values of density than other soils because of anthropogenic factor. Amount of unfrozen water at the mean annual ground temperature (–4.5°C) varied from 1 to 7 % for soils and from 17 to 25% for covers. Values of thermal conductivity for thawed/frozen soils and thawed/frozen covers varied in the range 0.86–1.49, 0.97–1.75 and 0.17–0.52, 0.38–1.13 W/m*K respectively. Obtained results given an additional contribution to the understanding main parameters influencing the active layer thickness.

The data, obtained during laboratory tests, were used for active layer thickness estimation by several methods. The results of estimations are in a good agreement with the field observation.

The Differences in the Stages of Development of the Archipelago West and East Atlantic Arctic due to Contraphase Peaks in the Little Ice Age in these Regions

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Historical and archaeological sources give reason to believe that the cause of the tragic pomors wintering in Spitsbergen and in Novaya Zemlya became difficult ice and weather conditions, most clearly manifested in the culmination of the Little Ice Age (LIA) around the middle of XVIII-first half of XIX century [Zakharov, Derzhavin, 2013]. The basis for this assumption was the reconstruction by V.F.Zaharov about the state of sea ice in the Arctic in the culmination of the Little Ice Age [Zakharov V.F., 2004].

Impact of climate change on fishing activities Pomors is an important factor that allows to specify time limits culmination of LIA and identify nodal stages of its major changes circulation, hydrological and glaciological conditions in the North Atlantic.

Overall, LIA lasted from 1430 to 1850. His peak of the index heavy ice conditions in Icelandic waters fell on the fortieth anniversary of the 1781-1820 biennium. This is confirmed by severe winters in Europe (1768 to 1816), as well as observations of the English whaler Scoresby Uilliama Jr. in the Greenland Sea. In 1806-1812 whalers there rarely managed to penetrate the north of 75° N.

According to the zoning of the Arctic Ocean in the Arctic coast includes all of Greenland, Iceland, Spitsbergen, Novaya Zemlya, Franz Josef Land. In the east, it is a border of Novaya Zemlya in the west - the east coast of Canada and the islands of the Canadian Arctic Archipelago [Zakharov V.F., 1996].

Active development of the Vikings off Greenland accounts for X–XIII centuries - the Little Climatic Optimum, characterized by a certain warming. However Pomors began to go to Spitsbergen and Novaya Zemlya only from the XVI century, but to Novaya Zemlya possibly earlier.

The most suitable in landscape climatically territory for Viking settlements was south-west coast of Greenland. There were two large villages (West and East) with many estates and farms around and between them. In the X century vikings arrived, but found absolutely uninhabited lands that began to settle. Later, when a cold snap in the XIV century and complication of the ice conditions, the Norwegian ships previously regularly brought colonists bread, metal, wood, were less likely to visit the Iceland.

Communication with Europe gradually weakened and further interrupted. The harsh climate also forced the inuit (who came here previously) to migrate from the north to the west coast of Greenland to the south. This led to the inevitable contact with the vikings. Relations between them were not always peaceful. In the XV century the villages were completely depopulated [Feinberg, 1971].

Among the main causes of death of the vikings (except cooling) is called the inability to adapt to changing climatic conditions, hostile relations with the Eskimos, the assimilation of the vikings and others. All these factors have taken place, but not a major. Determining also was a sharp cooling in the XIV-XV centuries and blocking of the south coast of Greenland by ice. Other causes of death of the vikings were only a consequence of the changed climate. It was at this time in this part of the North Atlantic was recorded peak of the LIA. And only in the second half XVI-early XVII centuries local ice conditions have softened. This allowed the Europeans to organize a number of marine expeditions in search of the Northwest Passage.

Thus, the culmination of the LIA in the southern part of Greenland took place about 250 years earlier than in Spitsbergen and Novaya Zemlya. This conclusion is also confirmed by the isotope analysis of Greenland ice cores, they point to the temporary differences in the peaks of the LIA, constituting about a quarter of the millennium. Current trends in the glaciers of Greenland and Spitsbergen confirm contraphases in their dynamics due to differences in the mode of supply and hydrological and meteorological conditions [Zakharov V.G., 2014].

Dynamic Active Layer Thickness of Permafroston Calm Site Umbozero

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In the context of global climate change special focus is given to the active layer thickness monitoring in the framework of integrated ecosystem studies. The main source of information on the perennial permafrost rocks (PPR) condition is measuring the seasonally thawing layer (STL) thickness in the framework of Circumpolar Active Layer Monitoring Program (CALM). Based on interannual variability data of the STL thickness it is possible to investigate its response to climate change.

Since 2011 to 2014 a measurement of seasonally thawed layer thickness was conducted within the framework of Circumpolar Layer Monitoring (CALM) in the western region of Russia – Umbozero (N 67.7724°, E 34.1820°). In geographical terms this is the westernmost CALM site in our country. The monitoring site is a square 100×100 m in size located in the sporadic permafrost area in the northern taiga on the second lacustrine terrace on the western Umbozero shore. Comparing this area with the others located on the southern boundary of the permafrost, has allowed considering it as the warmest CALM sites on the territory of Russia.

From 2011 to 2014 PPR at the platform was measured by standardized methods based on the difference in density of the thawed and frozen grounds in 121 nodes (the site is divided into 100 squares with a side of 10 meters). The measurements were carried out using a two-meter metal probe in four replications. Also the temperature was measured using miniature temperature sensors-loggers (NOVO Pro V2 2 Channel Temp Data Logger) installed at a depth of 0 cm, 15 cm, 50 cm, 75 cm, 100 cm, and 150 cm. The data on temperature, minimal night ground surface temperatures for the night were obtained at the nearest weather station, Lovozero, which is located 47 kilometers northwest of the monitoring site.

According to the data obtained in 2011 the permafrost was monitored in 89 areas, at a depth of 1.45 ± 0.45m on average, in 26% of the areas the thawing depth exceeded 2 m and in 4% of the areas the minimum depth of the active layer of 0.3–0.5 m was observed. In 2012 the thickness of the active layer could have been measured in 83 points, for which the average depth value of the active layer slightly decreased and amounted to 1.41±0.47 m. The smallest depth of the active layer of 0.3–0.5 m was monitored in 5% of the nodal points, and 31% of the nodal points had the active layer thickness outside the boundaries, which can be measured using the 2-meter probe. The active layer depth values, average for 2013 and 2014, decreased slightly and amounted to 1.38±0.47 m. However, there was an increase from 31% to 42.5% in the number of nodal points, in which the thickness of the active layer was outside the boundaries, which can be measured using a 2-meter probe. The smallest depth of the active layer of 0.3–0.5 m was monitored in 4% of nodal points.

According to the studies at the eastern CALM sites the main factors affecting the depth and speed of thawing are associated with mesorelief elements, therefore, in the future the authors plan to conduct in addition to the standard measurements the exploration of the soil moisture and the terrain nature. Evaluating the thickness of the moss-lichen cover, projective shrubs cover, bushes and grass cover is also on the agenda.

Thermokarst Lakes Morphometry Changes as an Indicator of Geological Environment Dynamics and Its Response to an Anthropogenic Impact (Bovanenkovo Gas Field)

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Active development of gas fields on Yamal peninsula poses a problem of estimation of dynamics of exogenous geological processes. Being a widespread relief forms, thermokarst lakes, their shape, quantity and density could be rated as an indicator of such dynamics and some peculiarities of a geological environment.

Our research is dedicated to an estimation of thermokarst lakes dynamics within the Bovanenkovo gas field (Yamal peninsula, North of Western Siberia, Russia). Main tasks of research are following: thermokarst lakes dynamics measuring; revealing of factors, affecting this dynamics; revealing of the links between thermokarst lakes dynamics and exogenous geological processes. Research had been held via calculating areas and quantities of thermokarst lakes by materials of different years: topographic map (1979); aero photos (2003); space photos (2009). Those data were digitized manually, results of digitizing were measured and counted via Mapinfo program complex. Some conclusions were verified by nature surveys.

Studied territory is situated on the western slope of Yamal peninsula. Relief of a region can be generally divided on two macrolevels – floodplain and watersheds. Major types of grounds – silty sands and loams. Grounds are frost on a whole territory. Major ground temperatures are from -4° to -6°. Dominating exogenous processes are thermokarst, thermoerosion, cryogenic slides, cryogenic heaving, solifluction, frost cracking.

Results of study are following:

- dynamics of a total lakes area is controlled by areas of largest and large lakes. Their dynamics, in its turn, changes due to geocryological and climatic conditions;

- area, occupied by lakes, is the most within lower geomorphological levels;
- emerging and disappearing of small thermokarst lakes are indicators of local geological and geocryological conditions;
- the biggest values of small thermokarst lakes quantity changes were noticed within the floodplain level. Watersheds were revealed as more stable surfaces by this factor;
- two previous thesis mean, that floodplains are the most active parts of studied territory, with relatively unstable geological environment;
- microrelief, defined by a geomorphological level, and average thermal conductivity of first 5 meters of rocks are the most important factors, which define small thermokarst lakes dynamics;
- the most important type of anthropogenic impact on the geological environment of studied territory are disturbance and interruption of a surface drainage. Those types of influence lead to an underflooding of vast territories and thermokarst activation. After being drained, beds of technogenic lakes become soil heaving prone;
- changes of small lakes density were revealed as an indicator of technogenic impact on a geological environment. Total lakes area doesn’t reflect technogenic influence;
- construction of industrial objects leads to small lakes amount decrease lower than those objects are built. This decrease is connected with surface drainage interception.

Session 2:
Physicochemical Properties of Permafrost

An Estimation of the Ice Crystal Charge Sing for Complicated Solution

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The mass transfer processes, interphase redistribution of charges, structure defect formation take place during freezing or thawing in the complicated solutions. As a result, the condition of ice crystal surface charging are different in complicated solution and in pure water. Processes of the ice surface charging in soil pore solutions are not completely studied.

Here, the technique and results of experimental estimation of ice charging in complicated thawing solution will be presented.

The used technique is based on the charge separation during solution filtration through the disperse matrix. The disperse ice (firn) was used as a matrix for the solution filtration. The fine quartz sand was used as a check sample because it has a stabile negative surface charge under broad condition. Both artificial and native soil pore solutions were used as a base to prepare the firn samples for experiments.

The firn was prepared using the solution dispersion inside the low temperature chamber. The examining firn was isolated in the vertical cylindrical cell with 12 cm diameter and 22 cm high. The cell was thermostated under the temperature –2^{o}C, which was at 1 degree less that the firn thawing point. The thermostated air (+2^{o}C) was filtered thru the firn-filled cell from above. Low speed of airflow provides the plane homogeneity of the flow and the volume homogeneity of the firn thawing. The filtrating air was came out from the cell thru the perforated cell base. The thawed solution was collected at the cell output fractionally. The isolated liquid fractions were analyzed using the inductively coupled plasma spectroscopy, titrimetric and ion metric techniques. As a result, both cation and anion concentration were measured in the samples. The yield curve was constructed for each ion using the data of fraction sample analysis. A comparison of anion and cation yield curve was used to estimate the surface charge sign for both check sand and examined ice samples.

A delay of the cation yield was observed during the solution filtration thru the check quartz material. It is explained because of the absorption damping of the cation transfer by the negative charged quartz particles.

An inverse situation took place during the filtration of thawed solution thru the firn samples prepared using the solution of the monobasic salt. The maximal yield of cations was observed in the first's fractions of the solution. The anion delay took place during solution filtration thru the firn because of the anion damping at the ice crystal surface. It indicated that the ice crystal surface has the positive sign of electric charge.

The positive charge of the ice crystals were observed in the firn, which was prepared using colored soil pore solution, which was isolated from the soil.

The anion and cation yield curves obtaining during the solution filtration thru the firn samples can be used to estimate the sign of surface charge in disperse ice, which has complicated chemical composition.

Formation of Natural Gas Hydrates in Dispersed Ice Stabilized by Hydrophobic Nanoparticles

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The development and practical application of alternative hydrate technologies of transportation and storage of natural gas in the form of hydrates in Cold regions is actively studied at present. However, technological problems can be retired by a slow rate of a hydrate formation and ice to hydrate conversion.

One of common methods for resolution this problem for example the use of dispersed ice to prepare the gas hydrates can be achieved in the laboratory. In this case the hydrate formation rate and the storage capacity can be significantly enhanced by increase of an ice-gas phase contact area.

In existing models it is proposed that the growth of methane hydrates from ice occurred in two steps. In first step, film-like hydrates were quickly formed from ice on the surface of ice. Subsequently, in second step which was defined by gas diffusion through the film to unreacted ice the hydrate formation rate decreased due to those films. The reduction of ice particle size can be decreased the diffusion step of the hydrate formation, and hence it can be increased the hydrate formation rate and the storage capacity.

Sintering presses of ice particles led to the reduction of ice dispersity, and hence the hydrate formation rate and the storage capacity decreased. Recently it was shown that dispersed ice which was stable to the sintering of ice particles could be prepared by a rapid grinding frozen water with an adding of hydrophobic fumed silica nanoparticles. However it was not carried out the hydrate formation from the dispersed ice stabilized by hydrophobic nanoparticles prepared by rapid grinding frozen water with the adding of hydrophobic nanoparticles earlier.

In this paper, the results of measurements on the formation rate of natural gas hydrates from ice stabilized by hydrophobic nanoparticles and that was prepared by the grinding frozen water with hydrophobic nanopowder were reported.

Influence of a content of the stabilized agent and a size of ice particles on the formation rate of natural gas hydrates from dispersed ice stabilized by Aerosil was studied. For this purpose kinetic curves of gas hydrate formation which was obtained from dispersed ice system with varying degrees of dispersity were plotted. Dispersed ice was prepared by grinding frozen distilled water with the adding of Aerosil content of either 5 or 10 wt %.

According to these studies it was investigated that the hydrate formation rate and amount of hydrates which was formed from ice particles increased if it had been added Aerosil at the grinding of ice. The initial rate of natural gas hydrate formation which was obtained in dispersed ice system prepared with Aerosil was more than 4 times than in ordinary ground ice. The conversion rate from ice to hydrate was higher by 15 % more for ice that was prepared with Aerosil than for ordinary ground ice.

Also it was shown that the increase the dispersity of ice ground with the adding of hydrophobic nanoparticles led to the increase amount of hydrates which were being formed from ice particles. The conversion rate from ice to natural gas hydrates was higher by 20 % more for a sample with the average size of ice particles of about 140 μm than in the sample with the average size of ice particles of about 220 μm.

Sorption of Some Carboxylic Acids on the Dispersed Ice Surface

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Ice crystals in frozen soils and glacial systems play an important role in migration of soluble substances. A liquid-like film on the surface of ice shows its dissolving properties, since it is known that the mobility of water molecules is increased and is close sufficiently to the mobility of molecules in bulk water.

Studies on the interaction of dispersed ice with some organic substances dissolved in the hydrophobic solvent indicated that transfer of these substances into the film is carried out in accordance with the distribution coefficient between the organic layer and the water.

Studies on the interaction of dispersed ice with water solutions (microcomponent plus supporting electrolyte) indicates that sorption of the microcomponent by dispersed ice depends on the concentration of hydroxyl ions in the system. These data also confirm the expression of dissolving properties of the transition surface film of ice, and the results indicate that the absorption of the microcomponent increases with the pH of the system. This regularity can be caused by an increase in thickness of the surface film due to disordering of the layers of the solid phase (ice) adjacent to the film by the action of the hydroxyl ions entering the film.

The disordering of these layers can occur under the influence of substances having high values of the heat of solution in water, similar to alkali. For example, magnesium ions have an effect similar to the action of the hydroxyl ions. Ethanol also has an increased heat of solution, but, is not conducive to the penetration of the microcomponent ions into the film of the ice surface. The quantity of ions sorption decreases with increasing concentration of the added ethanol. Alcohol molecules can penetrate the surface film as a water-soluble substance, but they have a hydrophobic part in their composition, because solubility of inorganic substances in the volume of the film is overall reduced. It is likely that, if the concentration of ethanol is increased, part of its molecules is adsorbed on the boundary of ice particles with the solution. It also prevents soluble inorganic ions from entering into the film.

Sorption isotherms of the formic, acetic, chloro-acetic, and o-bromo-benzoic acids on the ice surface from aqueous solution are S-shaped with a plateau in the curves. The values of sorption on the plateau for the first three acids are similar and considerably higher than for o-bromo-benzoic acid. These results can be interpreted in terms of acid ability to be dissolved in the surface film and of the ability to form the adsortsion layer on the ice surface.

It can be concluded that inorganic and organic substances influence the migration processes in the system with the solid phase of water. This is determined by the chemical properties of substances.

Structure of Ice Dispersion System Stabilized by Hydrophobic Fumed Silica Nanoparticles as New Material for Natural Gas Hydrate Storage

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Gas hydrates, or gas clathrates, are nonstoichiometric, crystalline inclusion compounds composed of a hydrogen-bonded water lattice. It is known that it may be economically feasible to transport and storage natural gas in a hydrated form. However, the absence of the effective way of gas hydrate formation thwarts the developing of gas hydrate technologies. The using of “dry water” dispersed system allows for the gas hydrate formation with the high speed and the water/ice to hydrate conversion rate. Nevertheless behavior of “dry water” at temperature below 0^oC and particularly at the phase transformations which is caused by the water/ice crystallization/melting is remained under-explored and difficult to understand.

It is known that the decrease in dispersed ice particles lead to the apparent increasing of the water/ice to hydrate conversion speed and rate. The influence of methods and conditions of such dispersed system preparing on the water/ice particle size of dispersed systems which are stabilized by hydrophobic fumed silica has never studied before. New method of production dispersed ice system stabilized by hydrophobic fumed silica was demonstrated in this work.

To prepare "dry water" we used distilled water and the hydrophobic fumed silica powder Aerosil® R202 (Evonik Industries AG, Germany) with a specific surface area of 100 $m^2 \cdot g^{-1}$ (by BET), a bulk density of about 60 $g \cdot l^{-1}$, and a carbon content of 3.5–5.0 wt%. The method of NMR relaxation spectroscopy was used to define the mean size of "dry water" particles.

Dispersed ice systems were prepared by two kinds of methods: 1) by "dry water" freezing; 2) by the mechanical grinding of ice and hydrophobic fumed silica powder mixture.

The particle size distributions for dispersed ice systems were defined by the screen analysis at temperature of -20 °C. The screens of 700, 500, 400, 160, 140, 80 μm were used. The particle size distributions for dispersed ice systems were plotted accordant with the procedure which described in the paper Kouzov, 1987.

According to the data which were got by NMR spectroscopy after the freezing/melting cycle the water droplet sizes of "dry water" dispersed system were significantly increased (about 60 %) as a result of freezing/melting cycle. The comparison between water droplet sizes and ice particles in the frozen "dry water" demonstrated that the water droplet crystallization during the freezing "dry water" lead to the particles increasing in the dispersion phase of the frozen "dry water".

It was found that the "dry water" freezing with the content of no more that 5 wt.% hydrophobic fumed nanoparticles led to form mostly the solid porous ice body.

It was shown that the "dry water" freezing with the content of Aerosil of 10 and more wt.% was provided to prepare ice particles which were more than dispersed ice particles which were produced by mechanical grinding without hydrophobic fumed nanoparticles.

It was determined that the crystallization/melting process of water/ice in the "dry water" dispersed system led to increasing water droplets in the dispersed system.

“Dry water” with the content of 10 wt. % Aerosil was more stable to freezing/melting cycles than “dry water” with the content of 3 and 5 wt. % Aerosil.

The present work was supported by the Council for Grants of the President of the Russian Federation (grant NSh- 3929.2014.5), Basic Research Programs of the RAS (program no. 8, and program the Arctic) and the Siberian branch of the RAS (interdisciplinary project no. 144).

Session 3:
Permafrost-affected Soils

Humus Specificity of Schirmacher Oasis Soils (East Antarctica)

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Antarctic soils are a valuable object for studying of the direction of initial stages of humus formation process in the bleak climatic conditions. Information about the primary direction of humus formation and quantitative characteristics of humus substances is necessary for revelation of laws of the early stages of soil formation. Quantitative parameters of the composition, structural features and properties of humic acid are also necessary for reconstructions of the paleoenvironment by pedohumus method based on the actualizm principles as part of the recent basis.

Different date about organic substance of Antarctic soils (including composition of humus and humus formation plants) are in the literature. However, they characterize not all geographical areas of this continent and not all diversity of soils formed under different ecological conditions.

One of the few studied territories in this aspect is the Schirmacher oasis.

The Schirmacher oasis located in the Central part of Queen Maud Land in 90 km from the Lazarev Sea is one of the coldest flat Antarctic oases.

Soils formed under different biocenose on the territory of the Schirmacher oasis are characterized by a very small capacity, accumulative type of humus profile, fulvic direction of humification process, absence of specific connections of humus group and fractional composition with type of biocenose, a low share of humic acids, a narrow ratio of humic acid carbon to fulvic acid carbon (Cha:Cfa), a wide ratio of hydrogen and carbon in elemental composition of humic acid and a high saturation of this humus component of nitrogen as well.

As a whole these characteristics are similar to soils of other areas of Antarctic regions.

At the same time, the soils of the Schirmacher oasis are characterized by a wide fluctuation of total organic carbon quantity and the predominance of brown humic acids and combined with them fulvic acids. These humus substances characterize a modern stage of humus formation process. They are the most mobile. Among these humus substances fulvic acids prevail which average from 10 to 30% (in some cases up to 40-45%) of the total organic carbon and exceed the quantity of humic acids in average 2.5–3.0 times.

In some cases the mobile form of humic acids are absent.

Humus of soils under studying is also characterized by a very low share of humic acids connected with calcium (no more than 2 %) and relatively high humic acid shares most strongly connected with clay minerals. Humus acids most strongly connected with clay minerals can make up to one third of total organic carbon that is specific characteristic for cryogenic soils of different regions of continental Eurasia.

The hydrogen and carbon ratio in elemental composition of humic acids does not depend on biocenose type, fluctuates within 1.4–1.6 and corresponds to climatic characteristics of the region. The preliminary data testify about wider ratio O:C in humic acids of soils under alga cenose.

Humus specificity of soils caused by biocenoses is revealed in a level of humic acids structure and properties, a ratio of aliphatic and aromatic share, different position of a maximum and the first moment in luminescence spectra. It also distinctions in a set of absorption strips and their position in infrared area of a spectrum.

Effect of Active Layer Thickness on CO_2 Fluxes of Frozen Peatland Soils (CALM R1, Western Siberia, Russia)

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The Circumpolar Active Layer Monitoring (CALM) program developed over the last decade as a leading edge in comprehensive efforts to study the impacts of climate change in permafrost environments.

Monitoring of active layer thickness, soil moisture, soil and air temperature are typical for all CALM sites. In connection with this CALM polygons are convenient for the study of spatial and temporal variation of soil parameters at fine scales.

The research CALM SITE R1 (Nadym Grid) is located in north of western Siberia (Russia, since 1997) within the zone of sporadic permafrost of north taiga. It is 1-ha (100m*100m) grid consists of a square array of permanent stakes separated by 10 m (121 data points per grid for all measurements). Permafrost is closely associated with frozen peatlands, bog and frost mounds. The typical soils are Turbic Cryosol of frozen peatland and Histosols of bog. For each point of CALM R1 site active layer thickness, carbon dioxide effluxes were measured in August 2013, 2014.

Active layer thickness and soil CO_2 effluxes are characterized by high spatial variability. Active layer thickness varies from 45 to 200 cm and more; average thickness is 136±10* cm (2013) and 166±8 cm (2014). The spatial distribution of active layer thickness is determined by hypsometric levels (r = –0,30, p-level <0,05) and winter temperature of soil surface (r = 0.38, p-level <0,05), as well as the different soil cover and the organic layers dimensions. Areas with deepest thaw (more than 200 cm) are developed in large sedge-moss pools within peatlands and in bogs and were not included in calculations. *(mean±1,96*SD)

In general, soil carbon dioxide emission is low and does not differ from year to year (156 ± 21 – 2013; 132±17 – 2014) $mgCO_2m^{-2}h^{-1}$ (ranging from 10 to 450 $mgCO_2m^{-2}h^{-1}$). Based on the regression analysis among more than 10 characteristics (hydrothermal, permafrost, soil) for CALM R1 site was revealed a high and significant correlation soil carbon dioxide efflux only with the active layer thickness (r = 0,45, p-level<0,05; y = 112 +0,13*x).

The active layer thickness, soil CO_2 effluxes and landscape parameters (relief, soil volumetric moisture, temperature of soil surface) of frozen peatlands (Nadym, northern West Siberia, CALM R1) are characterized by high spatial variability. We consider the main factor, which determine the soil carbon efflux is the depth of permafrost table; it determines the type of ecosystem in such transitional landscapes and organic matter transformation processes. Underestimation of the spatial variability of soil and vegetation cover in the region of discontinuous permafrost can lead to substantial distortion of estimates of the total greenhouse gases balance.

Interactions between Ground Surface Temperature, Topography, Vegetation and Snow Cover in Discontinues Permafrost Zone (North West Siberia)

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Ground surface temperature is a key parameter in the relationship between climate and the soil and active layer thermal regime. Numerical models of permafrost distribution predict the ground thermal regime at a site and commonly such models use estimates of ground surface temperature as an upper boundary condition. Because data is not enough for the northern areas, the surface temperature is often estimated (calculated) by the air temperature. However, ground surface temperature has greater local spatially variability than air temperature, and has only been monitored at a few sites with permafrost. The n-factor, or ratio of the seasonal degree-day sum at the soil surface to that in the air at standard screen height, has been used for more than 40 years in engineering studies to parameterize the temperature regime at the ground surface. In the discontinuous permafrost zone, correct application of n-factors is critical in predicting permafrost presence. This paper examines the relation between air and ground surface temperature at three sites in discontinuous permafrost of North West Siberia. The aim of this study was to evaluate the effect of local environmental factors, such as the snow cover, vegetation, micro-relief on the soil surface temperature.

Our study sites were situated about 30 km south-southeast of the city of Nadym at N 65˚19’, E 72˚53’. Permafrost is absent under forest site and exists under peatlands. The mean annual temperatures at Nadym from 2004 to 2013 were –4.5°C and annual precipitation was 550 mm. The forest site was in a lichen-pine forest without permafrost. The soils were classified as Albic Podzol. The young frozen peatland sites were in flat and slightly inclined surfaces of peatlands with cloudberry-*Sphagnum* cover. Permafrost occurs below 60 cm. The soils here were identified as Turbic Cryosol. The old frozen peatland is similar to the frozen young peatland except that it has deeper peat, abundant locally bare peat spots, sparse vegetation and permafrost below 50 cm in the peat layer. The soils here were identified as Cryic Histosols.

Air and soil surface temperatures were measured at each site from August 2013 to July 2014 six times per day with Thermochron ibutton™ data loggers at each of the three sites. Total 72 data loggers ware laid.

Mean annual ground surface temperatures (MGSTs) of soils sampled were positive, ranging from 0,8°C at old peatland site to 1.4°C at forest and young peatland sites. The winter (November – May) surface offsets (difference between monthly average soil surface temperatures and monthly average air temperatures) (MGST-MAT) is greater than in summer and varies considerably from site to site, whereas the summer (June–October) offset has less variability. Summer n-factor is close to 1.0 for the old peatland due to an absence of vegetation on much of its surface. Almost equal values of summer n-factors for the forest area and the frozen peatland indicate similar cooling effects of forest vegetation and moss-shrub vegetation. Summer n-factor for the surface hummock is more than for inter hummock. The highest value for winter n-factors occurred in the old peatland, which is associated with minimal snow cover. The values of winter n-factors (ranging from 0.07 at the young peatland to 0.2 at the old peatland) indicate a significant reallocation of snow cover among landscapes. A greater than two-fold difference in values for winter n-factors between micro-elevations and micro-depressions in the peatland indicates a significant reallocation of snow between the microrelief elements.

Statistical analysis for young peatland showed that the winter surface temperature strictly correlated with hypsometric level. It was also revealed that the winter surface temperature regime has a significant effect on active layer thickness.

Temperature Sensitivity of Frozen Peatland Soils In North-Western Siberia, Russia

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During the last decades the global Earth climate change processes have been observed. Among the other areas of Earth permafrost area is the most sensitive to modern climate changes. Permafrost area extends approximately to 60% of whole area of the Russian Federation – this fact requires many additional studies of modern climate impacts on permafrost ecosystems, especially on soils, developing in the conditions of permafrost.

The purpose of the study was to estimate the response of frozen peatland soils to increase in temperature of their functioning. The object of the study was frozen peatland soils of forest-tundra, North-Western Siberia, Russia (Nadym site, 65˚78ʿ26˝), developing under the influence of frozen bedrocks (active layer 60–80 cm).

The study included field and laboratory studies. Field studies were conducted in August 2014. Two monitoring sites on frozen peatland were selected to CO_2 efflux, temperature and moisture measurements at depth of 0 and 10 cm: control site and field-warming site (a "Greenhouse" was built to simulate the effect of increasing temperature). The field measurements lasted for 10 days and were triplicated. Soil microcosms[1] from the depth of 0–40 cm and medium decomposed moss peat samples from the depth of 0–10 cm were taken for further laboratory studies.

In laboratory the response of frozen peatland soils to temperature increase was estimated using such soil biological activity indexes as CO_2 efflux, basal respiration (BR) and $C_{microbial}$ (C_{mic}, Anderson, Domsch, 1978). During 2 months microcosms were subjected to sequential temperature increase in cryostat from 3 to 25°C. Every 3 days the temperature was raised up to 2°C and CO_2 efflux from microcosms was measured. For BR and C_{mic} analysis the frozen peatland soil samples were incubated for 30 days at elevated temperatures 5 (control), 15 and 25°C.

As a result of the field study the positive feedback of frozen peatland subjected to field-warming was revealed. We have determined the average daily temperature at field-warming site to be 2ºC higher than at the control site. The CO_2 efflux at field-warming site was also increased (88 $mg/m^{-2}\ h^{-1}$) in comparison with control site (66 $mg/m^{-2}\ h^{-1}$).

As a result of the laboratory study the different biological activity of frozen peatland soils in different temperature ranges was found. In “low” temperature range (0–15°C) we have determined the positive response of frozen peatland soils: CO_2 efflux and BR values tended to grow by 1.6 and 2.4 times correspondingly. On the other hand, in “high” temperature range (15–25°C) the negative response of frozen peatland soils was noted: from 17°C, as temperature was increasing, values of CO_2 efflux declined by 1.5 times, values of BR and C_{mic} decreased by 3 and 1,3 times respectively.

To summarize, the study experimentally showed the different temperature sensitivity of frozen peatland soils in different temperature ranges. Special attention must be paid to the fact that in “high” temperature range the temperature sensitivity of frozen peatland soils (determined by coeff. Q_{10}) was described as “very low”: in range of 15–25°C coeff. Q_{10} took the minimum values (<1). Such low coeff. Q_{10} values may indicate the possibility of frozen peatland ecosystems transformation from source to sink of carbon in case of significantly increase in temperature of their functioning.

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Pollen Data about Late Quaternary Vegetation in Northeast Asia

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The pollen data about the late Quaternary vegetation were obtained from site Duvany Yar (Kolyma lowland). We distinguished two spore-pollen assembleges in the section: 2.1–0.7m. and 0.7–0m. The basal assemblage is dominated by Poaceae and Asteraceae pollen and Selaginella rupestris (L.) Spring. spores. The minor herb pollen taxa (Ranunculaceae, Caryophyllaceae, Chenopodiaceae, Onagraceae, Caprifoliaceae, Brassicaceae, Polemonium, Valeriana) show a variety of ecological settings. Shrub pollen presents in small numbers except Pinus s/g Haploxylon (to 15%). The analysis of assemblage suggests mosaic herb-dominated communities existed in conditions of cool dry glacial climate. The abundance of Selaginella rupestris spores indicates on poorly vegetated landscapes on the dry stony slopes. The pollen of Pinus s/g Haploxylon can be referred to Pinus pumila and may be blown from long distances. However, this shrub can be presented in small numbers in the most favourable lowland habitats. Radiocarbon data are available, but similarity of these spectra to herb zone spectra from other dated sites (MIS 2) indicates a full-glacial age (Anderson, Lozhkin, 1995).

Betula and Ericaceae pollen increases abruptly in spectrum from interval 0.55–0.47m. This change in pollen assemblages reflects the influence of post-glacial climatic amelioration and replacement of herb tundra communities by Betula shrub tundra. This shift is dated in Northeastern Siberia by 12.5 thousand years.

These data give important information on vegetation changes on Pleistocene/Holocene boundary and paleoclimatic reconstructions on this interval in Kolyma lowland. The comparison of palynological data with materials from other regions of Northeast Siberia demonstrates similar changes in vegetation and climate.

Andesrson P.M., Lozhkin A.V. Late Quaternary lacustrine pollen records fron Northeast Siberia: new results // Pacific Geology. V.14. № 4. P.8-17.

Structure and Ecological Functions of Permafrost Table Microrelief

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Surface microrelief structure, complexness of soil-vegetation cover, lithological heterogeneity of the active layer, spatial differences of thermal properties of different elements of transient layer and other factors form the complicated pattern of permafrost table microrelief. This relief determines accumulation, redistribution and removal of matter and energy from the ecosystem. Spatial difference in structure and properties of the upper layer of permafrost may lead to the cryoconservation of organic matter, biophylic elements, contaminants, viable biota or contrarily they may thaw and contribute into the modern biogeochemical cycle.

The research was partially supported by RSF (14-14-01115); RFBR (14-05-31368mol_a, 14-05-31111mol_a, 15-04-03960a), grant of the President of Russian Federation (SS-3929.2014.5), interdisciplinary integrational project of SB RAS (№144).

Experimental Studies of Frozen Soil Composition and Properties, Baydara Bay Coast

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The Arctic coastal zone is very sensitive to any environmental changes. Understanding of the interaction between permafrost and sea is important due to active development of these territories (constructing coastal facilities, offshore pipelines, etc). The consequences of climate change include an increase in temperature, melting ice shields, changed movement patterns of icebergs, increased coastal erosion due to the lack of sea ice, increased river and shore erosion, intensified wave dynamics and loads, increased storm intensity and frequency, and melting permafrost.

Multicenter studies were conducted as a part of international research project SAMCoT (Sustainable Arctic Marine and Coastal Technology). This work concerned to Coastal Technology, aims to prediction of permafrost conditions and coastal engineering. Knowledge of soils properties are required for cryological forecasts. The studied area is located on the west coast of Baydara Bay, Kara Sea and characterized by continues permafrost distribution. According to 2 weather stations: (1) Mare-Sale, (2) Ust-Kara average annual temperatures of the air for studied territory are –6.6…–5.7°C (*rp5.ru*).

These investigations carried out on the 2 observation sites of Baydara Bay coast located on low and high marine terraces, which are composed by interbedding sediments, such as silty clays, silt and silty sands. Soils samples were collected and studied in the field and laboratory. Laboratory tests included the measurements of parameters for samples with different grain size composition, moisture, ice content, density, plasticity, soil salinity degree, mass of organic content. Also unfrozen water content for frozen samples and thermal properties for frozen and thawed state were studied.

All soil properties and soil classification were done according to the Russian normative documents and standards. Unfrozen water content was investigated by contact and cryoscopic methods. Thermal conductivity was investigated by 3 approaches, two of them are needle probe methods using different devices: (1) MIT -1 for field study, (2) KD2 Pro for field and laboratory investigations; (3) the first type regular mode method (known as α-calorimeter) use in lab. Heat capacity was studied by KD2 Pro device and also this parameter was estimated according additive relations between soil components.

The moisture content of samples varied from 10 to 205% and density varied from 1.15 to 2.05 g/cm3. Unfrozen water content in the soils for different grain-size soils varied over a wide range with highest values for saline soils and peats.

Thermal conductivity of frozen soils varied for sands from 1.53 to 2.05 W/m·K, for silts from1.0 to 1.7 W/m·K, for silty clays from 0.97 to 1.56 W/m·K, for peats from 0.8 to 1.3 W/m·K. In different frozen soils heat capacity varies in sands from 770 to 1500 J/kg·K; in silts – from 790 to 1650 J/kg·K; in clays – from 840 to 1770 J/kg·K.

Variability trends in thermal properties and phase composition of water in frozen samples were obtained, depending of temperature, moisture content, density, soil salinity and organic content.

The obtaining variability and trends of soil parameters can be used for simulation of permafrost conditions

Carbon and Nitrogen in Deposits Polygonal Bogs and Underlying Permafrost Tundra South of Western Siberia

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Data were obtained on the content gross carbon and nitrogen, metabolic activity of microbial communities in the peat column. Revealed that the variability of the gross carbon in the active layer is not so great, compared to total nitrogen. Metabolic activity of microbial communities depends on the value of the content of total nitrogen.

During the work we have selected a sample of lowland peat within interfluve Pyakupur-Lymbadyaha. Power peat deposit is 100 cm below underlain by sand deposits, with little power peat layers. Active layer thickness was 45–50 cm.

Our data on the content of carbon in gross peat deposits varies between 40.4–56.4%, in the active layer changes in the content were not significant. The sandstone underlain by its content decreases sharply (3.8%). Distribution of total nitrogen, compared with a gross carbon contrary has greater variability. Its content is in the range 0.5-1.4%. It is likely that such characteristics as the botanical composition, the degree of decomposition and metabolic activity of microbial communities have a significant impact on the nitrogen content, rather than on the carbon content.

Nowadays, more research devoted to the study of metabolic activity of microbial communities at low temperatures and long-seasonally freezing soils (Kryazheskih 2012, Mironov 2013, Gentsch, 2015). In the context of the north main function of microbial communities - decomposition of organic substances - is carried out in a short growing season. By increasing the nitrogen content in the active layer has the highest activity of microbial communities. This is due to the fact that the soil microbial community make up the bulk of the oligotrophic and oligonitrophilous microorganisms capable to recycle mineral nutrients and nitrogen from the ambient condition

These groups of bacteria are important because prevents the loss of soil nitrogen in the cycle involving the slightest amount of ammonia and with sufficient energy materials are used not only nitrogen organic compounds, but also to mobilize the gross forms of nitrogen.

The Role of Cryogenic Mass-Exchange in Distribution and Sustaining Viability of Ciliates and Heterotrophic Flagellates in Turbic Cryosols

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The studying of viable biota cryoconservation in permafrost deposits is of high priority during the last few decades. One of the uncertainties is the mechanism of eukaryotic microorganisms' transition into the frozen deposits. The vast majority of viable biological objects were isolated from the deposits enriched with plant remnants (organogenic and organo-mineral horizons of buried soils, buried peat, litter, root detritus etc.). The modern Cryosols are subjected to the different processes of cryogenic mass-exchange that redistribute the fragments of the uppermost soil horizons with microorganisms inhabiting this material. The aim of the study was to determine the role of cryogenic mass-exchange in distribution, sustaining of viability and further long-term cryoconservation of soil protists in the permafrost sediments.

Thirteen analyzed samples of organic and organo-mineral material from six pits of Turbic Cryosols were collected during 2014 field season in the Chokurdakh (North Jakutia) nearby and arranged into four groups according to the leading cryogenic mass-exchange processes: A) мodern uppermost undisturbed by cryoturbations; B) fragments that were buried by solifluction processes in the central parts of Cryosol profile; C) cryoturbated fragments in the central parts of Cryosol profile; D) cryoturbated fragments that were accumulated in the transient layer of permafrost. Radiocarbon age of plant remnants that were brought into the mineral part of Cryosol profiles by solifluction (B), cryoturbation (C) and cryoturbation+cryoconservation (D) processes varies within 2.1–4.5 Kyr.

Soil samples were analyzed for protist genera and species during enrichment cultivation without nutritional supplementation by the non-flooded plate method. The taxonomical analysis revealed 24 species and forms of heterotrophic flagellates from 9 taxonomical groups and flagellates *incertae sedis* and 21 species of soil ciliates from 9 taxonomical groups. The species diversity and patterns of culturable protists community structure were investigated used statistical methods: the hierarchical cluster analysis based on the Simpson indices similarity matrix and the principal component analysis (PCA). All computations were performed by program package PAST 1.89.

Communities of ciliates and heterotrophic flagellates isolated from the soil samples were divided into two groups by the species composition: 1) occur only in the modern uppermost (A) organic and organo-mineral soil horizons and 2) part of the protists' community (38% and 58% of ciliates and flagellates species respectively) that occur in material of organic and organo-mineral soil horizons both a modern (A) and buried into the middle and lowermost parts of Cryosol profiles by different processes of cryogenic mass-exchange (B, C, D).

Probably, features of the vertical distribution are related to the peculiarities of the resting cysts biology – adaptive and protective mechanisms enabling long-term cryptobiosis of soil protists in the inhospitable conditions of Cryosols and permafrost. Fragments of the uppermost soil horizons that were cryoturbated, buried by solifluction or accumulated in the transient layer of permafrost appear to be the environmental niche in profiles of Turbic Cryosols that can significantly sustain protists' viability. The conditions under which protists' cysts have proceeded into frozen state have a considerable impact on the formation of the fauna of "alive fossil" protozoa.

The research was partially supported by RSF (14-14-01115), RFBR (15-04-03960a, 14-05-31368-mol-a, 14-04-00500, 14-04-00554).

Session 4:
Permafrost engineering and hazardous processes

Experiments on Additional Cooling of Permafrost With Underground Oil Pipeline

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Almost one third of the first Russian main oil pipeline in permafrost area (ESPO-1 was built in 2006-2009 from Taishet to Skovorodino and its length is of 2.691 km) is underlain by permafrost ground. The thawing of this ground can be a cause of unacceptable risks of changes in the project plan-height position of the pipeline and, hence, be a threat of its functioning. Sites with ice rich permafrost and polygonal-vein underground ice are especially dangerous. They number about 300.

In this regard, experiments with additional cooling of permafrost are conducted in the Olyokminsky District of Yakutia. The experiments consist in regulating cooling and warming natural factors to reduce the influx of heat to underlying permafrost ground and increase its outflow in order (1) to preserve the virgin permafrost mass and (2) to cool this mass, and, accordingly, decrease «halo thawing» of permafrost under the duct.

On the experimental site number 1 two ways of cooling the soil were tested: (1) the removing of snow from mid-November 2013 to mid-March 2014 when snow depth was less than 5 cm and the (2) surface coating by polymer rock sheet of light gray color from May to September 2014. On control site snow was not removed, and the surface was not covered by the sheet rock, and snow cover was 40-41 cm in thick by mid-March

Observations of the temperature and the depth of soil thawing on the experimental and control sites showed that at the end of the warm period (09.10.2014) seasonal thawing depth at the experimental site decreased by 1.66 meters, or by 40.5%, and the cooling effect (by 0.7–4.5^{o}C) can be confidently traced to a depth of 3.5 m.

In November 2014, the rock sheet was replaced by awnings (height of 1.5) constructed from a metal frame coated by sandwich panels, which protected ground from sun and precipitation. This allowed even more cool the array of ground in winter 2014–15 years. Thus, in the middle of April 2015 the temperature of the ground in the range of 1–5 m on the experimental site was at 2–4°C lower than the control site.

On the site number 2 at the end of March 2014 it was built sun and precipitation awning in the form of a wooden skeleton of pillars, beams and planks, deck of profiled metal sheets on the crate from the boards and the layer of synthetic fabric. Equipped termoboreholes depth 15 and 10 meters under shed and off at 1, 3 and 10 meters from an underground pipeline. Also the measured depth of soil thawing metal probe at the control points 1, 3 and 10 m from the pipeline. Shading and preventing filtering summer precipitation into the soil allowed shedding 37–49% reduction in the depth of soil thawing.

Intensive cooling of the array of soil occurred in winter 2014–15. As under shed formed snow, cover reaches 40–50 cm beyond the shed. On April 23, 2015 (13 months after the construction of the shed), an array of ground in the range of 2–5 m under a shed it was colder by 3–7°C compared to the array of soil outside the shed. The further cooling of the array of soil will be even greater.

Thus, conducted experiments show that the cooling of the array of soil by adjusting the natural cooling and a warming factors can be very effective in ensuring the stability of the underground pipeline in the icy permafrost soils, as will significantly lower the temperature of the surrounding soil and reduce the aura of thawing them under the pipeline

Role of Oil Pollution in Formation of Saline Frozen Soil Properties

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Oil and gas deposits are situated mainly in the northern regions, and most of them - in the permafrost area. A significant part of the permafrost zone is occupied by saline permafrost.

Soil contamination with oil can occur in various ways: the development of deposits, during storage it in the fields and processing plants, as well as there is a danger of leakage during the transportation of oil and petroleum products. In the process of oil extraction both contamination and salinization of the soil can happen. The sources of salts in this case are the reservoir of liquid waste produced, water content of barns and other geochemically active substances used for extraction and oil desalting. In addition, co-salinization and contamination could occur with leakage of on saline soils, where are the way of oil transportation.

Forecast of soil temperature, seasonal thawing and freezing, development of permafrost negative processes and design of buildings and structures in the permafrost zone is impossible without knowledge of soil properties. Obtaining high-quality data on the thermal properties and phase composition of moisture in the soil has a great importance for the calculation of thermal fields in the ground and assessing the impact of thermal influence on the soil-foundations.

The authors worked on the experimental procedures and assess their applicability to the saline and oil-contaminated soil in the process of freezing and thawing. An experimental investigation of thermal properties and water phase composition was conducted for soils with different particle size distribution and different values of oil pollution and salinity. The characteristics of the soil were investigated, such as the freezing point, unfrozen water content, thermal conductivity, specific heat, thermal diffusivity. The changes of these parameters were obtained in the dependence of temperature, salinity and oil pollution. The role of oil pollution in the formation of thermal properties and water phase composition of saline soil (in the range of salinity and oil pollution) was established. The dominant influence of salinity is revealed for the freezing point and water phase composition. The mechanism of the joint effect of salinity and oil pollution on the thermal properties is more complex and depends of many other factors.

A Systematic Research on Cryosphere is the Basis of Effective Industrial Management

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Effectiveness of oil-gas industry management influence on Russian economy stability. More than 30% of exploring and more than 90% potential mineral and supply located on the permafrost.

Unique and extreme natural conditions define subarctic area and characterized by: inclement winter, that lasts more than 9 months; extremely hot and short summer period that contribute to development of hazard for exploring processes like the thermoerosion, thermokarst, thawing of polygonal ice wedges, solifluction and similar destructive disastrous processes. Western Siberia has been developing since the end of 19th century and it has big economical potential, including the most difficult to explore Yamal area.

The fact is that on the permafrost zone the cost of foundation could come to more than 70% from the total cost of the building. It is possible to reduce significantly the cost of foundation due to comprehensive research of geocryological factors of developing areas and due to forecasts based on modern climate trends, anthropogenic influence together with retrospective analysis drawing on developed fields.

Many authors emphasize that the engineer-geocryological conditions of developing areas were not considered properly at the stages of design, construction and operation because of the legislation gaps and weak access to the existing geocryologiacal and analytic data.

It is significant, that Russian permafrost area is good researched both in large-scale and in small-scale by the scientific community and the owners of the license areas. Unique long-term monitoring data is collected, it could be used to analyze and forecast geocryological dynamic. At the same time there is big potential to develop permafrost observation network.

According to the temperature modeling results, trends of processes development, estimation of anthropogenic and geoecological resistance Yamal peninsula is extremely adverse to the development. According to the processes estimation map (N.V. Tumel, L.I.Zotova) most of the perspective Yamal deposits are situated in the area with advanced stage of developing of cryogenic processes (thermokarst, thermoerosion, thermoabrasion, solifluction) which potential is "very strong" (the highest rate).

Next institutes carry out researches of Yamal area during past 60 years: Russian research Institute of hydrogeology and engineering geology (Moscow, 1970); Moscow State University named after M.V.Lomonosov (Moscow, 1970); State Hydrological Institute (Leningrad, 1974); Institute of YUZHNIIGIPROGAZ (Donetsk, 1976, 1978, 1995); a Russian leading engineering company of oil and gas complex JSC "VNIPIgazodobycha" (Saratov 1990, 2004), SOYUZMORINZHGEOLOGIYA (Murmansk, 1990); Scientific and technical enterprise "Krios" (1997), TYUMENNIIGIPROGAZ (Tyumen, 1994), LLC "Nadymgeokonsalting" (Nadym, 2011), a lot of divisions of "Gazprom dobycha Nadym" (Nadym, since 1970), and others. At the same time different scientists and scientific-research organizations held on permafrost monitoring of the Yamal regime sites.

Last 10years researches show, that above listed hazards are unique in complexity and need in a new approaches, including the compilation and analysis of existing data.

Developing GIS technology allows us to analyze huge database, to visualize the relationship and the influence of different factors. Identification, validation, collection and structurisation (widespread and all sort) data is the most difficult and routine work on the way of database creation.

Present time the author is developing a model and structure of the GIS database in purpose to collect and systematize the existence geocriolitological data of the Yamal Peninsula and of the Nadym-Pur watershed area, it should be the analytic basis of a multi-layer representation of a large number of geodata. Practice shows high efficiency improvement of enterprise management due to placement at interested institutions the available and timely information.

Methodological Approaches to a Geotechnical Cartographic Modeling

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Complexity, variety, as well as seasonal and long-term dynamics of engineering-geological conditions in permafrost regions pre–determine the complexity of design and construction. This primarily refers to the geotechnical substantiation for design of reliable foundation structures. Now, on the one hand, a vast experience has been accumulated in the areas of engineering survey and methods related to permafrost. On the other hand, quite an experience has been acquired in design and construction in the Arctic regions. Nevertheless, optimal use of the results of the above–mentioned studies of permafrost area cannot be underestimated for the design and construction.

The most important parts of the research methods are:

• Development of GIS cartographic models of engineering geological conditions in the permafrost areas and consistent specification of those models and its characteristics;

• Development of a wide range of geotechnical solutions for foundation structures on frozen ground.

• Development of geotechnical mapping models that interpret applications of engineering solutions in a variety of engineering and permafrost conditions.

Soil Temperature Monitoring System

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It has been offered to carry out temperature monitoring of facilities for the purposes of detecting and eliminating emergency situations in the areas of permafrost soil with the help of various temperature monitoring systems for operation security of transport infrastructure and oil and gas complex facilities in northern districts of Russia.

Developed monitoring systems are designed for field test of soil temperature according to GOST 25358-2012, where it is required to obtain data on the thermal state of soils. The introduction of developed technical solutions allows improving measurement accuracy and reliability, simplifying current temperature monitoring systems, broadening their scopes of application.

Developers of OJSC SPE "Etalon" attempted to eliminate the disadvantages of known temperature monitoring systems, such as complexity, high price, low measurement accuracy and poor tightness, which leads to device failure in the conditions of industrial applicability.

Architecture of developed measuring systems is very flexible; Depending on the assigned task, it allows conducting on-the-spot, autonomous and continuous monitoring of soil temperature under the footingss of buildings and constructions along the railway roadbed, thus ensuring performance and operation security of facilities in the conditions of permafrost.

Management options of on-the-spot, autonomous and continuous measurements of soil temperature, as well as the practical effects of equipment application of OJSC SPE “Etalon” by experts of Permafrost Station of ISSO Center - branch of OJSC “RZhD” in Tynda, has been considered.

Continuous logger measurements in relationship with thermistor chain during annual cycle gave whole new data on temperature behavior of roadbed object.

Ultimately, Permafrost station of ISSO Center intends to use information from loggers LTsD-1/100 and thermistors MTsDT 0922 for further evaluation of march of average annual temperature to forecast temperature behavior of constructions bases, performance assessment of freezing measures for one annual cycle, adjustment of original data to increase the accuracy of thermotechnical forecasts, etc.

The chronology of Cryogenic Slope Processes in the Subarctic

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It’s been more than 100 years since the Swedish geologist and archeologist J.G. Andersson (1874-1960) suggested the term “solifluction” for the description of “the slow flowing from higher to lower ground of masses of waste saturated with water (this may come from snow-melting or rain)” (Andersson, 1906, p.96), which he discovered during his expeditions to the Medvegiy Island to the south of Spitzbergen in 1898 and to the Falkland Islands in 1902. Since then in many regions of Earth there has been established the morphology of the solifluction slopes, mechanisms, distribution and modern intensity of the solifluction processes, the peculiarities of forming of solifluction sediments. Nowadays the reconstruction of the changes of intensity of the solifluction and other kinds of slope sediments in time is considered not only a fundamental, but also a practical aim, especially considering present climate changes. A powerful weapon in solving this problem became the method of radiocarbon dating of the slope sediments. Studies like this are held in Canadian Cordillera, Finnish Lapland, Spanish Sierra Nevada and Alps. For example, in Alps there has been detected 5–7 epochs of solifluction's activation (Oliva et all., 2009).

In European Subarctic Mountains dating of slope processes was begun in 1980s in Khibiny Mountains, where T.V. Vaschalova (1987) by radiocarbon dating of buried organic remains in avalanche cones determined three periods of decreases of the avalanche activity: 4100–3800 years BC, IV century BC- III century AD, 790-1560 AD, and also the period of its increasing during Little Ice Age (LIA) in XVII-XIX century.

Recently in the Central Yamal there have been revealed 7 periods of cryogenic landslides' activation, in 250 year BC and in 210, 640, 1000, 1300, 1700, 1989 years AD, which coincide with mild summer (Leibman, Kizyakov, 2007).

In 2010-2014 we held field works under different lithological and physical geographical conditions in Khibiny Mountains, on absolute heights of 500-600 meters in uppers of Medvegiy stream on 67°44,38 N, 33°16,94 O, and in Uksporriok valley on 67°39,37 N, 33°49,98 O, also on the slope of Barkov mountain in near Polar Ural region on 65°11,77 N, 60°20,26 O, on the height 940–980 meters. The dating of buried grassy turf allowed to determine several periods of activation of slope movement on Khibiny mountains in 1990–1779 years BC, 1600 years BC – 400 years AD, 540–990, 1270–1480 years AD. Nowadays the signs of active ground movements are rare. Part of dated terraces is being overgrown intensively, on the others there are no ground covering, as it is being harmed by cryogenic and aeolian processes. The soils during periods 1480–1670 was being formed during the period of a clear cooling (LIA), when little glaciers appeared in Khibiny again and are preserved till nowadays. On the Polar Ural the solifluction is happening with a considerable velocity, because the soils with more than 150 years of age has already deformed it.

The works are supported by the Russian Scientific Fund (project № 14-37-00038)

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Analysis of Off-road Vehicle Tracks Dynamics on Yamal Peninsula, Russia

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Study of off-road vehicle tracks dynamics at Central Yamal started in 1991 by O.V. Rebristaya and O.V. Khitun in connection with active gas field development and investigations for railway construction in this area.

After 2012 field survey and measurements, vehicle tracks were subdivided into 3 groups according to the degree of disturbance: with low, medium and high technogenic impact.

The current state of previously investigated vehicle tracks which are mainly not in use now is analyzed.

Low shrubs (Betula nana, Salix glauca, Salix lanata) and dwarf shrubs (Salix polaris, Vaccinium vitis-idaea etc.) are fully degraded in tracks with low impact on gentle slopes with hummocky shrub-sedge-moss tundra. Upper part of active layer is compacted. Active layer is slightly deeper by 1–3 per cent vs. background. Wet tracks are characterized by higher vitality and abundance of Carex concolor and Carex bigelowii ssp. Arctisibirica compared to background community. Projective coverage (PC) of grasses (Calamagrostis holmii, Alopecurus alpinus, etc.) increases in rather drained tracks. They are described in different parts of Arctic by several authors under the name "green trails" due to active growth, larger number of leaves and high content of nutrients in sedge and grass tissues. It seems that green trails form in response to the change of the mineral nutrition and wetness regime caused by disturbance. This phenomenon was particularly evident the first years after disturbance. After 20 years tracks with low impact almost completely recovered to the original communities.

Tracks with increased off-road vehicle traffic (medium technogenic impact) are characterized by mechanical destruction of moss-lichen cover which follows destruction of shrubs. Original vegetation is replaced by sedges and partially by grasses. Active layer is deeper by 0,1–0,25 m vs. background. The highest deepening of active layer by 20-30 per cent after disturbance by off-road vehicle is typical for poorly drained and overwet surfaces due to thick moss cover degradation.

With regular off-road vehicle traffic (high technogenic impact) tracks have different depths according to lithology and surface morphology. Vegetation cover is fully destroyed and expose the upper part of the active layer. Active layer is deeper by 0.3 m and even more due to vegetation (mostly moss) degradation. On overwet surfaces tracks are filled with water, which often leads to thermokarst.

Noticeable recovery of old vehicle tracks is observed on all sites and recovered communities are similar to the original ones, or are replaced by more hydrophilic species. The least visible is recovery of dwarf shrubs and lichens. It contradicts the results obtained by J.T. Kemper and S.E. Macdonald in the more southerly subzone in Alaska. Old tracks in shrub tundra of Alaska are marked by dwarf birch while in Central Yamal recovery not only takes more time, but old tracks are marked by willow shrubs. Dwarf birch in old fully recovered tracks has less coverage compared to background. Recent tracks are re-vegetating mainly by grass-sedge pioneer groups. Active layer depth in the vehicle tracks increases in connection to both the intensity of impact and the replacement of the typical vegetation cover (with high species diversity and a high coverage of shrubs and mosses) by mainly sedge communities.

Next step included assessment of landscape disturbance by vehicle tracks using satellite image GeoEye-1 of August 15, 2009, one year before railway construction. Total length of vehicle tracks was 243 km within 21 square km area. Total area affected by vehicle tracks was at least 1.04 square km. Only 24.5 km (10.4 per cent) of 2009 tracks could be interpreted as actively used, most of tracks were old and rarely used. Landscapes affected by vehicle tracks are characterized by different initial conditions of recovery of landscape components, or further technogenic activation of exogenous processes. More than one half of affected surfaces is consistently overgrowing when no further technogenic impact is applied.

Computer Simulation of Permafrost Soil Thermal Regime under the Thermal Influence of Engineering Constructions

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The problem of permafrost soil stability under thermal influence of various constructions is well known. Various basement/foundation deformations are the result of settlement and heave due to the respective thawing and freezing of underlying moist permafrost soils. These processes could cause serious damage to constructions. In order to predict basement/foundation deformations computer simulation can be used.

Computer simulation of permafrost thermal regime requires numerical solution of heat equation considering phase transition (“ice-water”). There is a number of numerical methods available for solving the nonlinear heat equation, however, they have some use limitations. Simulation of thermal interaction between the construction and permafrost ground is complicated with the fact, that in order to achieve required accuracy it is necessary to perform discretization of computational domain with the fine mesh. The large quantity of cells (multi-million) in the computational domain is necessary because of:

1) large-scale computational domain requires a large quantity of cells to provide accurate discretization;

2) cell size increasing is restricted due to small size of the objects that are presented in the computational domain;

3) a dynamic phase front requires a more refined mesh around the phase transition boundary, otherwise severe error increase will take place.

Solving a nonlinear heat equation for large sites (computational meshes) is a difficult memory- and time-consuming computational problem. As a result, existing thermal simulation methods require an unaffordable amount of time (such models would take some days or moths to process on common PCs).

A new numerical method, satisfying all the above requirements, for solving Stefan problem in permafrost soils was developed and has a high degree of parallelization. This method is implemented in Frost 3D Universal software package, which can be used for computer simulation of permafrost soil thermal regimes under the thermal influence of pipelines, production wells, hydraulic constructions etc., taking into account the thermal stabilization of the ground. The key advantage of Frost 3D Universal is the ability of three-dimensional computer simulation of large-scale problems (regions with linear sizes of kilometers, multi-million cell mesh) and non-liner thermal processes for long time periods (many years) spending a reasonable computation time (about several hours) on a common personal computers.

Yamal Gas-Emission Crater: Geomorphologic Description from Remote Sensing Data

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New permafrost feature - a gas-emission crater in central part of Yamal Peninsula was explored by our group during the field observations and by processing of remote sensing data. Remote sensing data were used to determine the time of crater formation and to describe the morphology of the studied area before and after the event.

Landsat 8 and SPOT 5 satellite images for various time spans were interpreted to distinguish the date when the crater appeared. As a result, we assume that the crater was formed in late fall 2013 within the time range between 2013/10/09 and 2013/11/01. After 2013/11/01 satellite images yield a series of pixels of low reflectivity. The size of the affected area was increasing at least until 2014/04/03. Presumably this specific reflectivity results from water-saturated deposits entrained from the crater forming a parapet and of the hole itself. In summer, when the parapet partially dried up and the barren ground was more reflective, the crater area appeared as a bright ring surrounding the hole.

For the key-site high resolution satellite images were acquired for the dates 2013/06/09 and 2014/06/15, closest available to the time before and after crater formation. These two stereo-pairs of WorldView-1 satellite images were used to determine the geomorphology of the study area through digital elevation models (DEM) creation.

Images and DEM of 2013 documented the existence of the bulge with base diameter 45–58 m and a height of about 5-6 m in the place of the future crater. This bulge occupied the border of the hasyrey (drained lake basin).

Morphometric characteristics of the crater were identified during field surveys, and as a result of interpretation of satellite images of 2014/06/15. The upper part of the crater was funnel-shaped, passing through a fairly sharp bend to the cylindrical hole down to the bottom of the crater.

High ice-saturated clayey deposits with sub-vertically oriented layers of ice and clayey sediment were exposed in the walls of the upper part.

Below in the vertical and even overhanging wall of the cylindrical part of the crater tabular ground ice with a few vertically oriented silt inclusions was exposed.

The crater is surrounded by a parapet of thrown out silt, loam, clay and turf blocks. Parapet height varies along the perimeter of crater presented by mounds from 0.5 to 4 m height. Some clods of the clay and fragments of turf mat were detected at a distance of 120 m from the crater rim.

The size of the crater at the beginning of the warm season of 2014 was as follows: diameter of the cylindrical portion 15–16 m, diameter of the rim 25–29 m, depth to the water surface at the bottom more than 50 m. By the end of 2014 the diameter of the cylindrical portion increased to 22–23 m, depth to the water surface reduced to 26 m.

An analysis of multi-temporal digital elevation models allowed calculating the volume of the crater void and of the parapet formed around it. The volume of discharged material (ejected from the crater and partially destroyed bulge) was 11 200 m^3, almost 6 times the volume of the material found in the parapet. The difference is due to a significant amount of ice that as results from field observations is exposed in the walls of the crater. Apparently it comprised a major portion of the material of the bulge which was ejected and thawed after ejection.

The program of further study of this phenomenon was developed in joint effort with the Russian Center of Arctic Exploration. This Program includes cryolithological, geomorphologic, geobotanical, geocryological, and geophysical surveys.

Technogenic Permafrost Outside the Cryolithozone

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Territories influenced by technogenesis are wounded differently and it is needed the various recultivations for them: from nonintervention in natural-recovery processes to full engineer-biological recultivation. Individual approach is important for recultivation in Arctic zone. Peculiarities of recultivation especially different in various geographical sub-zones because of different permafrost conditions and accommodated geocryological processes. Specific geocryological processes could take place in the technogenic permafrost outside the cryolithozone.

The Nazarovo coal pit is situated in the South-Eastern part of the West Siberian Plain (56°02' N, 90°30' E) near Krasnoyarsk city several hundred km southward the permafrost: the mean annual air temperature is about 0°C and the ground temperature is +2…+3.5°C. In spite of this the technogenic permafrost has been found in 10% of engineering-geological boreholes drilled in the dumps of Nazarovo coal pit (the ground had been moved by railroad or by digger). Thus the technogenic permanent frozen ground of this region are of interest mostly from the viewpoint of their behaviour during the thawing as a factor contributing to the ground bearing capacity retrogression, the development of ground subsidence process and the destruction of the recultivated areas.

The main type of the technogenic permafrost degradation in Nazarovo coal pit is its thawing. The duration of the thawing process is affected by:

- The thickness of ground overlying the frozen layer; the larger the thickness – the longer the thawing process.
- The ground type and the water content of the technogenic permafrost; the more disperse ground and the higher water content – the less is the rate of permafrost degradation.
- The ground type and the water content of the embankment overlying the technogenic permafrost; the more loose and drained is the embankment – the less is the rate of permafrost degradation.
- The thickness and temperature of permafrost; the larger the thickness and the lower the temperature – the slower the thawing.
- The complex of the external conditions – the mean annual air temperatures, the rate of precipitation in the frost-free season, the presence of the vegetation cover and the thickness of the snow cover well correlated (direct or inverse) with the heat flux into the ground.

Two types of frozen strata of various origin and structure have been found in the dumps during the operation of a coal deposit. The first type – NON-ICE-RICH PERMAFROST – is usually characterized by the thickness of 10 m and more; the top of permafrost occurs at the depth 4-12 m; the temperature throughout the whole frozen layer is -0.1…-0.3°C. The cryostructure of rocks is massive, the water content $W \cong 0.23$. The formation of the frozen ground of this type had taken place during leveling due to the digging up of the seasonally frozen soil and moving it to new position in winter.

The second type of the technogenic frozen layers – ICE-RICH PERMAFROST –is characterized by the lesser thickness (usually the first meters), the small depth of occurrence (the first meters as well), the higher ice content (Wc = 0.4) and the presence of ice lenses with the thickness up to 1 m. The permafrost degrades actively due to the small thickness and depth of occurrence. The high ice content ensures the essential subsidence. As a result 0.5-3.5 m depressions appear. Their “thermokarst” origin is verified by drilling. The ice, the frozen soil and the thawed cavities have been met in the bottom of “thermokarst” depressions and nearby them. The lateral shape of subsidence is very diverse.

ACKNOWLEDGEMENTS: RF President Grant NSH-5582.2012.5; RFBR 13-05-41509 RGO, 13-05-00811, 13-05-00854, 13-08-91001-ANF-a; Education and Science Board № 9093 and 1082.

The research is the Fundamental Programs VIII.75.1 and VIII.72.2; Integration Projects SB RAS-FEB RAS №9 and SB RAS №144, ONZ RAS № 12; Government Work for; International Programs TSP, LCLUC, CALM, SWIPA; VSEGINGEO Institute.

Минобрнауки № 9093 и № 1082, грантов Президента РФ НШ-5582.2012.5, РФФИ-РГО-13-05-41509 РГО, РФФИ 13-05-00811, 13-08-91001-АНФ-а, 14-05-00956, 15-55-71004\15,

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Defining Engineering Properties of Dry and Ice-Rich Martian Soil in Perspective of Preparation Exomars Mission

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This work has collected data on different properties of Martian soils, which can be of interest to developers of instruments and spacecraft for the exploration of this planet. Particularly, ExoMars program includes Russian - made landing platform which is constructed to deliver European rover equipped with drilling rig to Mars in 2018. Data necessary for modeling behavior of this spacecrafts with Martian soils are dispersed in numerous publications of different years, which are not always available; therefore, this collection will facilitate their search and study. It has been shown that, in the first approximation, the diversity of Martian soils can be reduced to four varieties of dry regolith, ice-rich regolith, soft rocks, and hard rocks. Information on the structure and composition of Martian soils and their physical, thermophysical, and mechanical properties is based on the analysis of orbital sensing data, those obtained by seven landing spacecraft, and analogous terrestrial materials. The drillability of Martial soils and risks for landers are considered separately.

Regional Formation Regularities of Thermokarst Processes in the South of the Eastern Siberia

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Thermokarst phenomena along a 2500 km oil pipeline in the South of the Eastern Siberia and the Far East was analyzed. This natural-technical system passes through different climatic, tectonic, landscape, and permafrost zones which require a variety of engineering geological and geodynamic conditions.

Based on a three-year monitoring survey (2010-2012) and geological surveys along the pipeline, 347 km with thermokarst phenomena were identified. The width of the survey area is one kilometer, therefore the phenomena were investigated not only in the pipeline affected zone, but also under natural conditions. A single technology was used during construction, with the pipeline buried completely underground along the length of the pipeline. This enabled the estimation of the degree of the technogenic bearing on thermokarst processes in different geographical and geological conditions.

The analysis showed large differences in phenomena distribution and morphological characteristics. All observed thermokarst phenomena were divided into 11 types based on their genetic and morphological characteristics.

We used large-scale maps of the pipeline area created by IEG RAS, as well as a series of small-scale maps of the territory. We also analyzed geological profiles along the length of pipeline, based on data obtained during engineering geological surveys. Average monthly changes in temperature and precipitation for the period from 2009 to 2012 were estimated according to data from 13 meteorological stations.

Using of independent criteria for mapping areas and phenomenon classification by type make it possible to apply a probabilistic assessment system.

Based on the comparison of the data available and data on the distribution of phenomenon, we determined the dependence of the formation of thermokarst processes on tectonic, permafrost, landscape, geomorphological, lithological and climatic conditions. The degree of the technogenic bearing on thermokarst processes in different geographical and geological conditions was estimated.

These dependencies will form the basis for the creation of a map zoning the formation of thermokarst processes based on the leading factors and conditions.

The extent of the pipeline and variety of phenomena prohibit direct engineering studies of the possible impact of thermokarst processes on pipeline construction. Instead, estimates of the impacts are required. Due to the large number of phenomena identified in the monitoring work, it is complicated to estimate the impact of thermokarst processes on engineering construction. Current engineering projects employ a single evaluation criteria to assess construction hazards. However, a wide variety of process types with varying degrees of activity, stage of development and conditions of formation limits this approach. Zoning on the leading factors and conditions in the formation of thermokarst process will improve the existing system of hazard assessments, as well as enhance the effectiveness of protective measures and forecast models.

Information-recording System to Determine a Temperature Field of Frozen, Freezing and Thawing Soils

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Information-recording system is designed to determine a temperature field of frozen, freezing and thawing soils in engineering and permafrost research carried out during the construction of pipelines and other facilities in non–hazardous areas and in the laboratory.

The operating principle of IRS-1 is based on the measurement of digital or analog signals received from temperature sensors using portable devices (data logger or reader) installed inside the sensor cables, and its subsequent conversion into I2C and 1-Wire interface signals for further transmission to the personal computer.

IRS-1 system consists of one or more cables with temperature sensors of production run SCxx in a set with ETDAL (electrothermometer digital automatic logger) and/or ETDR (electrothermometer digital reader). System IRS-1 has three modifications:

–ICR-101consists of a ETDR (reader) and sensor cable SCxx;

–ICR-102 consists of a sensor cable of production run SCxx and a logger ETDAL;

–ICR-103 consists of a sensor cable of production run SCxx, a logger ETDAL and a reader ETDR.

The sensor cable of production run SCxx is a network of temperature sensors connected to a common cable garland equipped with a connector to a portable reader or a logger. The sensors are used as the primary temperature transmitters with digital output or platinum resistive temperature sensors with a nominal static conversion characteristic (NSC) in accordance with GOST 6651. Cables may join in a network by their connection to the circuit in parallel by means of joint cables attached in this case to sensor cables. Sensor cables are available in modifications that differ in length, number of sensors and the distance between the "zero" level and the plug.

The reader ETDR and logger ETDAL are based on a microcontroller and are designed to read the measured parameters off sensor cables upon a single (not stationary) connection to it and subsequent conversion the data into temperature values and I2C and 1-Wire interface signals. Devices perform system maintenance allowing to obtain measurement data from the network of sensor cables or from a single sensor cable, to accumulate them in non-volatile memory, and to display information on the LCD display (only reader), and to transfer stored data when connected to a PC for further processing. Devices provide the following information: number of the object, serial number of a sensor cable and a logger (only for logger), the subsequent number of the data measurement, the date and time of measurement (for logger), the subsequent number of the sensor in a cable, the value of the measured temperature.

Software «KrioLab Temp» is not metrologically significant and is intended to be read and displayed in tabular and graphical form data from the logger and reader system when connecting them to a PC. Software is protected from unintentional and intentional change according to the grade «A». No special protection means are required, which exclude any possibility of unauthorized modification, update (download), or deleting and other intentional changes of metrologically significant part of the built-in software of a measuring instrument and measured data.

Experience in the Application of Probabilistic-Statistical Methods of Calculation for the Analysis of Thermal and Mechanical Interaction of Structures with the Environment

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Probabilistic and statistical methods have great advantages compared to deterministic methods that are part of almost all regulatory documents. Probabilistic-statistical methods take into account the random variability of all calculated data and on this basis to allow you to assess the risks of possible accidents structures before the end of their useful life that cannot be done using deterministic calculations. In this regard, the trial design takes on new meaning, it becomes possible to assess not just the cost, but also on the probability of their trouble-free operation.

Probabilistic and statistical calculations of safety and cost of the basses of construction was carried out on a computer program NAST (1994), developed at the department of geocryology of the geological faculty of Moscow Sate University.

Calculations of safety and total present value of the basses of construction made for two variants of freezing soil foundation. The first option (design decision) – freezing of foundation soils to produce a vapor-liquid thermosiphons in the process of construction and operation. The second option – before construction, conduct preliminary freezing of soils using a mobile refrigeration units (WTE-100) or a vapor-liquid thermosiphons.

From the obtained results of calculations it follows that for the first option with the project depth of foundation 21,5 m total present value of the basses of construction is 1.1857 USD Million and safety of the base at the end of the period (30 years) – 0,9975 fr.unit. In the second option, the optimum depth of foundation, with a minimum total present value of the basses (in the case of the preliminary freezing of a thermosiphon – 972.006 USD Thousand, and WTE-100 – 2,579684 USD Million), equal to 14.5 m. This depth of foundation corresponds to the optimal safety of the basses of construction and after 30 years is equal to 0/995 fr.unit.

In this paper it is shown that if applied preliminary freezing of foundation soils thermosiphons, then this option will be cheaper, by reducing the depth of foundation from 21.5 to 14.5 m, but lose in one winter season, which is the freezing of a thermosiphon. Not to lose time, we will be able in the case of machine freeze foundation soils, but it's 2 times more expensive than available in the project during the freezing of a thermosiphon.

Engineering-Geological Survey in Difficult Geocryological Conditions of Ice Complex (as in the Case of Seyakha Settlement)

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The ice complex is the combination of ice-rich permafrost sediments with syngenetic ice wedges.The ice complex has a great danger during construction and operation of buildings and structures. Because the volume of ice in the ice complex could sometimes approach 80–90%.

In this case the conducting of geological engineering surveys present a methodological difficulty. The employees of “The Fundamentproekt Open Joint-Stock Company” had got such a problem when carried out an investigation in the Seyakha settlement.

The Seyakha settlement is situated on the north coast of Yamal peninsula at the mouth of the river Seyakha (Zelenay) which flows into the Ob Bay. The territory of settlement is located within the second lagoon-marine terrace which was formed in a kargin-sartan time. Since that time the surface of terrace have been changing by erosion.

The thickness of Seykha sediments is better research among cryolotological outcrops of Siberia. The findings of the survey new data on the geological structure is clearly correlated with the available materials.

Drilling of engineering-geological was given more than 100 boreholes. The main attention was taken to the relation of ice wedges and enclosing and overlying sediments. We were determined mechanical and geochemical composition, genesis for enclosing and overlying sediments; the structure and morphology for ice wedges. During the survey were evaluated the spatial changing of cryogenic structure and the volume of ice into different sediments.

The results of engineering-geological survey:

1. The ice complex has a great thickness (20–25 m). It consist two layers which freeze simultaneously with sedimentation. The lithology of these layers is the same particles (silt composition). The lower stratum is represented the ice-reached peaty light silty loam having “belt” cryotexsture .Above the section passes into the ice-reached non-peaty loam. Especially the last one is the prevalence of micro and thin schlieren often layered cryogenic textures.

2. Layers of the ice complex include ice wedges. Ice wedges of the first generation (lower layer) more powerful than second (upper layer). Characteristic ice wedges of the lower part: average width is 3.5 m and average vertical thickness - up to 13.0 m. Characteristic ice wedges of upper part: average width is 1.0–1.5 m and average vertical thickness - up to 8.5 m. The volumetric macro-ice content for lower part of thickness is higher than for the upper part of thickness. The volumetric micro-ice content for both layers is identical.

3. The sediment of ice complex not salted. The total quantity of water-soluble salts changes from 0,035 to 0,085 %.

4. Close to the surface occurrence of ice wedges (1.0–1.5 m) flat terrain contributes to swamping territory. Swamping causes activation of the surface of thermokarst and processes areal and linear erosion.

5. Residential construction imposes a significant imprint on the permafrost and may lead to irreversible changes in their properties. Technogenesis is the reason for the change in mean annual temperature of permafrost. The temperature rises in some areas according to the field observationsat 3–4°C to critical –0,5°C (in on the interfluve –4,0÷-5,5°C, for erosion slopes –2,5÷-4,5°C).

6. According to the results of research were evaluated complexity of the engineering and geocryological conditions for construction purposes and the risk of occurrence of dangerous cryogenic processes in the economic development of the territory.

That's why the development of the territory, without taking into account peculiarities of the geological structure could lead to a significant intensification of cryogenic processes.

Determination of Frozen and Thawing Soils Viscosity, Using Method of Spherical Punch

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Rheological properties of soils, such as creep, stress relaxation, reduction of strength over time is closely related with the viscosity. Rheological model invariably includes the so-called Newton's model, connecting the strain rate ($\acute{\varepsilon}$) with pressure (σ) and viscosity: $\acute{\varepsilon} = \sigma/\eta$. Bingham–Shvedova equation, witch most commonly used in soil mechanics [Zaretsky, 1967], determine the rate of deformation of elastic-viscoplastic model also includes viscosity:

Viscosity used to describe patterns creep at all stages and the stress relaxation [Vyalov, 1978, 2000, Zaretsky et al., 1986]. Analysis of rheological curves for different tests showed that the method of test can greatly affect the viscosity. The viscosity values can differ by orders of magnitude. Currently, the viscosity is determined only by tests on uniaxial compression, according to GOST 12248-2010. But these tests are laborious and lengthy. So we started to develop methods for determining viscosity, using method of spherical punch. SS Vyalov (2000) noted, that this method should be used only in the range of "Shvedova" viscosity.

We developed a method for constructing rheological curve, using experimental data of spherical punch test, frozen and thawing soils and established a limit of maximum "Shvedova" viscosity. Studies have been carried out for different types of frozen and thawing soils. Test for frozen is performed in accordance with GOST 12248 - 2010. In total, we have processed more than 100 tests.

We got dependence of viscosity for different types of frozen ground on their composition, physical properties and temperature. Characteristics of these dependencies is as follows. Viscosity decreases in 4 times for clay, in 10 times for clayey silt, than silt compared (temperature $-1^{o}C$). Viscosity decreases with increasing salinity.

Research viscosity thawing soils carried out on disturbed soils (clayey silt and sandy loam). Method of test was follows. First, a sample was prepared with specified physical properties, then frozen soil were tested, using spherical punch, at a temperature of $-2^{o}C$, then the sample is thawed in the compression device under a load of 0.025 MPa. Then spherical punch tests were carried out on thawed soil. As a result, we got rheological curves of frozen soil and after thawing.

These data allowed us to calculate long-term equivalent cohesion (in accordance with GOST 12248-2010) and viscosity. We have found that after thawing of frozen soil equivalent cohesion decreases in 32–36 times, and viscosity in 347–375 times, when water content was as liquid limit, and equivalent cohesion decreases in 7–10 times, and viscosity in 262–321 times, when water content was as plastic limit.

The Influence of Thermal Properties for Filler Ground with Different Grain-Size Distribution on the Permafrost Table Position

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Nowadays North appears to be the main producer base of energy feedstock - oil and gas. The most of fields settled on the fills, for peat that is not suitable for technical constructions building, is the typical top natural layer of the territory. Fills composed by soils from the nearest quarries, usually sand. The installation of fills on permafrost soils results in significant changes the natural conditions of ground and atmosphere heat exchange. It causes the significant landscape changes accompanied with activation of negative cryogenic processes such as thermokarst, thermoabrasion, erosion, heaving and other.

The goal of our research – to recognize the influence of thermal properties for filler ground with different grain-size distribution on permafrost table position, drawing on the example of one fields in the Yamalo-Nenets Autonomous District.

The experimental data on thermal properties of sands with various grain size composition was obtained during laboratory tests. Water content and soils temperature influence on thermal conductivity and heat capacity was recognized.

The fine sands water content various in range of 0 to 25%. Thermal conductivity varies from 0.24 to 1.75 W/mK for unfrozen soils and from 0.33 to 1.98 W/m·K in frozen ones. Medium sands thermal conductivity for unfrozen/frozen state varies from 0.31 to 1.80 W/m·K in and from 0.41 to 2.30 W/m·K respectively (dry density of the soils 1.65 g/cm3.). Such significant variability in the thermal conductivity values is related to different grain size distribution. The values variability of heat capacity is negligible.

The potential freezing and thawing depths estimated using numerical and analytical methods that take into account the thermal characteristics obtained in the laboratory. Stefan's formula was used to estimate the parameters M and κ which characterize the direction of heat flow in the base of the soil fill M= , $\varkappa = k \cdot \lambda \cdot W$, where d_f is the potential freezing depth, d_{th} - potential depth of thawing, W - soil water content CU, λ - coefficient of thermal conductivity, W/m · K, k = 1). It was found that when M<1, the ground annual temperature becomes positive, which leads to the permafrost degradation. Extreme values for M and κ were determined, above which $d_{th} > d_f$.

According to the results of mathematical modeling obtained using WARM, usage of medium-grained soil with W>16% leads to decrease of freezing depth and increase of thawing depth, which will lead to the degradation of permafrost. Recommended soil for this area is medium-grained sand with W<16% and fine sand with any water content.

Thus, it is recommended to study the composition and properties of filler soil before replacing the existing to avoid extreme conditions occurrence, which may reduce the load capacity of piles being erected on the sandy soil filler.

Temperature Deformations as Special Physical-Mechanics Properties of Frozen Soil

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Frozen ground, just as like as all the hard bodies are influenced by the temperature deformations, which Condit the volume voltage changes. In the moment when the temperature voltages are higher than ice-cementation connections? There happens the limited state, in which cracks occurs. Frozen rocks cracking is the one of the most spread criogenic physical and geological processes in the cold climate conditions. This process is an important relief-forming factor, the reason of the appearance and growth of secondary-wire ices, and also influences negatively on the engineering constructions.

In the present time there have been worked out the series of mathematical models which describe the frost cracking process. At all of the models the one of the basic characteristics is the temperature deformations is the temperature deformations coefficient a, which happens to be "structure-sensitive" frozen grounds characteristics, quantifying a resistivity change of a ground volume while the temperature changes at the each degree.

In this work there has been clarified the methodic of temperature deformations coefficients researches. The researches were held in the temperature isolating box, that is set inside of freezing camera, and there has been used the electronic deformations measurer. This construction of experience set allows to higher the researches accuracy and makes the experiment holding easier.

There were got the dependences of temperature deformations from the humidity for the sandy loams, sand and clay loam at the range from –7°C to –1C°. There has been established that the abductee temperature deformations coefficient value increases while the humidity decrease and temperature lowering. This is explained with the fact that with the humidity decrease the degree of pores filling with air raises, which has the highest coefficient of temperature deformation.

It was reached to find out a very interesting regularity: the time of temperature deformations stabilization depends not only on the ground type, but also on the temperature and in a high degree increase in the same temperature. The stabilization time lowers with the temperature lowering, which happens to be the result of thermotheological process manifestation.

Parallelly there were held the tests of sample with the identical physical properties on the quick shift. There were got the values of conditionally instantaneous strength in the same temperature range (from –7°C to –1C°), as while the definition of temperature deformation coefficient as the sample humidity was less than the full water capacity, with the temperature decrease and humidity increase conditionally instantaneous strength increases.

In the same time with the change of the amount of unfrozen water and ice while the temperature changing, the content of gas component of the ground changes. It was shown higher, the formation of temperature deformation value, is introduced by the gas component exactly. As the temperature gas changes coefficient is rather valuable, so while the colding there happens the vacuum in pores that fills by the other ground components, first of all by the unfrozen water. This process is possible in the case if the “vacuum plovers” becomes bigger than internal powers of connection ground components, it flow in time, which causes its lag in comparance with the temperature change. In general for the three types of ground there is observed the increase of the conditionally instantaneous strength of frozen ground on the shift at the increase of the values of the relative temperature deformations with the temperature lowering.

Application of an Information and Analytical Program Complex for the Solution of Separate Tasks Regarding to Geotechnical Monitoring

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Active building of various objects in the conditions of the permafrost distribution leads to the change of many components of landscapes of the cryolithozone. The main component of these landscapes is temperature of frozen rocks. And development of the territory directly influences temperature forming components: vegetation, soil, microrelief, top horizons of the rocks, hydrogeological and hydrological modes, snow accumulation, etc. Intervention of the people to such environment accelerates considerably natural-historical change of the nature that further can lead to serious consequences. For supervision and the forecast of such changes there is a geotechnical monitoring (further - GTM).

GTM is the most important component of construction and operation of objects. Competent approach to creation of the GTM network and supervision over it gives the chance to prevent emergence and development of the dangerous geological processes and the phenomena influencing on integrity and stability of constructions.

Wide experience of exploitation of various constructions, especially in a permafrost zone, shows discrepancy in their real terms of functioning to the designed. It is often connected to various deformations, resulting from insufficiency of means of engineering protection and absence of the warning forecast of geospecifications changes.

Development of technologies doesn't stand still. The new equipment facilitating process of supervision over a monitoring network appears. Already today there is an equipment called a logger, allowing independently, to read out and keep results of measurements during the long period of time. Loggers are reliable and easy-to-work with and capable to work without replacement of batteries within, at least, five years, accumulating in themselves huge volumes of information.

The data files about a condition of the GTM network, coming to the operating organizations, often aren't subject to processing and the analysis and are only collected in archives of the organization. But even slightest oversight can lead to catastrophic consequences.

Automation is a creation of the analytical program of processing of regime supervision results, which will be able to store large volumes of data and to warn about the deviations arising (trend) and arisen from designed decisions. Automation is necessary for increasing of efficiency of work with information and, as a result, improvements of functioning of the GTM network.

In 2014 there was completed the development of the software product which doesn't have analogs today – "Information and analytical system of geotechnical monitoring "Yamal". Its rights are belonged to LTD Stroygazproekt. This program represents the uniform database allowing the user to organize storage and the subsequent analysis of results of regime supervision over a condition of the GTM network and changes of geospecifications in the basis of the construction objects which are in a zone of permafrost soil distribution and in the other difficult geological conditions with possibility of further transformation of a huge data file to geotechnical data sheet.

Need of the Accounting of Dangerous Exogenous Geological Processes and the Phenomena during the Development of the System of Monitoring for Gas-Field Objects of the North

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Gas transmission constructions and accompanying objects of infrastructure of the Bovanenkovo — Ukhta pipeline are constructed in unprecedentedly complicated geocryological conditions. In this regard special relevance is gained by control of dynamics of geocryological conditions in soil of the foundations and stability of buildings and constructions at a stage of building and operation for the purpose of timely identification of processes of destabilization, development and realization of preventive measures, and also the getting of the experience of experience in area of construction and operation of the foundations and the bases in especially difficult geocryological conditions.

Construction and the subsequent operation of the gas pipeline in the permafrost will lead to a new growth and activization of the geocryological processes developing in soil as in a zone of direct interaction with the pipeline, and in the territory adjoining to it, broken due to building of the gas pipeline. These processes may have essential impact on operability of the pipeline and be the cause of its accidents, and also break ecological stability of the natural geocryological environment.

Engineering and geocryological monitoring is a component of monitoring of environment which tasks the complex characterization of the change in the atmosphere, the hydrosphere, the biosphere, the geological environment.

During the creation and conducting of the engineering and geocryologic monitoring, the main technical solutions of the concrete constructions, made in the project, have to be considered: the principle of use the permafrost soil as the basement; features of thermal and mechanical interaction with soil of the basements; admissible values of the bearing ability of the basements and deformation of constructions; nature protection requirements, etc.

At the same time the general scheme of the organization and carrying out engineering and geocryological monitoring considering joint occurrence of features of constructions and the specification of an engineering and geocryological situation is already developed it includes: collecting, processing and analysis of information; preliminary forecast and evaluation of the territory; inspection of engineering objects and adjacent territories; organization and arranging of the work; data processing of supervision and evaluation of GTS dynamics; current forecast of dynamics of a geocryologic situation and geocryological processes; development and organization of protective measures; organization of supervision over protective measures.

Exogenous geological processes on the territory of research have, as a general rule, cryogenic genesis and are developed quite widely. Thus under natural conditions in the aspect of the planned building of the gas pipelines, the degree of territory prevalence by cryogenic processes and their genetic variety are rather small. However, under technogenic transformation of the territory sharp activization of many exogenous processes is possible.

Despite of all the uniqueness, the project of the gas pipeline Bovanenkovo-Ukhta doesn't include the organization of monitoring in the pre-building and construction period that further will complicate a lot its operation. For the period of the exploitation, the system of monitoring of the gas pipeline Bovanenkovo-Ukhta was developed, but, despite of so broad development of adverse factors, it is not proved at all: the net of the thermometric wells is set by not on certain conditions, but just mechanically on a grid, snow-measuring shooting isn't provided at all, still the same "net" levelling of the gas pipeline is included in the package. Supervision over exogenous geological processes and the phenomena aren't provided.

The analysis of field and cameral researches of the considered territory of the gas pipeline system allowed to establish that the complex of negative engineering-geological processes and dynamics of their development are in rather close connection with certain types of geotechnical systems. Thereof, first, supervision in system of monitoring can be concentrated within the separate representative key sites corresponding to the certain geotechnical systems (GTS), secondly, types of supervision and regulations of their carrying out will also be defined by features of structure of geotechnical system.

Comparison of Deformation Characteristics Thawing Soil, Obtained after Field and Laboratory Tests.

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Forecast deformation of frozen soil after thawing determined by decision temperature and mechanical tasks. Settlement thawing soils depend on the type of soil, thawing conditions, various physical properties. Therefore, forecast deformation is a difficult task, especially for clay soils. We need to conduct research, aimed at improving the reliability of the deformation characteristics thawing soil determination and patterns of their change.

Deformation characteristics thawing soils (thawing and compression coefficients) should be determined, using field tests (according to SP 25.13330.2012 Foundations on permafrost). If values of deformation characteristics obtained, using laboratory tests, these values must be multiplied by a correction factor $k_i = 1 + \square i_i$,, where $\square i_i$ is the difference between the total ice content of layer and ice content of the sample. You can also enter a correction for incomplete closing of macropores and swelling, if it is confirmed by experimental data.

Currently we have little information to compare the values of deformation characteristics, obtained after laboratory and field tests ceteris paribus. Analysis of the literature showed that compression coefficient, obtained after laboratory test, can be the same (mainly in sandy soils), or greater in 3 times. Thawing coefficient, obtained in laboratory, is substantially greater in 2–20 times. The cryogenic structure, water and ice content affect the value of deformation characteristics largely, so it is difficult to identify impact of test type.

We performed a mathematical modeling of thawing process, using program «Termoground». «Termoground» performs a two-stage solution: 1- thermal task, which resulted temperature fields for a fixed period of time, 2 - mechanical task with the calculation of soil settlement, using empirical formula.

We used Pahomova G.M. (1980), V.P. Ushkalov (1962), P.I. Kotov (2014) data for calibration program. Comparison of deformation characteristics obtained by the simulation data in laboratory and field showed, that thawing and compression coefficients of clay soil with plastic limit water content were the same. Increasing water content soils showed increasing values of deformation characteristics by 30–50%. The data of mathematical modeling confirm the results of literature analysis.

Thus, an important factor, greatly influencing on value of deformation characteristics, is redistribution of stresses, that occur in soil during tests (laboratory and field).

About the Influence of the Northern City on Aquatic and Terrestrial Ecosystems (Yakutsk city)

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As a result of three centuries of economic development of the valley Tuymaada (p. Lena) there have been radical changes in the structure and functioning of terrestrial and aquatic ecosystems. That has more to corresponding changes in the permafrost regime of permafrost soil. In most parts of Yakutsk almost no plot with natural soil cover, since the power of an inert mineralized horizon ranges from 2 to 4 m, sometimes more significantly. Under these conditions, green areas are formed only on artificial soil, brought from suburban areas, mainly withdrawn from the arable layer of fertile soil. On the other hand, as a result of the progressive population growth in Yakutsk (urban population now resides 300 thousand people) is enhanced technological and anthropogenic pressure on vegetation and soil cover and suburban recreational zone. Under intense pressure from the outside there is a deterioration of agro and agro-chemical conditions of growth of vegetation. In such extreme conditions, strengthens the processes of suburban arid lands, which naturally leads to a sharp drop in yields not only arable land and natural grassland cattle and horse breeding.

Similar adverse events occur in the life of the water bodies of the city. Hydrochemical monitoring of water bodies shows that the lake city polluted by nutrients (nitrite, nitrate, ammonia) and certain heavy metals (zinc, lead, copper). Also, there is the dynamics of increasing the content of them every year, exceeding the maximum permissible concentration (MPC). Especially alarming is the sharp deterioration of sanitary conditions of urban lakes. The main reason - the artificial elimination of their natural flowage.

The great concern of citizens is poor chemical composition of urban air, mainly due to air pollution by aggressive chemical elements due to a sharp increase in the number of cars. For this reason, soils under urban green areas contain some heavy elements (especially pigs) is significantly higher than the MPC.

All these negative phenomena in the natural environment of the city and its suburban areas have a very negative impact on the health of the population of Yakutsk.

Session 5: Permafrost hydrology

Fluctuations of Atlantic Arctic Glaciers and Cyclonic Activity from the Late XIX to the Early XXI Centuries

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Significant retreat of Arctic glaciers began after culmination of Little Ice Age, which (according Zakharov V.F., 2004) is from the second half of the XIX century. The Greenland and Iceland glaciers rapidly decline reduce in1890s, and Spitsbergen and Novaya Zemlya glaciers have drifted in 1900s-1910s (Zakharov V.G., 2014). Further reduction of these glaciations continued in meridional northern circulation epoch of the Northern Hemisphere (1899–1915 by Dzerdzeevskii, 1967; Kononova, 2009).

The convergence of Icelandic minimum and Azores maximum in 1928–1942, contributed to the strengthening of zonal circulation and warming in all regions of Northern Hemisphere (Baidal, 1978). Maximum of duration activity of zonal circulation epoch (1916–1956) was observed in second half of 1920s-1940s. At that time there was most significant for the XX century reduction of glaciation area in Arctic.

In meridional southern epoch of atmospheric circulation (1957-2000s) Greenland glaciers started to advance and increased surges number of Spitsbergen glaciers. However, in 1980s - 2000s Spitsbergen glaciation area continued to decline.

The general picture of Atlantic glaciers dynamics in 1890s - 1990s was characterized by resumption of Greenland, Iceland, Spitsbergen glacier surges and a slowdown in reduction of Novaya Zemlya and Zemlya Frantsa – Iosifa glaciations. This was connected with largest wave duration of elementary circulation mechanisms - ECM-13w 13s, which identified a sharp increase in cyclonic activity and increase of precipitation in Arctic.

During the XX century in Arctic glaciers fluctuations (as in Antarctic) was apparent a periodicity of 18.6 years connected with luni-solar tides.

It is established that the maximum duration of meridional southern circulation of the XX century (1989) almost coincided with maximum of dispersion of luni-solar tides in 1988. It is possible that the overlap of the two peaks of natural processes contributed to such an abrupt intensification of cyclonic activity and more intensive entrance of precipitation in the North Atlantic and Arctic basin.

New and Historical Data on Hydrological Cycle in Small Permafrost Basin to Simulate Water Fluxes in Cold Environments In Changing Climate

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The observations of individual processes of hydrological cycle on small research watersheds are the main source of information about mechanisms of runoff formation processes, current changes of hydrological cycle and the basis for hydrological models development. Nowadays Russia does not have any research watershed with carrying out regular observations of hydrological processes in permafrost environment although there were several of them in former Soviet Union. One of such research spot was Shestakovka river watershed that is considered representative in terms of hydrological regime and permafrost conditions for the Central Yakutian river basins.

The goal of the study is to numerically assess recent and on-going variations of runoff generation and its mechanisms at the Shestakovka River basin for the period 1951–2014. Combination of historical data analysis, results of new field measurements and process-based hydrological modelling are the base for the study.

The Shestakovka River is a left tributary of the Lena River near Yakutsk. The basin area is 170 km^2. Mean annual air temperature is –10.2°C, precipitation is 230 mm per year, flow depth is 24 mm. It was shown that air temperature at Yakutsk has increased by 3°C for the last decades. Precipitation does not show any significant trend. Although there is continuous permafrost zone with permafrost depth up to 500 m talik zones are found at the well-drained sandy slopes.

Extensive water-balance and permafrost observations including river runoff, evapotranspiration, surface and subsurface flow, groundwater levels, soil moisture, active layer thickness, ground temperature and water chemical analysis were carried out at the basin for 1977–1985. In 2015 water-balance and permafrost observations at the Shestakovka research watershed are partly resumed.

The approach to bring together hydrological modelling, historical and new field data for evaluation of mechanisms and change of runoff formation processes is the following: (1) analysis of annual and maximum Shestakovka river flow change for 1950–2014 (2) assessment of parameters and application of the hydrological model for the period 1977–1985 using data of detailed observations for the model validation (3) continuous simulation of snow, soil variable states and river runoff for the period 1950-2015 using validated model (4) evaluation of changes in runoff characteristics and its mechanisms based on combination of modelling results and data analysis.

Annual Shestakovka river flow depth has increased from 16.5 mm/year to 30 mm/year, mean maximum annual discharge has changed from 2.12 m^3/s to 4.09 m^3/s. for 1951–1978 and 1979–2012 respectively. To understand mechanisms of observed change process-based hydrological Hydrograph model is applied. The Hydrograph model describes not only all essential processes of land hydrological cycle but also explicitly accounts for soil heat dynamics and water phase changes. Main model parameters refer to observable soil and vegetation properties. Three runoff formation complexes are distinguished at the Shestakovka basin: pine forest on well-drained sandy slopes with deep thawing or permafrost absence, wet mixed and larch forest on peaty soils with intermediate thawing depth and bogs with very shallow active layer. The model parameters are adjusted on the base of detailed historical observations and used to continuously simulate snow, active layer depth and river hydrograph for the 1951–2015 period. Modelling results and evaluation of changes in runoff characteristics and its mechanisms will be presented.

Runoff Modelling in the Zone of Frost Mound Bogs by the Example of Small Watersheds of the Muravlenkovsky Research Station

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Hydrological modelling may serve as a tool not only to predict flow but also to study the processes of runoff formation. The goal of the work was to assess the parameters of hydrological model Hydrograph for the zone of frost mound bogs using the data of hydrological, meteorological and thermal balance studies conducted by the West-Siberian Expedition of the State Hydrological Institute (SHI) at research station Muravlenkovsky located in the continuous permafrost zone of Western Siberia.

The study objects are located within the basin of the Pur river. The watersheds of Haruchey-Jaha river with the area 824 km^2 and its tributary, the brook Svetly, area 62 km^2, are covered by wetlands (64 and 88%, respectively). The bogs of the basin are mainly frozen with domination of flat-mounds micro landscapes group (80%), which is typical for large territory within the areas of northern taiga and forest-tundra.

The West-Siberian Expedition SHI has conducted an extensive research in order to study the hydrometeorological regime of wetlands in Western Siberia from 1965 to 1993. The typology of wetlands, peat deposits structure, thermal and hydro-physical properties of active layer of peat deposits were studied as well. At the Muravlenkovsky station the observations of heat transfer in the active layer, temperature, freezing and thawing peat deposit, evaporation from wetlands, wetland water level, runoff and meteorological parameters were conducted during the period from 1983 to 1992. This unique data is still not processes and was never used for hydrological modelling.

The Hydrograph model was developed under the leadership of Prof. Vinogradov. This is a process-based model with distributed parameters. Input data includes standard meteorological information. The model parameters have a physical meaning and may be assessed on the base of observation data. The model has the block of calculation the dynamics of heat and moisture in the soil column which allow simulations of freezing and thawing processes in soil. The algorithm was verified in the conditions of mountainous areas of Eastern Siberia. The novelty of current work is to test it for watersheds of swampy area of Western Siberia in the conditions of permanent water stagnation in upper layers of soil and active layer of peat deposit.

The depths of freezing and thawing of the soil and runoff hydrographs of Haruchey-Yaha and Svetly watersheds for 1984-1992 were calculated. They are in a satisfactory agreement with the observations. This work is the first stage of runoff modeling for wetlands of Western Siberia.

Hydrological Processes in Post-Fire Permafrost Environment

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Wildfires lead to rapid short and long-term environmental transformation that include changes of vegetation cover, soil properties, heat and water fluxes between atmosphere and soil, hydrological regime, erosion and mass movement. The goal of the study was to identify wildfire effects on hydrological regime of watersheds in scarcely-gauged Russian Siberia and Far East in recent years using available hydrometeorological data and hydrological modelling.

Twelve mountainous basins of the Vitim Plateau (Eastern Siberia, Russia) with areas ranging from 967 to 18 200 km^2 affected by extensive fires in 2003 (from 13 to 78% of burnt area) were delineated based on MODIS Burned Area Product. The studied area is characterized by scarcity of hydrometeorological observations and complex hydrological processes. Combined analysis of monthly series of flow and precipitation was conducted to detect short-term fire impact on hydrological response of the basins. The idea of basin-analogues which have significant correlation of flow with "burnt" watersheds in stationary (pre-fire) period with the assumption that fire impact produced an outlier of established dependence was applied. Available data allowed for qualitative detection of fire-induced changes at two basins from twelve studied. Summer flow at the Amalat and Vitimkan Rivers (22 and 78% proportion of burnt area in 2003, respectively) increased by 40–50% following the fire. The impact of fire on flow from the other basins was not detectable. The hydrological model Hydrograph was applied to simulate runoff formation processes for stationary pre-fire and non-stationary post-fire conditions. It was assumed that landscape properties changed after the fire. Preliminary results of hydrological and meteorological data analysis suggested that it is possible to detect a fire influence on river flow only if heavy rains occur during the year after the fire. Basins with lower precipitation rates show no significant changes of runoff after the fire. Specific hydrological response to fire in different landscape, climate and topographical conditions across Russian

Siberia and Far East will be presented. The results of the Hydrograph model applications to the basins with pronounced fire impact in stationary and dynamic mode will be shown.

Modern Hydrochemical Assessment of Ponds and Waterways of Gas Deposits of Zone Hilly Bogs of Western Siberia on the Example of Medvedjie Deposit

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In view of the paucity of data on hydrological and hydrochemical mode of gas production areas of the permafrost in Western Siberia and sketchy information about their hydrochemical studies in the literature, is quite considerable modern hydrochemical assessment of surface water of deposits. In this connection, the aim of our study was the generalization of observational data for surface water quality for the period of open water over a longer period of time (2003−2014 years.) This data was received by the company "Gazprom dobycha Nadym" for Medvezhye deposit which is located in the zone of hilly bogs.

The draining Medvezhye deposit of the rivers are small, with catchment areas less than 5.000 km^2 and a length of less than 300 km. The investigated lakes inside hilly bogs have depths up to 3 m and the squares up to 2.5 km^2. Due to the short period of open water in the permafrost zone with a long and extremely low winter water flow with large thicknesses of ice (up to 1.5 m) or freezing of the rivers, monitoring and expeditionary research in the territory of Medvezhye deposit were carried out only in the warm season (May to September).

Hydrochemical assessment of Medvezhye deposit was conducted on the basis of statistical analysis of data by main indicators of a chemical composition of river and lake waters (pH, mineralization, main ions, weighed substances, dissolved oxygen, COD, BOD_5, nutrients, heavy metals, mineral oil, synthetic surfactant and phenols). The modern anthropogenically modified range of background chemical components for rivers and lakes for the deposit for the warm period of the year was established in this work.

As a result of hydrochemical assessment of Medvezhye deposit the following features were identified: river waters are weak acid reaction of environment, very low mineralization, high concentration of weighed substances, high contents of ammonium and nitrite nitrogen (two-time exceedance maximum allowable concentration on average) and higher phosphate concentration relative to the background for European part of Russia. In all waters are revealed excess MAC of the content of BOD_5 and total concentrations of iron and manganese. In spite of oil and gas exploration on the area of hilly bogs, the average oil contents in the river waters do not exceed the MAC.

The chemical composition of lakes differs from rivers of greater amplitude of change in pH on the territory (from acidic to neutral), higher mineralization (up to 150 mg/l in some lakes). The average value of BOD_5 for lake waters exceeded the MAC and have the value 1.5−2 times higher compared the river waters. Increased concentrations of ammonium nitrogen (0.9 mg/l on average), manganese (0.3 mg/l) and organic compounds (permanganate demand was up to 100 mg/l in some lakes) were also observed in the investigated lakes during the billing period, which indicates the influence of bogs drainage. The content of phosphates is up to 1.9 mg/l that allows us to include the investigated lakes to eutrophic ponds. The analysis of the obtained data of the investigated lakes by Alekin`s classification showed that at such low mineralization water ionic composition of the lakes is variable and is mainly determined by the composition of atmospheric precipitation, which can be sufficiently diverse. However, the lakes of hydrocarbonate-sodium (62%) and sodium chloride (23%) of ionic composition are dominated on the territory of Medvezhye deposit.

Thus, the obtained data on the chemical composition of the waters indicate the tension of the modern hydrochemical background of rivers and lakes of Medvezhye deposit, which is determined by their reduced natural ability to cleanse itself. This is caused by oxygen deficiency, which results in a reducing environment, accompanied by an increase in the content of iron and ammonium. In turn, the stream from bogs determines the high content of organic compounds and acidification of river waters, which also reduces their ability to self-cleaning.

All identified features of the chemical composition of the waters of rivers draining the investigated bogs, should be the basis for the development of conservation measures for Medvezhye deposit and other deposits located in the zone of continuous permafrost in Western Siberia.

Seasonal Dynamics of Organic Carbon and Metals in Thermokarst Lakes from the Discontinuous Permafrost Zone of Western Siberia

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Despite relatively good knowledge of the biogeochemistry of Siberian thermokarst lakes during summer base flow, their seasonal dynamics remains almost unexplored. This work describes the chemical composition of ~ 130 thermokarst lakes ranging in size from a few m^2 to several km^2, located in the discontinuous permafrost zone.

Lakes were sampled during spring flood, just after the ice break (early June), the end of summer (August), the beginning of ice formation (October) and during the full freezing season in winter (February). The lakes larger than 1000 m^2 did not exhibit any statistically significant control of the lake size on dissolved organic carbon (DOC), the major and trace element concentrations over three major open water seasons. On the annual scale, the majority of dissolved elements including organic carbon increased their concentration from 30 to 500%, with a statistically significant ($p < 0.05$) trend from spring to winter. The concentrations of most trace elements (TEs) increased in the order spring > summer > autumn > winter. The ice formation in October included several stages: first, surface layer freezing followed by crack (fissure) formation with unfrozen water from the deeper layers spreading over the ice surface. This water was subsequently frozen and formed layered ice rich in organic matter. As a result, the DOC and metal (Mn, Fe, Ni, Cu, Zn, As, Ba and Pb) concentrations were highest near the surface of the ice column (0 to 20 cm) and decreased by a factor of 2 towards the bottom. The main implications of discovered freeze-driven solute concentrations in thermokarst lake waters are enhanced colloidal coagulation and removal of dissolved organic matter and associated insoluble metals from the water column to the sediments.

The measured distribution coefficients of a TE between amorphous organo-ferric coagulates and lake water (< 0.45 μm) were similar to those reported earlier for Fe-rich colloids and low molecular weight (< 1 kDa, or < 1–2 nm) fractions of thermokarst lake waters, suggesting massive coprecipitation of TE with amorphous Fe oxyhydroxide stabilized by organic matter.

Although the concentration of most elements was lowest in spring, this period of maximal water coverage of land created a significant reservoir of DOC and soluble metals in the water column that can be easily mobilized to the hydrological network. The highest DOC concentration observed in the smallest (< 100 m^2) water bodies inspring suggests their strongly heterotrophic status and, therefore, a potentially elevated CO_2 flux from the lake surface to the atmosphere.

Session 6: Permafrost Microbiology

The permafrost Age as a Key Factor in the Cryoconservation Investigations

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The microbial communities from the frozen deposits are well known for decades. The global climate changes and astrobiology applications keeps this topic hot. There are several summaries of the recent achievements in this field, but some questions are not resolved perfectly. One of the basic issues in the interpretation of microbiological and molecular-biological data is the age of permafrost, which does not always coincide with the age of the sediments. The base of permafrost microbiology is the understanding that the age of microbial cells in permafrost is equal to age of the last freezing. To correctly interpret the microbiological and metagenomic data it is important to know the age of permafrost and its temperature history since the last freezing.

Microbiology of the Subglacial Lake Vostok: First Results of Borehole-Frozen Lake Water analyses

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The objective was to search for microbial life in the subglacial Lake Vostok (buried beneath 4-km thick East Antarctic ice sheet) by studying the accretion ice (naturally slowly frozen lake water) as well uppermost water layer entered the borehole upon lake entry (February 5,

2012) and then shortly got frozen within. The latest samples included the drillbit water frozen on a drill bit upon lake enter along with re-drilled borehole-frozen water ice.

The comprehensive analyses (constrained by Ancient DNA research criteria) showed that the accretion ice in general contains the very low microbial biomass. The only ice containing mica-clay inclusions (type I) allowed the recovery of few bacterial phylotypes all passing numerous contaminant controls. They included well-known chemolithoautotrophic thermophile *Hydrogenophilus thermoluteolus* (β-*Proteobacteria*), actinobacterium related to *Ilumatobacter fluminis* (95% similarity) along with unidentified unclassified bacterium AF532061 (92% similarity with closest relatives). In contrast, the deeper accretion ice (type II) with no sediments present gave no reliable signals.

As for the first lake water samples all they proved to be contaminated with drill fluid. The drillbit water was heavily polluted with drill fluid (at ratio 1:1) while borehole-frozen water samples were rather cleaner but still contained numerous micro-droplets of drill fluid. The cell concentrations measured by flow cytofluorometry showed 167 cells per ml in the drillbit water sample and 5.5 - 38 cells per ml in borehole-frozen samples.

DNA analyses came up with total 49 bacterial phylotypes discovered by sequencing of different regions of 16S rRNA genes. Of them only 2 phylotypes successfully passed all contamination criteria. The 1st remaining phylotype w123-10 proved to be hitherto-unknown type of bacterium showing less than 86% similarity with known taxa. Its phylogenetic assignment to bacterial divisions was also unsuccessful except it showed reliable clustering with the above mentioned unidentified bacterium detected in accretion ice. The 2nd phylotype is still dubious in terms of contamination. It showed 93% similarity with *Janthinobacterium sp* of *Oxalobacteraceae* (*Beta-Proteobacteria*) – well-known 'water-loving' bacteria. No archaea were detected in lake water frozen samples

Thus, the unidentified unclassified bacterial phylotype w123-10 along with another one (AF532061) might represent ingenious cell populations in the subglacial Lake Vostok. The proof may come with farther analyses of cleanly collected lake water.

Vital Amoebozoa in Arctic Permafrost Sediments

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Permafrost occupies about a quarter of the Earth's land surface. It has been shown that microorganisms trapped in permafrost sediments in Arctic and Antarctic regions can survive during long period of time. Permafrost contains viable bacteria, archaea, cyanobacteria, green algae, yeasts, actino- and micromycetes, viable spore of mosses and seeds of higher plants. Recently giant acanthamoebas viruses were described from buried soils. Viable protozoans – ciliates, flagellate and heliozoan were found in permafrost samples of different age and origin.

We isolated and studied 26 vital strains of Amoebozoa from Holocene and late Pleistocene Arctic permafrost sediments. The richest strata appeared Holocene floodplain deposits Peninsula Gydan. Many protists have been isolated from buried soils of late Pleistocene Ice Complex. A biodiversity of amoebas in the ancient permafrost is relatively small compared to modern tundra soils. We isolated species of genera *Acanthamoeba, Flamella, Phalansterium, Acramoeba, Filamoeba.* Most species have been undescribed previously. We investigated two new species of *Flamella*: *F. pleistocenica* and *F. berengiania*.

One can conclude that Amoebozoa is still poorly known taxon upon the whole. This study clear shows that amoeba cysts can be conserved for many thousands years and in the case of permafrost degradation could be included to active biological cycle.

Supported with RFBR grants 15-04-05267

Methanogenic Archaea and Sulfate Reducing Bacteria in Permafrost Ecosystems: Competition or Coexistence?

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Despite the common understanding of the low speed of biochemical reactions occurring at low temperatures, the global contribution of the low-temperature microbial communities can be very significant, given the scale of the territories occupied by them. Recently, interest in microorganisms from such communities intensified because of the global warming. In the case it continues to elevate, a huge amount of buried organic matter (OM) will be re-involved in biogeochemical cycles.

The anaerobic digestion of polymeric compounds is accomplished by the collaboration of various microbial trophic groups. In anoxic conditions, sulfate-reducing bacteria (SRB) and methanogenic archaea (MA) are important terminal oxidizers in the anaerobic mineralization of organic matter to CO_2 or to CH_4 and CO_2 in sulfate-depleted and rich environments, respectively. The factors affecting competition, coexistence and synergies between the two groups of SRB and MA are still controversially discussed in microbial ecology.

Permafrost deposits are characterized by low redox potential and, in general, weakly mineralized. In Arctic permafrost grounds there are lenses of overcooled water brines (cryopegs) sandwiched within permafrost marine sediments. They remain liquid at the *in situ* temperature of –10°C as a result of their high salt content (60–300 gL^{-1}). Arctic cryopegs are characterized by a high content of sulfates (0.62–3.84 gL^{-1}). Therefore, in permafrost ecosystems there are conditions for both sulfate reduction and methanogenesis.

Here we analyzed the data on the distribution of SRB and MA obtained in the last two decades using microbiological and molecular methods in samples of the Arctic permafrost. Results received to date confirm the dominance of dissimilatory sulfate-reducers in cryopegs. The possible final stage of OM destruction in permafrost grounds is determined by the permafrost genesis. A synergistic relation between methanogens and sulfate-reducers in the absence of sulfate diffusion requires an active role of SRB in the fermentation process. Preliminary results indicate that in Arctic permafrost SRB and MA can simultaneously coexist and compete for the carbon sources. Subsequent studies of anaerobic communities of this ecosystem will confirm or refute these assumptions.

Resistance of Cysts of Modern and Ancient Ciliate *Colpoda Steinii* to Low Temperature Stress and Ionizing Radiation

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Communities of microorganisms isolated from the Siberian permafrost have the little-known strategy of the cell survival over geologically long time. Possible mechanism for the survival of protists in deep permafrost sediments is the formation of a dormant stage - morphological structures that are extremely resistant to inhospitable conditions and can remain viable for a long time.

The objective of this study was to investigate the resistance and adaptation response of the ancient and modern Siberian ciliates' cysts to low-temperature stress and gamma irradiation.

We investigated resting cysts of soil ciliate *Colpoda steinii*, obtained from the modern tundra soil samples (strain PMSc-25, GB# KF732885), and late Pleistocene buried in permafrost burrow radiocarbon dated as 32 thousand years old (strain PABBc-11, GB# KJ607914). For the irradiation experiment, we used strains of *C.steinii* that had survived the four-week exposure to the outer space conditions while at the Earth's orbit aboard the FOTON-M4 satellite. In order to distinguish between the living and dead cysts we evaluated cell membrane permeability and excystation rate. Cyst wall permeability was assessed by a dual-fluorescent staining assay using AO and PI fluorescent dyes. Excystation rate and cyst morphology were determined according to the standard cultivation and morphometric techniques.

We compared resistance of the modern and ancient *C. steinii* cysts to the repetitive supercooling simulating stressful conditions of the polar habitat. In the experiment, we used two types of ciliate cysts, dry cysts and those stored in the liquid mineral medium. The cysts were exposed to 42 cycles of cooling down to -5°C without cryoprotectors and heating. The medium did not freeze at −5°C, remaining in a supercooled state.

We established a reduced resistance of the ancient *C. steinii* ciliate cysts to repetitive supercooling stress compared to the ciliates isolated from the modern tundra soil.

The resistance of the ciliates cysts to gamma irradiation was investigated by subjecting the cysts growing on the bottoms of the Petri dishes in the liquid mineral medium to a range of irradiation doses from 0,1 to 5 kGy. According to the excystation assays, irradiation at 0,1 kGy and more resulted in an increased lag phase and significant reduction in number of the excysted ciliates compared to the control subsamples. Excystation capability of the ciliates terminated at a dose of 1,5 kGy. Using the cultivation-independent method of the vital fluorescent staining, we found that damaged but still viable cysts persisted up to dose of 5 kGy. We observed an increase of the cysts radioresistance for strains of ciliates survived in the FOTON flight and for all strains if measurement was occurred between 7-8 days after the irradiation.

The Bioluminescent Detection of Viable Cells in the Soil Samples of Low-Temperature Ecosystems

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Identification of various living microorganisms in the soils of low-temperature ecosystems indicates their high potential of survival and retention of functional activity. The widely applied classical microbiological methods using culture media allow to detect only cultivated microorganisms. Detection of viable but non-culturable cells implies the utilization of alternative analytical methods.

Adenosine triphosphate (ATP) is the main source of the chemical energy in the cells of all living organisms and the main marker of their viability. The intracellular ATP content is a function of the energetic status of the cell. The most sensitive, rapid and specific method for ATP detection is the bioluminescent ATP-assay based system luciferin-firefly luciferase. The firefly luciferase (EC 1.13.12.7), catalyzing the oxidation of D-luciferin by oxygen in the presence of ATP and Mg^{2+} ions, is one of the most highly specific biocatalysts and efficient energy converters from the biochemical reactions to the light. The light intensity is proportional to the concentration of ATP in the linear range from 10 fM to 1 μM ATP. Thus, the aim of this work is the detection of living microorganisms in the soil samples from low-temperature ecosystems by measuring intracellular ATP with bioluminescent ATP-assay.

In this work we have developed a method for determination of total and intracellular ATP in the samples of permafrost soils of different geographical location. Preparation of the samples included the resuspension of the sample (1 g soil/ml of saline solution with the addition of non-ionic detergent) followed by separation of insoluble particles by centrifugation (1000 rpm, 2 min). Then the content of total ATP (intracellular+extracellular) was determined in the supernatant by calibration curve method using dimethyl sulfoxide for the extraction of intracellular ATP and ATP-reagent on the basis of the mutant firefly luciferase of *L. mingrelica* for its determination. Intracellular ATP was determined after hydrolysis of extracellular ATP by potato apyrase. The results of bioluminescent analysis of the samples showed that extracellular

ATP was absent, and the intracellular ATP content was in the range 10^{-11}–10^{-13} mol/g of soil.

It should be noted that the soil samples contain soluble components that can inhibit luciferase activity and interfere with the determination of ATP. To reduce the potential errors, a method of ATP additives was developed. It was shown that the results of ATP content determination by this method were at 10–30% higher in comparison with the calibration curve method. Thus, for an accurate determination of ATP in the permafrost soil samples the additives method is a method of choice. Assuming that the average content of ATP in the cells is 10^{-19} mol/cell, these samples contain from 10^5 to 10^8 cells/g of soil. The number of cultivated microorganisms (according to microbiological analysis) in the samples ranged from 10^2 to 10^6 CFU/g of soil. Thus, the existence of high level of intracellular ATP in samples indicates the presence of non-culturable microorganisms in the amount which is by one to four orders of magnitude higher than the number of cultured cells.

Next Generation Research Opportunities in Microbiology and Biogeosciences of Siberian Permafrost

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The continuous ancient permanently frozen sediments in the Kolyma-Indigirka Lowland in northeast Siberia represent the oldest undisturbed permafrost in the Northern Hemisphere. In this region 90% of permafrost is comprised of frozen wetlands of multiple origins. The persistent harsh, cold climate with the mean annual air temperature of –13.4°C creates excellent conditions for formation and permanency of frozen sediments.

The research projects supported by National Science Foundation will integrate the next generation sequencing approaches, including metagenome and single cell genomics, with classical microbiological and physical-chemical approaches. The application of these approaches will help to obtain satisfactory answer for a major unresolved question in microbial ecology of permanently frozen sediments - whether microbes recovered from deep permafrost sediments are living fossils, representing an ancient surface community preserved through time, or an active extant community that has been interacting and evolving continuously since becoming buried. The main educational mission of the projects is to engage students in research, encourage international collaboration, and expend a network of personalized and collaborative studies. We are welcoming individual scientists and scientific groups to come together to improve and extend knowledge of permafrost environment. The educational and research opportunities for undergraduate students in microbiology and biogeosciences of Siberian permafrost will be directed to multidisciplinary education, personalized learning, next generation tools strategies, and innovations for implementing breakthrough techniques. Undergraduate-driven questions, derived from an individual's natural curiosity, will form the basis for personalized projects within the context of research conducted in the Laboratory of Soil Cryology, the Institute of Physicochemical and Biological Problems of Soil Sciences. The projects will be designed to offer undergraduate students an integrated research, academic mentoring and cultural experience. The follow-on research including preparation of genome and metagenome libraries followed by sequencing, assembly, annotation and analyses will be conducted in the Center for Environmental Biotechnology of the University of Tennessee Knoxville.

The international nature of this project will provide the platform for improving the network of collaborative research in the form of open-system data management, knowledge sharing, and professional cross-training. Moreover, it will have a significant impact upon formulating the careers of the participants by opening their eyes to new and exciting opportunities in the biological and geochemical sciences arena.

Acknowledgments: This research is supported by NSF IIA 1358155 and NSF DEB 1442262.

Study of the Plant Remains from Teeth of Wooly Rhinoceroses of the Northeast of Russia

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Woolly rhinoceros as a typical representative of Mammoth fauna is actual object for researchers of the Quaternary Period. The anatomy and morphology of woolly rhinoceros are well known. But the animal diet and its natural habitat require specification.

Primary study of the plant remains from tooth cavities collected from 17 skulls of woolly rhinoceroses found in the Northeast of Russia (collection of the Ice Age Museum) is presented. The first investigation of the vegetative remains from teeth is dated back to the end of the XIX century (Garutt, 1970).

The material of tooth cavities includes small twigs, bits of wood, bark or cork, seeds, small leaf parts, as well as undefined organic remains and thin-grained (fine) mineral particles. The latter prevailed in the majority of the studied samples. The remains from the teeth contain approximately 0.2–8 g of plant material. Two skulls contain solid «cork», consisting of the wood remains, which probably represent the animal last meal. The plant remains found under the « cork» in teeth cavities could probably be accumulated during animal lifetime. It is possible that some micropaleofossils (e.g. spore and pollen) could be introduced in to tooth holes after animal death. This fact could be used for characterization of deposits and determination of age when these deposits were formed, which could reflect environment and time of the animal life.

The photoliths, spores and pollen were isolated and processed using standard procedures. Single grains of family *Pinaceae* were found. Phytolith analyses showed presence of grasses, herb epidermis, plant vascular tissues, and stomatal complexes of species *Ericaceae* and *Poaceae* in tooth cavities. The phytoliths are scanty. The phytolith assemblages contain trapeziform, polilobate, globular, cylindric forms, elongate parallepipedal and smooth sticks.

Tissues of mosses and sedges are absent. The diatom algae were found in several samples and probably they got there during diagenesis processes. They reflect regional flora and can be distant wind carried. Twigs *Salix* sp. and *Betula* sp. were also detected. Wood remains likely belong to a larch.

The composition of vegetable remains and other inclusions from teeth indicate mainly heterogeneous grazing landscape with larch and shrubs-grasses communities. These results could be used for reconstructions of environment and diet of wooly rhinoceroses.

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A Small Mobilizable Plasmid Palwed1.8 Harboring Non-Cassette Aada Gene and Its Distribution in Permafrost and Contemporary *Acinetobacter* Strains

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The studies of the origin of antibiotic resistance genes and the mechanisms of their distribution are necessary to develop precautions preventing the spread of multidrug resistance between clinical strains of bacteria. Earth permafrost from the polar region is the most static and balanced environment, where microbial communities survive for thousands and millions of years. Thus, studies of resistance genes from bacteria conserved in permafrost sediments can provide a unique opportunity for analysis of microbial communities dwelling long before the introduction of antibiotics into clinical practice. Previously, we showed the efficiency of our approach, which consists in the study of resistance genes and mobile elements associated with them from ancient bacteria, conserved in the permafrost. Such investigations allowed to clarify the processes of formation and distribution of resistance determinants.

In continuation of these studies we started a project aimed at the research of plasmids from permafrost *Acinetobacter lwoffii* strains resistant to antibiotics. Two strains resistant to streptomycin and spectinomycin were found to contain identical plasmids with new variant of *aadA* gene, encoding resistance to both above mentioned antibiotics. The new plasmid designated pALWED1.8 has a size of 4135 bp.

In addition to the *aadA* pALWED1.8 harbored genes *mobA* and *mobC* responsible for its mobilization by conjugative plasmids. It was shown that *mobA* and *mobC* are functionally active genes and are able to mobilize pALWED1.8 during conjugation with frequency $2{,}3\times10^{-3}$. The nucleotide sequences of *mobA* and *mobC* are similar to mobilization genes (81% of identity) of the modern plasmid pRAY, widespread among pathogenic *Acinetobacter* strains. In contrast to pALWED1.8, pRAY and related plasmids contain the gene *aadB*, which provides resistance to gentamicin, kanamycin and tobramycin.

Small plasmids, almost identical to pALWED1.8, were detected in 4 of the 50 investigated *Acinetobacter* strains, from our collection of environmental bacteria: three ancient and modern strains of *A. lwoffii* and modern strain of *A. johnsonii*. Moreover a plasmid almost identical to pALWED1.8 was detected among whole genome shotgun contigs of strain of *A. parvus* CM11 isolated from intestine of mice. Also we found in GenBank six previously unidentified variants of plasmids, related to pALWED1.8 and pRAY.

In contrast to the most of described *aadA* variants which are the cassette genes and are inserted into integrons, gene *aadA27* harbored by pALWED1.8, is non-cassette (autonomous) and has its own promoter. Non-cassette *aadA* genes with 96% similarity to *aadA27* were detected also into chromosomes of *A. gyllenbergii* and two strains of *Acinetobacter* sp. In addition, it was first discovered that the autonomous *aadA*-like genes are present in chromosomes of gram-positive and gram-negative bacteria. Phylogenetic analysis of amino acid sequences of all identified AadA proteins revealed that (1) chromosomal non-cassette *aadA* genes can be inherited both vertically and transferred by horizontal gene transfer; (2) clinical cassette *aadA* genes form a separate monophyletic group.

***Pseudogymnoascus pannorum* - a Typical Representative of Permafrost and Its Importance to Basic and Applied Microbiology**

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Fungi *Pseudogymnoascus pannorum* (syn. *Geomyces pannorum*) are able to grow in cold environments with reduced nutrients and high salt content. They could change not only cultural and morphological characteristics, but metabolism in response to varying of abiotic factors. The studying of fungal diversity in 122 samples of Arctic active layers and permafrost sediments of different depth and geological age showed that fungi *P. pannorum* were the most frequently occurring (26%) in these habitats. In the Arctic cryopegs this percentage is even higher (75%). Fungi of this taxon were also found in samples from Antarctica stations - Novolazarevskaya and Leningradskaya.

It is believed that the fungi of this genus make a significant contribution to the carbon cycle and the ecosystem functioning in extreme environments. For example, in the study of the microbial degradation in Ernest Shackleton' hut (1908, Cape Royds, Antarctica) it was established that the most frequently isolated fungal genera from the historic woods samples belonged to ascomycetes *Cadophora* (44%), *Thielavia* (17%), *Pseudogymnoascus* (*Geomyces*) (15%) (Blanchette et al., 2010).

Recently information of utility of psychrotolerant strains *P. pannorum* in bio-industries recently appeared. The strain of this taxon was reported for the first time as a novel biocatalyst for O_2-promoted oxidation of α-pinene. The main product of the reaction is the compound of high commercial value (verbenol). The process was most active at 10°C (Trytek et al., 2015).

VKM possesses a collection of 100 strains *P.pannorum*, isolated from low-temperature habitats, which can be used both for studying the adaptive potential of these micromycetes and for carrying out taxonomic studies. In particular, the genus *Pseudogymnoascus* attracted much attention due to a devastating epizootic "bat white-nose syndrome" (WNS). Since causative agent of WNS *P. destructans* grows only at low temperatures (optimum 14°C), the mycologists compared the morphological characteristics of pathogen with the Arctic strains *P. pannorum* stored in VKM (Kochkina et al., 2007). It was shown genetic and phenotypic similarity between both groups of strains. The greatest similarity was found between the pathogens and psychrotrophic strain VKM FW-2264 (VKM F-4571) isolated from saline permafrost sediments aged 100000-120000 years (Gargas et al., 2009).

Recently genotypes of 14 strains *P. pannorum* isolated from modern samples and permafrost aged up to 3 million years were sequenced. A comparison of modern and ancient strains showed that this species with clonal structure of genome was ancient (at least 50 million years old) and had several distinct clades (Leushkin et al., 2015).

Under conditions of low temperatures, high salinity of the medium, and the absence of oxygen, metabolism of these fungi becomes more effective, providing survival and competitiveness under extreme conditions. Under the action of stressors the desaturation processes of fatty acids are enhanced (Konova et al., 2009). In the absence of oxygen the metabolism of *P. pannorum* can also be effective and accompanied by the accumulation of acetate and lactate as the fermentation products. Moreover, activity of strains increased in the presence of NaCl in the medium (Shcherbakova et al., 2010).

In collaboration with Laboratory of evolutionary genomics MSU we study cells' responding to diverse environmental stresses (low temperature and high salinity). Cultures *P. pannorum* were grown under the action both of "single" stressor and the combined effect of stressors. After that RNA-sequencing, the primary analysis of the transcriptome and measurement of differentially expressed genes were carried out. The first results showed a significant enrichment of genes with reducing level of expression that control cell division and proliferation. These data correspond to the observed decrease in the growth rate of fungi under the action of stressors. Among the genes that increase in expression in 15−40 times there is, for example, a gene mannitol-1-phosphate dehydrogenase - a component of the mannitol-specific phosphotransferase system (Vasilenko et al., 2014). It is known that mannitol is required for stress tolerance in conidiospores of some anamorphic ascomycetes (Ruiter et al., 2003).

This work was supported by the RFBR (research project No. 13-04-02082; 15-29-02629).

The Microbial Community Inhabiting Ancient Arctic Permafrost Withstands Gamma Irradiation Dose of 1 MGy in Simulated Martian Conditions

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The reasonable choice of objects of research is important for planning the space missions having astrobiological tasks. In this regard, it is necessary to conduct laboratory experiments simulatiing conditions most approached to the conditions of target astrobiological space objects possible with the assessment of viability of microorganisms *in situ*. . One of the most promising astrobiological objects now is Mars. This research was focused on an assessment of possible duration of preservation of dormant microbial cells in martian regolith. The object of the study was the ancient Arctic permafrost sample (age 1.8-2 million years) as one of the closest terrestrial analogues of Martian regolith. The sample was treated by gamma radiation in a dose of 1 MGy under low pressure (1 Torr) and the low temperature (−50°C). This experiment simulated the key physical parameters of the surface layer of martian regolith protected from UV radiation and dose accumulation over time had been taken into account.

The microbial community of the Arctic permafrost showed high resistance to the influence of model conditions. According culturing on solid nutrient medium in the irradiated sample was found more than 5×10^5 CFU/g of aerobic heterotrophic bacteria. Epifluorescence microscopy revealed not less 2×10^8 cell/g containing intact DNA. GC-MS lipidic analysis detected markers more than 30 different groups of bacteria. In the structure of microbial community in situ in the irradiated sample bacteria of genera *Methylococcus,* Clostridium, Acetobacterium and Nitrobacter dominated.

According Curiosity rover data, intensity of ionizing radiation on a surface of Mars averages 0.076 Gy/year (Hassler et al., 2014). Based on these data, our results allow suggesting possibility of preservation of viability by the potential Martian biosphere in an anabiotic state in the regolith surface layer (protected from UV radiation) during at least 20 million years after loss of the atmosphere by Mars.

This research was supported by the Russian Foundation for Basic Research grant № 13-04-01982 and by grant of the Program №9 of Presidium of Russian Academy of Sciences.

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Assessment of Sustainability of Spring Wheat Treated with Bacteria Isolated from Permafrost, to Low Temperature Conditions

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Plants have to adapt to environmental conditions. Their ability to endure adverse weather conditions is directly dependent productivity of crops.Studies show that bacteria can increase the adaptation potential of plants. In this regard, perspectives create phytostimulators based bacteria isolated from permafrost. They have high levels of adaptive capacity. This allows them to survive in harsh environmental conditions.

Objective: To assess the impact of strains bacteria of the genus Bacillus, isolated from permafrost on morphometric parameters of spring wheat varieties Irgina in low temperature conditions.

The experiment was carried out on the seeds soft spring wheat varieties Irgina that were processed by soaking them for 2 hours in the suspensions of strains of bacteria of the genus Bacillus (2/09, 6/010, 6/29, 9/08, 15/62 (2)) selected on the basis of the results of preliminary experiments.Seed sown in the calcined sand. The experiment used 100 seeds for the treatment of each strain. After 7 days was evaluated the germination, on day 20 morphometric parameters: the length of the sprout, the length of coleoptile length the first leaf, the maximum length of the roots, the mass of sprout, the mass of roots, number of roots.

Seed germination in treatment options strains 2/09 and 9/08 was significantly ($p < 0.05$) exceeds the control value. Furthermore, wheat germ, treated these strains were superior to the control in all investigated morphometric indcators. In the embodiment, the treated strain 6/010, germination was at the level of control, and the remaining - significantly reduced ($p < 0.05$). However, morphometric parameters in wheat seedlings in all variants was observed stimulation effect.

Thus, we concluded that all investigated strains of bacteria of the genus Bacillus of permafrost increases plant resistance to low temperatures and increase morphometric parameters of seedlings. Two studied strains (2/09, 9/08) increase seed germination. Is assumed to conduct a comprehensive study of these strains to create on their basis f phytostimulate preparations that increase the adaptive capacity of plants to stress factors and their productivity.

The Thermostability and Special Features of the Structure of Cold-Active Esterase Estpc from Permafrost Bacterium *Psychrobacter Cryohalolentis* K5^T

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The permafrost regions occupy more than 50% of terrestrial surface of Russia. Permanently frozen sediments pose unique challenges to its resident biota: low temperatures and small amounts of liquid water, limited access to nutrients. It was shown previously, that permafrost contains the unique microbial community adapted to these specific conditions. It is inhabited by bacteria, green algae, yeasts, mycelial fungi. One of survival strategies for these microorganisms is the expression of cold-active enzymes.

Esterase EstPc is a recently discovered lipolytic enzyme from permafrost bacterium *P. cryohalolentis* K5^T, possessing relatively high thermal stability and elevated enzymatic activity at temperatures near 0°C.

To unravel the molecular mechanisms underlying such unusual properties of EstPc we have utilized the site-directed mutagenesis. We have obtained and studied mutant variants of EstPc containing substitutions of amino acid residues near the catalytic triad's residues and deletions of various regions. Mutant proteins with substitutions near the catalytic residues histidine and aspartate demonstrate optimum activity shifted to lower temperatures, and low thermal stability. Also the amino acid substitutions led to decline in the protein stability as evidenced by scanning calorimetry. Furthermore, the mutants of EstPc possess lower α-helical content according to circular dichroism spectroscopy, and increased tendency to aggregation. The deletion variant which lacks the N-terminal alpha-helix has reduced activity and a temperature optimum within a narrow temperature range but exhibits an elevated resistance to heating at high temperatures. Mutant proteins with deletions of various length within NC-loop exhibited a lower temperature activity optimum and narrow range of substrate specificity and temperature dependence. Overall, our data demonstrate the important contribution of these regions to the thermal stability of EstPc, since their changes or deletions result in the disappearance of the characteristic properties of the protein. This proves to be important for elucidation of the structural traits exploited by permafrost microorganisms for adaptation to low-temperature conditions.

The work is supported by RFBR grants 14-04-31573 mol, 15-04-07772.

The Results of the Impact of Psychrotolerant Mesophilic Bacteria of the Strain *Bacillus* on the Morphometric Parameters *Allium cepa L.*

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The material for the experiment served as the Allium cepa L. variety Stuttgarter Risen. Plants weighing 2–3 g were grown in test tubes filled with 20 ml of distilled water. After 48 hours, the plants were taken without the green leaf, root length of 16 ± 6 mm. Formed 4 experimental groups of 10 plants. The first control (C) group as a medium used for the cultivation of distilled water to wash the agar. The second experimental group (10^6) - the bacterial cell suspension at 1×10^6 microbial cells / ml of distilled water, and the third (10^9) – the suspension concentration of 1×10^9 microbial cells/ml of distilled water in the fourth (10^{12}) - slurry concentration of 1 × 10^{12} microbial cells/ml with distilled water. Psychrotolerant mesophilic bacteria of the strain was cultivated on Bacillus strain of 2/09 state standards R 51758-2001.

After 96 and 192 hours of the experiment were recorded morphometric parameters Allium cepa L. The data measured on bulbs without visible damage. Statistical analysis was done with BioStat.

Before starting the experiment, the length of the root system in the Group was as follows: Group C – 16,6 ± 5,3 mm, a group of 10^6 – 16,2 ± 5,4 mm, a group of 10^9 – 15,4 ± 4,9 mm, the band 10^{12} – 16,4 ± 4,9 mm.

After 96 hours in groups of 6–7 plants had no visible damage. Group C: The average length of the root system was 38,2±5,1 mm; the average length of green leaves – 110±17,4 mm; the average number of green leaves on one plant – 2,7±0,76. Group 10^6: The average length of the root system was 38,7±4,8 mm; the average length of green leaves – 118±15,8 mm; the average number of green leaves on one plant – 2,7±0,83. Group 10^9: The average length of the root system was 42,8±5,8 mm; the average length of green leaves - 115±13,4 mm; the average number of green leaves on one plant - 3,2±0,89. Group 10^{12}: The average length of the root system was 37,5±4,8 mm; the average length of green leaves – 113±16,7 mm; the average number of green leaves on one plant – 2,7±0,83.

After 192 hours in groups of 3–4 plants had no visible damage. Group C: The average length of the root system was 39 ± 4,4 mm; the average length of green leaves – 159 ± 20,9 mm; the average number of green leaves on one plant – 3 ± 0; the average mass of green leaves – 3,8 ± 1,1 g. Group 10^6: The average length of the root system was 48±3,6 mm; the average length of green leaves - 156±31,1 mm; the average number of green leaves on one plant – 3 ± 0; the average mass of green leaves – 3,5±0,8 g. Group 10^9: The average length of the root system was 56±7,7 mm; the average length of green leaves – 177±33,4 mm; the average number of green leaves on one plant – 3,3±0,87; the average mass of green leaves – 5,5±2,1 g. Group 10^{12}: The average length of the root system was 46±6,2 mm; the average length of green leaves – 171±25,7 mm; the average number of green leaves on one plant –3,7±0,82; the average mass of green leaves – 4,9±1,8 g.

Output. Psychrotolerant mesophilic bacteria of the genus *Bacillus* strain of 2/09 did not adversely affect the morphometric parameters of the root system and green leaves *Allium cepa L.*

Assembly of Microbial Genomes from Antarctic Metagenomes

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Antarctica, being hardly accessible location, still remains relatively obscure territory in terms of microbial ecology and biodiversity. Only limited numbers of microbial species were described and characterized from the area to date. Thus, biodiversity and microbial ecology of Antarctic region are of great interest. Combination of classical microbiological methods and metagenomics approaches is the best way to address the challenge. As majority of soil microorganisms are considered being “non-culturable”, shotgun metagenomics is the perfect tool to gain knowledge on microbial ecology without isolation pure cultures.

Antarctic Dry Valleys are one of the most interesting and harsh ecotopes of the continent. For the study two types of permafrost sediments were collected on the west edge of Lake Miers (78°05′ S, 163°48′ E) in Miers Valley, Antarctica (for review see Gilichinsky et al., 2007). Samples were taken along borehole 4/95 from depth of 2.01 and 3.75 m. Microcosm experiment was designed to provoke growth of anaerobic microorganisms. As 0.64 ml/kg of methane was found in the former sample, microcosms were maintained at methanogenic conditions. After more than 18 month of incubation period at +20, +6 °C and purging of CO_2/H_2 as carbon and energy source, and unsuccessful transfers, shotgun metagenomics was applied to reveal functional and taxonomic structure of the microbial communities. Total genomic DNA was extracted from both enrichments and sequenced on Illumina HiSeq 2000 generating 2x100 bp paired end reads. Following metagenomic assembly, taxonomic binning and reassembly produced draft genomes of dominant species in both samples. Thus, contigs related to *Methanosarcina* sp. and *Brevundimonas* sp. were derived from sample without methane and containing one, respectively. Former bin consists of 565 contigs spanning 3.30 Mb with N50 of 9454 nt. Second one has 138 contigs, 3.34 Mb, N50=39242 nt.

Comparative genomics analysis of the derived draft genomes are in progress.

Ground-Based Measurements and High Resolution Remote Sensing of Permafrost Thaw Subsidence on Yedoma Uplands in the Lena Delta Region

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Ground-ice rich terrain in the East Siberian coastal lowlands is being destabilized by continuing permafrost degradation. This degradation includes not only warming of cold permafrost, but also its thawing with consequences for local hydrology, ecosystems, biogeochemical cycling, and sometimes communities. However, thaw-associated mobilization of soil organic carbon and associated release of methane or carbon dioxide as well as relative sea level rise due to terrain subsidence of vast coastal hinterlands has potential regional to global impacts. Regarding land surface elevation of ground-ice-rich terrain, questions remain over whether the absolute surface level returns back to its initial state after a complete annual thaw-freeze cycle or if irreversible loss of ground ice occurred due to active layer deepening, leading to subsidence. Within drained thaw lake basins or areas of current thermokarst activity on yedoma uplands, seasonal thaw-freeze mechanisms proceed simultaneously with long-term geomorphic processes of land surface lowering.

Now there are initial indications that ground ice in permafrost is thawing in response to rising temperatures in the Arctic, however, still only few observations of widespread and irreversible thaw subsidence exist. Permanent subsidence depends on topographic gradients enabling effective removal of ground ice melt water. Readjustment of drainage systems due to a landward advancing coastline or thermokarst lake expansion or partial drainage is likely to facilitate thaw subsidence in the coastal hinterland and calls for a more comprehensive consideration.

In this study, we placed our observations in the context of an alas-yedoma thermokarst landscape that has already undergone considerable permafrost degradation in the past. Our work aims at finding commonalities and differences of change or no change on uplands, slopes, and thaw depressions on the landscape scale using multi-temporal DEMs from historical aerial photographies and modern very high resolution satellite imagery such as WorldView and GeoEye. In summer 2014 we established several long-term survey grids with geodetic benchmarks on Sobo-Sise island in the eastern Lena Delta and on the Bykovsky Peninsula in North Siberia. Initial ground-based measurements were used to create and evaluate multiple digital elevation models (DEMs) produced with satellite image stereophotogrammetry. The datasets will be used to identify inter-annual trends. Annual repeat ground measurements starting in 2015, relying on our small grid of fiber glass pipes anchored in the permafrost down to 2m depth, will provide information on spatio-temporal variations of local elevation changes in polygonal tundra.

Permafrost Conditions of Coastal Area of the Ob Bay in the Region Sabetta

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In recent years, active construction has been carried out in the South Tambeyskoye field. The authors of the article participated in permafrost studies in the areas surrounding construction of liquefied natural gas (LNG) plant and shore installations of Sabetta port. The depth of soil studies varied from 15 to 25 m, sometimes up to 50 m.

Permafrost has a continuous distribution and power up to 200–280 m inside the study area. Permafrost is broken thawed rocks under the water area of the river Sabettayaha and the Ob Bay. The average annual temperature of permafrost changes within a small range – from minus 5.0 to minus 6.5°C, which is caused by uniformity of the landscape and the scarcity of vegetation. The depth of zero annual fluctuations in temperature of soil is 12–13 m.

The project is located in the coastal area of the Ob Bay within the first marine terrace and Laida. The area is characterized by extremely complicated engineering geocryological conditions. They are related to the lithological variety and heterogeneity properties of soils (ice content and salinity) both in the section and along the strike. Saline chilled sands are found at depths 10–15 m, 1–4 m thick, containing cryopeg. Type of local waters is sodium chloride, with mineralization up to 55–81 g/l.

Mechanical properties of saline frozen soils are highly dependent on the relations between temperature and salinity. The natural temperature of frozen soils is variable seasonally as well as multi–year cycles. The strength properties of soils may change two-fold and more. The interference of such variability with dependency of soil mechanical properties from the lithological composition, ice content and salinity increases the range of probable values of strength properties up to irrational big intervals of values (basic properties can change up to 10 times).

During the development of the field the temperature regime of the frozen soils is significantly changing in comparison with the natural conditions partially due to the influence of pads at the construction sites, the height of which is usually 2–3 m, but sometimes reaches 5–7 m. As a rule, disturbance of natural cover and subsequent padding results in change of the soils temperature regime. Therefore, during the period of facility construction and maintenance the soil physical and mechanical properties are determined by the changes of the soil foundation temperature regime, which in its turn greatly depends on the accepted technical solutions.

The regulation of temperature regime in the developed areas is based on the geocryologic monitoring, and usually it includes the control of snow accumulation, thermic stabilization and other actions. The registration of the natural temperature field is a ground zero for the forecast of the soils thermal condition during construction and maintenance of the facilities.

The New Genetic Type of Super Dynamic Rock Glaciers in Central Asia

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The Gorodetsky is one of the largest and active rock glaciers of the Northern Tien-Shan. From 1923 to 2003 its frontal slope moved 72 m down, and the area has considerably increased [Gorbunov et al, 1997; Marchenko, 2003]. During the same time, the area of glaciers in the overlying drainage basin decreased by 25–30%, and their edges retreated on 200–250 m. In 2012–2014 the multi-approach geological and geophysical study of this landform has allowed to establish the following.

The body of rock glacier consists of 3–4 generations, derived from the contemporary terminal moraines formed over the retreat of the

Gorodetsky paleo-glacier since LIA. The earliest prefrontal generation is completely thawed and composed with a watered gravel-block-loamy ground. But it is the most dynamically active part of the rock glacier moving with velocity 1–2 meter per year.

The later generations are characterized by "honeycomb" internal structure in which the large buried blocks of clear metamorphic ice are packed into a rock glacier's body with water-filled gravel-block-loamy ground.

One of the ice block up to 70 m length and 25 m depth outcrops in thermo-cirque depression in the middle part of the rock glacier. The constitution of the section shows the absence of epigenetic ice and post-genetic plastic deformations. This indicates the buried ice blocks have passive movement in the body of rock glacier. The ice features reflect intensive syngenetic micro folding of LIA paleo-glacier that discordant to the rock glacier stratigraphy and could not originate during its current movement.

The composition of stable isotopes of buried ice blocks similar to ice of modern glaciers in the region, and isotopes ratio also indicates the absence of epigenetic recrystallization and isotopic fractionation. As well as the isotopic composition of rock glacier water runoff is similar to buried ice block that indirectly indicates the absence of significant amounts of epigenetic ice.

The temperatures and runoff duration together with geophysical sensing data confirm the absence of MMP in the marginal generations of the rock glacier. The geomorphological features also indicate that the runoff of the upper-catchment is carried out by the drainage through the rock glacier. So its body plays the role of natural filter of glacial loam, which is accumulated replacing of the melting ice blocks and filling the pores between debris. The surface portions with well-developed micro-relief at the same time are the most thawed and watered parts of the rock glacier.

Thus, collected data provide a basis to assign the new genetic type of complex ice-debris-loam rock glaciers developing over glacier retreat in specific geomorphological conditions. Physics of such formations cannot be described by the Glen's law of plastic deformation that often used to derive the movement velocities of usual rock glaciers as well as common glaciers. The rheology ice-debris-loam rock glaciers can probably be modelled by behavior of a pseudoplastic (non-Newtonian) fluids and thixotropic systems.

Investigations were carried out with support of the Russian Found of Basement Research, Project № 14-05-00435-a.

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New Changes of Insolation and Last Glaciations in Western Siberia

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There are three components of the astronomical theory of climate change: the problems of the orbital and rotational motions of the Earth and the problem of its insolation depending on the parameters of the orbital and rotational motions. All three problems were solved in a new way. Our independent solutions of the first and third problems confirmed the researches of predecessors. But the results of rotational motion are others. The amplitude of the angle of inclination of the Earth's equator to its orbit, known as obliquity ε, is higher in about seven or eight times. According to the former theory on the time span of 200 thousand years ago (t.y.a.) the obliquity ε varies from 22.21° to 24.43°. But according to our solutions the obliquity ε varies from 14.8° to 32.1° on the same time span. Approximately the same range of variation of the obliquity ε is obtained by solving the problem for the future of 200 t.y.

These fluctuations of the obliquity ε give such changes of insolation that can explain the climate variations in the past. For example, according to the former theory the summer insolation I in equivalent latitudes at latitude 65° varies from 60° to 70°. It is unlikely that changes the amount of heat at latitude 65° to such values, which are now available at latitudes 60° and 70°, can lead to significant warming or cooling. According to the new theory, the amount of heat in the summer at latitude 65° may be greater than now at the equator, and at other times may be less than now at the pole.

The moments of occurrence of the insolation extrema are also others. The first small peak summer insolation at latitude 65° of Northern hemisphere Q_s^{65N} = 5.97 GJ/m^2 occurs 4.16 t.y.a. Note, the contemporary insolation is equal 5.92 GJ/m^2. The first extremum coincides with the Holocene optimum. According to S. A. Arkhipov, M.G. Grosswald and many others the optimum of the Holocene clearly manifested in the range of 9 t.y.a – 3.3 t.y.a.

The second extremum, significant low insolation Q_s^{65N} = 5.36 GJ/m^2, occurs 16.04 t.y.a. It matches the last glaciation, which is referred to as the Sartan horizon in Western Siberia and to as the late Weichsel in Scandinavia. For example, J. I. Svendsen the maximum glaciations in the Archangel region relates to 17 t.y.a. and deglacial – to 16 t.y.a. The deglacial of the East of lake Onega is related to 14.4 t.y.a. – 12.9 t.y.a. The age glacier in Taimyr of late Weichsel or Sartan glaciation refers to 18 t.y.a. – 7.5 t.y.a. The space between southern Novaya Zemlya and Northern Norway is covered by ice-sheet up to 10.7 t.y.a. According to S.A. Arkhipov the radiometric age of Sartan glacial horizon is located within 23 t.y.a. – 10 t.y.a.

The third extremum, maximum of insolation Q_s^{65N} = 7.43 GJ/m^2, occurs 31.28 t.y.a. That's the largest peak of heat on the interval from 0 to 200 t.y.a. It corresponds the Karginsky interglacial period in Siberia. J. I. Svendsen believes that the former Barents-Kara ice sheet completely disappeared to 40 t.y.a. According to S.A. Arkhipov the Kazym layer of Karginsky horizon (dorp Kazim-Cape, the right bank of the lower Ob) extends along the Ob valley to the Kolpashevo and the Vasyugan river basin, as well as to the village Lipovka on the Tobol. Its age is 33 t.y.a. - 31 t.y.a. On the lower river Yenisei from the town of Igarka to the mouth Bakhty traced konoschelsk layers, similar to Kazym layer with the age of 33 - 32 t.y.a. As a rule, there are the alluvial-lacustrine deposits with layers of peat.

According to A.G. Illarionov the third terrace of the Irtysh and Tobol with an altitude of 70–75 m near the village Lipovka composed of lacustrine-alluvial deposits. The age of wood and crop residues is from 31.78 t.y.a. to 32.77 t.y.a. The fossil remains of bison, woolly rhinos and horses have the same age.

The fourth extremum Q_s^{65N} = 4.72 GJ/m^2 occurs 46.44 t.y.a. It is the most significant low insolation on the interval from 0 to 200 t.y.a. It coincides with Ermakovsky glacial period. S.A. Arkhipov the most southern belt of moraines, reaching the foot of the Siberian ridges, refers to Ermakovsky horizon. J. I. Svendsen the age of the maximum stage of the Barents-Kara ice-sheet relates to 50 t.y.a.

So, a small warming in the Holocene and the last two ice ages and interglacial period between them are consistent with the extrema of insolation and their values.

Thermal Regime of Submarine Permafrost in Kara Sea

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Distribution, structure, and thermal regime of submarine permafrost (SMP) in the Kara Sea region have been understudied. Thermal regime of SMP can be determined only on the base of direct measurements in boreholes or modeling, which provides only approximate estimations. Analysis of published and archived data on SMP temperatures suggests the occurrence of two types of SMP with different thermal regimes. The first type is represented by relic permafrost with ground temperatures close to phase-transition temperature, which depends on texture of soils and content of salts. This quasi-equilibrium temperature for the Kara Sea varies from –0.8 to –1.5°C. Similar quasi-equilibrium temperatures are also typical of stock-like permafrost massifs, which have formed due to stream degassing of methane originated from underneath of the permafrost stratum.

The second type was determined during the drilling of boreholes in the mouth of Obskaya Guba, when SMP with the temperatures of –4.0 to –4.5 °C were encountered. The sea in this area was 13 to 15 m deep, and permafrost table was detected at depths of 25 to 30 m from the sea bottom. A temperature profile characterized by the abrupt decrease in permafrost temperatures with depth indicates rapid permafrost degradation. Presumably, such distribution of SMP temperature with depth is the evidence of recent submersion of this area.

Thus, SMP of the Kara Sea shelf are divided according to their thermal regimes into two types: (1) relic and stock SMP with temperatures close to the phase-transition temperature, and (2) SMP within recently submerged areas with low temperatures and a temperature profile which indicates an active warming and thawing of the upper permafrost.

An analysis of dynamics of the Kara Sea bottom temperature revealed that during the last 100 years permafrost temperature has increased by 0.3 to 2.2°C. The biggest increase in the near-bottom temperature was observed in the south-eastern part of the Kara Sea. This temperature increase has resulted in the rapid SMP degradation with the rates of 0.5 to 2.5 cm/year. The map of regions with the rapid SMP degradation is presented.

Evidence of Past Permafrost near St.Petersburg, Russia

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Late Pleistocene permafrost environment inferred from polygonal networks of sand wedges is well studied in regions of Poland, Russia, Germany and several others countries of Western Europe. Recently, the wedge-shaped features were discovered in sand and gravel deposits of an abandoned sand quarry to the west of St. Petersburg, 7 km from the shore of the Gulf of Finland. The study area is located on a flat surface of the third coastal plain terrace at 41–45 m a.s.l. The goal of the study was to determine the genesis of the ground wedges using lithological, geocryological and geophysical methods.

Previous work conducted by researchers from IPE RAS in the same quarry reported about a dozen wedge-shaped structures that have been identified as paleo-seismic dislocations. Ground wedges of more than 3 m height and 1.5–2.0 width at the upper part are filled with light-gray sandy loam, sand and gravel. The enclosing layers of strata are bending down in the direction of wedges. Large pebbles in the wedges are vertically oriented and positioned to 0.05–0.15 m lower than the pebble horizons of enclosing strata from which they fell. Wedges are narrowing with depth and continue in layered sand.

Geophysical methods determined that the wedges have a considerable length, and the distance between the adjacent wedges has spatial intervals of about 20–35 m. Smaller sand wedges are found in-between the larger ones. Smaller wedges are characterized by heights up to 0.7 m and widths up to 0.5 m. They are filled with well sorted gray-brown sand, and have no apparent stratification and inclusions of pebbles. Sand wedge bottoms are intruded into horizontally oriented layers of gravelly sand.

Samples from the sand wedges, enclosing sediment strata and overlying wedges layers were taken to determine the particle size distribution in order to estimate the coefficient of cryogenic contrast (CCC). Analysis of samples showed that the sediments filling the wedges have CCC equal or greater than 1, indicating the active cryogenic processes in the past. Particularly harsh environments are characteristic of the sediments filling the upper part of the sand wedges where CCC values are 1.6–1.8. The temperatures reconstructed from CCC values correspond to the ground temperature of –8.0^{o}C found in the Antarctic dry valleys (Shmelev, 2015).

The results of the field investigations and the radiocarbon age of the deposits (Nikonov, Rusakov, 2010) confirm the permafrost dominated environment near St. Petersburg at the 59°57'N during DR3. The estimated permafrost thickness is 100 m (Tokarev, Avramenko, Voronyuk, 2015) with mean annual ground temperature from –6 to –8°C. The studied profile show syngeneic freezing of sands and pebbles in coastal or floodplain environment.

Our study did not confirm the presence of continental ice sheet or presence of deep periglacial lake in the area of the Gulf of Finland in interglacial time. This study also refuted the seismic nature of the wedge-shaped structures.

Geocryological Features of Quarternary Sediments in the North of Western Siberia as a Key to Their Genesis, Depositional Environment and Palaeogeographic Features

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Cryogenic structure and forms of ground ice in the Quarternary deposits of the Arctic territories can be a key to their genesis, palaeogeographic conditions during and after sedimentation, and sometimes even their age. In the present study, we analyse different types of ground ice in the Quarternary sections of the northern part of Yamal and Gydan Peninsula, Western Siberia, based on the data obtained during the expeditions "Yamal-Arctic-2012" and "Yamal-Arctic-2013" by a multidisciplinary team of the "Arctic-Region" research group.

Within Yamal and Gydan Peninsula, different types of ground ice are found. Massive ice beds are more wide-spread on the western coast of Yamal; however, they also occur on the eastern coast and within Gydan Peninsula. Their genesis can be different: some of them are intrasedimental, formed as a result of the movement of water towards the front of freezing inside the sediment, some can be formed as a result of injection, and some are supposedly buried glacier ice, firn or snow. On the eastern, Yamal, coast of the Baydaratskaya Bay, massive ice beds have been found between the mouths of Liyakha and Niarmayakha Rivers. They are included in heavy lacustrine loams with horizontal parallel lamination and are 0.5–1.5 m thick. The ice is white and crumbly; it breaks easily, and separate grains are well-seen. This ice is probably buried firm from local snowfields and doesn't occupy considerable areas. In contrast to it, massive ice beds found near cape Nyadasalya, south-western coast of Mamonta Peninsula (Gydan), are characterized by transparent crystal ice, included in non-laminated dark grey clay and loam. The visible thickness of the ice is 2–3 m; it lies in the bottom part of the section; in this way, its thickness can be much more considerable. The structure of the clayey and sandy layer, lying stratigraphically below the ice (sand xenoclasts, folds, striated pebble) indicates that these are remnants of marine sediments, replaced and folded by a glacier. The overlaying non-laminated dark grey clays and loams with occasional cobble are moraines of the Pleistocene glaciation (presumably about 60 kA BP). In this connection, and judging by its contacts and structure, the massive ice beds can probably be considered as glacier ice, which forms here a whole geological layer.

Similar massive ice beds underlying the same non-laminated dark grey clays were encountered on the western coast of the Gulf of Enisey, to the west of Omulevaya river mouth. Their outcrops are considerably inclined. The curve of the $\delta^{18}O$, δD and Dexc shows uneven distribution without a clear maximum neither at the centre nor on one of the sides of the outcrop. The $\delta^{18}O$ values vary from –8–23%₀ at one outcrop to – 21–26% at another one, and, therefore, indicate relatively low winter temperatures. In this way, in spite of numerous features indicating glacial buried origin of these massive ice beds, the question of their genesis still remains open.

Ice wedges, both syngenetic and epigenetic, occur almost in every part of Yamal and Gydan Peninsula. They form as a result of the frost cracking in winter, and the filling of cracks by meltwater in spring. On Beliy Island, several generations of ice wedges were explored. The time of their formation is related to the Holocene, and the distribution of the $\delta^{18}O$, δD and Dexc values is typical for ice wedges with a maximum at the centre indicating a general trend of warming.

Winter Atmospheric Paleo-Circulation and Isotope Composition of Ice Wedges

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Ice wedges develop as a result of infilling of frost cracks with snow and snowmelt water. This means that the composition of stable isotopes of oxygen and hydrogen in syngenetic ice wedges allows reconstructing winter paleo-temperatures.

The key problem of paleo-climatic studies related to stability of the atmospheric circulation in the entire Arctic during the alternating cycles of warming and cooling in the late Pleistocene-Holocene still remains unsolved.

For our analysis, only the data on the isotope composition of syngenetic ice wedges, which have the same age as the adjacent sediments with reliable dates, were used.

The data base on the isotope composition ($\delta^{18}O$, δD и d-excess) of syngenetic ice wedges and elementary ice veins was developed. Besides our own data, all available published data on the isotope composition of syngenetic ice wedges of known age were analyzed. The data base comprise information on 30 segments of the Eurasian Arctic with available data on $\delta^{18}O$, δD and d-excess obtained from ice wedges of different ages – from modern and MIS 1 to MIS 4. MIS 1 and MIS 3 correspond to the periods of global warming (thermochrones) and MIS 2 and MIS 4 – to those of global cooling (cryochrones). Sampling sites locations cover the area of the Eurasian Arctic from 66 to 78^{o}N and from 15 to 171^{o}E. All sampling sites are located at the sea coasts or close to the coastal area.

Spatial distribution of $\delta\ ^{18}O$ values of the ice wedges in the Eurasian Arctic is shown separately for ice wedges of MIS 1 – MIS 4 and modern elementary ice veins. The pattern of this distribution has remained stable during the last 50,000 years, which indicates a stable trend in atmospheric circulation from 50,000 yr BP to the present. Probably, dimensions of the ice sheet were not big enough to change directions of atmospheric transfer from west to east. This is confirmed by the new data on boundaries of glaciers during the Last Glacial Maximum (LGM) based on studies of till distribution at the bottom of Barents and Kara Seas and composition of erratic material in Scandinavia.

Differences in winter temperatures indicated by the isotope composition of ice wedges during MIS 3 (thermochrone) and MIS 2 (cryochrone) were relatively small. This confirms a recent hypothesis about relatively cold winters during MIS 3.

Thus, based on the trends of spatial distribution of the isotope composition of ice wedges, we suggest a hypothesis about a stable character of atmospheric circulation in the Eurasian Arctic during the last 50,000 years.

Stable isotope analyses of wedge ice were performed by Dr. Hanno Meyer in the Laboratory of Isotope Research (Alfred Wegener Institute for Polar and Marine Research, Potsdam, Germany).

The Pleistocene Cryogenesis in the Area of the Volyn' Upland (Ukraine)

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The poess-palaeosol succession of the Volyn' Upland include all Middle and Upper stratigraphical units of the Quaternaty framework of Ukraine (Veklitch et al., 1993). Several generations of cryostructures have been previously studied here by A. Bogutsky (1990) and Nechayev (1983). All units were cryoturbated during the periglacial and subperiglacial stages, as it has been revealed in the studied sections: Boremel, Kolodezhi, Smykiv, Bakivtsi, Novostav, and Novy Tik. The horizons of cryogenic deformations are the reliable stratigraphical markers and indicators of cold climatic events, even when sediments of periglacial units are not preserved in the sections.

21 phases of palaeocrygenesis have been shown in the studied area. Each of them is characterized by a specific set of genetic types of cryoturbations and a certain intensity of cryogenesis. In the Volyn' periglacial region, the most intense cryogenesis occurred during the glacials which correspond in the Ukrainian framework to Tyligul (500–410 kyr BP), Oril' (250–230 kyr BP), Dnieper (180–130 kyr BP), Tyasmyn (110–104 kyr BP), Uday (74–55 kyr BP), Bug (27–18 kyr BP) and Prychernomorsk (15–10 kyr BP) stages. During these times, the deep frost cracking occurred: ice wedges, ground and sand wedges were formed, as well as solifluctional and gelifluctional deformations and postcryogenic textures. During the Late Pleistocene glacials, the humidity of the cold climate increased as it is indicated by the large sizes of cryopolygons, predominance of ice wedges, solifluctional structures and the other plastic astructutal deformations of the interstadial palaeosols.

Development of cryogenic processes has been also revealed within some stages of soil formation. Thus, the palaeosols of Lubny (600–500 kyr BP) Zavadivka (410–250 kyr BP) Kaydaky (130–110 kyr BP) and Dofinivka (18–15 kyr BP) stages were separated by a cold phase with cryogenic processes. There have been detected three phases of periglacial cryoturbations within Pryluky stage (104–74 kyr BP) and two phases within Vytachiv stage (55–27 kyr BP). During all these phases, ground wedges of smaller sizes were formed, as well as involutions and postcryogenic textures. The majority of these cryoturbations occurred outside the continuous permafrost zone, though during the inter-Prykuly and inter-Vytachiv cold phases, solifluctional structures were formed within an active layer. Solifluctional processes developed mostly during the first wetter part of a glacial (or cold phase). For instance, during Zavadivka, Orul' and Tyasmyn times, the formation of the largest ground wedges and solifluctional textures was asynchronous.

Sizes of cryostructures are controlled by palaeorelief: for instance, in depressions during the Bug time, ice wedges and syngenetic ground wedges were the largest, the thickness of solifluctions reached 4 m, and thermokarst forms occurred. A type of postcryogenic textures is controlled by the depth of their formation in relation to the buried surface, depth of active layer, duration of a cold stage and lithological characteristics. For instance, the most expressive postcryogenic platy textures have been revealed in the E soil horizons of the forest soils of Kaydaky and Prykuky units that were positioned close to the former soil surface.

Cryogenic deformations of the last palaeocryogenic stage (around 11 kyr BP) can be easily observed in aero-space shots of the area, particularly polygonal structures and thermokartstic depressions. In the Volyn' Upland, palaeocryogenic structures have an impact on the modern relief-forming processes: the appearance of fissures and suffosional downs, as well as positioning of intense colluvial processes and abrasional processes on the steep river banks are controlled by location of the former ice wedges.

Ice Complex on the Southern Coast of Kotelny Island, New Siberian Islands: New data on Isotopic Composition

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On the southern coast of Kotelny Island the Ice Complex (IC) is exposed in separate quite wide thermoterraces (up to 50–60 m extent into the coast). In 2012 in the framework of the Russian Geographical Society expedition the group of Faculty of Geography (MSU) have been studied and sampled two outcrops (K-1 and K-2) of large syngenetic ice wedges on the south of the island. There is almost no detailed data on isotopic composition of the IC for Kotelny Island. The data of V.M. Makeyev are known on the O^{18} content of IC at the Balyktah River valley (cited by Vasil'chuk, Kotlyakov 2000, p.395).

In K-1 outcrop IC with visible thickness of 5 m is exposed in coastal bluff of 14.5 m height above sea level (ASL). It lies almost directly under the active layer and is overlaid by the horizon of icy silt. In the sampling section ice is exposed in the range of heights 11.2–14.7 m ASL, ie it has a vertical thickness of 3.5 m. 33 isotopic samples were selected, which allowed to characterize the conditions at the time of ice formation, ie, during the Late Neopleistocene - at the beginning of the Holocene. The ^{18}O content varies from –29…–24‰ in the lower visible part of the ice wedge (2.5 m depth) to –25…–20‰ at the top. The heavier isotopic composition is marked in the middle, the youngest part of the wedge. This isotopically heavier ice wedge was formed later than one sampled in outcrop K-2.

The K-2 exposure reveals the IC of 8 m height (visible) in the coastal bluff of 18.5–19 m height ASL. Ice is also overlaid by thin horizon of icy silt; the underlying deposits content the peat horizons. Mean values of ^{18}O content varies from 31‰ in the lower part of the wedges to 29.5‰ in the upper part. The average value of δ^{18}O is 30.7‰ (from 32.2 to 28.4‰, 32 samples).

Dating of similar outcrops in the Balyktah River valley on the east of Kotelny Island revealed that IC there is of Late Neopleistocene–Holocene age (Pavlova et al., 2009). According to V.M. Makeyev, IC of the middle part of Balyktah strata dated 24.3–12.7 kyr BP is characterized by δ^{18}O values of –30.0 to –27,4‰ closer to the base of sequences, in schlieren soldered to the ice –27.4 to -24,6‰. At the same time in the wedges, which are located stratigraphically slightly higher (closer to the top), δ^{18}O values varied in one from –26.2 to –22.9‰, and in the other from –27.1 to –24,9‰ (cited by Vasil'chuk, Kotlyakov 2000, p. 395).

The isotopic composition of ice in K-2 outcrop is similar to that in the middle of Balyktah strata. The IC studied in the south of Kotelny Island could be formed simultaneously with syncryogenic strata of Balyktah River valley at the end of the Late Neopleistocene (24.3–12.7 kyr BP).

Peat lenses in the middle part of Balyktah strata are dated 28640±700 BP and 28410±210 BP (Makeyev et al., 1989). These dates are close to those on peat lenses on the north-west of Kotelny Island in the lower part of silty clays of edoma – 29750±1100 BP in the middle part and 28220±1000 BP on top (Lozhkin, 1977). The presence of similar peat horizons at the base of the K-2 outcrop is also an indirect evidence of Late Neopleistocene age of investigated ice complex.

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Evolution of Coastal and Submarine Permafrost of Kara Sea during Late Pleistocene – Holocene

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The team of Earth Cryosphere Institute together with Moscow State University (faculty of Geography) and VNIIOkeangelogii (St. Petersburg) investigated the geological and cryogenic structure of coastal exposures of the Kara Sea region. This work focused on the key sites on the Western Yamal (Cape Marre-Sale), Western Taymyr (near Dixon village, estuary of Krestyanka river, Sopochnaya Karga cape and etc.), and Gydan peninsula (near the mouth of the river Ery-Maretayaha and Paha-Sale cape).

An integrated study was carried out in each of the key sites. It includes detailed description of geological and cryogenic structure, sampling of frozen Quaternary sediments and ground ice for the grain size, chemical and isotope analysis of sediments and ice. The gas composition of frozen sediments and ground ice of various geneses has been analyzed and quantitatively described.

New data of geological and cryogenic structure, geological age has been obtained that expand the existing knowledge of conditions for formation and freezing of quaternary deposits and underground ice. Based on the findings, the scheme of Late Pleistocene - Holocene History for Kara Sea region has been developed.

Marine sediments of Sanchugovskaya suite (MIS 8-6) and Kazantsevo horizon (MIS 5) take up the alluvial-marine plains. Really dated deposits of Zyrjankaya time (MIS 4) have not been identified. Karginsky time (MIS 3) is represented by continental deposits.

The syngenetic ice wedges are formed mainly into two stages - at the Sartan cryochron (MIS 2) about 20–11 kBP and at the Holocene (MIS 1). The climatic conditions of that time were reflected in the stable isotopes composition. It allowed to reconstruct paleoclimatic conditions and ice wedges age on the base of isotopic analysis. Paleotemperature reconstruction based on stable isotope content showed that average winter temperature of the Holocene was 3–6°C below the present and at the end of the Late Pleistocene was 8–10°C colder than present.

Spatial and temporal distribution of paleotemperature is discussed in this report.

Distribution and Evolution of Thermo-erosional Landforms along the Yukon Coast, Canada

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Processes associated with permafrost degradation in the arctic coastal zone contribute significant amounts of organic carbon to the Arctic Ocean. Thermo-erosion, as a mechanism of rapid permafrost thaw, reshapes arctic landscapes and has a clear impact on the mobilization and distribution of carbon and nitrogen in permafrost terrains.

However, the effects of thermo-erosional disturbances are at present not taken into account in the models of permafrost carbon-climate feedbacks. This gap is partially caused by the limited amount of studies available on this topic.

Therefore is there a need for accurate estimates of the contribution of thermo-erosion to the carbon cycle at a regional and pan-Arctic scale.

As a first step, our preliminary study assesses the distribution and the evolution of thermo-erosional drainage pathways – including gullies and valleys – and specific thermokarst features such as retrogressive thaw slumps, along the coast of the Yukon Territory, Canada.

Using the software OrthoEngine from PCI Geomatica we used a large set of high resolution multispectral satellite images from 2011 (GeoEye and WorldView) for geocoding aerial photographs from the 1950s. The aerial photographs originated from the National Air Photo Library, Canada. This dataset allowed us to manually digitize and classify thermo-erosional gullies, valleys, retrogressive thaw slumps and active layer detachments using ArcGIS 10.3.

We gathered additional observations during fieldwork in July and August 2015 on gully and valley morphologies and on the current development stage of retrogressive thaw slumps. Based on remote sensing, we calculated and compared the surface area occupied by slumps in 1950 and in 2011 and the types, number and lengths of thermo-erosional drainage pathways.

Over this time span, we observe an important increase in the number and the surface area of the retrogressive thaw slumps and active layer detachments. There is, however, large spatial and temporal slump dynamic variability among different terrain units along the coast. We did not detect a specific increase in the length and number of thermo-erosional drainage pathways.

This dataset will be complemented by additional data collected from literature and during the upcoming field campaign along the coasts of the Yamal Peninsula and the Laptev Sea. The output of this work will provide a better overview of thermo-erosional landform evolution on a pan-Arctic scale.

Permafrost and Seasonal Frozen Ground in Coastal Zones of Kara and Pechora Seas

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Investigations of permafrost and seasonal frozen ground in coastal zones in the areas of Mys Kamenniy settlement (west coast of fresh water Obskaya Bay, Kara Sea) and Varandey settlement (Pesyakov Island, Pechora Sea) were carried out. These investigations included core and auger drilling, drill rods penetrating into active layer and temperature measurements in boreholes with a thermistor strings.

Drilling in the area of Mys Kamenniy was taken in May 2012 from fast ice to determine depth and width of seasonal frozen ground zone under fast ice and depth of permafrost roof under water layer. As a result of drilling next conclusions were made:

1) The thickness of the seasonal frozen layer (when the frozen deposits are underlain thawed ground) reaches 3 m. The width of the longshore zone of seasonal frozen ground is about 70 m. The temperature of the seasonal frozen layer varies from –0.3°C to –1.5°C.

2) Permafrost roof plunges from a depth of 3 m near the shore line to 11 below the bottom of the Gulf of Ob at a distance of 400 m from the shore line.

3) The width of the contact zone of fast ice with bottom depends on the topography and incline of the submarine coastal slope and snow cover and fast ice thickness. If the thickness of fast ice is about 2 m, width of contact zone varies from 100 m at a relatively steep-bottom shores up to 300 m on the shallow shores.

Drilling in the area of Varandey was taken in July 2012 at different landforms of Pesyakov Island (beach, laida, coastal barrier and dune belt) to determine depth of permafrost roof and temperature of frozen ground. As a result of drilling next conclusions were made:

1) Active layer thickness ranged from 0.8 m at high laida to 2.2 m on a flat sandy surface of the coastal barrier and 4 m at the top of the dune belt. The average height of the top of the permafrost core of the island ranges from 1 to 2 m above sea level, rising on positive forms of relief (on avandune – up to 2,5 m above sea level) and sinking near the coastline below sea level.

2) The main feature of the geocryological structure of Pechora Sea coast are cryopegs which observed at a depth from 0,3 to 4 m below sea level.

3) The temperature of the top of permafrost at laida in summer is –1°C...–2°C. In the same time the temperature of the top of the permafrost at avandune (which located closer to open sea) in summer does not fall below 0°C. Probably, this is due to the warming effect of the sea.

Zone and Regional Features of Bolshezemelskaya Tundra Cryolithozone: Results of Landscape and Geocryological Multi-Scale Mapping

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On the basis of landscape and geocryological large-scale researches covering a considerable part of Bolshezemelskaya Tundra we made the survey of geocryologic map M 1:1 000 000. The basic method is a landscape indication. The spatial variability of geocryologic characteristics was reflected at the levels of natural subzones and groups of the dominating stows. The analysis of morphological structure of genetic landscapes allowed to reveal stows-indicators the occurrence of which means the transition from one geocryologic subzone to another.

There are all permafrost zone types present at Bolshezemelskaya Tundra. It is possible to consider that the subzone of continuous permafrost distribution corresponds to subzones of typical and southern shrubby tundra, the subzone of discontinuous permafrost distribution corresponds to the northern forest-tundra, massive and island zone zone - to the southern forest-tundra, island zone - to the northern part of the Extreme North taiga. On the coast of the Barents Sea there is a line of azonal seaside landscapes; along the large rivers there are intrazonal landscapes (a valley complex). The borders between geocryologic subzones are uneven that is caused by the zonal and regional factors which interfere on them.

8 main genetic landscapes have been identified (sea level is 55–330 m) as well as the landscapes of modern sea terraces, sea coast, river valleys. Within them 26 zone types of representative natural boundaries, which unite in the groups according to the character of vegetation, have been identified. The greatest number of natural boundaries types (19) is typical for subzone of discontinuous permafrost distribution; the smallest number (10) is - for the subzone of island permafrost distribution. The same natural boundary you can meet in different subzones (about 8–11 "general" natural boundaries for the neighboring subzones) thus, its geocryologic characteristics differ.

Within each geocryologic subzonethere are sites with a characteristic combination of various groups of natural boundaries: 23 combinations for zone landscapes, 5 are for intrazonal and azonal. Each contour on the mapis characterized by a set of geocryologic characteristics: an interval of temperatures and their background values, permafrost distribution on the area, developmentlevel of taliks/permafrost of not merging type, type of cryolithogenesisof the top part of the soil section, a complex of modern cryogenic processes, depths of seasonal frost/ thawing penetration (active layer). As an additional component it is presentedhere the localization of especially protected natural territories dated for cryolithozone.

In general within Bolshezemelskaya Tundra the geocryologiczonality is formed according to landscape; it is shown in distribution of frozen rocks on the area and in their temperature condition to a lesser extent. The last one substantially is defined by landscape conditions at the level of natural boundaries. Even in the continuous permafrost the rock temperature rises up to 0°C.

The active layer isn't correlated with landscape zonality according to the depth but is accurately connected with natural boundaries; first of all with rock structure, ground covers and a mesorelief. Cryogenic processes and a cryogenic structure partly correspond to landscape zonality but substantially depend on regional landscape categories.

About Two Levels of Cryogenic Structures in Central Parts of Interglacial Area of the West-Siberian Plain during the Last Glaciation.

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In cover of Last Glaciation (Würm, Valdai, Sartan, MIS-2) in Western Siberia was very insignificant and spread it only on shelf of the Kara sea (Svendsen et al., 2004, Velichko & Nechaev, 2009, Astakhov, 2011, 2014 etc). However permafrost in that time was spread from the Ice Sheet boundary to the Southern Mountainous Belt of Siberia, i.e. to mountainous glaciation (Aubekerov, Chalikhyan, 1974, Aubekerov, 1992, Volkova et al., 2002, Velichko & Nechaev, 2009 etc). Recent continuous permafrost in Western Siberia reaches the Polar Circle (Brown et al, 1997). In the continuous permafrost zone cryogenic structures (ice and ice-soil veins, soliflуctions etc) were formed both during Sartan time and Holocene (Vasilchuk, 2007). At present such structures are formed in mountains surrounding the West-Siberian Plain. On the Plain itself in the foothills cryogenic structures in Sartan time formed several levels, maximum up to seven levels near Aksor Lake in upper stream of the Irtish-River (Zykina & Zykin, 2012). Only one level cryogenic structures of Sartan time is distinguished on the rest part of the West-Siberian Plain (Aubekerov, 1990, 1992, Volkova et al., 2002 etc). They are presented by occasional pseudomorphs on ice and ice-soil veins (Aubekerov, 1992, Laukhin et al., 2012, Larin et al, 2012 etc), which are spread on south-western part of the Plain till 55°11’ N, 64°59’ E (Galishowo section), but further south on south-eastern part of it. Pseudomorphs on ice veins of Sartan age forming polygonal net in Vinzily section 56°55’ N, 65°49’E were examined later (Larin et al., 2013). Other cryogenic structures are known in some section series of West-Siberian Plain, but they can not be referred to Sartan time, because have not such dates.

In upper part of Kotochigi section (56°49’ N, 70°56’ E) located on Irtish-Ishim dividing approximately on the same distance from cover glacier boundary on the Kara shelf and from mountainous glaciation of the Altai-Saiany Mountainous Region, we (Larin et al., 2014) observed two levels of cryogenic structures of Sartan time. Buried soil whose age is 25090±1270 years according ^{14}C data (LU-7265) embed there from top to bottom in the depth interval from 4.3 m to 4.5 m. This buried soil is greatly disturbed by solifluction (lower level of cryogenesis). In the interval 4.08–4.3 m flat-laying lake sand with plenty mollusks typical for warm climate underlay (Laukhin et al, 2015). Lake loams overlay. Occasional pseudomorphs on ice-soil veins (upper level of cryogenic structures), which according to their manner of occurrence, composition and stratigraphic position are similar to pseudomorphs in Galishovo section, can be evidenced in the depth interval from 3.2 m to 4.08 m. Due to the fact that Sartan cover glacier on the West-Siberian shelf was short-lived and covered not a great territory, its traces and stages are not very much investigated. That is why the stages of Sartan cover glacier in Siberia could leave more evident traces just in driftless area particulary in the form of different levels of criogenetic structures.

Work was supported by RFBR grants №№ 13-05-00854 and14-05-00956

Yedoma Distribution in the Coastal Lowlands of Yakutia

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Yakutian coastal lowlands formed as a result of thawing Late Pleistocene ice-rich Ice Complex (IC) deposits in Holocene. The climate warming in the end of Pleistocene – beginning of the Holocene contributed to the activization of thermokasrt, which has become the leading relief-forming factor during the Holocene. The spatial distribution of Yedoma formed by Ice Complex deposits is important for the understanding of the development of the territory in the past and present times, for the monitoring studies and assessment the content of organic matter to predict the emission of greenhouse gases. Objective assessment of the Yedoma distribution for most territories of IC deposits spreading is still absent.

The study region is lying mainly in the watersheds of the Kolyma and Indigirka rivers and encompassing the tundra and northern taiga zone of the Kolyma Lowlands and the eastern part of the Yana-Indigirka Lowlands. The total area of the study region occupies about 95000 km^2.

According to the Decisions of Interagency Stratigraphic Committee [1987] and the Geological State Map [2000] the area was divided into three regions: Region 1 – East of Yana-Indigirka Lowland, Region 2 – Bolshaya Chukochya and Alazeya river basins, Region 3 – eastern part of Kolyma Lowland. The mapping of geological features was done manually based on the Landsat 7 ETM+ and Landsat 5 TM images. The allocation of the geological units was done based on the spectral characteristic of the image (bands RGB 543), morphology of the relief features, absolute heights and information from the State Geological Map of scale 1:1000000. The Quaternary deposit levels from the State Geological Map were grouped by their genesis: Yedoma, Alas, alluvial, alluvial-marine, marine and bedrock.

Most part of the area is covered by alases (46.8%). Yedoma represent 13.2% of area and 21% are alluvium. 16.2% of the study area is represented by alluvial-marine deposits, 2.1% - marine plains and 0.4% of area is located by solid rocks. Regions 1, 2, and 3 represent 34, 42, and 24% of total area respectively. Alases dominate in area within the Region 1 (East of Yana-Indigirka Lowland) and Region 2 (Bolshaya Chukochya and Alazeya rivers basins) and covers 37% and 72% respectively. The maximum area of Yedoma is also in Regions 1 and 2. Within the Region 3 (eastern part of Kolyma Lowland) the area of Yedoma and alases is the same (11.5% and 16.5%), whereas East of Yana-Indigirka Lowland and Bolshaya Chukochya and Alazeya rivers basins alases dominate yedoma (37 vs. 14 %) and (72 vs. 13.5 %) respectively. This distribution of alases and Yedoma is explained by the predominance of relatively elevated foothills in the East of Yana-Indigirka Lowland and eastern part of Kolyma Lowland in contrast to Bolshaya Chukochya and Alazeya rivers basins where low-lying plains are dominated.

Megaformations of the Ice Complex and Massive Ice Beds: Geography, Origin and Interrelations

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Late Neopleistocene history of high-latitude areas of the cryosphere was marked by the forming of the most spectacular in terms of scale of underground ice formation and the most widespread syngenetic formations that have survived to the present time – the Ice Complex and formation of Massive Ice Beds. The first one is confined to areas of extremely continental cold climate at the north-east of Eurasia, at the south of the New

Siberian Islands archipelago and in Alaska, the second – to areas of temperate marine cold climate in the north-east of the European part of Russia, at the north of Western Siberia, in the northern part of the New Siberian Islands and in the Canadian Arctic. Ice Complex is spatially and stratigraphically attached and overlap with gradually transmission the Massive Ice Beds formation. The area of the Ice Complex distribution in the northern Yakutia on the north is outlined by zone of distribution of Massive Ice Beds formation. All data support the space-time connections and parageneses between these phenomena.

The time of accumulation of the Ice Complex was characterized by extremely severe, very dry climate. At the same time the high ice content is an evidence of abundance of water in freezing sediments. This led to a deep cooling of the upper horizons of the lithosphere and to the formation of enormous amounts of ice wedges. But in modern cryosphere there is no similar phenomenon of such broad ice wedges formation. Thus, in addition to excess cooling, some other characteristics of the environment are necessary. The works of V.I. Solomatin (1986, 2013 and others) contain theoretical and empirical data that clearly indicate the buried glacier nature of the Massive Ice Beds formation in a number of areas of cryolithozone, which are characterized by cold, but, in contrast to the area of the Ice Complex, temperate marine climate. The combination of low temperatures and sufficient rainfall resulted in the accumulation of subaerial glacial formations and significantly reduced freezing and ice formation in the upper layers of the lithosphere, i.e., of cryolithozone.

As a working hypothesis we propose the following relationships between two megaformations. Late Neopleistocene cooling caused the formation of terrestrial glaciation in the Arctic regions with temperate maritime climate. In the vast Eurasian continent favorable conditions for this were formed in the western Atlantic sector of cryolithozone and along the northern coast of Eurasia, which during Late Neopleistocene aligned on the outside edge of the dry Arctic shelf and ended on the eastern coastal Chukotka. Glacial formations apparently weren’t thick and probably were quite passive, according to the relatively unimpressive traces of glacial exaration in most regions of the Eurasian Arctic. However, these glacials were a kind of dam and impounded the river flow in the Arctic basin. Most of the year there was no runoff from the frozen continent. On the vast territory in the Late Neopleistocene dry shelf the shallow dammed pool arose, or a series of basins separated by narrow strips of land. Fine-grained sediments, accumulated in this basin(-s), were carried away here from the south down from the mountains framing by the less active, short-term runoff having a significant component of sheetwash. V.V. Kunitskiy (2006) supposed nivation agents and sheetwash to be the main factors of Ice Complex lithogenes. The sediments accumulated in shallow basins with short ice-free period and with shallow permafrost top, became frozen almost simultaneously with the accumulation process. This provided increased segregation ice accumulation, active thermal contraction cracking and the growth of large ice wedges. Wedge and segregational ice, which often composed more than a half of the deposits, contributed to the increased speed of syncryogenic process and to the growth of sedimentation surface.

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Paleogeographic Conditions of Kysyl-Syr Sand Complex Sedimentation

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Sand complexes (Yakutian “Tukulan”) of Vilyuy river basin, Central Yakutia, are unique permafrost-related landscapes. Tukulans consist parabolic dunes of different orders. It characterized by variable composition and combination of alluvial and eolian sand deposits with lacustrine-boggy and buried soil horizons, plant and wood remains, and uneven-aged cores [1]. It specifies that tukulan’s origin is connected with climate changing. The aim of this paper is disclose genesis and sedimentation conditions of tukulans using results of grain size and micromorphological analyzes, cryogenic texture analyze of its sediments, and radiocarbon dating.

Provided radiocarbon dating of organic matter was used to determine the timing of sand complex “Kysyl-Syr” formation period. It was formed during last 40-50 kal. This period covers second half of the Late Pleistocene.

In lower part of the profile, crosswise sand and sandy loam overlay peat horizon having age about 55 kal. Grain size analyze and quartz grain micromorphology specify eolian genesis of sand and sandy loam, and it happened in arid conditions climate under processing of flood plain sediments.

Over with stratigraphic discontinuity sustained frozen horizon of lacustrine sediments overlays. This horizon has horizontal and convolute bedding with polygonal structure. Polygonal grid has 8 m in in length and 10 m in width. Over with also stratigraphic discontinuity well sorted sub-horizontal sand sustained with eolian or flood plain-eolian genesis. Stagnant basin sediments (sandy loam) overlay this horizon with stratigraphic discontinuity. Stagnant basin sediments have attributes of periodic desiccation and formation of polygonal grid, deflation, frost heaving and subdivision. In upper part of the profile, this horizon is overlaid with peat deposit (0.5-2 m). Its formation relates to Atlantic interval of the Holocene. Climate was more humid. This led to vegetation development and sand complexes stabilization, and reduction of eolian activity areas within this region. Complex of modern active blowing sand complete this profile. Radiocarbon dating of buried trees showed 30-100 years. It indicates on high activity of sand complex formation from the end of Little Ice Age.

Thus, composition of tukulan “Kysyl-Syr” is unique and variegated. Sediments change from aquatic to aerial, uneven-aged epigenetic cores and peat horizon. It characterizes high activity of cryogenic and eolian processes during The Late Pleistocene and Holocene. It’s necessary to study these phenomena in future using palynological, diatomaceous, geochemical methods to provide paleoreconstruction of climate changing during Late Pleistocene and Holocene. In this region.

Research supported by project of RFFR # 15-45-05129 r_vostok_a.

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