Permafrost researchs report of Russia 2019

The main results

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Earth Cryosphere Institute, Tyumen Scientific Centre, Siberian Branch, Russian Academy of Science (**ECI Tyumen Scientific Centre SB RAS**) **http://www.ikz.ru/**

1. Vasiliev, D.S. Drozdov, G.V. Malkova, A.G. Gravis, G.E. Oblogov ,
A.A. Gubarkov, Yu.V. Korostelev, O.E. Ponomareva, M.R. Sadurtdinov, I.D. Streletskaya,
D.A. Streletsky, E.V. Ustinova, R.S. Shirokov. **Permafrost degradation: the results of many years of geocryological monitoring in the Western sector of the Russian Arctic // Earth`s Cryosphere, 2020. No. 2 (accepted in print).**

Based on the long-term data monitoring of the permafrost zone of European North and North of Western Siberia, a new previously unknown natural phenomenon has been revealed - the widespread degradation of permafrost and the lowering of its upper table by 4-10 m due to climate changes. In the zone of northern taiga and forest-tundra, permafrost thawing from above proceeds most actively at speed up to 0.6 m / year. In the zone of the southern tundra, the permafrost is generally prepared for active thawing. Here, the thawing rate is 0.1 m / year. In the zone of a typical tundra, the permafrost remains stable and according to forecast estimates will remain stable for about 10-20 years. An assessment a diagram map of the permafrost state of the Western sector of Russian Arctic has been compiled (Fig.).

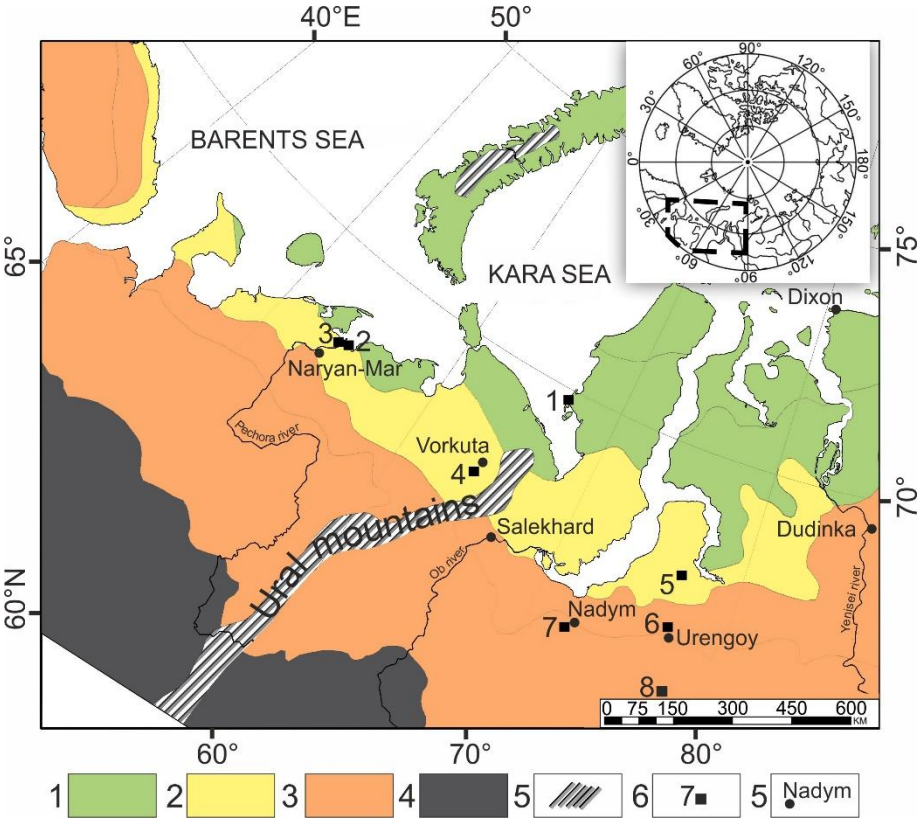

Fig. Diagram map of the permafrost state of the Western sector of Russian Arctic
The regions in which permafrost changes within an acceptable framework are highlighted in green. The yellow regions indicate the beginning of permafrost degradation and the decreasing bearing capacity of the foundations. Regions in which permafrost is actively degrading and

lowering its upper table are highlighted in orange. All large cities in this zone are at risk; dangerous deformations and even destruction of buildings and structures are possible here.

2. Studies conducted since the discovery of gas emission craters (GEC) in 2014 in the Yamal Peninsula included field, laboratory, and remote sensing studies. The features of the landforms, specific geological section, the properties of frozen deposits in the areas where GEC appeared, and the depth to ground ice in their walls were determined. A conceptual model of GEC formation is proposed (Figure) and a map for assessing the territory by resistance to GEC formation is constructed. Main factors in GEC formation are the region of high gas saturation of the upper geological section, characteristic of the north of West Siberia, and the existence of thick layers of ground ice in the section that contribute to gas accumulation. The trend of permafrost temperature increase, accompanied by extremely high summer temperatures in some years, served as a trigger for the process.
A team of the Earth Cryosphere Institute Tyumen Scientific Centre SB RAS, Lomonosov Moscow State University, Scanex, VNIIOceangeology Institute, Institute of Microbiology RAS, Tyumen State University for the last 5 years worked on the problem of gas emission craters – new permafrost feature. Main publications are as follows:

1. Arefyev S.P. et al. 2017. Dendrochronologic reconstruction of gas-inflated mound formation at the Yamal crater location. Earth's Cryosphere XXI (5):107-119.
2. Babkina E.A. et al. 2019. Activation of Cryogenic Processes in Central Yamal as a Result of Regional and Local Change in Climate and Thermal State of Permafrost. April 2019. Russian Meteorology and Hydrology 44(4):283-290.
3. Dvornikov Y, et al. 2018. Terrestrial CDOM in Lakes of Yamal Peninsula: Connection to Lake and Lake Catchment Properties. Remote Sensing, 10(2), 2018, 167.
4. Dvornikov Y, et al. 2019. Gas-emission craters of Yamal and Gydan peninsulas: a proposed mechanism for lake genesis and development of permafrost landscapes. Permafrost and Periglacial Processes, 30, 2019:146–162.
5. Kizyakov A.I. et al. 2015. Sonyushkin A.V., Leibman M.O., Zimin M.V., Khomutov A.V. Geomorphological conditions of the gas-emission crater and its dynamics in Central Yamal. Kriosfera Zemli (Earth's Cryosphere), XIX(2): 15-25.
6. Kizyakov, A. et al. 2017. Comparison of Gas Emission Crater Geomorphodynamics on Yamal and Gydan Peninsulas (Russia), Based on Repeat Very-High-Resolution Stereopairs // Remote Sensing, 9(10), 2017, 1023.
7. Kizyakov, A. et al. 2018. Microrelief associated with gas emission craters: Remote-sensing and field-based study. Remote Sensing, (10) 2018: 677.
8. Savvichev A.S. et al. 2018. Microbiological Study of Yamal Lakes: A Key to Understanding the Evolution of Gas Emission Craters. GEOSCIENCES, 8, 2018, 478.

3. Joint Finnish-Russian project "Mechanisms, pathways and patchiness of the Arctic ecosystem responses and adaptation to changing climate" (ClimEco) holded its progress meeting on 5-6 March 2019 in Finnish Meteorological Institute (Helsinki, Finland). The Meeting's Agenda was including keynote presentations by leaders of Finnish and Russian project teams, discussion of them first results and planning further work in each Work Package. Dmitry Drozdov and Gleb Oblogov took part in the meeting from the Russian side from Tyumen State University. In particular, the results of data processing of more than 100 weather stations in the Russian Arctic and Subarctic region were presented. The distribution of the spatio-temporal variability of trends.

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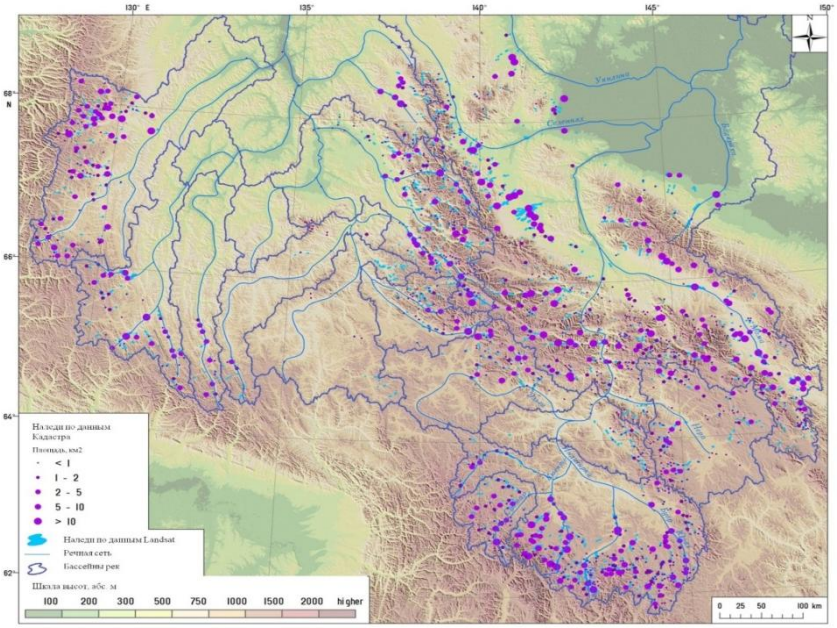
Melnikov Permafrost Institute, Siberian Branch, Russian Academy of Science (MPI SB RAS, Yakutsk) http://mpi.ysn.ru/en/

Selected Research Results

A detailed spatial geodatabase of aufeis (icings) within the Indigirka River watershed, Russia, was compiled by a team led by Olga Makarieva from historical Russian publications (Inventory of Icings in the North-East USSR, 1958), topographic maps, and Landsat images (2013–2017). The Landsat-based dataset includes 1213 aufeis fields with a total area of 1287 km^2. Over 600 icings identified from recent satellite imagery are missing in the 1958 Inventory. The total area of icings, including the giant Moma Icing, is 1.6 times less at present compared to the mid-20th century. The study suggests that the dynamics of icing extent can be a useful indicator for understanding climate change effects on hydrogeology and hydrogeology in remote permafrost regions.



Icings in the Yana and Indigirka River basins derived from the 1958 Inventory and recent Landsat images.

Field investigations by MPI continued in East Siberia, northern Tian Shan, Altai, and Verkhoyansk Mountains. Investigations in the northern Tian Shan included monitoring of active layer and permafrost temperatures in the Trans-Ili Alatau and observations of active rock glaciers, ice-cored moraines and meltwater in the Bolshaya Almatinka basin (Vasily Lytkin and Liudmila Lebedeva in collaboration with the Laboratory of Alpine Permafrost and the Kazakhstan Institute of Geography).

V.Lytkin, L.Lebedeva abd V.Goncharenko examining rock glaciers in the Trans-Ili Alatau, Northern Tian Shan, summer 2019.

Investigations in southern Yakutia continue as part of the MPI's basic project "Understanding the Development of Subsurface Temperature Fields and Permafrost in Major Tectonic Structures of the Siberian Platform (Principal Investigator: Mikhail Zhelezniak, D.Sc.). During summer 2019, additional sites were established in three Mesozoic basins, Tokorikan, Guvilgra

and Ytymja, within the Aldan Shield to expand the network of ground thermal monitoring stations. Fieldwork also included installation of automatic weather stations, geobotanical description, and stream water sampling for chemical analyses.

An automatic weather station with ground temperature measurements in the Ytymja River area.

A field team comprising landscape scientists, hydrogeologists, geochemists, and geophysicists conducted surveys along the Power of Siberia Pipeline route during the spring of 2019. This field campaign was a second stage of the contract project aimed at assessing potential permafrost-related hazards associated with pipeline construction and climate change (2018-2020, Principal Investigator: Vera Samsonova). Specifically, field work included forest-ROW-embankment snow surveys along the pipeline corridor, UAV topographic mapping of icings and valleys, icing water sampling, hydrological measurements of streams and icing meltwater, and direct observation of natural and pipeline-induced icings for spatial and genetic characterization. These studies provide baseline information on permafrost hazards along the Power of Siberia Pipeline corridor and will be continued during pipeline operation.

Aerial view of Bolshaya Cherepanikha valley crossed by the Power of Siberia Pipeline, March 2019.

A team led by Alexey Galanin continued sampling and analysis of stable isotopes (O^{18} and D) of rain, snow, ground ice, surface water, and ground water from the sand dune areas in central Yakutia as part of the RFBR and SB RAS-funded projects to study the origin and evolution of Late Quaternary periglacial eolian sediments and landforms in North-East Asia. During the last year over 150 samples were added to the stable isotope database which now contains over 450 determinations.

A field camp on a sandbar on the Vilyu River, July 2019.

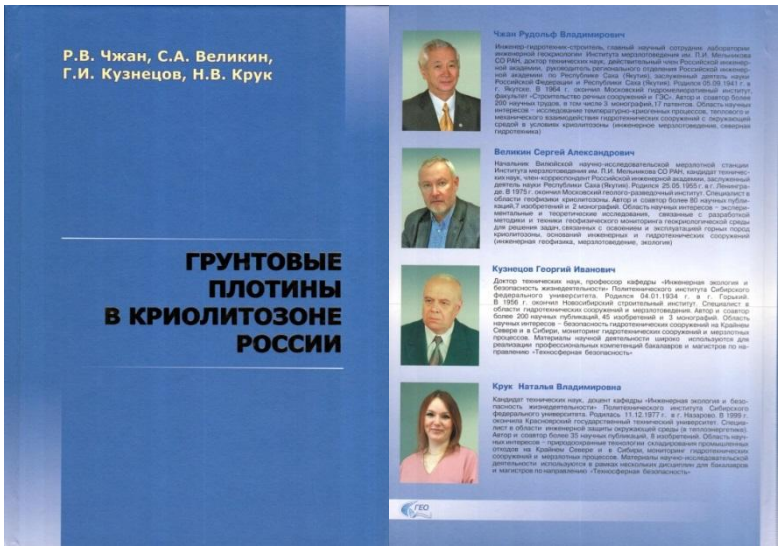
Experimental studies are in progress in a collaborative project with the State Key Laboratory of Frozen Soil Engineering (Lanzhou, China) funded by the Russian Foundation for Basic Research (RFBR) and the National Natural Science Foundation of China (NSFC). The project led by Mikhail Zhelezniak and Zhi Wen aims to compare the influence of convection flows of water and air on the thermal state of permafrost in the Aldan-Stanovoy Upland and the Tibetan Plateau. In the summer of 2019, Alexander Zhirkov and Anatoly Kirillin visited SKLFSE to take part in completing an experimental setup at 4600 m elevation on the Tibet Plateau.

Setting up an experimental system for monitoring rainfall influence on the ground hydrothermal regime, Tibet Plateau, summer 2019.

From 24 to 27 June 2019, MPI hosted the Russian Research and Practice Conference on Thermal Physics and Energy Engineering for the Arctic and Subarctic The conference was dedicated to the memory of Dr. Rev I. Gavriliev to honor his important contributions to permafrost and thermal sciences. The conference was attended by 118 participants representing research institutes and universities from Yakutsk, Moscow, St. Petersburg, Novosibirsk, Irkutsk, Omsk and Krasnoyarsk, as well as the regional government and energy industry companies. The Program Committee included Academicians Vladimir Fortov, Joint Institute for High Temperatures (Moscow), and Dmitry Markovich, Kutateladze Institute of Thermophysics (Novosibirsk), among other prominent scientists. Over 100 papers were presented in four sessions: 1. Thermal physics: theoretical studies (Thermo-mechanics and heat/mass transfer in multiphase systems); 2. Thermal physics: practical aspects for cold regions (Thermophysical properties of materials - research results, measurements, methods, equipment and automated systems); 3. Energy engineering (Thermal engineering. Energy supply. Efficient energy technologies for Arctic regions. Traditional and renewable energy sources); and 4. Geo-thermal physics (Permafrost studies. Mining thermal physics. Landscape thermal physics). Extended abstracts of the papers were published in print format before the conference.

A plenary talk by V.A. Stennikov, Melentiev Institute of Energy Systems, Irkutsk.

In November 2019, a 427-paged monograph "Embankment Dams in the Russian Permafrost Zone" by R.V. Zhang, S.A. Velikin, G.I. Kuznetsov, and N.V. Kruk was published in Novosibirsk by Geo Academic Publishers (in Russian). The monograph reviews the case histories of embankment dam construction for water supply and power generation purposes in the Russian permafrost region. The results of field studies are presented which document the thermal evolution of dams which rely on permafrost for structural integrity and seepage control. Environmental issues of dam construction and operation in a changing climate are addressed. The role of geocryological monitoring and its implementation are discussed, along with geophysical methods that are capable of early detection of potential seepage through permafrost. Thermophysical principles of tailings dam performance are considered and guidelines are provided for their construction, operation and maintenance in permafrost regions. An innovative hydraulic well mining technology for dam construction is presented, as well as ways for using Earth's cryogenic resources for dam stability improvement. A location map of embankment dams and description of their current condition are provided. The book is intended for researchers and hydraulic engineers involved in dam design and operation in permafrost regions.



Cover of the book "Embankment Dams in the Russian Permafrost Zone" by R.V. Zhang, S.A. Velikin, G.I. Kuznetsov, and N.V. Kruk, 2019, Novosibirsk: Geo, 427 pp.

In 2019, three young MPI researchers successfully defended PhD dissertations. The doctoral study of Yana Tikhonravova focused on the structure and texture of wedge ice in the northern Gydan Penisula and the Pur-Taz Watershed, West Siberia. Alexander Zhirkov completed and defended his dissertation titled "Influence of Rainfall Infiltration and Internal Condensation on the Ground Thermal Regime in Central Yakutia". Based on the results of manipulated experiments at the Tuymaada monitoring site, the study demonstrated the significance of non-conductive heat transfer by water and water vapor and quantified the effects on the ground

thermal regime. The PhD study by Svetlana Kalinicheva titled "A Method for Identifying Frozen and Unfrozen Ground in the Mountainous Regions of Southern Yakutia Using Thermal Satellite Imagery" showed that the late summer land-surface temperature (LST) derived from satellite images can be used as a reliable indicator in mapping the occurrence and distribution of mountain permafrost.

Alexander Zhirkov, Yana Tikhonravova and Svetlana Kalinicheva after the public defense of dissertations, November 2019.

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The studies of 2019 were conducted in a number of directions, traditionally distinguished in the scientific research of the Department of Cryolitology and Glaciology.

Cryolithological research:

V.V. Rogov continued his study of loess cryogenic properties in Russia. The results of cryolithological analysis confirmed the role of cryogenic factors in formation of loess deposits in the Lower Volga region (Rogov et al., 2019b).

The study of the isotopic composition in various water categories in finely dispersed soils was carried out. It was shown that bound water (unfrozen in the frozen state) has excellent isotopic composition characteristics in contrast to free (bulk) water (Rogov et al., 2019a).

N.A.Shpolyanskaya obtained and analyzed data, confirming the natural kind of ongoing modern climate changes (Shpolyanskaya, 2019). The published monograph represent the results of a study about Late Cenozoic history of permafrost zone in the Russian Arctic continent and shelf.

I.D. Streletskaya (2019) obtained new data on permafrost relicts and pseudomorphs distribution on melted polygonal vein ice in the Lower Volga and Ural regions. For interpreting the sections of loose sediments cover in permafrost distribution areas, the main differences between permafrost structures and seismic dislocations were formulated.

In the north of Western Siberia and Yakutia was made a study of cryolithological structure of permafrost sections with underground ice inclusions. It has been established that methane concentration can be used as an indicator of occurring permafrost processes, including thawing and redeposition of rocks (Fedin et al., 2019). The data on the cryogenic structure of Quaternary sediments, including underground ice, were summarized for the Yamal and Gydan Peninsulas (Pismenyuk et al., 2019).

Kizyakov A.I. and Streletskaya I.D. with colleagues analyzed the characteristics of chemical, isotopic and gaseous composition of annual sea ice, according to core data from BARNEO drifting stations for 2013–2015. (Kizyakov et al, 2019b). The possibility of using data from composition of salts in polygonal vein ice for paleogeographic reconstructions in the Arctic with the restoration of the position of the coastline is proposed.

Yu.B. Badu and K. Nikitin show confinement of pingos to gas-bearing areas in the north of Western Siberia (Nikitin, Badu, 2019).
Based on the analysis of a data complex, morphodynamic zoning of the Kolguev Island shores was performed (Kizyakov et al., 2019a).
V.I. Grebenets, F.D.Yurov and V.A.Tolmanov identified regional aspects of cryogenic processes and infrastructure interactions (Yurov, Grebenets, 2019). For large settlements in the Yamal-Nenets Autonomous Okrug, the degree of damage to the territory by cryogenic processes and danger level for buildings and structures by geocryological processes were estimated (Tolmanov, Grebenets, Yurov, 2019).
Special studies were conducted to assess the destructive effect of large man-made dumps moving similar as rock glaciers (Grebenets et al., 2019, a). Information on the storage of wastes in permafrost zone is generalized and their negative impact on the geocryological conditions of economically developed territories is estimated (Grebenets et al., 2019, b).
Snow surveys were carried out in residential areas of Norilsk, the largest industrial center in the permafrost zone (Grebenets et al., 2019, c); it was revealed that snow dumps with a height of more than 2.5 m, that are actually formed annually at the same places, often have a destructive effect on permafrost and contribute to the activation (during snowmelt) of dangerous cryogenic processes, primarily thermokarst and thermoerosion.
N.V. Tumel and L.I. Zotova summarized the results of many years of work by scientific team on geoecological research in the permafrost zone (Tumel, Zotova, 2019). A number of conceptual provisions have been proposed for assessing and mapping geoecological situations in case of anthropogenic surface disturbance in the Russian Federation cryolithozone from the point of view of landscape stability to activation of dangerous cryogenic processes. For the first time, a step-by-step procedure for diagnosing permafrost-ecological situations on a regional-regional scale using the methods of landscape indication, interpretation, expert estimates and statistical calculations is shown.
L.I. Zotova and A.Donetskov conducted a multivariate expert assessment of the geosystems lithocryogenic resistance to development of dangerous exogenous processes using weight coefficients and an interval cent scale. Medvezhye key site was selected as example (Donetskov, Zotova, 2019).
V.I. Grebenets and A.A. Maslakov carried out annual monitoring work to study the dynamics of seasonal thawing of grounds as part of the CALM (Circumpolar Active Layer Monitoring program) program at sites in the Talnakh region (in the north of Krasnoyarsk Territory) and in Eastern Chukotka.
The 20-year series of observations on seasonal freezing of grounds in Central Russia was continued by V.I. Grebenets at the Zvenigorod Biostation of Moscow State University.
In the atlas-monograph “The Russian Arctic: Space. Time. Resources ”(2019) were published a series of maps on the distribution of permafrost and glaciation in the Arctic, prepared by the Cryolitology and Glaciology department.
Glaciological research:
Under the leadership of V.V. Popovnin a complex of 4-month field work was carried out in the basin of the representative mountain glacier Dzhankuat in the Central Caucasus (Rets et al., 2019). The most important indicators of his condition for the 2018/19 balance year were calculated. The accumulation and ablation modulo 15-18% exceed their long-term average values, so that the final mass balance turns out to be negative (-400 mm), which means a net decrease of mass by about 120 mm more than the average for 50 years. A dynamic increase of surface moraine cover was revealed in the upper part of the ablation region.
For Kyrgyz glaciers of the Inner Tien Shan (Karabatkak, Sary-tor and Bordu) V.V. Popovnin calculated the negative values of their material balance. Data on the retreat of the De los Tres glacier in Patagonia is obtained.
D.A. Petrakov and N.V. Kovalenko continued field research on the Kolka glacier. It was established, that in 2014–2017 the surface of Kolka glacier increased by an average of 2.2 m per year, it contrasts sharply with a decrease in the surface of the Dzhankuat and Garabashi glaciers, which are representative for the Caucasus. Since 2002, the Kolka glacier continues to gain mass against the reduction of other Caucasian glaciers (Aristov et al., 2019).
D.A. Petrakov continued his cycle of work on the study of the Tien Shan glaciation (Petrakov et al., 2019). The catalog of Ak-Shiyrak massif glaciers was created as of 2018. In the Ak-Shiyrak massif, small glaciers located on the slopes of the southern exposure are most rapidly

shrinking. Faster shrinking of small glaciers, compared to large, observed throughout all high mountain Asia. Against the background of shrinking glaciers, the onset of technogenic rock glaciers continued. They are stacked with ice, displaced from Davydov glacier, and waste rock (Shpuntova et al., 2019).

N.V. Kovalenko conducted expeditionary glaciological studies on glaciers of the Aktru basin (Altai). This glacier was reference for the World Glacier Monitoring Service (WGMS), but all observations was abandoned in 2012. This year the mass balance operations on the Leviy Aktru glacier have been resumed.

In August 2019, V.V.Popovnin and N.V. Kovalenko, with the participation of students and graduate students of department, conducted expeditionary research on the glaciers of the northern ledge of the Lama mountains, Putorana plateau (Uspenskaya et al., 2019).

M.N. Ivanov in the Polar Urals carried out field glaciological studies on the Obruchev and Chernov glaciers, for the first time since 2010 (Nosenko et al., 2019).

N.A. Volodicheva and A.D. Oleinikov continued snow-avalanche studies to detect changes in snowfall and avalanche activity at the Elbrus educational and scientific base of Moscow State University. A decrease in the degree of avalanche activity has been established due to predominance of snowy, warm winters in the last decade with a peak in snow accumulation and avalanches in the spring (Oleinikov and Volodicheva, 2019). The past winter season has been identified as mid-snowy and abnormally warm.

The collection and processing of data on the most significant avalanches in the Khibiny mountains was continued. Winter 2018-2019 characterized by average snow cover thickness of 120 cm and an average degree of avalanche activity of about 100 avalanches in 40 avalanche runout zones near the city of Kirovsk. Especially large avalanches, that go beyond the average values, were not found during the routes along the Khibiny. As part of the GIS “Khibiny Avalanches” and the collection of data on snow avalanche victims, an assessment and analysis of changes in social and individual avalanche risk in the Khibin territory was conducted (Vikulina, 2019).

Student practice, field schools:

Traditionally, second-year students practice in the north of Western Siberia (practice in cryolithology) and in the Caucasus (practice in glaciology).

Under the guidance of V.I. Grebenets and D.A. Streletsky, the International Arctic Field Courses on permafrost and north science were held in conjunction with the Department of Geography of George Washington University. Students studied the landscape-permafrost features of Alaska in various geographical zones (northern taiga, forest-tundra, southern, typical and northern tundra) and geological and geomorphological conditions: mountains, foothills, coastal plains. Monitoring work was conducted to study the dynamics of seasonal thawing and its geographical differentiation from south to north.

Under the leadership of M.N. Ivanov and M.A. Vikulina, a winter expedition of the scientific student society was held at the Khibiny educational and scientific base of Lomonosov Moscow State University. The studies were conducted as part of the study of winter snowfall and avalanche activity in a changing climate. In the process of work, stationary and route observations were carried out.

A 20-year series of observations on seasonal freezing of soils in Central Russia was continued. Traditionally, under the guidance of V.I. Grebenets, with the participation of V.A. Fedin, two trips of the winter training school were organized and conducted - field educational seminars of the Department of Cryolithology and Glaciology based on the Zvenigorod Biostation of Lomonosov Moscow State University.

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«Georadar - 2019»(13-15 of march 2019) is a Russian scientific-practical conference. It is the new way of the previously held GPR-oriented conferences at the Moscow State University in 2000s. The official program of the "Georadar - 2019" conference includes a master class on GPR, an exhibition of geophysical equipment and software, presentations, field demonstration of modern GPR equipment and software, and discussions.

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http://geoenv.ru/index.php/ru/

As a result of field and laboratory studies conducted by the Institute of Geoecology of the Russian Academy of Sciences, the fundamental possibility of filtering greenhouse gases in permafrost with increasing temperature has been proved. The studies are of high importance in connection with the modern hypothesis of the growth of greenhouse gas emissions into the atmosphere of the Arctic during thawing of permafrost soils. The results show that the emission of greenhouse gases into the atmosphere begins earlier than the complete thawing of soils. This circumstance must be taken into account when making forecasts of greenhouse gas emissions from permafrost under the influence of global climate warming and the technogenic impact of engineering facilities.
Moscow State University and IEG RAS realized together with Norway the second stage of Russian-Norwegian project "Research-based Education in Cold Regions Engineering"

(RuNoCORE). Moscow State University and NTNU has long history of research cooperation on Arctic and cold region engineering that could give better education to students at both universities. Through this cooperation, we have better understanding about culture and traditions that should be spread to students. The main activities in the project is to invite Norwegian students to fieldwork in northern part of Russia and to arrange an intensive course in both countries for students from Russia and Norway. In reality, this project became international in 2019 (Fig. 1). Students from Greenland, Denmark, Italy and Norway participated in educational and scientific practice. Interexchange of research methods and teaching practices promotes a future common understanding of the trends of landscape changes and infrastructure risks in the Arctic (Fig. 2).

Fig. 1. International student team near Khanovey Station.

Fig. 2. Permafrost affects the railway near Vorkuta.

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Institute of Physicochemical and Biological Problems in Soil Science, RAS (Soil Cryology Laboratory)(Pushchino, Russia) http://www.issp.psn.ru/

1. The results of the “Exobiofrost” experiment aboard the BION-M1 biosatellite showed that the impact of space flight factors (ionizing radiation, g-force, and temperature fl uctuations) did not lead to complete sterilization of the permafrost samples. According to the Post-flight analysis, a signifi cant part of the bacterial community has remained viable after the space experiment. A comparison with control samples showed that modern tundra colpodas are more resistant to the eff ects of space conditions, than representatives of ancient permafrost, and that *Colpoda steinii* strains are more resistant than ciliates of the *Exocolpoda augustini* species. The greatest resistance to space flight conditions demonstrated by acanthamoeba cysts (*Acanthamoeba* sp.) allows to view them as model organisms for both the Earth and space experiments in future.

2. The diversity of anaerobic and aerobic microorganisms (prokaryotes) was studied in permafrost soil sampled at a depth of 0.5 to 3.7 m during the 2016 expedition of the State Scientifi c Centre of the Russian Federation the Arctic and Antarctic Research Institute (AARI). The estimated number of organotrophic microorganisms varies from 3.29 ·10 to 7.0 ·104 CFU ·g–1 for aerobic, and from 3.0 ·10 to 2.3 ·104 cell ·g–1 for anaerobic organisms. In separate anaerobically cultivated samples, methane and acetate were observed, while sulfate and iron reducing prokaryotes were detected in none of the samples. In the course of research, 60 strains of aerobic psychrophilic and psychotolerant bacteria were isolated. The taxonomic position of the isolated microorganisms was established by sequencing the 16S rRNA genes and using MALDI mass spectrometry. The created collection of strains consisted of representatives of the *Actinobacteria*, *Firmicutes*, *Betaproteobacteria* and *Gammaproteobacteria* phyla.

3. This study summarizes seasonal thawing data collected in different permafrost regions of northeast Asia over the 1995–2018 period. Empirical observations were undertaken under the Circumpolar Active Layer Monitoring (CALM) program at a range of sites across the permafrost landscapes of the Yana-Indigirka and Kolyma lowlands and the Chukotka Peninsula, and supplemented with 10 years of observations from volcanic mountainous areas of the Kamchatka Peninsula. Thaw depth observations, taken using mechanical probing at the end of the thawing season, and ground temperature measurements, were analyzed with respect to air temperatures trends. The data from 24 sites reveal different reactions of the active layer thickness (ALT) to recent changes in atmospheric climate. In general, there is a positive relation between ALT and summer air temperatures. Since the early 2000s positive ALT anomalies (compared with mean data from all sites) prevail in the Kolyma and Chukotka area, with only one alas site showing a negative ALT trend.

Abramov, A., Davydov, S., Ivashchenko, A., Karelin, D., Kholodov, A., Kraev, G., Lupachev, A., Maslakov, A., Ostroumov, V., Rivkina, E., Shmelev, D., Sorokovikov, V., Tregubov, O., Veremeeva, A., Zamolodchikov D. Zimov, S. Two decades of active layer thickness monitoring in northeastern Asia. ***Polar Geography*, 2019**. pp.1-17. https://doi.org/10.1080/1088937X.2019.1648581

4. From April 15 to April 18, 2019, the International Permafrost Conference: “Solving the Puzzles from Cryosphere” was held at the laboratory of Soil Cryology. The confere

nce was attended by 150 participants, including 12 from abroad. Conference materials are available on the laboratory website: http://cryosol.ru/images/phocagallery/conference/cryospherepuzzles/PushchinoPermafrost_ConferenceProgrammAbstracts2019_compressed.pdf

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http://www.irigs.irk.ru/

The study area is the Tunkinsky intermountain depression (south-western Baikal, Republic of Buryatia) – an area of island permafrost. Soil temperature is a key factor controlling many biotic and abiotic processes in soils. It is important to perform monitoring of freezindg and thawing regimes in peat and mineral soils. The object of study is umbric cryosol on sandy lake-alluvial sediments. The first study site represented by natural umbric cryosol under spruce forest, the second site soil was affected by anthropogenic activity (abandoned cropland) at 1960-s. During the last 20 years the croplands were abandoned and recovered by steppe grasses. Both sites are located on permafrost. The atmospheric-soil monitoring system was used to study the temperature regime of perennial and seasonal permafrost at both sites. Soil temperature observations were carried out in automatic mode in 1 hour from 1 July 2013 to 30 June 2017 in soil profile from surface to 320 cm depth. Anthropogenic influence at one of the sites led to differences in vegetation cover, soil moistening regime, and distribution of fractions of particle size along the soil profile. It was found that these differences are the cause of differences in the soil temperature regime, degradation of the permafrost and lowering permafrost top. Soil at abandoned cropland site is better warm up, then soil under the spruce forest. Maximum temperature on the surface of former cropland in the annual course is higher by 10 °C and at a depth of 320 cm by 5 °C. The minimum temperature on the surface in the annual course is 7 °C lower and at a depth of 320 cm by 1 °C. A warm period (soil temperature > 0 °C) on the surface of former cropland is longer by 22 days than in the natural site on average. The described differences are observed at all depths. As a result, permafrost is observed under the spruce forest below 130 cm (soil temperature is –0.2 ÷ –0.9 °C throughout the year). On the abandoned cropland site the zero isotherm during seasonal thawing drops much deeper than 320 cm, while the soil in the 240–320 cm layer warms up to 2–5 °C.

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The results of the most fundamental and advanced investigations, important results on the programs of the Earth Cryosphere Institute (ECI SB RAS) and of the many others Institutes and organizations specializing on permafrost/cryosphere researches are presented in the journal "Earth's Cryosphere" ("Kriosfera Zemli"). Journal is translated into English since 2014, all the articles are available online for free at the website of the journal: http://www.izdatgeo.ru/index.php?action=journal&id=8&lang_num=2. The abstracts of the most interesting papers are submitted for the consideration of readers.

1. The new key section of the Dolkuminskaya formation in the Viluy river basin and the history of the late quaternary dune formation in Central Yakutia

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The general cross-section of the Kyzyl-Syrskiy dune massif (tukulan) in the low stream of Viluy river (Central Yakutia) is studied on the base of 27 C-14 dates and biostratigraphy data. Based on key-sections of dune sediments in different districts of Central Yakutia, published by previously researches, as well as on Kysyl-Syrskiy key-section and new absolute age dates authors take an attempt to reconstruct of the Late Quaternary environment and the origin of aeolian landforms and sediments in the Region. Authors conclude these deposits are related to the Dyolkuminskaya Formation, which was formed through the Last Cryochrone (MIS 2) till the Holocene under conditions of severe desiccation and desertification of the territory. During the Boreal optimum of the Holocene (12-6 kyr), the dune cover was

stabilized with soil-vegetation cover. The modern dune massifs have been originated no more than 1 thousand years ago and associated with the climatic events of the Small Ice Age.

Dunes, aeolian formations, grain size analysis, dunes mineralogy, absolute age, palynology, cryolithozone, Dolkuminskaya Formation, Pleistocene, Quaternary period, Vilyuy, Central Yakutia, Eastern Siberia

2. Coastal dynamics of the Bering Sea, Lorino settlement, Chukchi AO, Russia

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The study presents the results of monitoring of the Bering Sea's coastal section near Lorino settlement. Studied coast is marine terrace scarp and has length of 750 meters. Quantity relationship between erosional bluff edge retreat rate and coastal zone parameters was analyzed; influence of thermo-abrasion and thermo-denudation on coastal destruction intensity and erosion rate of coastal deposits was assessed. There was revealed that studied coast section retreat rate was increased for the last 50 years in an order: from less than 0.5 $m \cdot a^{-1}$ in 1967-2010 to 4.2 $m \cdot a^{-1}$ in 2010-2017. Observed spatial differentiation of coastal dynamics is well explained by predominant destructive processes, coastal parameters and erodibility of the deposits, exposed to coastal erosion.

Thermal abrasion, thermal denudation, coastal dynamics, Lorino, Chukotka, Bering Sea

3. Ice dynamics and structure in the area of the snow-landing strip of Mirny Station, East Antarctica, based on the data collected in 2016-2017 summer and winter seasons

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Wide range glaciological and geophysical applied investigations in the area of the Russian Mirny Station (East Antarctica) were performed during the austral winter of the 61st RAE (2016) and austral summer field season of the 62nd RAE (2016/17). The visual and instrumental observations showed that the landing-strip site is completely safety for the aviation operations. The ice surface elevation chart with the accuracy of 15 cm was compiled based on collected geodetic data. The height varies from 37 m in the northern part to 71 m in the south-west. Results of the monitoring showed that the ice velocity varies from approximately 6 to 80 m/year. Multi-offset GPR soundings improved the dielectric permittivity model of the glacier and humidity to the depth of about 25 m in two points.

East Antarctica, Mirny Station, GPR sounding, multi-offset soundings, ice dynamics, ice sheet structure

4. Micromorphological features of quartz grains surface, Kysyl-Syr dune massive, Central Yakutia

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Micromorphological researches of quartz grains from Kysyl-Syr dune massive have been carried out. Analyze of roundness and dullness has been made. In addition, genetic groups of diagnostic elements on quartz grains surface has been allocated. Based on executed researches and results in this paper two stages formation of Kysyl-Syr dune complex has been allocated. During the first stage (more than 40 ka BP) fluvial processes of sedimentation is prevailed. Second stage of sedimentation (Late Neopliestocene – Holocene) is characterized with aeolian conditions.

Aeolian sediment, Neopliestocene, Holocene, micromorphological analysis, Central Yakutia

5. Permafrost ice content of frost mounds in Kheygiyakha river basin (feeder of Nadym river)

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[5] *Lomonosov Moscow State University*
In Western Siberia northern taiga "classical type" frost mounds with high ice content are widespread. Along with them, morphologically different forms of grumous relief are found. It differ from "classical" frost mounds in size and more flat form of top surface. To establish genesis of this flat top mounds total thickness of segregated ice schlieres and volume ice content at the expense of ice inclusions were analyzed. This information was received from core sample of ten-meters boreholes. To flat top mounds good correlation between surface height and volume ice content of constituent grounds was revealed. It has been found that flat top mound grounds have more high volume ice content than depression between them. These facts indicate to local ice formation and consequently testify that investigated landforms originated from cryogenic heave and are not thermoremnants.
Frost mound, thermoremnant, ice content, total thickness of segregated ice schlieres, local ice formation, volume ice content at the expense of ice inclusions

6. Three innovative proposals in the field of the construction on the continental Arctic Shelf.
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The problems of the construction, arising during the economic development of the Arctic seas' continental shelf for the purpose of the developing of carbon deposits are discussed. There are some ways to solve these problems with the help of new designs for ice and ice ground islands as well as with the mining boreholes that do not have any heat influence on the containing surroundings. These islands provide with high safety of mining and allow to develop water areas at such depths that are not available to steel and concrete fixed platforms.
Arctica, shelf, carbon deposits, economic development, above water and under water ice, ice ground island, ice island, mining borehole.

7. The influence of the summary heat borehole's group action on the parameters of the thawed arear at permafrost
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Earth Cryosphere Institute SB RAS, 625000, Tyumen, 1230, Russia, gorelik@ikz.ru
A calculation results on the determination of the thawed area parameters near the borehole's group at permafrost are important both to finding the minimal distance between outfalls of the boreholes and to taking into account the additional lauds on the borehole's support for guarantee its safety in the exploitation process. On the base of the calculation results for various external conditions it is shown (as opposed to prevail practice) the necessity of the taking into account the summary heat borehole's group action for the correct procedure of the determination the thawed area parameters. This factor is needed to take into account for all permafrost regions, but with moving to the North the inaccuracy in the calculations, connected with disregard of this factor, will be run up.
Frozen soil, thawing soil, borehole, thawed area parameters, vertical loads, distance between outfalls

8. Application of electrical resistivity tomography for frozen ground and saline permafrost identification
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In this article the results of electrical resistivity tomography surveys performed in several areas of the Yamal Peninsula are presented. The ultimate goals of the current study are acquiring information about the structure of near surface deposits and locating the saline soils. Through the simultaneous general geophysical information analysis, tomography data statistical processing, and advanced petrophysical modelling the authors were able to distinguish and map deposits with various salinity in this permafrost. There is provided procedure to estimate pore solution concentration according to resistivity of cross-section within the selected geomorphological levels.
Electrical resistivity imaging, electropetrophysical modelling, saline permafrost, near surface geophysics

9. An assessment of glacier albedo in the Ak-Shyirak massif (Inner Tian Shan) on the basis of ground-based data and images from Landsat satellites
D.A.Petrakov, O.V.Tutubalina*, A.M.Shpuntova*, N.V.Kovalenko*, R.A.Usubaliev**, E.A.Azisov**, P.G.Mikhailyukova**
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In the paper we present and discuss results of ground-based measurements and remote assessments of glacier albedo in the Ak Shyirak massif (Inner Tian Shan). Tendencies of decreasing albedo are typical for many glacierized mountain regions and lead to accelerated glacier downwasting. In the Ak-Shyirak massif the situation is complicated by technogenic dust pollution, whose contribution to albedo changes was unknown. Ground-based albedo measurements were carried out across 11 glaciers during summers 2015 and 2016 using Sp Lite 2 Kipp&Zonen albedometer. On the basis of ground albedo measurements of two glaciers we developed a model to correct albedo values obtained from satellite imagery. 27 images from Landsat satellites were selected to assess glacier albedo in the Ak Shyirak massif by weather conditions. In comparison to some other mountain regions we do not observe a decrease of glacier albedo in the Ak Shyirak massif since 1990s. Glacier albedo in the Ak Shyirak massif is driven by environmental factors, mostly by weather conditions prior to satellite survey, especially snowfalls, and elevation driving the snow melting. Technogenic impact (mechanical disturbance of glaciers within the Kumtor mine) is detected only locally, while technogenic dust on the background of natural dust is not traceable, with imagery from Landsat satellites, on glaciers across the Ak-Shyirak massif.
Albedo, mountain glaciers, Tian Shan, Ak-Shyirak massif, technogenic impact

10. Model study of mountain glaciers' evolution on the example of Sary-Tor glacier, inner Tien Shan

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[6]*Tien Shan High-Mountains Scientific Center of Institute of Water Problems and Hydropower NAS KR, 722400, Kyzyl-Suu, Chikayeva, 9, Issyk-Kul Region, Kyrgyz Republic*
[7]*Institute of Water Problems and Hydropower NAS KR, 720033, Bishkek, Frunze, 533, Kyrgyz Republic*
In the paper, we consider evolution of Sary-Tor Glacier, Ak-Shiyrak Massif, Inner Tien Shan under changing climatic conditions. We describe in necessary detail structure of the model and set-up of the numerical experiments. For calibration and validation of the model we use results of measurements in snow pits and on ablation stakes in 2014-2016. A series of ten prognostic numerical experiments of 90 model years duration was performed. As a climatic forcing, we used air temperature and precipitation records on the weather station Tien-Shan-Kumtor located in the vicinity of the glacier. In the schematic scenarios, average daily surface air temperature grows with gradients 0-4°C / 100 years. Present-day glacier configuration is in imbalance with the climate of 2014-2016. As a result, its area and volume proceed to decrease until equilibrium is achieved after several tens of model years. Under extreme rates of temperature increase (+4°C / 100 years) Sary-Tor almost diminishes by the end of experiments. Glacial run-off rapidly decreases after initial growth in the first half of the experiments. Mathematical model inevitably contains simplifications of the real natural conditions. Nevertheless, obtained results will be useful in prognostic water balance c alculations.
Mountain glacier, Sary-Tor, Tien-Shan, mass balance, climate, climate change, mathematical model, numerical experiment

11. Revealing of potential thermo-suffosional soil loosening sites across the Federal Highway A-360 "Lena", Central Yakutia

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The article presents the results of studies of thermo-suffusion processes since 2008 to 2017. Based on electrical sounding by electrotomography a high dynamics of geocryological and hydrogeological conditions within the Ulakhan-Tarin ground water spring, Central Yakutia, have been determined. It has been established that under intra-permafrost ground water heat affection permafrost thickness degraded on 4 m during 4 years. Five places of thermal-suffosional soil loosening and probable surface subsidence have been identified along the Lena Highway.
Thermo-suffosion, intra-permafrost groundwater, supra-permafrost groundwater, talik, permafrost, electrical resistivity tomography

12. Structure of lacustrine deposits in the cultural layer, city of Yakutsk

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This paper presents the results of field and laboratory investigations conducted in 2009–2015 as part of the permafrost monitoring program in a small area of Yakutsk city. It describes the structure and thermal state of lake sediments cored from the cultural layer. Cryolithological characteristics are used to define thickness of these sediments, as well as to assess their role in the development of engineering-geological conditions in the urban area. It is concluded that urban ecosystems in permafrost regions have distinctive geocryological characteristics due to the presence of sediments of the cultural layer.
Permafrost, alluvium, lacustrine sediments, water ecosystem, cryogenic landscape, cultural layer

13. Composition and microstructure of shelf sediments of the Kara sea
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The results of studies of the shelf sediments of the Kara Sea on the traverse off the Shpindler Cape (Yugorsky peninsula) and the Marresale Cape (the western Yamal peninsula) using laser granulometry, powder diffractometry and electron microscopy are presented. Three facies types of the bottom deposits are distinguished on the base of lithological, mineralogical, morphological and cryogenic characteristics: marine, coastal-marine sedimentation and continental redeposition. The established signs of cryogenesis in the studied sediments are interpreted as introduced either due to destruction of the coastal terraces or iceberg drift.
Arctic shelf, the Kara Sea, bottom deposits, microstructure, cryogenesis

14. Subsea permafrost of the Ob and Taz bays of the Kara Sea
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In 1995-2013 a series of geotechnical boreholes has been drilled with the depth range from 10-20 m to 50-70 m below the seabed in the Ob Bay and Taz Bay water areas. Four boreholes showed presence of permafrost there. These frozen soils vary considerably in ice content, salinity and temperature. In the northern part of the Ob Bay near the Yamal coast borehole №№1 and 2 revealed low-temperature (-4.1…-4.8°C as minimum) formations, generally of high salt content. There are no any ice inclusions in them. At the same time located also in the northern part of the Ob Bay borehole №3 showed frozen soils being of relatively high temperature (-0.9…-1.2°C) , of low-medium salinity and rich with ice inclusions. Revealed in a single borehole drilled in the port of Yamburg permafrost strata are specified by heterogeneity in their composition, ice and salt content. As a result, it is found that in boreholes №№1 and 2 permafrost strata form a part of the Holocene near coastal cryorelics, relatively young. The frozen formations in borehole № 3 are referred to the Sartanian insular relic permafrost, rather ancient. Found in the port of Yamburg frozen deposits occur under water due to operations to deepen and expand the port water areas. While the Ob and Taz Bays water area per se represents an extensive open talik covering their considerable part.
Kara Sea; Ob bay; Taz bay; permafrost; soil; salinity; Quaternary deposits.

15. Isotopic composition of different water categories in the fine disperse ground
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Laboratory researches of isotope composition of water as a part of fine disperse ground have been carried out. It has been established that in interaction of water with grounds, there is a fractionating of isotopes ^{16}O, ^{18}O, H, ^{2}H, depending on structure and peculiarity of ground and, at that the time isotope composition of the associated water is easier, than the free one.
Stable isotopes of water, isotope fractionating, water categories, segregation ice

16. Experimental study of the influence of gas composition and gas pressure on the freezing temperature of pore water in gas-saturated sediments
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The feature of freezing of pore water in dispersed sediments under gas pressure is considered based on the experimental modeling of the processes encountered in the freezing of gas-saturated sediments in closed conditions as a result of cryogenic gas concentration.
The results of an experimental study of the effect of gas pressure on the temperature of pore water in dispersed sediments saturated with nitrogen, methane, carbon dioxide, and a mixture of gases (50% CH_4 + 50% CO_2) are presented. The pressure in the experiments should be below the pressure of gas hydrate formation.
The research has been studied experimentally using natural artificially frozen in the laboratory sand and silt samples, on a specially designed system, which allows to record the temperature change in gas-saturated soil samples under gas pressure during their cooling and heating. It has been established that the freezing temperature of pore water under gas pressure depends on the pressure and on the chemical composition of the gas. At the same time, the chemical composition of gas has a significant effect on lowering the freezing temperature of pore water only in the presence of highly soluble gases, such as carbon dioxide, however, the presence of salt ions in the pore water reduces this effect. For poorly soluble gases (nitrogen and methane), the coefficient of lowering the freezing temperature for the studied sediments is about 0.1℃/MPa. With the advent of carbon dioxide in the gas, the coefficient increases to 1.36℃/MPa. The experimental data experiments on the effect of gas pressure on the freezing temperature of pore water and thermodynamic calculations based on the activity of pore water were compared.
Gas-saturated sediment, freezing under pressure, experimental modeling, freezing temperature, methane, carbon dioxide, nitrogen

17. Soil temperature regime in postagrogenic ecosystems under the expansion of self-restoration succession of tundra vegetation (The Russian European North-East)

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The features of the temperature regime of soils and permafrost table depth in postagrogenic meadow ecosystems of the cryolithozone of the European northeast of Russia, developing under the conditions of the expansion of self-restoration tundra vegetation succession (2009-2016) have been studied. A comparative assessment of the studied parameters with those of the agricultural period when agrogenic meadow ecosystems existed (1996-1999) was carried out. Present day temperature increase in loamy Anthrosols and Stagnosols, formed under conditions of a relatively shallow (up to 2 m) and deep (more than 2 m) permafrost table, occurred as a result of activation of self-restoration tundra vegetation succession in the background of climate change. During the study period, the increase in soil temperature had resulted in active layer thickness increase from 1.5 to 1.8 m in the river terrace site and from 1.8 to 2.0 m in the watershed site, respectively.
Soil temperature regime, permafrost, post-agrogenic ecosystems, self-restoration succession of tundra vegetation

18. Degradation of the mountain glaciation of Prins Karl Forland (Svalbard)

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The results of field research conducted on the glaciers of Prins Karls Forland in 2016 revealed signs of significant degradation. Comparison of topographic maps of the last century and satellite images indicate that in the past 80 years the area of the glaciers of the island has decreased threefold. In the first half of the twentieth century, the rate of glacial reductions increased and peaked at the end of the century. The smallest mountain glaciers, located below 500 meters, decreased most of all, as they were deprived of the feeding area due to the rise of the snow line. Large glaciers, located in the northern and most elevated part of the island, retreated to a lesser extent, as they preserved areas of food. Since 1936, the area of the glaciers of the Prins Karls Forland has decreased by approximately 58 km², in 2017 their area was 56,01±3 km². Reduction of the area of glaciers in 2008–2017. We estimate an average of 1,23 km² per year or 2% of the total glaciation area of the island. They are caused, first of all, by the retreat of the fronts of the largest glaciers of the island (Murraybreen, Millerbreen, Sore & Nordre Buchananisen, Fallbreen), and also the reduction of small mountain glaciers.
Over the last century, the glaciers of Prins Karls Forland reveal the maximum rate of decline in comparison with other areas of Spitsbergen.
Area of the glaciers, degradation, mountain glaciers, Prins Karls Forland, Svalbard, retreat of the glaciers

19. Cryogenic mineral formations of caves at Priolkhonie region (Western Pribaikalye)

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The article provides information about the cryogenic mineral formations of four caves in the Western Baikal region with seasonal and constant glaciation. Calcite and its metastable phase, ikaite, predominate in the cryogenic material; gypsum and chalcedony are also was found. Differences in the morphology of cryogenic mineral formations, depending on the internal facial conditions of mineral formation, were described. The isotopic composition of C and O of cryogenic flour (from cave Aya $\delta^{18}O$ –7,0‰ VPDB и $\delta^{13}C$ +7,9‰ VPDB; from cave Mechta $\delta^{18}O$ –5,3‰ VPDB и $\delta^{13}C$ +13,2‰ VPDB)and pseudomorphs of calcite to ikaite were determined. It was revealed that the isotopic composition of pseudomorphs may be similar to calcite flour, and may differ significantly from it and have a lighter composition of carbon. This difference was found in the composition of ikaite from the Malaya Baydinskaya cave ($\delta^{18}O$ –22,3‰ VPDB и $\delta^{13}C$ –3,3‰ VPDB), which is explained by the formation of the mineral during slow freezing.
Caves, cryogenesis, Western Pribaikalye, calcite, ikaite, coarse-grained cryogenic cave carbonates

20. Zones of methane and carbon dioxide hydrate stability in the sediments of the Vilyui Syneclise

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The gas hydrate stability zones (GHSZ) boundaries for methane and carbon dioxide at 46 sites in the Vilyui syneclise sedimentary basin are presented. Geothermal data and phase diagrams for CH_4-H_2O and CO_2-H_2O systems are used for calculation of the GHSZ boundaries. The results are shown in the summary table. These data were used to construct a scheme for location of the methane GHSZ lower boundary within the Vilyui syneclise and for location of all methane GHSZ boundaries along the latitudinal profile through Khapchagaysky megaval. The results allow concluding that in the sedimentary cover of the Vilyui sineclise there are favorable conditions for the formation of gas hydrates: sandy sections, high concentrations of dissolved methane in the underground water throughout the section, as well as the considerable thicknesses of GHSZ.
Vilyuiskaya syneclise, cryolithozone, hydrates of methane and carbon dioxide, zones of gas hydrates stability

21. Permafrost microorganisms in the outer space: results of the "Exobiofrost" experiment

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The results of the EXOBIOFROST experiment on the BION-M1 biosatellite showed that the effects of space flight factors (ionizing radiation, g-force, and temperature fluctuation) did not lead to the complete sterilization of the permafrost samples. The significant part of the bacterial community has retained viability after the outer space experiment Post-flight analysis and comparison with control samples showed that modern tundra colpodas are more resistant to the effects of space conditions than representatives of ancient permafrost, and that strains of *Colpoda steinii* are more resistant than ciliates of the *Exocolpoda augustini* species. The greatest resistance to space flight conditions was demonstrated by cysts of acanthamoeba (*Acanthamoeba* sp.), which makes it possible to consider this organism as the model one for further experiments both in outer space and on Earth.
Permafrost, microorganisms, outer space

22. Diversity of cultured prokaryotes in permafrost sediment samples of West Spitsbergen Island

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The diversity of anaerobic and aerobic microorganisms in permafrost samples taken at a depth of 0.5 to 3.7 m in the 2016 expedition of State science center “Arctic and Antarctic natural-science institute” was studied. Organotrophic microorganisms number is determined, it varies from 3.29×10^1 to 7.0×10^4 CFU$\times g^{-1}$ for aerobic, and from 3.0×10^1 to 2.3×10^4 cell$\times g^{-1}$ for anaerobic organisms. In separate anaerobically cultivated samples, methane and acetate were observed, while sulfate and iron reducing prokaryotes weren’t detected in any of the samples. In the process of research, 60 strains of aerobic psychrophilic and psychotolerant bacteria were isolated. The taxonomic position of the isolated microorganisms was established by sequencing the 16S rRNA genes and using MALDI mass spectrometry. The created collection of strains consisted of representatives of the *Actinobacteria*, *Firmicutes*, *Beta*- and *Gammaproteobacteria* phyla.

Permafrost sediments, West Spitsbergen Island, microbial communities, psychrophilic microorganisms, anaerobic prokaryotes

23. Research of two-phase flows of carbon dioxide during the cooling of grounds by the horizontal evaporator system

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An experimental study of the functioning of a two-phase flow of carbon dioxide in a seasonal cooling device designed to freeze soils under structures built on permafrost has been carried out. It is shown that the difference between the temperature of the condenser and the temperature of the evaporator is 0.46 °C, which indicates a small internal thermal resistance of the installation. The ultrasonic flow meter measured the average velocity of the fluid exiting the condenser. Based on the time dependences of the condenser and evaporator temperatures, the amount of steam in the installation was calculated from the beginning of its launch to reaching the steady state. By comparing the experimental data with the data of mathematical modeling, the main parameters of the two-phase flow of carbon dioxide in each section of the evaporator tube were determined.

Two-phase flow, carbon dioxide, horizontal evaporator system, simulation