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THE 11th INTERNATIONAL CONFERENCE ON PERMAFROST (Potsdam, Germany, 20–24 June, 2016)

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The world's largest specialized conference on permafrost is held every 4 years. In 2016, it gathered more than 700 participants in Potsdam, Germany. The article provides an overview of the sections' work made by the Russian co-chairs.

Geocryology, permafrost monitoring, periglacial geomorphology, Arctic, Antarctic, climate change, carbon cycle, historical geocryology, geocryological mapping, geocryological monitoring, thermometry, microbial communities, planetary geocryology, yedoma, permafrost hydrogeology, permafrost hydrology, offshore geocryology, gas hydrates, geocryological processes, coastal dynamics, thaw settlement, frost heave, remote sensing, geophysical methods, geocryological hazards, risk assessment, mountain cryolithozone, engineering geocryology, laboratory methods, popularization of science, teaching methods

On June 20–24, 2016 an important International Conference on Permafrost took place in Potsdam, Germany (ICOP). Such an event is held once in four years, and the city which previously hosted the global geocryological community (2012) was Salekhard, Russia. The conference in Germany became the eleventh one held since 1963.

In Salekhard, scientists from 15 countries took part in the conference, with the total number of the participants exceeding 600. In 2016, already 740 researchers from 36 countries of the world came to Germany. This reflects the interdisciplinary importance of geocryology, in the area of which mostly geographers, geologists, biologists and soil scientists work. The geography of the studies is expanding, as the attention to Arctic, Antarctic and mountain permafrost regions is growing. Participation of Europe in polar and high-altitude research has grown, too. Whereas previously "the great four" of the countries (Russia, USA, Canada, Norway), where geocryological research is being conducted, were the subject of the most frequent discussions in the conference lobbies, this time the notion of "the great five" was expressed more than once, with Germany having occupied the fifth position, as its scientists, due to the essential government support and active striving for international cooperation, including collaboration with Russia, have advanced in practically all the areas of traditional geocryology.

New areas of research and new methods are discussed at the conferences of such a level. The conference work was organized in 33 sections, which were proposed, selected and named on an iteration basis. The list of the section names reflects the current in-

terests and priorities of the science and includes the following:

– Policy symposium-permafrost research at the science policy interface (organized jointly with the International Arctic Science Committee, IASC);

– Periglacial geomorphology (co-organized by the International Association of Geomorphologists);

– Antarctic permafrost, soils and periglacial environments (co-organized by SCAR);

– Ground Ice and cryostratigraphy;

– Arctic and Antarctic cryosols: frontier of global change and human action;

– Climate change and the permafrost carbon feedback: past, present and future;

– Towards regional assessments of permafrost-atmosphere carbon fluxes;

– Reconstructing past permafrost: spatial dostribution and temporal changes;

– Permafrost mapping and data;

– Results from GTN-P: Thermal State of Permafrost (TSP) and Circumpolar Active Layer Monitoring (CALM);

– Paleoenvironments in permafrost affected areas;

– Microbial ecology of permafrost ecosystems;

– Planetary permafrost and earth analogues;

– The Yedoma region: origin, records and future projections in a changing Arctic;

– Permafrost hydrology and groundwater systems;

– The importance of lakes and ponds in permafrost regions;

– Where, when and why will the Arctic become wetter or drier;

– Integrating hydrology and biogeochemistry along the land-to-ocean continuum;

– Submarine permafrost, Arctic gas hydrate deposits and greenhouse gases in Arctic coastal waters;

– Polar coastlines in transition;

– Permafrost-related land surface subsidence and frost heave;

– Integrating field and remotely sensed measurements of thaw-driven landscape change in permafrost regions;

– Ground based and airborne geophysical applications in permafrost;

– Hazards and risks related to changing mountain, low-land and coastal permafrost;

– New frontiers in mountain permafrost research;

– Changing permafrost and its impacts across High Asia;

– Frozen ground engineering;

– Infrastructure stability in permafrost terrain;

– Permafrost engineering in mountainous terrain;

– Permafrost problems in mineral, oil and gas exploration asnd production;

– Frozen ground properties: field and laboratory testing;

– Permafrost in history and culture;

– Permafrost education and outreach: students, communities and the world.

Below is the review of the sections primarily performed by their Russian co-chairs.

The Yedoma region: origin, records and future projections in a changing Arctic

The section devoted to the study of Yedoma deposits was organized at the initiative of Jens Strauss, Germany. Such a section was first held in the framework of the European Conference on Permafrost EUCOP-2014. At this conference, 9 oral presentations and 14 poster presentations were made. A large part of the presentations were devoted to the characteristic and conditions of sedimentation formation in different regions of Siberia and Canada (D. Froese et al., Canada; D. Fortier et al., Canada; P. Trevor et al., Canada; S. Wetterich et al., Germany; H. Meyer et al., Germany; D.G. Shmelev and V.N. Konishchev, Russia). The study of the unique outcrop of Batagay, situated in the most continental part of Siberia, was the subject of the presentations made by K. Ashastina et al., Germany, and J. Murton et al., Great Britain. L. Schirrmeister et al., Germany, made a presentation on comparing the grain size distribution characteristics of the examples from two Yedoma sites in Alaska and Siberia using the robust end-member modeling analysis (EMMA). The data provided in the presentation confirm the polygenetic concept of the origin of the Yedoma deposits. According to this concept, formation of Yedoma deposits took place under similar climatic conditions, while the differences between them are caused by regional specifics: the composition and the properties of the soils of the Yedoma of the underlying deposits, the terrain features, etc.

The issues of terrain evolution and climate changes in the areas of Yedoma deposits over the Holocene period were discussed. The results of the complex study of the Yukon plain regions, Canada (M. Edwards et al., Great Britain) and Central Yakutia (M. Ulrich et al., Germany) were presented, with paleographic and remote methods demonstrated. Interesting are the results of the climate change studies in the Holocene based on the investigation of the stable isotope records from ice wedges in the coastal region of the Laptev Sea (T. Opel et al., Germany), which showed significant warming in the winter period while the summer temperatures decrease, from Late Holocene to the present time.

Studies of the Yedoma deposits are especially topical due to the high content of the fossil organic matter stored in permafrost. Estimations of its con-

tent and characteristics in the Yedoma deposits were presented at the section by M. Fuchs et al., Germany; N. Darshan et al., Germany, as well as the estimations of the content of methane (M.Yu. Cherbunina, D.G. Shmelev, Russia). J. Strauss, Germany, presented data on estimation of the content of nitrogen in the Yedoma deposits. In the presentation by K. Walter et al., USA, the results of comparing the carbon content in the Yedoma deposits and in thermokarst sediments were provided. The use of isotope analysis to determine the carbon source in thawing of Yedoma deposits was considered in the work by J. Vonk et al., Netherlands. The presentation by S. Ewing et al., USA, was devoted to the results of determining the age of ice on the basis of using the ratio between the uranium isotopes $^{234}U/^{238}U$ and the behavior of carbon in Yedoma thawing.

The report by the section chair J. Strauss et al., Germany, on the activities of the action group of the International Permafrost Association (IPA) relating to Yedoma studies (IPA action group "The Yedoma region: a synthesis of circum-Arctic distribution and thickness") generalized the available literature and archive materials relating to different characteristics of the Yedoma deposits. An important result of the work is Yedoma mapping, using the available geological maps of Siberia, Alaska and Canada.

Climate change and permafrost carbon feedback: the past, the present and the future

The section dedicated to carbon in permaforst was among the largest ones (in total, 69 presentations). 22 presentations, which provided the most interesting results of research and experiments, held both on the local and global scale by team of scientists from different countries, were accepted as talks. Various issues were discussed relating to the carbon cycle, climate change in high altitudes, the role of the cryolithozone in the total carbon balance and assessment future changes. The following presentations devoted to different subjects of the section should be mentioned: local experiments on assessment of greenhouse gases emission from permafrost ecosystems (T.H. Maksimov et al., Russia; M.J. Kwon et al., Germany); contribution of individual components of permafrost lanscapes for the carbon balance, such as thermokarst lakes and bogs, and the active layer dynamics (L. Brosius et al., USA; K.M. Walter Anthony et al., USA; L. Cannone et al., Italy; presented by M. Guglielmin, Norway); global assessments of the carbon pools in permafrost soils (G. Hugelius et al., Sweden), as well as modeling greenhouse gas emissions from thawing soils due to the observed rise of temperatures in Arctic and emission estimates for different scenarios of climate change (T. Schneider von Deimling et al., Germany). It is necessary to point out the importance of all the studies presented at the section: those aimed at the global assessment of the role of carbon in the cryosphere and those directed at the study of the local processes influencing the carbon behavior. Global assessments ensure understanding of the trends in the emission of greenhouse gases in the cryolithozone due to climate warming, whereas local experiments allow the role of certain components of the permafrost landscapes in the carbon balance to be cleared out, as well as contribute to improving of the global models.

Ground ice and cryostratigraphy

Four oral and five poster presentations were made in the section devoted to underground ice and the cryogenic structure of frozen soils. Of considerable interest was the presentation made by C. Burn, Canada, about a field experiment on launching the process of frost cracking by removing the grass cover on the bottom of Illisarvik Lake, artificially drained 1978 by J. Ross MacKay.

Integrating hydrology and biogeochemistry along the land-to-ocean continuum

12 oral and 24 poster presentations were made at the section devoted to the study of permafrost terrains, in the majority of which the behavior of terrains and their components was examined. A large part of the presentations were devoted to the dynamics of thermokarst lakes. Interesting was the report made by A. Liljedahl et al., USA, on degradation of ice veins and on hydrological impacts on terrains in different regions of Arctic. It was demonstrated that the observed degradation of vein ice is related to anomalous summer temperatures and, resulting from the increased runoff, sensitivity of soils and of the reserves of surface water to climate changes rises. Part of the presentations was devoted to the study of vegetation and its dynamics. Of special interest was the report by D. Walker et al., USA, in which the results of studying the Eurasian Arctic transect, made across the Yamal Peninsula and Franz Josef Land, were presented, on studying the relationship between the climate, the soil cover, vegetation and the active layer depth. The presentation by I. Nitze et al., Germany, should be specially mentioned, in which an automated method of studying the terrain behavior on the basis of using Landsat satellite images of different time was proposed.

Where, when and why will Arctic become wetter or drier?

Five oral and five poster presentations were made at the section devoted to changes in the hydrological regime in different regions of Arctic. G. Grosse et al., Germany, made a presentation on studying the dynamics of thermokarst lakes on the Seward Peninsula, Alaska, where active partial and complete drainage of lakes has been observed. In the report by

J. Boike et al., Germany, on the results of studying the dynamics of the terrains of Central Yakutia for the period from 2000 to 2011, the areas of the lakes were shown to have grown. In the authors' opinion, this results from the observed trend for the growth of air temperatures in the spring period. Some presenters offered answers to the question asked in the section name. Describing the example of studying the tundra of the Yano-Indigirka lowland floodplain, M. Heijmans et al., Netherlands, came to a conclusion that, given the current trend of climate warming and of the rise in precipitation, the terrains would become moister.

Periglacial geomorphology

One of the largest sections of the conference, "Periglacial geomorphology", was very diverse for its contents and researchers united from different areas of the science, involved in elucidating the origin and development of the cryogenic relief in the past and in the present. Presentations were made related to the permafrost processes in highlands: discussed were the issues of topography development under conditions of mountain permafrost, of interaction of perennially frozen rocks with glacier ice and snow (D. Draebing et al., Germany; A. Haberkorn et al., Switzerland); of the behavior of rock glaciers in different mountainous regions of the world: from the Alps (researchers from Switzerland M. Phillips et al.; J. Müller et al.; B. Staub et al.; M. Kummert et al.) and from the Pyrenees (M. González-García et al., Spain) to the mountainous regions of Argentina (C. Halla et al., Germany). Special attention was paid to slope processes (rock falls, rock slides) and to mechanical processes in frozen rocks (N. Matsuoka, Japan; I. Hartmeyer et al., Austria; P. Mamot et al., Germany), as well as to cryogenic slope processes in loose deposits, for example, solifluction (J. Eichel et al., Germany). Many presentations were devoted to the origin and development of the topography of plains composed by permafrost soils: from the Lena River delta (G. Veh et al., Germany), the Yamal Peninsula (A.V. Baranskaya, Russia) and Siberia as a whole (V.S. Sheinkman and V.P. Melnikov, Russia) to Greenland (S. Cable et al., Denmark), Spitsbergen (G. Rachlewicz and K.G. Rymer, Poland) and the Arctic regions of Canada and Alaska (S.A. Wolfe et al., Canada; R.I. Waller et al., Great Britain, S. Kokelj et al., Canada; G.V. Frost et al., USA). The processes of thermal erosion, thermokarst, suffusion, along with the impact of the seal level changes on the sea level on the topography of the cryolithozone were discussed. In addition, the issues of topography development of territories where permafrost existed in the past and where relic cryogenic forms are preserved were discussed: the Iberian Peninsula (M. Oliva et al., Portugal) and Great Britain (S.J. Price et al., Great Britain).

Permafrost-related land surface subsidence and frost heave

The section devoted to the processes related to thawing and heaving of the ground and the corresponding methods included 16 presentations. The emergence of new high-resolution methods allowing monitoring of the height of the ground surface on various spatial scales with different periodicities was responsible for the development of this area of science over the recent decade.

In the presentation by R.R. Muskett et al., USA, possible restrictions were demonstrated, related to the use of the day surface height in assessing ground subsidence on large areas, for example, in Alaska, according to the data sent from the satellites NASA ICES at GLAS and JAXA ALOS PALSAR. Both platforms allow estimation of relative changes in the ground surface to be calculated with the precision around 1 centimeter; however, the data quality is much dependent on the atmospheric effects and the unevenness of the underlying surface, which questions the accuracy of such spatial estimates. In the presentation by D.A. Streletsky et al., USA, a spatial method of measuring ground subsidence and heaving was described, in which a high-precision deferential GPS system was used, which allowed the authors to trace the year-from-year changes in the day surface height in the area of Barrow, USA, from 2003 to 2015. It was found that the observed changes in the elevation of undisturbed landscapes were due to ground subsidence when ice-rich deposits are thawed on the base of the active layer and in the transition layer. Progressing summer warming results in ground subsidence, while even greater warming in the winter period leads to the decrease in ground heaving. This results in the overall the subsidence of the day surface. J. Liming et al., China, provided results of the study focused on the ground subsidence obtained with a high-fidelity system SAR on the Tibet Plateau. Measurements were made for 66 hours, during which more than 600 high-resolution inferograms were made, which allowed millimeter changes in the height of the day surface related to thermokarst growth to be seen. The report of the study conducted by I. Beck et al., Germany, is to be mentioned, in which an attempt was made to use a complex of the land survey methods (using DGPS and LIDAR) and the TanDEM-X satellite to monitor the ground subsidence in the area of Inuvik, Canada. F. Günther et al., Germany, conducted a comprehensive study of the behavior of the terrain of the Eastern Siberian coastal lowland (Yakutia), demonstrated the relationship between the terrain and development of forms related to ice melting of Yedoma and compared them to the development of thermokarst typical of alas depressions.

The results from the Global Terrestrial Network on Permafrost (GTN-P): the Thermal State of Permafrost (TSP) and the Circumpolar Active Layer Monitoring (CALM)

52 presentations were made at the section, with 19 reports being oral. The focus of the attention was on the recent results of monitoring the permafrost soils and of the active layer thickness both in subpolar and highland regions. The GTN-P observation network uses a specially developed data management system relating to permafrost soils as the most significant component of the environment, reflecting climate changes (B.K. Biskaborn et al., Germany). The data management system includes generalized statistics of meta data, quality control and data processing.

Permafrost hydrology and groun water systems

This section was one of the most popular ones: 18 oral and 41 poster presentations were made there.

The main regions under study (Eastern and Western Siberia, Greenland, Alaska, the Andes, Tibet) are situated in the area of continuous and discontinuous permafrost, as well as in mountainous areas and in the areas of sporadic permafrost (the catch basin of Lake Baikal). Presentations were made on modeling hydrological processes, on forming the land and underground runoff, on hydrophysical processes in the active permafrost layer, about erosion-caused and geochemical processes, on the characteristics of the snow cover and its impact on hydrological processes, on transport of contaminations, on hydrology and agriculture, on characteristics of taliks abnd their physical modeling, on the impact of glacier melting on runoff, etc.

High-level scientific results were presented at the section in many areas of knowledge: simulation of hydrological processes, which was used to evaluate surface and underground runoffs; estimations of the impact of permafrost thawing in Tibet, primarily of the Yangtze River; estimation of the under-evaluated runoff in the basin of the Amazonka River; the role of fires in forming runoff in the permafrost zone, etc.

To make hydrological calculations and predictions, the scientists used such mathematical models as WaSiM (M.V. Debolsky et al., USA; M. Kaiser et al., Germany), the biospheric model ORCHIDEE (S. Dantec-Nédélec et al., France), Water Balance Simulation Model (R. Daanen et al., USA), the hydrological model for average catch basins of the discontinuous permafrost zone data management system (A.M. Endalamaw et al., USA), the determinate model "Hydrograph" (L.S. Lebedeva et al., V.A. Kurovskaya et al., N.V. Nesterova et al., O.M. Semenova et al., Russia), the OpenFOAM and PermaFOAM models (L. Orgogozo et al., France), the Thermo-Hydraulic model (C. Grenier et al., France), etc. Laboratory methods analysis and simulation of taliks were used (F. Costard et al., France) and of the thermal regime of lakes and of the active permafrost layer (R. Daanen et al., USA; M. Kaiser et al., Germany; N. Roux et al., France; S.L. Painter et al., USA). The use of remote sensing methods, including satellite survey, is an essential component of many studies (M. Haver et al., France; Pannetier et al., Sweden), as well as geophysical measurement methods (Sh. Gao et al., China), analysis of the isotope composition of water (P. Yi et al., China).

The geochemical studies in the permafrost zone were represented by the investigation of the carbon runoff in the active layer (O.N. Bobrova et al., Russia), the permafrost thawing on hydrochemistry and ecosystems in the transit systems of Alaska (J. Koch et al., USA), the connection of diluted substances in watercourses with their color index (T.V. Skorospekhova et al., Russia), the mechanisms of substance transport between the active layer and hydrogeological systems (A. Frampton et al., Sweden), and the impact of climate changes on the quality of water in the catch basins of rivers (S.F. Lamoureux, M.J. Lafreniere, Canada).

Hydrogeological studies were suffucuently well described at the section: the influence of permafrost melting on the runoff of the Yangtzee River (V.F. Bense et al., Netherlands, China), ground waters under shallow land waters and their influence on carbon runoff into the Arctic basin (M.T. O'Connor et al., USA), hydrogeochemical studies in Canada (A. Rudy et al., Canada), evaluation of the impact of hypersaline springs on the temperature regime in Nunawut (M. Ward and W.H. Pollard, Canada), seasonal fluctuations of ground waters in the basin of the Ogilvie River, Canada (N. Baranova and J.D. Clark, Canada).

No less important were the presentations about the glacier runoff of the Aconcagua River, Chile (J. Janke et al., USA), about thermokarst lakes, cryogenic processes and growth of taliks on the Tibet Plateau (Sh. Gao et al., China), about the influence of seasonal changes on deformation of coastal slopes (O.Ya. Maslikova et al., Russia), about the role of cryoforms in the water balance of the Chilean and Argentinian Andes (P.A. Wainstein et al., Canada), about the erosion of the banks in the middle reaches of the Lena River during the high water period (E. Gautier et al., France), about modeling ground waters in the marshes of the discontinuous permafrost zone (Y. Sjoberg et al., Sweden), about the characteristic features of the hydrological processes and taliks in the delta of the Lena River (I.V. Fedorova et al., Russia).

Related sciences are represented by the study of the snow cover and ice (N.R. Sileo et al., Argentina; S. Singh et al., India; S. Stuefer et al., USA), evaporation and transpiration (G. Simpson et al., USA), soil

characteristics (G. Wang et al., China) and the impact of changes in the active layer parameters on the river runoff (Q. Wang et al., China).

Applied aspects were discussed when analyzing the influence of glaciers and snowbanks on the agriculture of Chile (A. Bellisario et al., USA, Chile), describing contaminant migration along the river beds in connection with permafrost degradation (E.I. Debolskaya et al., Russia), the influence of the processes occurring in the catch basins of Arctic rivers on the coastal zones (A. Gädeke et al., USA) and on the productivity of the Alaskan ecosystems (J. Koch et al., USA), as well as in modeling small catch basins on the territory of the Muravlenkovo gas field (A.S. Musina and O.M. Semenova, Russia).

Noted in practically in all the presentations was degradation of permafrost soils (A. Shiklomanov et al., USA, Russia; L. Wang et al., Germany), the influence of climate on hydrogeological processes (R. Pannetier et al., Sweden; C.R. Rushlow et al., USA; S.F. Zastruzny et al., Denmark; F.J. Ferrando Acuna and A. Bellisario, Chile, and the hydrogeological processes.

Noteworthy were the poster presentations of young scientists (S.F. Zastruzny et al., Denmark; A. Gädeke et al., USA; Gao Hushui et al., China; L.S. Lebedeva, Russia), who presented not only well-prepared posters but also significant scientific results.

The most interesting oral presentations were the report made by W.H. Pollard in collaboration with M. Ward, Canada, on the seasonal dynamics of accumulation of stone salt tuffs (hydrohalites), related to hypersaline ounderground springs; the report by M. Cochand et al., Canada "On the behavior of underground waters and hydrogeochemical markers"; the presentations on modeling the dynamics in the "climate–permafrost–underground waters" chain by N.N. Romanovsky et al., Russia, and by C. Grenier et al., France, on the results of computations based on a thermohydraulic model and their comparison with the computations based on other known models used for predicting the temperature regime in the permafrost zone.

Arctic and Antarctic cryosols: frontier of global change and human action

6 oral and 8 poster presentations were made at the section. The majority of the presentations were devoted to Arctic; only three presentations were delivered on the subject of Antarctic soils. One of the most interesting and most discussed presentations was the talk of G.V. Matyshchak "On the global experiment with transformation of Arctic ecosystems", dealing with the effect of the thermal impact of pipelines on the condition of permafrost soils and with the ecosystems developing in the regions subject to this impact. The presentation by A.S. Yevgrafova (Switzerland) was recognized to be the best presentation of a young scientist. It was devoted to detailed analysis of changes in the vegetation cover due to transformation and degradation of permafrost soils in the north of Siberia.

Frozen ground engineering

4 sections were devoted to the subject of engineering, with 100 presentations made, which dealt with the issues of stability of engineering structures, engineering problems in the mountains, production of minerals, oil and gas, ground studies, specialized engineering and geological mapping and the changing environmental conditions.

Ground based and airborne geophysical applications in permafrost

A special section containing 27 presentations was devoted to geophysical methods of studying permafrost. The method of electrical resistivity tomography (ERT), applied by the permafrost scientists of Canada, Russia, Germany, Iceland and Greenland, is recognized to be the most effective method of imaging frozen and thawed soils used to determine the permafrost table and filtration windows and to monitor permafrost thaw after fires in Canada (J.E. Holloway, A. Lewkowicz, Canada); to monitor the glacier dynamics in Switzerland (C. Hilbich et al., Switzerland; C. Pellet et al., Switzerland) and on Spitzbergen (I. Berthling et al., Norway). Automated geoelectrical monitoring allowed the properties of frozen soils on the territory of Ilulissat airport in Greenland to be identified during three years (S. Tomaskovicova, T. Ingeman-Nielsen, Denmark), along the Alaskan highway in Canada for five years (A. Lewkowicz et al., Canada) and on the Schilthorn permafrost monitoring site in Switzerland, during 17 years (C. Mollaret et al., Switzerland). Using the method of nuclear magnetic resonance, taliks were identified under lakes and residual taliks under drained lakes in Alaska (A. Parsekian et al., USA). Magnetic studies of alases, faults, intrusive bodies and magnetic field were conducted in the delta of the Lena River to predict permafrost degradation (L.V. Tsybizov et al., Russia). In most cases, all the geophysical studies are corroborated by the drilling data. The reliability of the study results grows when different geophysical methods are combined, for example, ground-penetrating radar sounding combined with ERT, which was applied along the Alaskan highway (J. Dawson et al., Canada) or combined with seismic survey in the area of the Kumzha field (M.R. Sadurtdinov et al., Russia), and on the margin of the Greenland ice sheet (J. Engstrom et al., Finland). At the experimental permafrost station Farmers' Loop located in Alaska, the cross sections of ERT were compared to the images of airborne laser scanning and field measurements (T. Douglas et al., USA). Three-dimensional (3D) survey with 3D cryostratigraphic models were extensively developed (N. Allroggen et al., Germany; A. Emmert and C. Kneisel, Germany; A.N. Fage et al.,

Russia; S. Schennen et al., Germany). Based on electrical tomography data, cryohydrogeological models were developed in Canada to search for drinking water and to study the behavior of permafrost thawing, in accordance with different climate change scenarios (R. Fortier et al., Canada).

Frozen ground properties: field and laboratory testing

The major part (12 oral and 18 poster presentations) was devoted to the methods and results of studying the mechanical and thermal properties of frozen soils. Significant attention was paid to studying the heaving properties of the ground. Of special interest was the report by W. Tengfei et al., China, devoted to the study of the impact of ground heaving on screw piles in order to determine the most stable structures. In the report by E.S. Grechishcheva (in collaboration with R.G. Motenko, Russia), the specific features of working with modern equipment determining the thermal properties of ground are discussed and restrictions of using the method in the work with saline ground are discussed. The presentation of A. Kruse et al., USA, was devoted to determining the amount of unfrozen water in the frozen ground by the method of nuclear magnetic resonance, in which new approaches to the interpretation of data obtained by this method were proposed. The report made by E.M. Chuvilin, V.A. Istomin et al., Russia, presented a totally new method of determining the unfrozen water content in the frozen ground, based on determining the water potential. Determining the unfrozen water content by this method takes several times less time than that by other known methods.

Permafrost in history and culture

The relevance of the problem of the interaction between the mankind and the permafrost, of adaptation to the changing climate and to permafrost conditions served as a basis for the formation of the action group under the International Permafrost Association (IPA) in 2014 named "Permafrost and Culture" (PaC). To combine the study of geo-environmental and social issues of permafrost investigation, the organizing committee of ICOP-2016 first established a new section named "Permafrost in History and Culture".

8 oral and 11 poster presentations were made, as well as one plenary presentation delivered by Otto Habeck, Germany. The major part of the presentations was devoted to interaction between geo-environmental and social development issues in the permafrost zone. The issues of people's adaptation to modern climate and permafrost changes were discussed on the reports of O.A. Anisimov, Russia, and M.J. Flynn, Germany, and J.O. Habeck et al., Germany.

Quite a large number of presentations considered the changes in the permafrost terrains under the human impact (R.V. Desyatkin, A.N. Fedorov, Russia; T. Kumpula et al., Finland; P.N. Skryabin et al., Russia; M. Buchhorn et al., USA) and the urban environment under modern conditions (A.S. Gubanov et al., Russia; K.E. Nyland et al., USA; I.I. Syromyatnikov et al., Russia).

Reportson the history of geocryological studies covered a wide range of subjects: from the role of the first permafrost scientists (D. Fritzsche, Germany), E. Tammiksaar, Estonia), individual expeditions (F.E. Nelson and R.D. Lukens, USA) and the development history of permafrost studies in the cold war period (P.-Y. Chu, USA) to the experience of construction in Alaska (M.H. Cysewski and Y.L. Shur, USA). The following issues were discussed: terminology (W. Dobinski, Poland), priority studies (H. Lantuit et al., Germany), tourism (R.I. Ivanova and A.N. Fedorov, Russia) and the role of international programs in the study of the living conditions of people's life and work in the Arctic permafrost environment (D.A. Walker et al., USA).

Events for young participants

The conference organizers paid special attention to the events organized for the young participants. The conference was preceded by a two days' Young researchers' Workshop, a seminar for the members of the Permafrost Young Researchers Network (PYRN), at which they had a possibility of acquiring the practical skills and abilities required for achieving high results in science. 153 participants from 18 countries were invited to take part in the seminar, who were selected to be granted financial support. The delegation of the young Russian permafrost scientists was second after the German delegation (11 people). The workshop agenda included a three hours' plenary lecture "How to get published in scientific journals" and an hour-and-a half breakout sessions on the following topics:

– Community-based research;
– Acquiring remote sensing data for your project;
– Permafrost modelling;
– Data management;
– Scientific field work: planning Arctic expeditions safely and successfully;
– How to prepare for and present at a conference;
– Working outside academia: perspectives in the private/public sector;
– (University) teaching methods – a short introduction;
– How to present and communicate your science to the public and media.

The workshop also contained the key notes of 'young' and 'senior' professors, who told those present about their career in science, about the advantages

and disadvantages of the professions of a teacher and of a researcher in informal atmosphere.

During the conference, a "Young meet senior lounge" site was arranged specially for young permafrost researchers, where they could order tea or coffee, sit down at the table and talk to their senior colleagues in a quiet place. Besides, a job/study notice was there, where each employer could place a job offer and where each young researcher could place a resume. Altogether, 5 job offers and 12 resumes were placed there.

In each conference section, a young researcher from PYRN was one of the co-chairs, who took part in the session's work at all stages – from selection of presentations to oral sessions chairing. This allowed the young co-chairs to learn to chair a session.

Traditional for all the international and regional permafrost conferences was holding a contest of the young scientists› oral and poster presentations and of frostbytes, short videos about the scientist›s own activity. S.S. Bricheva, a PhD student of the geology, seismics and geoacoustics department of the Faculty of Geology of the Lomonosov Moscow State University, became the winner in the nomination of the best frostbyte. She shot a computer-animated video "A method of ground-penetrating radar detection of visible and 'hidden' ice wedges in the Chara Depression (Eastern Siberia, Russia)" with growing wedge ice built from a Lego construction kit (the video is available at: https://vimeo.com/channels/1086084/170138147).

The Executive Committee of PYRN was elected for 2016–2018. A.A. Bobrik, A.A. Maslakov and D.M. Frolov were elected members from Russia. S. Dumais, Canada, became the president of PYRN.

Working groups

In addition to the main sessions, working groups devoted to different subjects were organized before and during the conference, which were held primarily as round-table discussions. Below are the results of the working group's work, in which the paper authors took place.

A session of the *Cryosol Working Group* was held during the conference. The group members took a decision to hold an international conference on cryopedology in Yakutsk in 2017. The group decided to upgrade the functions and the content of the group's website (http://www.cryosols.org/) and to present some pages of the group in social networks, in order to sustain interest for the issues of permafrost soil study. The organizing committee of the working group was elected. Sebastian Zubrzycki (Hamburg University, Germany) and Dmitry Konyushkov (Dokuchaev Soil Institute) became the group's co-chairs, while Alexey Lupachev, Dmitry Kaverin, Alevtina Yevrgrafova, Megan Balks and Markus Philips became members of the Executive Committee. The working group is ready to consider any proposals, which can be sent to: m.balks@waikato.ac.nz, a.lupachev@gmail.com.

Before the conference start, the *Arctic coastal dynamics* (ACD) working group held a meeting entitled "Coastal permafrost under changing conditions". At the meeting, P.P. Overduin, Germany, V. Rachold, Germany, and D. Forbes, Canada, summed up the many years' work of this group. This work resulted in developing a comprehensive geo database of arctic coastal dynamics. B. Radosavljevic, Germany, presented the group's new website (http://arcticcoast.info/), at which, apart from other information, the above mentioned GIS on arctic coastal dynamics was published to open access. Discussed were the issues of improving the modern methods of monitoring coastal dynamics, modeling and predicting permafrost coastal changes, Special attention was paid to the possibilities of setting new monitoring sites and to continuation of observations at the existing key monitoring sites. In addition, the issue of new data supplement and further processing of the existing GIS was raised.

The working meeting of the group devoted to the study of the Yedoma deposits (*Yedoma workshop*) was organized by J. Strauss. An important result of the meeting was evaluation of the credibility of the constructed map of Yedoma occurrence in different regions. The definition of Yedoma is still a matter of dispute, as well as determining the thickness of the Yedoma deposits, which is now evaluated primarily by the exposure, whereas the major part of the surface composed by Yedoma deposits is represented by slopes, and the actual thickness of the deposits becomes much less than the available estimates.

The conference summary

The resolutions of the IPA Council at the ICOP-2016 are as follows:

- Considering the growing recognition and diverse impact of permafrost on global society and climate; and
- Considering the impact of permafrost on those who live or work in polar and high mountain regions; and
- Considering the need to adapt engineering infrastructure to changes in the permafrost environment; and
- Considering it imperative to coordinate and integrate knowledge of the carbon cycle and other biogeochemical cycles in permafrost regions; and
- Recognizing that solutions to scientific questions and engineering challenges associated with permafrost require interdisciplinary teams and international collaboration; and
- Reaffirming the importance of involving members of the Permafrost Young Researchers Network (PYRN) in all of its activities,

It is resolved that over the next four years, through its collaborations with other organizations and its own Action Groups, Interest Groups, and Standing Committees, including PYRN and the Global Terrestrial Network for Permafrost (GTN-P), the International Permafrost Association will:

• Improve representation of perennially frozen ground in earth-system modelling using GTN-P products, permafrost maps, and new technologies;

• Improve understanding of hydrology, ground-ice characteristics, and permafrost-related processes associated with the vulnerability of infrastructure, ecosystems, and land use in permafrost areas, and knowledge of hazards in these environments;

• Empower citizens concerned with the changing permafrost environment by developing education and outreach products and projects for schools, universities, professionals, and civil society.

In accordance with the existing tradition, the Council of the International Permfrost Association (IPA) was held, which considered proposals of the member countries regarding the potential venues of the next global and regional conferences and the current results of the working groups' studies. The members of the Executive Committee were elected. H.H. Christiansen, Norway, was elected the President of IPA for the period of 2016–2020. Currently D.S. Drozdov is the representative of Russia in the IPA Council, whereas D.O. Sergeev will continue to work in the Executive Committee of IPA for two more years. Lánzhōu, China, was chosen to be the venue of the next conference to be held in 2020. The 2nd Asian Conference on Permafrost will be held in Sapporo, Japan (July 2–6, 2017, http://acop2017.arc.hokudai.ac.jp/). The 5th European Permafrost Conference will be held in Chamonix, France (2018).

References

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