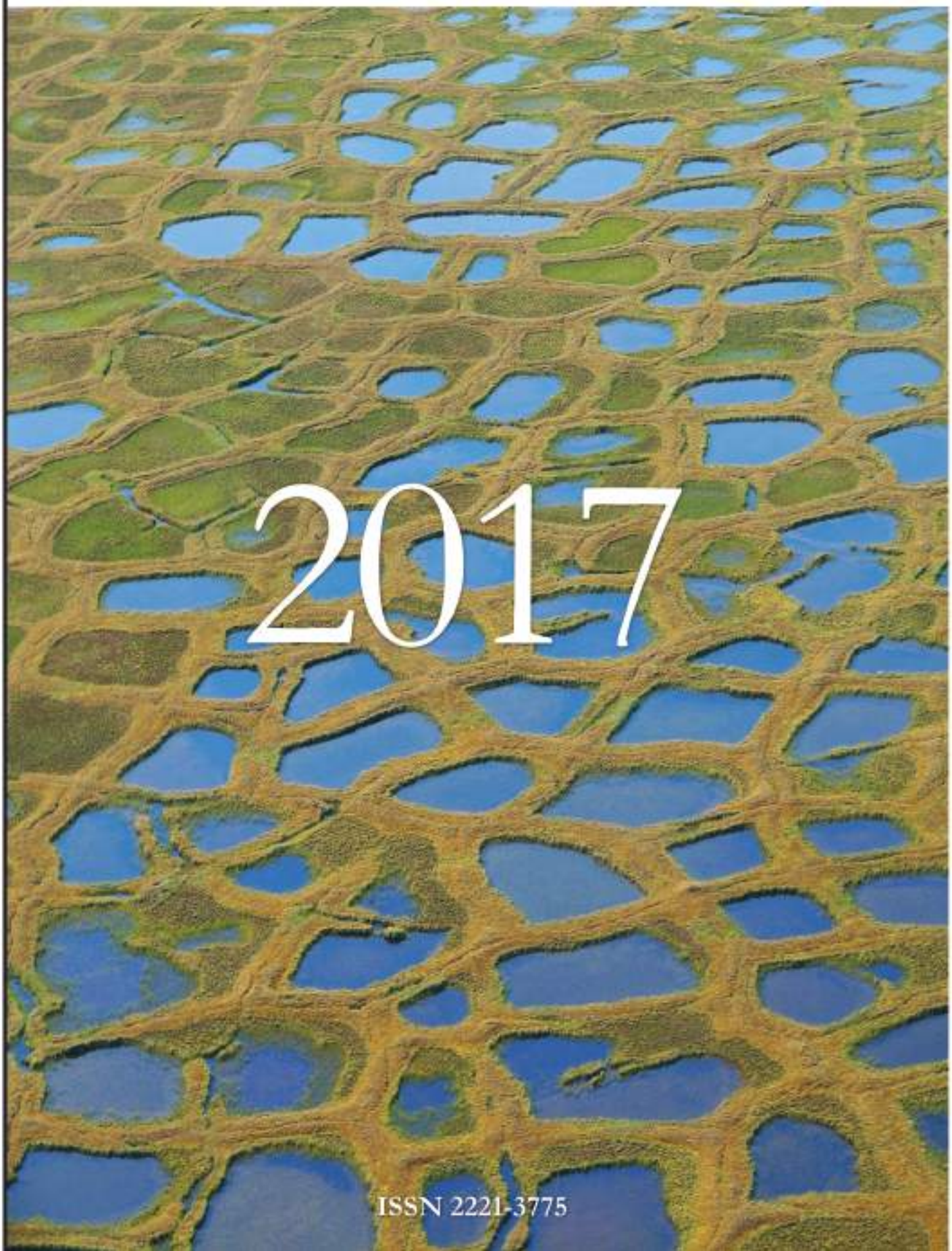
COUNTRY REPORTS

Reports from the Adhering Bodies of the International Permafrost Association



2017

ISSN 2221-3775

Table of Contents

Other Country Members:
Denmark
Germany
Iceland
Kyrgyzstan
Mongolia
Netherlands
Romania
Spain
Switzerland

Argentina (and South American Partners)

At the beginning of 2017 Estefanía Bottegal concluded her doctoral thesis titled: "*Cryodynamics and Permafrost Inventory in the Cordillera Frontal, Mendoza, Argentina"* very successfully at the Universidad Nacional de Córdoba, Argentina (Photo 1).

Photo 1.

Within the framework of an extensive scientific and academic cooperation project titled "Rock glacier permafrost in the Central Andes of Argentina (PermArg): regional distribution ice content hydrological significance" between the DFG (Deutsche Forschungsgemeinschaft) Germany, through the University of Bonn (Prof. Dr. Lothar Schrott) and the Geocryology Unit of the CCT-CONICET (Dr. Dario Trombotto) several field campaigns with the participation of German students were carried out. Dario Trombotto also is co-director of a doctoral thesis presented at the University of Bonn (by Christian Halla). In March the student group from Bonn made a field excursion to the Cordón del Plata (Argentina).

In May, Dario Trombotto took part in the EDU-ARCTIC Project Consortium, using scientific research in a direct dialogue with schools from Poland, Rumania, Greece and Croatia. The general topic of the academic lesson was "The Andean Cordillera".

At the XX Congreso Geológico Argentino (Argentine Geology Congress), held in San Miguel de Tucumán (7th to11th of Aug. 2017), Cryospheric Sciences were included in the technical sessions for the first time ever. This session was coordinated by Dr. Ana Lía Ahumada (Fundación Miguel Lillo-CONICET) and Dr. Adrián Busso (Instituto Antártico Argentino). The technical session was supported by the AASP (Argentine and South American Association of Permafrost) and the Subcommittee of Cryospheric Sciences of the IACS. It included 24 conferences about different cryospheric topics concerned with the Andean Cordillera between Argentina and Chile, the Argentine part of Antarctica and the surrounding ocean (Photo 2).

(http://congresogeologico.org.ar/gestor/wp-content/uploads/2017/08/ST-18.pdf).

Photo 2.

At the congress in Tucumán one meeting was dedicated to the Argentine and South American Association of Permafrost (AASP), where Dario Trombotto was confirmed in his charge for one more period, and another to the PYRN group. At the first meeting Carla Tapia Baldis was elected Secretary of the AASP.

In October 2017 Dario Trombotto was invited to the Annual Meeting of the Geological Society of America in Seattle, Washington, (USA) and as Visiting Professor to the Quaternary Research Center of the University of Washington. The author held conferences and seminars and initiated joint research with the team of the University.

In November 2017 Dario Trombotto held the international postgraduate course: "The periglacial environment. Geocryology of South America" at the University of San Juan. He has also been designated Visiting Professor of that University.

Field tasks were continued in two different projects that included collaborative and research work: in the first place between Prof. Ronald Sletten from the "University of Washington" and the "Quaternary Research Center" of Seattle, USA and the Geocryology Research Unit, CCT-CONICET, Mendoza, directed by Dr. Dario Trombotto Liaudat and second between Prof. Peter Kuhry, University of Stockholm, Sweden and the Geocryology Research Unit. The topic of the latter is the assessment of carbon storage in organic soil in current mountain permafrost environments.

Silvio Pastore (Universidad Nacional de San Juan, Argentina) was elected as Scientific Coordinator of the Provincial Glacier Inventory of the San Juan river basin. The inventory of this part

of the Central Andes consisted of 5530 geoforms characteristic of the glacial and periglacial environment, 2615 of which are identified as active rock glaciers (!) with an area of 239 km^2. The total studied area was 492 km^2. 18 glaciers are being studied with different topographic and geophysical methods as well with geodetic mass balance. In the case of rock glaciers, ice rich permafrost was detected and kinematic studies have been initiated.

In 2017 Trombotto was appointed Honorary Member of the IGU COMMISSION: Cold and High Altitude Regions (CHAR).

Prepared by Dario Trombotto
Dec. 22, 2017, Mendoza

Austria

Permafrost-related activities relevant for Austria and Austria's scientists

The annual meeting of the AK-Permafrost (AK abbreviates "working group") together with a PYRN-DACH meeting (DACH stands for Germany, Austria, Switzerland) took place in Einsiedeln, Switzerland, during the three days period 9-11 February 2017. Several Austrian Scientists from Salzburg (Stefan Reisenhofer), Innsbruck (Ingo Hartmeyer), Graz (Viktor Kaufmann, Andreas Kellerer-Pirklbauer) and Vienna (Annett Bartsch, Stefan Pfeiler) participated in this meeting together with participants from Switzerland and Germany.

The national project "Oe-Kryonet" aiming to cross-link Austrian data bases related to the cryosphere was successfully finalized. The project was led by Annett Bartsch, Vienna and was funded by the Climate Change Centre Austria (CCCA).

The General Assembly 2017 of the European Geosciences Union (EGU) took place in Vienna, Austria, during the period 23-28 April 2017. About 14.500 scientists from 107 different countries participated in this event (http://www.egu2017.eu). As in the last years, several sessions related to permafrost and periglacial processes and landforms have been organized and held particularly in the program groups "Cryopheric Sciences (CR)" and "Geomorphology (GM)".

The 6th international symposium for Research in Protected Areas took place in Salzburg, Austria, during the period 2-3 November 2017. One session – chaired by Andrea Fischer (Innsbruck) – was dedicated to the cryosphere in a warming climate with several contributions related to permafrost and rock glaciers. Visit http://www.nationalparksaustria.at/de/pages/6th-international-symposium-for-research-in-protected-areas-2017-d-121.aspx for details.

The second Austria GCOS-Report ("Global Climate Observing System Austrian Inventory Report 2017") was finalized in 2017. The report was edited the by Silke Adler and Hermine Fürst (both Central Office of Meteorology and Geo-dynamics/ZAMG). The report gives an overview about climate-relevant monitoring networks in Austria and was compiled with the joint effort of various universities, federal agencies and alpine organizations. The first part of the report describes the relevant institutions and organizations. The second part describes the different monitoring network including information about data access and contact person. In the cryosphere section (strongly linked to the above mentioned Oe-Kryonet project) some detailed information about permafrost monitoring are given and a new "Austrian Rock Glacier Monitoring network (ARGMN)" is proposed in this document. For details refer to the pdf via: http://www.zamg.ac.at/cms/de/dokumente/topmenu/gcos/gcos-report-2017.

Specific reports from the different permafrost research groups in Austria

Salzburg

Research activities at the permafrost monitoring site Kitzsteinhorn (3.203 m asl), Hohe Tauern Range, have been continued at the University of Salzburg in close collaboration with alpS and Georesearch (Ingo Hartmeyer, Markus Keuschnig, Jan-Christoph Otto).

At the Hoher Sonnblick permafrost monitoring site services for the borehole instrumentation were conducted. Within the project PERSON-GCW, which is funded by the Austrian Federal Ministry of Agriculture, the spatial distribution of permafrost is investigated by ZAMG (Stefan Reisenhofer) in the Sonnblick area. To determine near-surface temperature conditions in the underlying investigation areas, 42 ground surface temperature loggers and six shallow boreholes with depths up to 140 cm were read out and redeployed. Additionally, two new shallow boreholes in the northern face of the Hohe Sonnblick were installed with temperature sensors at depths of 100, 80, 60, 40, 20 cm and at the surface. Furthermore, mid-March BTS measurements were carried out at 98 locations. The project ATMOperm (see report of last years; in collaboration with the University of Graz) was continued at Hoher Sonnblick.

Graz

The Institute of Geodesy of the Graz University of Technology (Viktor Kaufmann) has successfully continued its annual geodetic measurements at the rock glaciers Dösen, Hinteres Langtalkar, Weissenkar, Leibnitzkopf and Tschadinhorn. Flow velocities obtained on all rock glaciers are still high but do not reach the maximum values of the two previous years. On Tschadinhorn rock glacier a UAV-based aerial survey was carried out for the second time. At this time overflights using four different UAVs (Fig. 1) were accomplished supporting a joint research project of Graz University of Technology (Institute of Geodesy, Institute of Applied Sciences, Institute of Computer Graphics and Knowledge Visualisation) and University of Graz (Department of Geography and Regional Science). Using this image data and older orthophotos an image-based change detection analysis will be carried out.

Figure 1: UAV-campaign at Tschadinhorn rock glacier, Hohe Tauern Range, accomplished jointly by the Graz University of Technology and the University of Graz. Mt. Grossglockner, Austria's highest peak (3798 m asl.) is seen in the background (Foto: Viktor Kaufmann, Date: 22.08.2017).

Research within the project "RGHeavyMetal - Water resources management issues of rock glaciers in alpine catchments of the Eastern Alps - storage capacity, flow dynamics and hydrochemistry in particular heavy metal pollution" was continued by the research group of the Institute of Earth Sciences of the University of Graz (Gerfried Winkler, Thomas Wagner, Roswitha Pleschberger) and colleagues from the University of Innsbruck (Karl Krainer, Markus Ribis). Their work was supported by Andreas Kellerer-Pirklbauer (Department of Geography and Regional Science, University of Graz) and Stefan Hergarten (University of Freiburg). The first compiled national rock glacier and rock glacier catchment inventories (polygon-based; partly based on earlier inventories) of the Austrian Alps based solely on airborne laser scan data (ALS-data) with a resolution of 1 m are nearly finished. The monitoring and data acquisition to improve our understanding of the discharge behavior and storage capacity of (relict and intact) rock glaciers and their spring water hydrochemistry was intensified and complemented with artificial tracer tests at two active rock glaciers.

Researchers at the Department of Geography and Regional Science, University of Graz (Andreas Kellerer-Pirklbauer, Gerhard Karl Lieb, Oliver Sass, Wolfgang Schöner, Georg Heinrich, Michael Avian, Wolfgang Sulzer, Gernot Seier, Joachim Götz) continued and partly extended (in terms of instrumentation and sites) its permafrost-related research in the three Austrian mountain regions Hohe Tauern Range, Niedere Tauern Range and in the Northern Calcareous Alps (Fig. 2) collaborating with the Institute of Geodesy of the Graz University of Technology, the Institute of Earth Sciences, University of Graz, and the ZAMG (see above). Multidisciplinary permafrost and periglacial monitoring was continued particularly at four active rock glacier sites (Dösen, Hinteres Langtalkar, Leibnitzkopf, Weissenkar), one active rock fall site (Mittlerer and Hoher Burgstall, near Pasterze Glacier), and four marginally permafrost sites (Hochtor area, Fallbichl area, Hintereggen valley, Hochreichart area). A second UAV-survey was jointly accomplished with the Graz University of Technology at the Tschadinhorn rock glacier (see above).

Figure 2: Drilling of a new shallow borehole to monitor near surface ground temperatures at the GTN-P site Koppenkarstein North Face, Dachstein Massif, Northern Calcareous Alps. The site is located just above the glacier surface of the Schladminger Glacier (Foto: Andreas Kellerer-Pirklbauer, Date: 08.09.2017).

A paper was published discussing potential weathering by freeze-thaw action in alpine rocks in the European Alps during a nine year monitoring period (Kellerer-Pirklbauer 2017; DOI:10.1016/j.geomorph.2017.08.020). A further published paper deals with solifluction rates and environmental controls at local and regional scales in central Austria (Kellerer-Pirklbauer 2017;

DOI:10.1080/00291951.2017.1399164). Finally, two recently published papers are related to rock glacier research: One paper deals with deglaciation and its impact on permafrost and rock glacier evolution (Kellerer-Pirklbauer and Kaufmann 2017; DOI:10.1016/j.scitotenv.2017.10.087). A second paper reviews multidisciplinary long-term rock glacier monitoring at Dösen Rock Glacier in Central Austria (Kellerer-Pirklbauer et al 2017; DOI:10.17738/ajes.2017.0013.

The Schmidt-hammer exposure-age dating method was applied at further rock glacier systems in the Niedere Tauern Range, Central Austria, confirming earlier findings (Kellerer-Pirklbauer 2016; EGU2016-13977). The project ATMOperm was continued. A new project aiming to monitor abiotic natural processes in the Hohe Tauern National Park, Austria, at a long-term scale (Gerhard Karl Lieb, Andreas Kellerer-Pirklbauer) was launched in 2017.

In the framework of the DFG (German Research Foundation) funded project PermARG ("Rockglacier permafrost in the Central Andes of Argentina", 11/2015-10/2018) the research group of Lothar Schrott (University of Bonn, Germany) in cooperation with Dario Tromotto (IANIGLA, Mendoza, Argentina) conducted the first field campaigns at the Morenas Coloradas and Dos Lenguas rock glacier complexes in 2016 and 2017 (Fig. 3). The main objective of this project is to quantify water storage capacities of rock glacier permafrost in the semi-arid Andes of Argentina. Research is carried out by Lothar Schrott, Christian Halla, Jan Blöthe, Simon Terweh (all University of Bonn), Estefania Bottegal and Carla Tapía (both IANIGLA, Mendoza). Joachim Götz is one of three project collaborators within PermARG and supports the field and analyses activities.

Figure 3: View to the north towards Dos Lenguas rock glacier from the road to Paso de Aqua Negra. Note the steep slopes of the active twin-rock glacier front (Foto: Christian Halla, Date: 11.03.2016).

Innsbruck

Researchers at the Institute of Ecology of the University of Innsbruck (Karin Koinig, Boris Ilyashuk, Elena Ilyashuk, Roland Psenner, Bernd Fritz) continued their rock glacier research project "ChangeLake" supported by eurac research, Bozen/Bolzano, Italy (collaborators Ulricke Tappeiner, Roberta Bottarin). They focus on monitoring of lakes affected by rock glacier meltwater discharge in comparison to lakes without that impact. Their recently published article "Rock glaciers in crystalline catchments: Hidden permafrost-related threats to alpine headwater lakes" (Boris Ilyashuk et al. 2018; DOI:10.1111/gcb.13985) discusses the effect of rock glaciers in three lakes in the Eastern Alps. They analyzed rock glacier related changes in metal concentrations and the decadal impact on chironomids and invertebrates.

The project „Economic aspects of rock glacier springs in areas composed of metamorphic rocks in the Eastern Alps" initiated in 2016 at the University of Innsbruck, Institute of Geology (led by Karl Krainer) and carried out in cooperation with the University of Graz, Institute of Earth Sciences was successfully continued.

The Institute for Interdisciplinary Mountain Research (Austrian Academy of Sciences) and the Verein Gletscher Klima continued the long-term monitoring program of surface displacement at Äußeres Hochebenkar rock glacier and carried out the annual geodetic measurements at the site (Lea Hartl, Martin Stocker-Waldhuber, Andrea Fischer). Hochebenkar rock glacier has been integrated into joint efforts by a number of European institutions (under the leadership of Andreas Kellerer-Pirkelbauer) to compile data on recent changes in rock glacier kinematics (to be presented at EUCOP 2018). The Institute of Interdisciplinary Mountain Research joined an application for an IPA Action Group on rock glacier inventories and kinematics and hopes to expand research activities at the Äußeres Hochebenkar site in the future.

Vienna

The DUE GlobPermafrost initiative (project period 2016-2019) of the European Space Agency for exploitation of satellite data for permafrost research was continued in 2017. The project is coordinated by Annett Bartsch. The first version of thematic products developed by DUE GlobPermafrost have been released in September 2017. They include InSAR-based land surface deformation maps, rock glacier velocity fields, spatially distributed permafrost model outputs (northern hemisphere), land surface properties and changes (trends from Landsat data 2000-2015), and ground-fast lake ice. WebGIS access is possible via http://maps.awi.de/map/map.html?cu=Globpermafrost_Overview; Data catalogue access via http://apgc.awi.de/group/persys.

Canada

The Canadian permafrost community has had a busy year. Highlights included meetings and workshops focussed on creation of a Canadian Permafrost Association and a Canadian Permafrost Network and a session on permafrost at the Yellowknife Geoscience Forum. A major northern infrastructure project, the Inuvik-Tuktoyaktuk Highway, was also completed and opened in 2017.

New Initiatives

Canadian Permafrost Association

A movement is underway to form the Canadian Permafrost Association. Canada needs this association to offer a coherent picture of the importance of permafrost and permafrost change to northerners, indigenous groups, communities and governments, industry and all Canadians. The serious and growing impacts of thawing permafrost on infrastructure and communities, and the potential for greenhouse gas emissions, mean that interest in permafrost is greater than ever. The Canadian Permafrost Association plans to meet these demands through a mission that includes:

- Providing an annual forum for knowledge exchange about permafrost among scientists, engineers, policy-makers, Indigenous Peoples and communities;
- Assisting in the development of educational and outreach products about permafrost;
- Encouraging the formation of coordinated permafrost research networks; and
- Supporting the development of the next generation of permafrost researchers, especially those from the North.

A Steering Committee, chaired by A. Lewkowicz, and with broad representation from northern Canada, industry, academia, knowledge users, and government (federal and territorial), was formed in summer 2017 by the Canadian National Committee for the International Permafrost Association. The Steering Committee has been working continuously since then to create the framework for a vibrant association.

The proposed association received enthusiastic support from the many attendees at an open meeting at the Yellowknife Geoscience Forum in November. Feedback received built on ideas discussed in an earlier workshop focused on a permafrost research network. The Steering Committee is now working to make sure that the constitution, legal set-up, business plan and initial activities of the Association will allow stakeholder goals to be achieved. A preliminary list of about 500 names was compiled and a first e-mail was sent in December 2017. The next stage of the plan is to call for nominations from the community for the first board which will allow the Association to be legally constituted as a non-profit organisation by the spring of 2018.

Contact: A. Lewkowicz, University of Ottawa

Workshop: Toward a Canadian Permafrost Network

A diverse community of almost 60 individuals met at Carleton University, February 14-15 2017, for a workshop on the creation of a pan-Canadian permafrost network. Attendees represented federal, and territorial governments, Canadian university researchers, and the private sector. The objectives were to gain a shared understanding of what a Canadian permafrost network would involve and to provide opportunities for people to network and build relationships. Through moderated discussions, the workshop provided concrete outcomes on the development of a permafrost network for Canada. The initial purpose identified was “To advance knowledge about changing permafrost environments.” Following the workshop, a proposal for a Strategic Partnership Network Grant (NSERC) was developed and the formation of the Canadian Permafrost Association was initiated. These complimentary activities aim to address the core needs of better representation and of better research collaboration and data management. Details on the workshop and its outcomes are available online at: https://carleton.ca/permafrost/network_short/

Further discussion on network development took place at the Yellowknife Geoscience forum in November 2017.

Contact: S. Gruber, Carleton University

Northern Infrastructure Standards Initiative

Canada’s North is on the front line of climate change. In addition to the rapidly changing physical environment, Canada’s north presents unique environmental, socio-economic, cultural, and geographic circumstances compared to other regions of Canada. New policies and mechanisms are therefore needed to help Northern communities

adapt and reduce the vulnerability of their infrastructure to the impacts of climate change. With funding from the Federal Government, the Standards Council of Canada (SCC), in partnership Indigenous and Northern Affairs, created the Northern Infrastructure Standardization Initiative (NISI) to develop northern specific standards. The NISI program was so successful from 2011 to 2016, the Government of Canada renewed the program for an additional 5 years, with SCC receiving the funding directly.

The most recent published standard, was CAN/BNQ 2501-500 Geotechnical Site Investigations for Building Foundations in Permafrost. This establishes a consistent methodology for performing geotechnical site investigations so that the results can be used to design building foundations with due consideration, in a risk management framework, of the conditions prevailing at the building site, including: distinctive characteristics of permafrost; seasonal and interannual climate conditions; and the projected climate conditions over the service life of the building foundations. It is a foundational reference and is an important complement to the existing and upcoming NISI standards which will include comprehensive permafrost sections:

- Planning, design, operation and maintenance of wastewater treatment in Northern communities using lagoon and wetland systems;
- Selection of foundation types for buildings in permafrost; and
- Erosion protection in permafrost.

Contact: C. Moore, SCC

Northern Transportation Adaptation Initiative

Transport Canada's Northern Transportation Adaptation Initiative (NTAI) provides funding for research and capacity development to adapt transportation infrastructure in northern Canada to a changing climate. One of the program's focal points is the adaptation of infrastructure built on permafrost, with work guided by a network of experts made up of government, academic and industry representatives.

Since 2011, the NTAI has supported nearly 50 permafrost-related research projects, including nine underway in early 2018. These have generally addressed the collection of baseline data about climate change and its impacts on transportation infrastructure, the generation of basic knowledge about the interactions between permafrost and transportation infrastructure and operations, and the piloting of adaptation techniques and practices.

Funding has supported the development and testing of instrumentation and models; the assessment of various construction and maintenance techniques to improve the resilience of road and runway structures, site investigations at airports and along roads and highway sections; and risk, vulnerability and cost/benefit analyses. One key project took advantage of the construction of the all-season Inuvik-Tuktoyaktuk Highway, which connects Canada's highway network to the Arctic coast, to support the Government of the Northwest Territories' investigation into the use of a geotextile to reinforce embankment design.

Contact: C. Kim, Transport Canada

Opening of the Inuvik to Tuktoyaktuk Highway (ITH)

The vision of an all-weather road to the Arctic Coast in the Northwest Territories, Canada, is now a reality. On November 15, 2017, the ITH opened to the public with a ceremonial ribbon-cutting in Inuvik, NT, and an inaugural drive to the Arctic coastal community of Tuktoyaktuk, NT. The ITH is seen as the final link connecting Canada's highway network to the Pacific, Atlantic, and Arctic Oceans, bringing to fulfilment a strategic goal held by the Government of Canada since the 1960s.

Joined by dignitaries and residents from across the Territory, Her Excellency the Right Honourable Julie Payette, Governor General of Canada; the Honourable Amarjeet Sohi, Minister of Infrastructure and Communities; the Honourable Carolyn Bennett, Minister of Crown-Indigenous Relations and Northern Affairs; the Honourable Robert R. McLeod, Premier of the Northwest Territories; and the Honourable Wally Schumann, Minister of Infrastructure, marked the official opening of the ITH with the ribbon-cutting ceremony in Inuvik and community celebrations in Tuktoyaktuk.

Premier McLeod and Governor General Payette cut the ribbon in Inuvik. (Photo: Ed Grozic)

Constructed in about four years over delicate tundra and permafrost, the $300 million, 137 km road is a civil engineering and construction achievement. At the peak of construction, about 600 individuals were employed, of whom 72% were residents of NWT. To protect permafrost, typical 'cut and fill' construction techniques could not be used. Instead, a thick fill embankment design was employed, and most construction activities took place during winter

when frozen soil was placed on the tundra to preserve the underlying permafrost. Eight bridges and over 350 culverts were installed along the road. Thermal analyses supported the design for the road embankment, bridge structures and alignment. The ice-rich permafrost terrain along the length of the highway features ice-wedge polygons, massive ice, and pingos, which presented opportunities for innovative construction techniques, and are a source of significant research opportunities. Scientists and researchers are keen to understand how a changing climate will affect the road's performance and long-term maintenance costs. Several ongoing research projects include sentinel permafrost monitoring sites, deep fill test sections, experimental culverts, and ecological recovery in northern borrow pits. The sentinel permafrost monitoring network alone consists of over 70 ground temperature monitoring locations with automatic data acquisition equipment to collect data along the ITH for the Northwest Territories Geological Survey and the GNWT Department of Infrastructure.

ITH, summer conditions looking north with pingos and Arctic Ocean in the background. (Photo: Tetra Tech Canada Inc.).

Contact: B. Yadav, Director of Transportation, Department of Infrastructure, Government of the Northwest Territories
www.dot.gov.nt.ca (follow the links for the ITH)
Prepared by: E. Grozic, Tetra Tech Canada Inc.

Canadian Delegation Attends Permafrost Workshop in China

An international delegation of permafrost scientists and engineers participated in a workshop to discuss highway construction in permafrost regions. The workshop was held in August 2017 at the First Highway Design Institute in Xi'an and co-hosted by the State Key Laboratory of Frozen Soil Engineering in Lanzhou. The Canadian delegation was organized by R. Fortier (Laval) and included L. Arenson (BGC Engineering), G. Zhang and N. Goldup (Tetra Tech Canada Inc), and J. Oswell (Naviq Consulting Inc.) Other delegates were from the USA, Russia and Norway.

Participants traveled to Xining and then drove the newly constructed 500 km long divided highway between Gonghe and Yushu on the eastern edge of the Qinghai-Tibet Plateau. The delegates enjoyed the outstanding hospitality of their Chinese hosts and were impressed by the engineering strategies to address highway construction in warm, sometimes ice-rich permafrost.

Participants gather on the Gonghe to Yushu highway on the eastern edge of the Qinghai-Tibet Plateau.

Permafrost Engineering Course

With growing interest in Northern development (i.e., new mines being developed, infrastructure requiring replacement and development activity in Nunavut increasing), there is a growing need for geotechnical engineers with expertise in permafrost engineering. The University of Alberta Geotechnical Centre and the Cold Regions Geotechnology Division of the Canadian Geotechnical Society hosted the International Short Course (Nov 30 – Dec 5 2017) on Permafrost Engineering: Effective Design and Construction in Permafrost Regions in Edmonton, Alberta. Topics covered in the 40-hour course included the logistical challenges of building in Northern Regions, understanding the origin and different types of ground ice and evaluating and designing foundations and slopes in permafrost. Lecturers include D. Sego, N. Beier, K. Biggar, L. Arenson, J. Oswell, K. Jones and N. Parry. The 29 participants came from academia, geotechnical consulting companies, northern dam design organizations, oil companies, regulators and government staff.
Contact: V. Giang, University of Alberta

Frozen Canoes

Canadian scientists are involved in a three year joint Can-Norway project, led by H. Christiansen (UNIS) on permafrost science and engineering education.

The project is called Frozen Canoes. Frozen is obvious and Canoes is Canada-Norway-Engineering-Science. It will involve creation of on-line modules and three short courses in the field at Trondheim (NTNU), Svalbard (UNIS), and Yukon (Yukon College, soon to be Yukon University). The topics will range from design and construction in environments with deep seasonal freezing, through design of municipal infrastructure, to design, construction, and maintenance of linear infrastructure, especially roads and airstrips in permafrost environments. Each short course will aim to give scientists and engineers hands-on experiential learning in field settings as well as classroom and computer instruction. The first course will be in 2019. Young professionals will be involved in the administration and delivery of each module in the program, as well as participating. The Canadian participants are Carleton (C. Burn and S. Gruber), Université Laval (G. Doré and J. Côté), and Yukon College (F. Calmels).

Northwest Territories Geological Survey (NTGS)

NTGS, supported by Polar Knowledge Canada and NWT Cumulative Impact Monitoring Program is working with Territorial, Academic and Federal partners to recover, organize and archive permafrost ground temperature and geotechnical data from communities and infrastructure corridors in the Northwest Territories. The goal is to organize and publish the information in a database so that it is available for climate change adaptation and infrastructure planning, monitoring and scientific research. NTGS, Department of Infrastructure (DOI), Geological Survey of Canada and several university partners conducted a geotechnical drilling program in late winter 2017 along the Inuvik to Tuktoyaktuk Highway road corridor to examine variability in permafrost conditions and to establish a thermal monitoring network that complements monitoring of the ITH by DOI. In 2017, terrain and geohazard mapping continues to be focused on the Dempster and ITH corridor and adjacent environments. In this region, the NWT Centre for Geomatics and Canada Centre for Mapping and Earth Observation have implemented UAS methods to examine the nature of surface displacements resulting from permafrost thaw and developed Landsat derived datasets which examine broad-scale landscape change resulting from permafrost thaw. Broad-scale permafrost terrain disturbance maps for northwestern Canada were published in 2017 and additional products defining the spatial extent of fluvial, lacustrine and coastal system impacts by thaw slumping and mass wasting are being developed.
Contact: S. Kokelj, NTGS

Trail Valley Creek Research Station – Wilfrid Laurier University (WLU)

The Trail Valley Creek Research Station (68°45'N, 133°30'W), is located at the northern edge of the boreal forest-tundra ecotone in continuous permafrost approximately 50 km north-northeast of Inuvik, NWT. Water and climate monitoring began in the late 1970's and 1999 respectively, and continuous hydrological research has been carried out since 1991. Renewal of the camp infrastructure began in 2014 by Philip Marsh, Canada Research Chair in Cold Regions Water Science at WLU.

At Trail Valley Creek, warming has led to deepening frost tables and thaw of ice-rich ground promoting subsidence and thermokarst. Recent PhD research by Evan Wilcox (Supervisor: P. Marsh) has found significant differences in frost table depth between tundra, and, birch and alder shrubs. Redistribution of snow by the shrubs in the winter leads to varying snow-free dates and frost table depths with these differences persisting throughout the thaw season. A field study to examine the influence of snow accumulation in shrub patches on active layer thaw and permafrost temperature has been established through a series of thermistors data collection planned during the summer of 2018. Through collaboration with Julia Boike and colleagues at the Alfred Wegener Institute in Germany, instrumented boreholes were established in different landscape units to monitor the influence of vegetation on permafrost temperature.

A new doctoral research project led by Tim Ensom (Supervisors: P. Marsh & S. Kokelj, NTGS), will examine the effects of climate change on permafrost in stream and riparian systems. Ground temperature, water temperature, and winter runoff are being investigated in small stream channels along a latitudinal and ecological gradient between Inuvik and Tuktoyaktuk. Temperature cables were installed along the highway to monitor temperatures in riparian margins and creek beds. Instruments were also installed in undisturbed systems at Havikpak Creek, near the Inuvik Airport, and at Trail Valley Creek. Existing instrumentation will be supported with Electrical Resistivity Tomography in the spring to examine subsurface conditions at stream crossings. This research aims to identify the watershed characteristics, ground thermal conditions, and meteorological events that promote and trigger icing development along the ITH.

Through continued collaborations with the NTGS, NWT Geomatics Centre and the Geological Survey of Canada, Ashley Rudy (Permafrost Research Associate, WLU) will use displacement maps derived along the ITH utilizing RADARSAT-2 imagery and interferometry. The goal is to evaluate the accuracy of these displacement products and to examine the sensitivity of different geomorphic

terrain types to seasonal thaw across a climatic and permafrost ground temperature gradient.

This research is supported through WLU's Canada Foundation for Innovation funded Changing Arctic Network (CANet) infrastructure, and Northern Water Futures, a Global Water Futures funded project. With this support, WLU recently opened a research office in Yellowknife to further assist in enhancing and broadening the important partnership and to support our growing capacity for research needs in the NWT.

Contact: P. Marsh & A. Rudy

Carleton University

In addition to the Permafrost Network Workshop organized by Stephan Gruber (see report above), scientists at Carleton University have been busy with many projects over the last year. The Carleton permafrost research group (carleton.ca/permafrost) holds a weekly seminar where current research is presented and discussed. This allows students (undergraduate to PhD) to present their research, obtain critical feedback, and interface with other researchers. Scientists from the Geological Survey of Canada (GSC) and Canada Centre for Remote Sensing attend the seminars and guest speakers from other institutions often deliver lectures and engage in discussion about their research.

Research projects

Researchers and students participated in the Slave Province Surficial Materials and Permafrost Study led by the NTGS. A drilling campaign at KDI camp, situated in the forest-tundra transition 300 km ENE from Yellowknife established a cluster of 12 boreholes with thermistor chains, complemented by near-surface and air-temperature loggers and analyses of recovered core. This expanded the existing network of 43 sites with boreholes near Ekati Diamond Mine (tundra) and Yellowknife (forest).

Near Yellowknife, three test sites were instrumented to measure liquid-water content over time in permafrost and surface heave/subsidence to observe permafrost thaw more completely. Spectral induced polarization (SIP) measurements, a geophysical technique with potential to reveal ice and water content in the subsurface, were performed to provide spatial context and establish the method's potential. The SIP work is a partnership with R. Grimm and D. Stillman from Southwest Research Institute in Boulder, Colorado.

A. Castagner and R. Subedi participated in a drilling campaign along the ITH. This was a collaboration of the NTGS, NWT Department of Transportation and the GSC.

C.R. Burn is supervising several graduate student projects. M. Phillips (PhD) is working on geomorphic controls on carbon sequestration in permafrost soils of the Mackenzie delta area. A. Wilson (MSc co-supervisor E. Humphreys) is reconstructing vegetation succession at the Illisarvik drained lake and determining vegetation growth have moderated ground temperatures. A-A. Laforce (MSc co-supervisor E. Humphreys) investigated the carbon budgets of various surfaces within the Illisarvik drained lake and the age of carbon emissions from various vegetation communities. S. Bishop-Legowski (MSc) is examining the thermal regime in talus slopes of northern Ontario that leads to the presence of permafrost 400 km south of the continental limit. D. Tokarski (MSc co-supervisor M. Richardson) is examining snow sampling methods for effective forecasting of the water balance of the south Slave region, NWT, with respect to the requirements of the NWT Power Corporation. J. Humphries (MSc co-supervisor E. Humphreys) is examining the use of artificial and natural snow fences to sequester snow away from the Dempster Highway near the Yukon/NWT border for more effective highway maintenance and to minimize permafrost thaw beside the road. H.B. O'Neill completed his doctoral thesis on the ground thermal regime of the Peel Plateau, NWT and has joined GSC as a post-doctoral fellow.

Several graduate projects are being supervised by S. Gruber. X. Quan (postdoc) is developing software and methods for effectively using three atmospheric re-analyses to drive process-based permafrost simulations, globally. N. Colombo (co-supervisor M. Giardino, Torino, Italy) defended his PhD thesis that investigated interactions between permafrost and physiochemical characteristics of high-elevation lakes in the Western Italian Alps. A. Castagner (PhD) is examining the spatial estimation of ground ice amounts and characteristics in the Canadian Arctic. R. Subedi (co-supervisors C. Burn, S. Kokelj) completed his MSc thesis on depth profiles of geochemistry and organic carbon from permafrost and active layer soils near Lac de Gras, NWT. N. Brown completed his MSc thesis examining techniques for estimating soil properties using measured temperature time series, a ground temperature model, and optimisation methods. S. MacDonald (MSc) is investigating the use of advanced time-series analysis to characterise the influence of snow cover on ground temperatures. A. Hill's MSc research (co-supervisor A. Adler) focusses on a device for temperature-dependent dielectric spectroscopy of frozen soil in a collaboration between Systems and Computer Engineering and Geography. L. Padilla-Ramirez (MSc) is investigating how well continental-scale climate and remote sensing data can predict spatial patterns in permafrost data for Canada. C. Peart (MSc) is using terrestrial laser scanning and surveying to examine the repeatability of areal elevation measurements as a basis for revealing subsidence with known accuracy.

Masters programs in Northern Studies
In September 2017, Carleton University initiated one-year, intensive, course-based Master programs in Northern Studies (MA & MSc). These degrees include a one-term workplace assignment. The first cohort of students has secured placements that include work with Yukon Highways Engineering Branch and with Yukon College for two students who will be directly engaged with problems related to permafrost. Other students will work on biophysical issues concerning the permafrost environment at the Inuvialuit Joint Secretariat and Aurora College in Inuvik and CHARS in Cambridge Bay.
Contact: C. Burn & S. Gruber

The Ontario Far North, Hudson Bay Lowlands

The Ontario Far North extends through the continuous, discontinuous, and sporadic permafrost zones of the Hudson Bay Lowlands (HBL). Since 2009 five permafrost stations, with maximum sensor depth of 4-11 m, have been installed in the continuous zone near Peawanuck and in the discontinuous zone west of Attawapiskat. Changes in the extent of palsas and peat plateaus are being investigated using Worldview-2 satellite imagery in combination with historical aerial photographs. In a test area in the sporadic discontinuous zone, the area occupied by palsas and peat plateaus decreased by 26.3% between 1954 and 2011. Active areas of research include assessment of carbon dynamics as well as hydrological and ecological changes associated with permafrost degradation at a range of spatial and temporal scales, supported by a network of stream gauges, Eddy Flux towers, and peat and permafrost sampling.
Contact: J. McLaughlin & M. Packalen, Ontario Ministry of Natural Resources and Forestry

Laurentian University

The new Laurentian University Permafrost Research Laboratory was launched in 2015 and focusses on permafrost degradation and recovery in Arctic and subarctic peatlands. Current student projects include: (1) assessing permafrost distribution near Fort Severn, in the Hudson Bay Lowlands; (2) using the GEOtop model in collaboration with S. Gruber (Carleton U.) to investigate the effects of increased soil moisture on permafrost sustainability; and (3) examining organic matter content, microbial communities, and CH4 /CO2 emission potential in cores from palsas and associated degradation features in Polar bear Park, Hudson Bay lowlands, in collaboration with J. McLaughlin and M. Packalen (Ontario Ministry of Natural Resources and Forestry) as well as N. Basiliko and N. Mykytczuk (Laurentian U. Vale Living with Lakes Centre). Other on-going research projects continue to investigate interactions between water bodies and permafrost in a central Yukon peatland.
Contact: P. Roy-Léveillée

Université Laval – ARQULUK Program

Construction of roads, highways and airstrips in permafrost areas inevitably affects the thermal regime of frozen soils, which may cause degradation of the underlying permafrost, thereby threatening the structural and functional capacities of those infrastructures. Maintaining stable and safe transportation infrastructure in northern Canada is a priority, but also a major challenge.

The ARQULUK engineering research program at Laval University, Québec, is a Cooperative Research and Development Program, funded by NSERC and 12 partners from public and private sectors. The research focus on improving current knowledge on permafrost degradation and ability to adapt by developing expertise, procedures and techniques to better understand and mitigate instabilities affecting transportation infrastructure.

The program's achievements include tools and procedures based on the needs of the stakeholders involved in the development and management of northern transport infrastructure. To improve understanding of degrading permafrost, research has focussed on: 1) Adaptation of microgravimetry and road profilometry techniques for the detection of thaw-sensitive permafrost; 2) Development of a laboratory testing procedure to characterize the mechanical behavior of marginally frozen soils subjected to cyclic loading which showed that the effect of heavy vehicles (dynamic creep) needs to be considered for thin embankments; 3) Design and manufacture of an oedometric core-barrel for in situ measurement of thaw consolidation properties of permafrost.

In order to limit the impact on thaw-sensitive permafrost, adaptation techniques and methods for transportation infrastructures have been developed that will allow northern stakeholders to: 1) Rapidly evaluate the relevance of limiting heat-intake by using high albedo surfacing; 2) Design low-impact drainage system considering the geometry and the optimal number of crossings (culvert); 3) Determine the required embankment slope to minimize snow accumulation for cross-wind embankment sections; 4) Design convective mitigation techniques for embankments on thaw sensitive soils.

Finally, a methodology and a software were developed to quantitatively calculate the risk associated with common permafrost-supported embankment infrastructure hazards. The analysis uses several geotechnical, climate and permafrost parameters to determine probabilities of occurrence

of hazards, based on user-input serviceability limits and/or limit state considerations. The analysis of the risk considers direct maintenance or rehabilitation costs related to hazard occurrence and its impact to safety of users and on communities.

The results of this research program will have significant impacts on the quality of transportation infrastructure built on permafrost, thus contributing to a sustainable social and economic development of northern Canada. The knowledge and research products developed can also be exported since the problems encountered in Canada also affect the development of other northern territories.

Contact: G. Doré & C. Lemieux

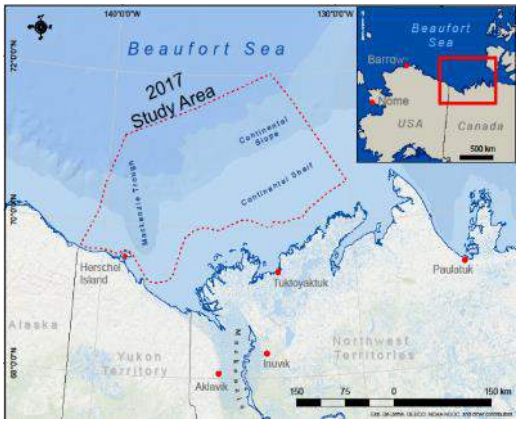
Geological Survey of Canada (GSC)

In 2017, GSC initiated new research activities to support climate change adaptation in permafrost regions. Research focusses on exiting or proposed transportation/development corridors including the Dempster-ITH, in order to address questions of landscape change and to inform strategies to manage and mitigate risk associated with a changing climate. Field investigations are being integrated with analysis of remotely sensed data and syntheses of existing data. Research is conducted in collaboration with territorial and university partners. A key objective is to improve permafrost mapping. A pilot project was also initiated to increase public availability of permafrost data through the adaptation of existing web-based tools.

Canada-Korea-USA Beaufort Sea Geoscience Research Program

GSC continued its investigation of geohazards related to the occurrence of offshore permafrost in the southern Beaufort Sea. In fall 2017, a research expedition was conducted onboard the RV Araon, an icebreaker owned and operated by the Korea Polar Research Institute (KOPRI). This 17-day multidisciplinary field program was a collaboration between the GSC, KOPRI and the Monterey Bay Aquarium Research Institute and included ~45 scientists and technicians from seven countries. Primary geoscience research tasks included multichannel seismic program, ROV and AUV operations, and sediment coring. Complementary oceanographic and atmospheric science studies also took place.

The permafrost research goals were to investigate the occurrence of offshore permafrost in the Mackenzie Trough and Yukon side of the Continental Shelf as an extension to framework studies that have been conducted in areas along the eastern side of the Trough. The seismic studies will allow quantification of permafrost properties and distribution (imaging, P-wave velocity and full wave form inversion modeling) as well as a basis to map the occurrence of permafrost and marine gas hydrates. The AUV, ROV and coring programs focussed on assessing active geologic processes that could be triggered by thawing permafrost. For further information, contact S. Dallimore (GSC).



Study area for the 2017 research program.

Araon 2017 research team on the bow of the vessel with the Diomede Islands in the background.

New Book

S. Harris (U of Calgary) is editor (with A. Brouchkov, C. Guodong) of the new book *Geocryology: Characteristics and Use of Frozen Ground and Permafrost Landforms.* This book covers the entire topic of geocryology and provides a comprehensive description of permafrost processes and landforms, and includes research previously only available in Russian and Chinese. It will be of interest to both professionals and students. For more information: www.crcpress.com/Geocryology-Characteristics-and-Use-of-Frozen-Ground-and-Permafrost-Landforms/Harris-Brouchkov-Guodong/p/book/9781138054165

Report prepared by Sharon Smith, Geological Survey of Canada

China

Main cold region projects and corresponding research works

The Qinghai-Tibet Railway, successfully running more than 10 years

The Qinghai-Tibet Railway (QTR) is milestone project in the permafrost regions. It has been safely running more than 10 years since it was opened to traffic since 2016. The monitored data from 88 sites along the railway in the permafrost sections showed that more than 90% of the sites were stable, both in thermal and deformation state, meaning that the settlement was no more than 5 cm per year. However, the maintenance and reinforcement works are still necessary to reach the long-term stability and safety of the QTR. Some engineering-problem-control measures base on “actively cooling principle” were suggested by the State Key Laboratory of Frozen Soil Engineering, CAS, and were adopted to the maintenance works. The mainly include slope air-convection reinforce embankment, duct-ventilation embankment reinforced with crushed-rock covering on the slopes, air-convection reinforce crushed-rock layers on the slopes (Fig.1), thermosyphone and crushed-rock layer composited embankment. It was particularly pointed out that ground water treatment near the embankments is very important in the maintenance works. The monitored data showed the effectiveness of these measures.

Figure 1: Test site of slope air-convection reinforce embankment

The new opened Gonghe-Yushu Express Highway in the Eastern Qinghai-Tibet Plateau

The first express highway in the permafrost regions of the Qinghai-Tibet Plateau (QTP), named Gonghe-Yushu Express Highway (GYEH), was constructed since 2011 and opened to service in 2017 (Fig. 2).The total length of the line is 634.8 km, of which 227.7 km crosses the degenerative permafrost in the QTP, meaning a new milestone of permafrost engineering in the world. Thus this line is the longest express highway, with black asphalt surface, largest width and thickest surface layer, in the permafrost regions around the world. The highway was jointly designed by the Qinghai Province Highway Design Institute and the CCCC First Highway Consultant Co. Ltd., under a principle of “protecting the frozen soil, mitigating the melting and preventing engineering diseases". The principle was proposed by the CCCC First Highway Consultant Co. Ltd., to solve the thermal problems caused by strong heat absorption from the black asphalt surface, heat storage from the thick pavement layers and large scale embankment structures.

Figure 2: The new opened Gonghe-Yushu Express Highway (scenery over the Heka Mountain)

The jointed research works were led by Dr. Shuangjie Wang from the CCCC First Highway Consultant Co. Ltd. Based on the construction and maintenance experiences from the Qinghai-Tibet Highway, he proposed a concept termed “scale effect”, which illustrated the variation of thermal state and deformation performance with the scale (dimensions) of road embankments, such as road width, height, along with the thick pavement layer. For controlling the “scale effect”, Wang and his team suggested to design the highway considering the heat budget balance in the underlying permafrost from both spatial and temporal dimensions. Some new cooling methods, including dispersion ventilation structure, crushed-rock layer and chimney composite structure, and air-convection reinforced slope and internal structure were tested and adopted along the highway. Demonstration sections around 38-kilometer long were constructed along the highway. In August 2017, some experts of frozen soil engineering from China, Canada and Russia visited the GYEH (Fig. 3) and confirmed the cooling methods applied in the construction.

Figure 3: Visiting the test sites along the GYEH (left: in the Huashixia Field Station; Right: on the Bayankala Mountain)

China-Russia crude oil pipeline (CRCOP)

The 813 mm diameter China-Russia crude oil pipeline (CRCOP), a spur line from the Siberia–Pacific Pipeline System, enters northeast China at Lianyin, Mo'he County, Heilongjiang Province, and crosses 441 km of discontinuous, sporadic and isolated patches of warm permafrost, and 512 km of seasonally frozen ground, before reaching Daqing (Fig. 4). The first line of the CRCOP was completed and formally operated in January 2011, transporting 1.5×10^7 tons Russian crude oil to China per year, and the second line was built in winter of 2017 and formally operated in January 2018. Two lines can reach the China-Russia contracted annual throughout of 3×10^7 tons.

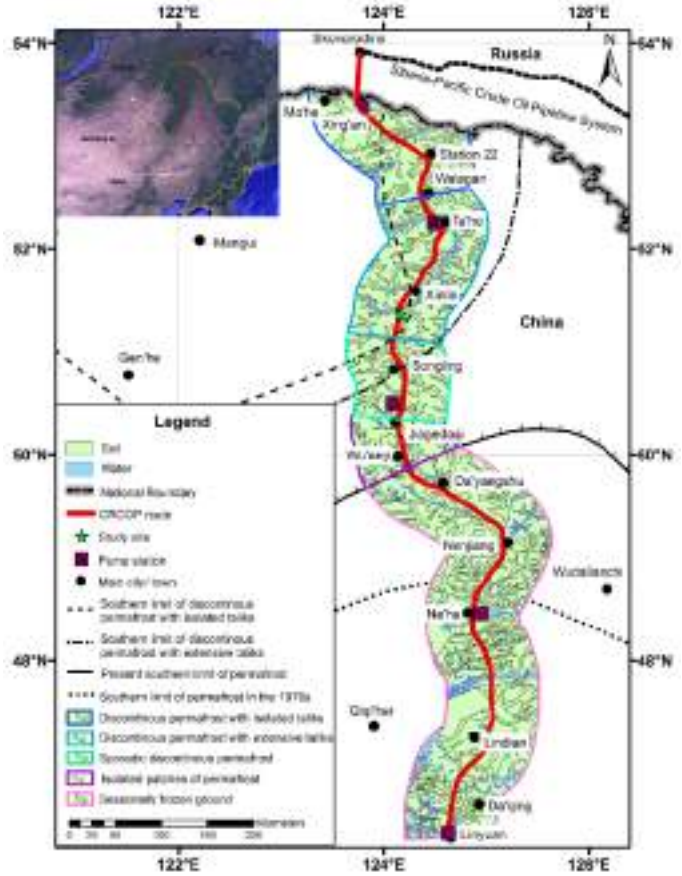


Figure 4: Permafrost distribution along the C RCOP (by Dr. Yongping Wang)

The field monitoring system was established in three sites including 14 cross sections and 29 boreholes to measure the ground temperatures, moisture content of and the displacements of ground surface and pipe. Field observations of ground temperatures at Kilometer Post (KP) 391 + 600 show that the underlying permafrost is degrading and related thaw settlement had been happening beneath the right-of-way (ROW). Thermosyphons were adopted to mitigate the thaw-induced problems in permafrost regions. Monitored data indicate that permafrost underlying the uninsulated pipeline without thermosyphons is degrading including the increasing of the active layer thickness at an annual increasing rate of about 1 m/a and warming of deep permafrost (15-20m). The thermally affected region of warm oil pipeline expanded to more than 4.0 m. Because the monitoring system along the second line of the CRCOP was just completed and the data was not measured. The further evaluations about thermal regime of permafrost heated by two pipelines together will be done according the field observations.

Development on research of frozen soil mechanics

A fractional order creep constitutive model of warm frozen silt

In the State Key Laboratory of Frozen Soil Engineering, s series of triaxial creep tests were conducted on warm frozen silts extracted from Qinghai-Tibet Plateau at temperature of -1.5 °C under confining pressures of 0.5, 1.0, and 2.0 MPa, respectively. The test results indicate that the creep strain increases with the increase of applied stress level and there is a stress threshold, based on which the test results can be classified into two types of creep strain curves. The creep strain curve only includes primary and secondary creep stages when the stress level is less than the threshold value. When the stress level exceeds the threshold value, the creep strain velocity gradually increases and the specimen quickly fails in tertiary creep stage. Based on the creep test results, a fractional order rheological element model is established for warm frozen silt, which is also generalized from uniaxial stress state to the three-dimensional stress state. From the analysis on the features of the stress threshold, a creep strength criterion is also proposed simultanously. Comparing the calculated results of the warm frozen silt with the tested ones, it is found that the predicted results of the proposed model are in good agreement with the test results (Fig. 5). In the proposed fractional order model, the relationship between the damage factor and time is established to describe the damage degree of the specimen. Comparing with Nishihara's model, widely used in geomaterials, the proposed fractional order creep model can more accurately simulate the creep behavior of warm frozen silt. And the proposed model with fewer parameters and better precision is

more advantageous than the creep models proposed by the other researchers.

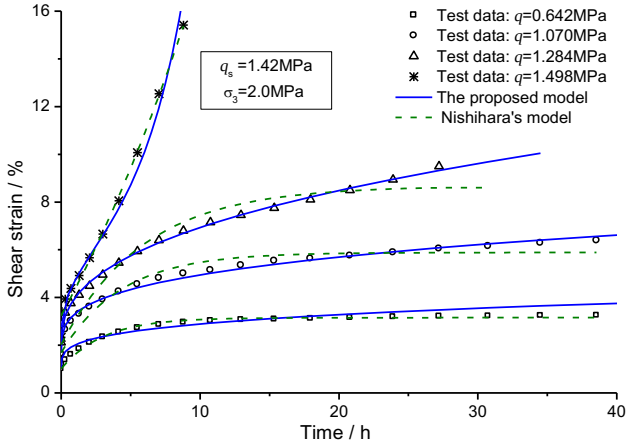


Figure 5: Comparisons among Nishihara's model's, the present model's and test results

Development on research of permafrost distribution in China

The thermal degradation of permafrost in the Qinghai-Tibet Plateau

The potential thermal degradation of permafrost over the Qinghai-Tibet Plateau (QTP) from the 1960s to the 2000s was evaluated using estimated decadal mean annual air temperatures (MAATs) by integrating remote sensing-based estimates of mean annual land surface temperatures (MASTs), leaf area index (LAI) and fractional snow cover values, and decadal mean MAAT date from 152 weather stations with a geographically weighted regression (GWR). The results reflect a continuous rise of approximately 0.04 °Ca^{-1} in the decadal mean MAAT values over the past half century. A thermal condition classification matrix is used to convert modelled MAATs to permafrost thermal type. Result shows that the climate warming has led to a thermal degradation of permafrost in the past half century. The total area of thermally degraded permafrost is approximately 153.76×10^4 km^2, which corresponds to 88% of the permafrost area in the 1960s. The thermal condition of 75.2% of the very cold permafrost, 89.6% of the cold permafrost, 90.3 % of the cool permafrost, 92.3% of the warm permafrost, and 32.8% of the very warm permafrost has been degraded to lower levels of thermal condition. Approximately 49.4% of the very warm permafrost and 96% of the likely thawing permafrost has degraded to seasonally frozen ground. The mean elevations of the very cold, cold, cool, warm, very warm, and likely thawing permafrost areas increased by 88 m, 97 m, 155 m, 185 m, 161 m, and 250 m, respectively. The degradation mainly occurred from the 1960s to the 1970s and from the 1990s to the 2000s. This degradation may lead to increases in risks to infrastructure, increased flood risks, reductions in ecosystem resilience, and positive climate feedback effects. It therefore affects the well-being of millions of people and sustainable development at the Third Pole.

Report prepared by Niu Fujun

Finland

The INFRAHAZARD (Geomorphic sensitivity of the Arctic region: geohazards and infrastructure, 2015–2018) research project (J. Hjort & O. Karjalainen, University of Oulu, and M. Luoto & J. Aalto, University of Helsinki) continued successfully. The project focuses on the modelling of the Arctic Earth surface systems (ESSs) in a changing climate and production of geographic information system (GIS) based infrastructure risk maps for decision making and land use planning. So far, the INFRAHAZARD project has constructed a comprehensive circum-Arctic database on ESSs (e.g. ground temperature, active layer, and permafrost features), environmental conditions (e.g. climate and ground properties) and infrastructure (residential, transportation, and industry) at high (<1 km) resolution. Moreover, the project has compiled field-based data on ESS processes (e.g. frost action) at local scale (more than 600 observation sites have been inventoried). Using the compiled data sets we have, for example, projected the ground thermal regime in current and future climates (e.g. using RCP4.5 and 8.5 scenarios) and modelled geomorphic features across scales. We have found that: (i) local environmental conditions control the current and future geomorphic process activity in high-latitude landscapes (Fig. 1), (ii) the distribution of permafrost landforms can be modelled across the Arctic at high resolution, (iii) there will be substantial degradation of (a) circum-Arctic permafrost and (b) periglacial process activity in N Europe by the middle of this century, and (iv) Arctic infrastructure is at risk in the near future owing to thaw of ice-rich permafrost (Fig. 2).

Figure 1: Students in field nearby Kilpisjärvi research station, NW Finland (photo by J. Hjort). The summits of the rounded mountains on the back (> 900 m above sea level) belong to the zone of discontinuous permafrost.

Nitrous oxide (N_2O) emissions from permafrost soils have been traditionally thought to be negligible, but during the last decade evidence has been accumulating of substantial N_2O emissions or production from different kinds of northern soils. In July 2017, the Biogeochemistry Research Group of the University of Eastern Finland (BGC UEF) conducted a field expedition to the Kolyma Region, NE Siberia. The field work was part of the Yedoma-N project funded by the Academy of Finland (PI: C. Biasi, UEF) that aims at investigating nitrogen cycling in yedoma permafrost after thaw, and the potential of this widely spread permafrost type for N_2O release. The field work was continuation from previous year's measurements at the yedoma exposures on the Lena River delta. In the Seida study site, jointly maintained by BGC UEF and the Komi Science Center, a field warming experiment continued on permafrost peatlands and upland tundra heath soils. The experiment makes use of ITEX type open top chambers and has been running since 2012. In December 2017, BGC UEF was represented at the annual meeting of the Permafrost Carbon Network, a US based network that aims at synthesizing existing research about permafrost carbon and climate in a format that can be assimilated by biospheric and climate models.

The Department of Geographical and Historical Studies, University of Eastern Finland (T. Kumpula, A. Colpaert, E. Lotsari, M. Verdonen) have conducted annual high accuracy RTK GPS measurements in two palsas in Laassaniemi and Peera since 2007 (Kilpisjärvi area). The both palsas studied have about 150 plots from which XYZ and active layer depth are measured annually in the end of the August/beginning of the September. In Peera palsa mire also temperature and soil moisture monitoring with loggers have been going on since 2011. Unmanned Aircraft System have been used in monitoring of palsa mires between Markkina and Kilpisjärvi since 2015 (T. Kumpula, P. Korpelainen, M. Verdonen). At the moment, 15 different palsa mires are annually monitored with UAS drones in the early June and at the of August.

Temperature monitoring (J. Hjort) of palsas at the Kevo site in NE Finland (Vaisjeaggi1, a Global Terrestrial Network for Permafrost site) and in NW Finland (close to Peera) continued.

Figure 2: Damaged road due to permafrost thaw in Peera, NW Finland *(photo by J. Hjort).*

Report prepared by Jan Hjort, Geography Research Unit, University of Oulu (Jan.Hjort@oulu.fi)

France

During 2017, the activities of the French permafrost community are going on Western Alps, Iceland and Central Yakutia (Russia). Permafrost studies in France are covering a wide range of different activities: e.g. geomorphological field study, field monitoring, laboratory simulation in cold rooms and numerical modelling of water/permafrost interactions.

During 2017, research activity focused on a field campaign in Nunavik, northern Quebec, Canada was led by Armelle Decaulne, CNRS LETG-Nantes and Najat Bhiry, Centre d'études Nordiques, Université Laval, Québec. Part of Labex DRIIHM and OHMi NUNAVIK program, the aim of that work was to document activity on slopes in villages and their surroundings, and in National Parks. The areas investigated in August 2017 were (i) Kangiqsualujjuaq (George River) in NE Nunavik (figure 1), by the Hudson Strait; (ii) Umiujaq and Tasiapik valley, on the Hudson bay in W Nunavik; and (iii) Lepage and Aux Foreurs islands in Wiyâshâkimî lake (Lac à l'Eau-Claire), in the eastern part of Tursujuq National Park, SW Nunavik. Due to the development of the area, driven by both demographic increase and global change, slope instabilities represent hazards that may cause concern to local population and tourists visiting Nunavik. While little or no knowledge exist on the type of slope processes, their potential runout and their triggering factors in most of Nunavik communities, investigation of fresh and inherited landforms are propose to characterize these slope processes (mainly scree development, rockfall, debris flow, snow avalanche, landslides) and talus organization (morphometric properties of clasts), and age.

Figure 1: Kangiqsualujjuaq, August 2017. The village is threatened by snow avalanches. The 1999 event killed 9 people and injured 25. Image from A. Decaulne.

These past years, researches conducted by EDYTEM Lab (X. Bodin, F. Magnin, L. Ravanel, Ph. Deline) and Institut de Géographie Alpine (Ph. Schoeneich) have been focus on the thermal regime of permafrost and on the rock fall activity in the Mont Blanc Massif. To demonstrate the hypothesis that permafrost degradation leads to an increase in the frequency and volume of rockfalls can only be considered from the study of a large body of data. Since 2007, a network of observers is operational and allows each year to document several tens of rockfalls. After Alp-Risk, the new smartphone app Obs-Alp must facilitate data collection. Among the large number of rockfalls that occurred during the hot summer 2017, the 44,000 m^3 rockfall that affected the Tournier spur (north face of the Aiguille du Midi; 3842 m a.s.l.) is the largest since 2005 (figure 2). Ice was collected in the scar and is being analysed (structure, age).

Figure 2: Rockfall that affected the Tournier spur (north face of the Aiguille du Midi, Mont-Blanc. Image: L. Ravanel.

The historic network of sensors for monitoring rockwall permafrost, originally concentrated on the Aiguille du Midi, has been densified and expanded to three new sensitive sites: (i) Aiguille des Grands Montets (cable car), (ii) the lower Cosmiques ridge (refuge), and (iii) the Aiguille du Goûter (refuge and access). A 17-m-deep borehole was instrumented at the Grands Montets. A research axis has been developed on the issue of the role of the ice/snow covers and hanging glaciers on the distribution of permafrost. Three of them were instrumented using a 1 to 16-m-deep borehole.

Antoine Séjourné, Francois Costard and Christelle Marlin (GEOPS laboratory, Paris-Saclay, France) in collaboration with A. Fedorov (Melnikov Permafrost Institute of Yakutsk) has continued their research on the dynamic an alas valley at the Syrdakh site in Central Yakutia (Siberia), (figure). New regional research reveals that a large fraction of permafrost carbon is vulnerable to release within in case of abrupt thaw. However, sediment transport and carbon burial/mineralization providing transitory carbon reservoirs at some locations within the hydrosystem is not fully understood. A new project aims to assess lateral transport (by surface and/or groundwater) in relation to active thermokarst sources (slumps and lakes) in a landscape unit representative of ice-rich permafrost in Central Yakutia (figure 3). During summer 2017 field surveys, the objective was to characterize the signature of thermokarst lakes of different ages

(from Holocene to modern age) and, the relation between river and lakes. Lakes and river were sampled for chemical and isotopic analysis and characterization of particulate organic carbon and dissolved inorganic carbon.

Figure 3: Studied site in ice-rich permafrost area in Central Yakutia (eastern Siberia). Image from A. Séjourné

Together with the GEOPS team (Paris-Saclay, France), Christophe Grenier and Eric Pohl (LCSE, Gif sur Yvette, France) did some monitoring of a small river within an alas valley (air, river and soil temperatures, river discharge, ground water levels, soil water content) across a valley cross section to study the inter-annual evolution of the thermal imprint of the river. During the field trip they 1) gathered further information about the active layer zone and soil properties through geophysical surveys and soil pit measurements at the main river-valley cross-section; 2) installed a soil water content (SWC) monitoring network (the only access to SWC was until 2017 possible through pits made during September surveys); 3) derived information about the active layer-permafrost boundary by geophysical means (GPR and ERT) at several cross sections along the river valley; 4) derived a digital elevation model of the river-valley system between the Upper and Lower Lake through drone-borne imagery and DGPS measurements.

Figure 4: Localisation of the Syrdakh site in Yakutia with the monitoring sites (red boxes).

The 2012 – 2017 Syrdakh dataset is now being organized into a spatially database for easy access to the data. The next phase will deal with numerical simulation of the heat and water transfers along 2D cross sections of the river-valley system.

The third InterFrost meeting was held from 22-23 November 2017 in Ecole des Mines, Paris. The first phase of the InterFrost project dealing with the intercomparison of 13 codes on coupled 2D thermo-hydraulic academic test cases is now completed. The database and results are to be found on the InterFrost web site (wiki.lsce.ipsl.fr/interfrost) and presented through the associated paper, currently under review (Grenier et al., "*Groundwater flow and heat transport for systems undergoing freeze-thaw: Intercomparison of numerical simulators for 2D test cases*"). The present phase of InterFrost deals with the validation of codes from an experiment inspired from the TH2 Academic Case. It was conducted in close association with the GEOPS Laboratory. This very challenging experiment was implemented in controlled conditions in the cold room laboratory of GEOPS. The presentation of the setup and results has attracted the interest of participants who will run their codes on these results. Preliminary outcomes will be presented during the next EUCOP2018 meeting in Chamonix.

The development of a high performance computing tool for the modeling of the thermo-hydrological dynamics of permafrost undertaken by L. Orgogozo (Geosciences Environment Toulouse laboratory) has allowed a mechanistical modeling study of water fluxes in the Kulingdakan watershed, in Central Siberia, in collaboration with the Sukachev Institute of Forest of Krasnoyarsk. The developed modeling tool, permaFoam, is implemented in the open source tool box for computational fluid dynamics OpenFOAM® (www.openfoam.com). PermaFoam solves numerically the equation of transfer of water in variably saturated soils and the equation of thermal transfer with freeze/thaw within soils, which are both non linear and strongly coupled. The evapotranspiration phenomena are taken into account in a spatially distributed and time dependent way, on the basis of the potential evapotranspiration and of the hydrological and thermal state of the considered soil. One can see on figure 5 as an example of results a comparison between measured and computed temperatures in the mineral soil of the south aspected slope of the Kulingdakan watershed, which is covered by a larch forest, and thus is strongly affected by evapotranspiration during the growing season (period of maximum radial growth : end of may to july). These numerical results are obtained through a purely mechanistical approach without any parametric calibration.

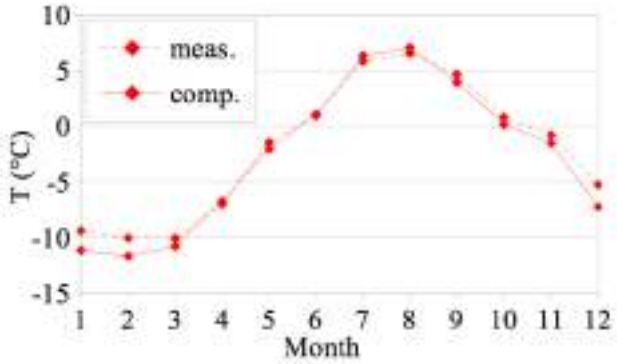


Figure 5: Measured (meas.) and computed (comp.) annual temperature evolutions at 20cm depth in the mineral soil of the south aspected slope of the Kulingdakan watershed.

Report prepared by François Costard
francois.costard@u-psud.fr

Italy

Western Alps

Many activities were performed by the Environmental Protection Agency of Piemonte (Arpa Piemonte) (Luca Paro). These activities started in 2006 and developed significantly thanks to the partnership in EU projects: in 2008÷2011 Alpine Space project “PermaNet - Permafrost long-term monitoring Network” and in 2016-2017 Al.Co.Tra.(Italy-France)project “PrévRiskHauteMontagne”.

The main 2017 activities of Arpa Piemonte were:

- management of the permafrost monitoring regional network consisting in 6 stations (boreholes 5 to 100 m deep, 2500 to 3020 m of altitude) and of the new geotechnical-thermal station of M. Rocciamelone (borehole 30 m deep at 3150 m a.s.l.), and updating analysis of monitoring data related to climate conditions (Fig. 1).
- in situ sensor calibration at the Sommeiller station (2980 m a.s.l.) in collaboration with INRiM (A. Merlone, G. Coppa, F. Sanna) in the framework of MeteoMet2 project.
- installation of active layer monitoring site at the Salati Pass (3050 m a.s.l.) to evaluate thermal effects of the new ski buildings;
- management and development of GST monitoring and of temperature monitoring in cave sites (in collaboration with Turin Polytechnic, B. Vigna).

Maintenance, data download and analysis have been carried out on the already existing 8 sites and new 20 sensors and new 2 sites have been installed.

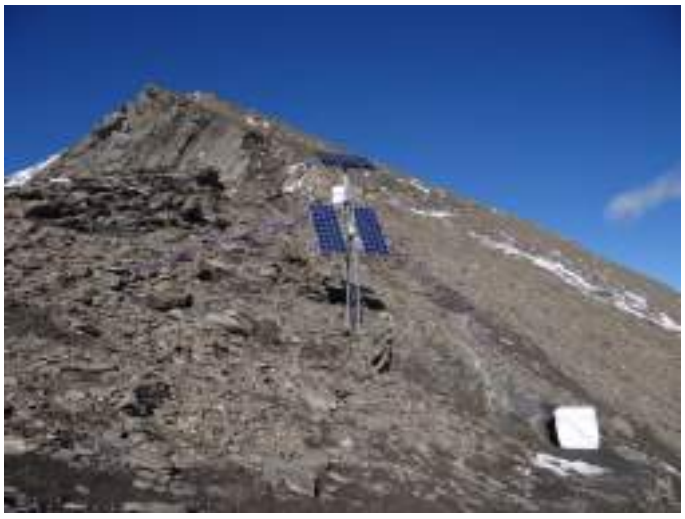


Figure 1: M. Rocciamelone meteo station (Western Alps).

- survey of 2 rock glaciers. In the framework of the agreement between Arpa Piemonte and University of Pisa (A Ribolini), geophysical surveys have been carried out in two rock glaciers: GPR on the “Vej del Buc” rock glacier in Maritime Alps (probably the southernmost active rock glacier of the Alps) (Fig. 2) and ERT and HVSR on the “Mt. Granero” rock glacier in Cottian Alps. In these sites UAV photogrammetry surveys have been made by Arpa VdA (U. Morra di Cella).

Figure 2: GPR survey on the Vej del Bouc rock glacier (Western Alps)

Other activities in the Western Alps were undertaken by the Italian National Research Council, Research Institute for Geo-Hydrological Protection (CNR-IRPI).

In 2017 CNR-IRPI (R. Paranunzio, M. Chiarle, G. Nigrelli, G. Mortara, L. Turconi, F. Luino), in collaboration with Politecnico di Torino - DIATI (F. Laio) collected data on slope instability events that occurred at high elevation in the Italian Alps in the period 2000-2016 and analysed climatic data recorded by nearby automatic weather stations, with the aim to identify climatic anomalies associated to the occurrence of natural instability processes in permafrost slopes.

In the framework of the RiST Project, co-financed by Fondazione CRT, CNR IRPI (G. Nigrelli, M. Chiarle, P. Silvestri), in collaboration with the MeteoMet Project (A. Merlone, G. Coppa, C. Musacchio) continued the geomorphological, climatic and thermal monitoring of the Bessanese glacial basin (Lanzo Valleys, TO), aimed to measure the temperature of air, rock and debris by means of sensors with known uncertainty of measurements, increase the knowledge about the thermal conditions of different types of rock and debris, study relations between climate variability and morphodynamic processes in permafrost areas. The preliminary results of these studies will be presented at the EUCOP5, in Chamonix, on June 2018.

In 2017 CNR-IRPI (G. Nigrelli and M. Chiarle) in collaboration with the Earth Science Department of the University of Turin (S. Fratianni), continued the studies related to the local altitudinal temperature

lapse rates in the Western European Alps, for increasing knowledge on the relations between air temperature and rockfalls at high- elevation sites in a context of climate change.

In 2017 ARPA VdA (E. Cremonese, U. Morra di Cella, P. Pogliotti) has been partner of the project PrevRiskHauteMontagne (EU Alcotra ITA-FR program) with the objective of study the risks related to snow, glaciers and permafrost in high mountain environments. Within the project ARPA VdA has improved the study of drone-derived surface velocities in many rock glacier sites (Gran Sometta, Arpisson and Punta Coppi (with FMS) and Vei del Bouc (with ARPA Piemonte)), has maintained the key permafrost monitoring sites of the Valle d'Aosta and contributed to the outreach activities of the project. ARPA VdA continues the long-term monitoring activity of permafrost thermal regime in the Cervinia basin on the sites of Cime Bianche, Capanna Carrel and Matterhorn Summit and in the Mont Blanc area on the sites of Petit Grapillon, Grandes Jorasses and Aiguille du Midi. ARPA VdA will participate to the next EUCOP in Chamonix and will organize one of the regional field-trip.

In 2017 Fondazione Montagna sicura (FMS) (F.Troilo, E. Motta, C. Lucianaz, S.Gottardelli, P.Picco) has been partner of the project PrevRiskHauteMontagne (EU Alcotra ITA-FR program) with the objective of study the risks related to snow, glaciers and permafrost in high mountain environments. Within the project FMS has performed a GIS-based risk assessment study on the regional inventory of Rock Glaciers, that led to the individuation of the Arpisson and Punta Coppi rock glaciers, where further studies have been carried out with Arpa Vda and Edytem. FMS is also monitoring the rock falls of the Brenva Face in the Mont-Blanc Massif, in order to prevent Ice-Rock avalanche Phenomena; the rock falls are very likely to be related to permafrost degradation, but further studies need to be carried out. FMS will participate to the next EUCOP 2018 in Chamonix.

Central Alps

The activities carried out in this region of the Italian Alps in 2017 comprise the collection of different kind of data from study sites located in the Adamello Presanella, Ortles Cevedale and Dolomites.

GST from several sites located on bedrock and on various landforms (active and inactive rock glaciers, scree slopes, glacial deposits) were collected. Measurements of annual surface displacements over three active rock glaciers have been carried out and GST data from several monitoring points on the same landforms were retrieved. Furthermore, on these rock glaciers the data from the stations installed for measuring the snow cover thickness and the air temperature were also retrieved.

The monitoring of subsurface ground temperature, together with in-situ atmospheric variables, continued in two boreholes drilled in bedrock (Cavaion and Lobbie Hut sites) (Fig. 3).

The PhD program initiated in late 2016 (University of Pavia in cooperation with EURAC Research) continued its activities in 2017, mainly focusing on combining satellite SAR interferometry and ground-based data for the study of slow movements in permafrost-affected areas of South Tyrol.

The activities involved the following institutions and people: University of Padova (G. Dalla Fontana, A. Bondesan, A. Carton, L. Carturan, T. Zanoner); University of Pavia (R. Seppi, F. Zucca, A. Bertone); Autonomous Province of Trento (M. Zambotto, M. Zumiani); Edmund Mach Foundation, Trento (M. Tolotti); EURAC Research, Bolzano (C. Notarnicola, M. Callegari, G. Cuozzo).

Figure 3: Vioz Hut, Trentino (~3500 m a.s.l.). Ground surface temperature data are collected from some highly-fractured bedrock points in the surroundings of the building.

Antarctica

The monitoring of ice-wedge thermal regime, started on 2004, continues at Backer Rocks, Boomerang Glacier and Mount Jackman (Northern Victoria Land).

The study highlights very low temperatures and high temperature gradients between the ground surface and the top of the ice wedge that may trigger cracking. Moreover, stable isotope analyses of ice-wedge samples suggest that vapour condensation and sublimation processes play an important role during the formation of these ground-ice bodies, particularly at high-elevation sites.

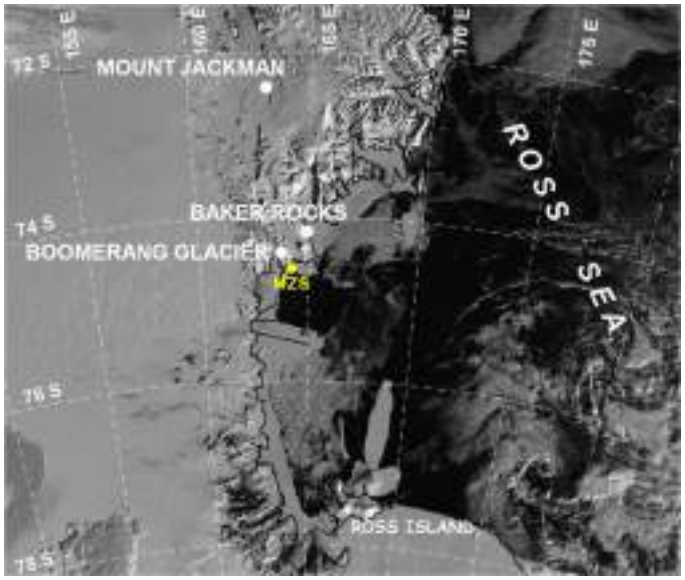


Figure 4: Location of the ice-wedge thermometric stations. MZS: PNRA Mario Zucchelli Station.

Figure 5: Baker Rocks

Japan

Overseas Research Activities

In Svalbard, N. Matsuoka and T. Kizuki (University of Tsukuba) and T. Watanabe (Kitami Institute of Technology) continued a long-term, multi-method monitoring of the dynamics of patterned ground (ice-wedge polygons and mudboils) and a polar rock glacier, as well as UAV mapping of these periglacial features in late August to early September 2017, in collaboration with H.H. Christiansen (UNIS, Norway). Twelve years of monitoring revealed significant interannual variations and the effect of long-term warming on both ice-wedge and rock-glacier dynamics.

A Swiss-Japan collaboration, called the UV-project, has shifted to the second stage (UV2) with broadened topics and institutions in an attempt to compare geomorphic dynamics from seasonal to post-glacial timescales between U-shaped valleys in the Swiss Alps and V-shaped valleys in the Japanese Alps. Participants for 2017 are N. Matsuoka, F. Imaizumi, Y. Matsushi, Y. Kariya and A. Sasaki (Japanese universities), and M. Stoffel, M. Fehlmann and J. Ballesteros (University of Geneva). A multi-method approach evaluates long-term dynamics of valley-side slopes in both situations, including permafrost creep, frost weathering, rockfalls, landslides and debris flows.

During the first two years (2016-17) of the 3-year project “Assessing and projecting greenhouse gas release from large-scale permafrost degradation” (an Environmental Research and Technology Development Funded project by the Ministry of Environment, Japan), ice cores sampled at nine sites in Alaska, and at four sites in Siberia have been analyzed for gas content and methane concentrations. Numerical models (both conceptual and global) are under development and calibration to project future impacts of GHG release from ice-rich permafrost degradation on climate (K. Saito, H. Ohno, G. Iwahana, T. Yokohata).

Japan-Mongolia collaborative researches have been ongoing with the focuses on thermal states and distribution of marginal permafrost. In addition studies on landform deformation due to thermokarst in continuous and sporadic permafrost zones of Mongolia have started using high resolution topographic data from InSAR and UAV (M. Ishikawa, T. Hiyama, A. Dashtseren, Y. Jambaljav).

Collaborative researches between Japan and Sakha, Russia have been conducted intensively in central part of Lena River basin (Central Yakutia). Thermokarst subsidence processes have been detected based on the analyses by fine scale mapping using UAV and InSAR remote sensing along with historical land use change in Churapcha area (Y. Iijima, H. Saito, A.N. Fedorov, P.Y. Konstantinov, N. Basharin).

Using the Japanese L-band SAR satellite imageries, Space geodesy group at Hokkaido University have detected the ground displacements associated with a wildfire episode in 2014 near Batagay, eastern Siberia. This group are planning to extend the analysis area and the temporal coverage (K. Yanagiya, M. Furuya).

Domestic Research Activities

On Mt. Fuji, a new network of shallow temperature monitoring was prepared along the huge gully to study ground freeze-thaw and rockfall/rockslide activity (A. Ikeda, Univ. of Tsukuba; F. Imaizumi, Shizuoka Univ.).

First stage of the Japan Database for domestic ground temperature and frost depth, consisting of 34 stations of the Japan Meteorological Agency, and seven sites of the Hokkaido Research Organization (Agriculture), is ready to be open (K. Saito, T. Sueyoshi, K. Watanabe, K. Takeda).

Through the correlation analysis to evaluate the influence of ground freezing on the growth of larch (*Larix Kaempferi*) in eastern Hokkaido, the tree ring index showed a negative relation with the seasonal maximum frost depth during 32 winters with a correlation coefficient of -0.451 ($p < 0.01$) (M. Imamura, K. Takeda, Y. Hinokawa, Y. Nobori, M. Kimura, S. Taki).

Education and Outreach

Under the umbrella of international educational program between Japan (Hokkaido University, Kitami Institute of Technology, University of Tsukuba) and Norway (University of Oslo, University of Svalbard), CryoJANO, more than 10 Norwegian students have visited in permafrost and volcanic sites of Japan in July 2017. Several Japanese students also visited Southern Norway in September 2017 and University of Oslo in January 2018 in order to attend field excursion and remote sensing courses (M. Ishikawa, T. Watanabe, N. Matsuoka, B. Etzelmüller, H.H. Christiansen, S. Westermann, A. Kääb).

New Zealand

New Zealand to host the 1st Southern Hemisphere Regional Conference on Permafrost in December 2019 (SouthCOP I)

We are delighted to welcome everyone to the first IPA permafrost regional meeting in the Southern Hemisphere. The conference will be held in Queenstown in the Southern Alps, an area surrounded by glacial landforms and within range of a daytrip to Fiordland.

A Pre-conference fieldtrip is planned to travel from Christchurch to Queenstown via the Tasman glacier and the eastern margin of the Southern Alps. The Post-conference fieldtrip will return via the Fox and Franz Joseph Glaciers and New Zealand's wild west coast along the west side of the Southern Alps, which is marked by the 450 km long Alpine Fault. A number of local experts will be leading and contributing to the fieldtrips.

Being in the Southern Hemisphere there will be a particular focus on Antarctic Permafrost and Cryosol research and fieldtrips will have an opportunity to visit the International Antarctic Centre in Christchurch which gives a world-class experience of the great southern landmass. Papers will also be welcomed on all other aspects of permafrost research.

Figure 1: Aoraki/Mt Cook, NZ's highest mountain viewed from the Mt Cook National Park, one of the places we will visit on the preconference fieldtrip (Photo Tourism NZ).

Proposed upgrade of Scott Base

Antarctica New Zealand is planning a major upgrade and rebuilding of New Zealand's key Antarctic Research Station, Scott Base. The rebuild is likely to take place over ten years and will result in major improvements to the science support capability of Scott Base. Issues being considered that relate to permafrost include; engineering design requirements for construction on permafrost, potential impacts of the building activity on adjacent environments, and the effects of removal of parts of the existing Scott Base which may change microclimates in some areas with potential to lead to changes in the permafrost that has developed in equilibrium with the existing base footprint.

Figure 2: Scott Base as it currently appears. The proposed upgrade will replace many of the current buildings with new "state of the art" facilities (Photo Megan Balks).

Current Antarctic permafrost research

Our Soil and permafrost climate stations continue to operate (now in their 19th year of continuous monitoring with the first 4 sites established in Jan 1999) and now comprising 9 soil permafrost sites and two 30 m deep boreholes. These sites are run in collaboration between Landcare Research, University of Waikato, USDA, and Mauro Guglielmin of the Italian Antarctic Programme. This summer Chris Morcom (University of Waikato) and Fraser Morgan (Landcare Research) are going south to undertake the annual maintenance and data download. Cathy Seybold at USDA continues to undertake data management. Megan Balks and MSc student Annette Carshalton are currently undertaking an approximately 5-yearly review of the data so look out for our latest results at Chamonix!

This summer Tanya O'Neill is travelling to Antarctica to continue the work commenced by Pierre Roudier on Landcare Research's "Terrestrial data analysis for the Ross Sea Region" project. She will be collecting large numbers of surface soil samples in the Taylor Valley.

Congratulations to Fiona Shanhun and Josh Scarrow who have both undertaken cryosol and permafrost related thesis research and are now both employed at Antarctica New Zealand in science and logistics management roles.

Norway

The University Centre in Svalbard (UNIS) - Arctic Geology Department

In the periglacial research group in the Geology Department of The University Centre in Svalbard, UNIS, PhD student Graham Gilbert submitted his PhD thesis entitled: 'Cryostratigraphy and sedimentology of high-Arctic fjord-valleys'. Post Doc Brendan O'Neill worked until May as a researcher in our group in the LowPerm JPI project (lowperm.group.shef.ac.uk/), in which the Norwegian part is funded by the Norwegian Research Council. The project focuses on understanding nutrient transport within permafrost landscapes that may lead to changes in greenhouse gas production and fertilization of the Arctic Ocean. Brendan investigated the physical ground ice conditions and cryostratigraphy in the lowland permafrost in Svalbard. He studied the dynamics of ice-wedge fracturing using innovative shock logger technology. Sarah Strand started in May as part time PhD student focusing on permafrost ground thermal dynamics in Svalbard and N Greenland, combining this with her part time work as Executive Director operating the IPA Secretariat.

We organized in May the international workshop 'Developing research and education collaboration across the largest climatic gradient in the Arctic between Svalbard and Northern Greenland' funded by the Svalbard Science Forum at UNIS in Svalbard. It is unique and important to be able to study across the largest climatic gradient in the Arctic from cold Northern Greenland to warm Svalbard. So far, this has not been possible due mainly to logistical challenges and the remoteness of the northern Greenlandic area. With the newly established Villum Research Station at St. Nord (81N) it has become possible to start planning the scientific and logistical use of this gradient. Already in August Ole Humlum, Wesley Farnsworth and Sarah Strand did an INTERACT Transnational Access research visit to the Villum Research Station in N Greenland located at Station Nord to perform detailed geomorphological mapping and service the two deeper permafrost boreholes operated there since 2014.

We keep running the AG-218 'International Bachelor Permafrost Summer Field Schools' at UNIS, in 2017 for the fourth time. This course was designed first as part of the University of the Arctic Thematic Network on Permafrost (TNP). Since 2016 UNIS has provided full funding to run this course still in collaboration with our partners from the TNP. The aim of the course is to provide overview of how diverse permafrost studies are in modern Earth System Science; ranging from focus on potential carbon release due to permafrost thawing, to projects on designing various types of infrastructure on permafrost knowing the dynamics of the different landforms.

We coordinated the application for the just funded project called 'Landscape and infrastructure dynamics of frozen environments undergoing climate change in Canada, Norway and Svalbard' FROZEN CANOES, which is an INTPART project funded by the Norwegian Research Council and the Norwegian Centre for International Cooperation in Education. The aim is to develop a joint research-based educational field-based programme, combining geoscience and engineering to address perennially and seasonally frozen ground undergoing climate change, using innovative educational knowledge from both the Norwegian (UNIS & NTNU) and Canadian (Laval Uni., Carleton Uni. and Yukon College) partners. From UNIS both the Arctic Geology and Arctic Technology departments are involved. Three interdisciplinary and complementary master level field-based courses will be developed and run in the project: One at NTNU; Norway in 2019, one at UNIS, Svalbard in 2020 and one at Yukon College, Canada in 2021. Each course will be coordinated by an early carrier scientist and have guest lecturers from the project partners. Also research collaboration will be improved as stipends are available for staff and student exchange for short stays at the other participating institutions. New teaching methods and online modules will be part of the project. The project will start in summer 2018.

University of Oslo – Department of Geosciences – Oslo

At the Department of Geosciences, UiO, we work on three main topics: (a) monitoring and modelling mountain permafrost (Bernd Etzelmüller), (b) remote sensing techniques in permafrost mapping (Westermann, Kääb) and (c) numerical modelling of

landscape development in permafrost lowlands (Westermann).

Concerning (a) we maintained our borehole network in Norway and Iceland, which have been operative since 2004. Within the Research Council of Norway (RCN) funded CRYOWALL project (coord. Bernd Etzelmüller), cooperation between UiO, TU Munich, Norwegian Geological Survey and the Road administration, we have employed 25 rock wall loggers all over Norway. These data have been used to analyse thermal dynamics in rock walls, make prediction maps based on the data and for validation of transient numerical modelling.

In northern Norway we (lead: Karianne Lilleøren) started investigating some rock glaciers in northern most Finnmark which end at sea level (Nordkynn, Iversfjorden). Those rock glaciers have been classified earlier as fossil rock glacier. We have analysed multi-temperate air photos, drone images, laser scans and ERT profiles, to investigate if those landforms may be active, which would change our understanding of the geomorphological and climate history in this part of northern Norway.

(b) In the framework of the ESA GlobPermafrost (www.globpermafrost.info) (lead: Kääb) and the RCN-funded SatPerm projects (Lead: Westermann), we have presented different techniques to infer the ground thermal state using remote sensing data, from globally applicable schemes, see also:

http://maps.awi.de/map/map.html?cu=globpermafrost_overview#home,

to transient methods. Fieldwork in Ny-Ålesund, Svalbard, was accomplished in spring and summer to support these activities, targeting the spatial variability of the ground thermal regime and its connection to snow cover.

(c) Peat plateaus in Northern Norway were intensively investigated in March and September, using drone aerial surveys, differential GPS and miniature logger arrays. These data contribute to the RCN-funded Permanor and the European Commission JPI Climate program-funded COUP projects (lead: Westermann) which aim for a better representation of small-scale processes with significance for landscape evolution in Earth System Models. The work has also led to participation of the Horizon 2020 project “Nunataryuk”, lead by the Alfred Wegener Institute, Germany.

Frans-Jan Parmentier received funding from the Norwegian Research Council for his Young Researcher Talent project “WINTERPROOF”. He will work closely together with “Permanor” in Oso and “Feedback” in Bergen to improve the way that wintertime processes in permafrost environments are represented in land surface models. The project will start in the second half of 2018, and hire one PhD student in Oslo, and one in a related project at Lund University in Sweden, funded by the Swedish Research Council.

Finally, we have educational exchange funded by the Norwegian centre for internationalization of education (SIU) with three Japanese institutions (Sapporo, Kitami and Tsukuba). In 2017 we organised a joint work shop in Hokkaido, northern Japan, in association to the regional ACOP2017 in Sapporo.

Norwegian University of Science and Technology - Department of Geography, Trondheim

Ivar Berthling and Radmil Popovic has continued field measurements of sorted circles on Kvadehuksletta, Svalbard using SfM (digital photogrammetry). Together with Bernard Hallet, University of Washington, we have re-measured some of Hallet’s old sites on Kvadehuksletta, attempted to safeguard these installations, and transformed the methodology using SfM from ground-based images, to enable continuing these measurements into the future. Our goal is to document how ground surface movements and cryoturbation have responded to the amplified effects of global warming at high latitudes, and to understand this response.

Norwegian University of Science and Technology - Department of Civil and Environmental engineering, Trondheim

As a part of SAMCoT activities, the research team from Moscow State University (MSU) organized a

field work in Baydara Bay. Main field activities included drilling new boreholes and continuation of temperature measurements in existing ones, DGPS coastal line mapping, geophysical investigations etc.

Figure 1. Drilling boreholes up to 15 m deep for understanding long term temperature fluctuations in permafrost.

The Norwegian GeoTest Sites (NGTS) project (see https://www.ngi.no/eng/Projects/NGTS-Norwegian-Geo-Test-Sites) aims to develop a unique testing facility with five reference test sites available for at least 20 years. One of the sites is in permafrost in close vicinity to UNIS and Longyearbyen. The sites will be readily available for the entire geotechnical profession for the purpose of basic and applied research and education. The project also seeks to establish a network of international test sites to exchange information for a large range of soil conditions worldwide. Four of the test sites are located in Norway and one on Svalbard. The permafrost site on Svalbard consists of four subsites, covering a range of permafrost and soil conditions. Investigations have focused on drilling and sample retrieval, ground thermal monitoring, and determining index parameters and secondary geotechnical testing. Adjunct professor Arne Instanes, UNIS, (arne.instanes@unis.no) is the coordinator for the permafrost site in Longyearbyen.

The geotechnical group of NTNU, as a part of SAMCoT, has developed a new thermo-hydro-mechanical constitutive model for simulating the behavior of frozen soil during freezing and thawing. It drew the attention of a commercial software company “PLAXIS”, and is now implemented in their software and is the only commercially available tool in the field of saturated frozen soils. The accuracy and efficiency of the model has been verified by simulating several boundary value problems as well as element testing examples. The elastic-viscoplastic version of the model was also developed in order to simulate the long-term behavior of frozen soils, e.g. creep phenomenon.

In the SAMCoT project there is a direct interest of knowing the critical shear stress value of Arctic coastal segment, which will feed more accurately hydrodynamic models like MIKE 21 or X-Beach, or also allow to quantify the surface wash process affecting thawing coastal bluff. It can also have direct interest in frozen soil engineering, as for example in assessing the erodibility of thawing soil in ditch along transportation infrastructures embankment (Julie Malenfant-Lepage, PhD student in Laval University in Canada and started as a researcher at NTNU from January 2017).

In August and September 2017, Julie Lepage and Benoit Loranger performed the field test on permafrost soils by using the cohesive strength meter. The area of investigation was permafrost soils close to Salluit village in Nunavik and around Whitehorse in Yukon (Canada).

Figure 3: Field investigations of critical shear stress of permafrost soils (Julie Lepage).

The “Frost Protection of Roads and Railways” (FROST) project started in 2015 and was designed to tie together knowledge from cold regions engineering, thermodynamics, geology and mineralogy, and bring together researchers from Norway and Canada. The primary objective of this project is to build new knowledge on behavior of crushed rock materials and subgrade soils, used in road and railway construction, under cold climate conditions. In addition, the design methods for frost

protection layer of roads and railways in Norway and other cold region countries will be improved. Research is conducted based on three main aspects: laboratory investigations, field observations, and numerical analyses to simulate different climate conditions, thickness of structures and material combinations.

Benoit Loranger is a PhD student in the FROST project and his main focus is frost heave and frost susceptibility characteristics of frozen soils and crushed rocks material used in the road construction. In the laboratory he is going to measure the segregation potential of pavement subgrade materials by conducting the freezing tests.

Elena Scibilia (Kuznetsova) is a researcher at NTNU and currently is a project manager of the FROST project. Her research background is in the field of permafrost and cold climate engineering. Her master and PhD research focused on measuring and analyzing thermal properties and unfrozen water content of frozen soils, which had practical applications to modelling of permafrost distribution in mountain areas. As postdoc research fellow at NTNU she has been investigating new solutions for improving the frost protection layer in road construction in areas with cold climate conditions.

Elena and Benoit will work on finding a connection linking the segregation potential, which have numerous applications in the design of cold region constructions, and Julie's soil sensibility to erosion results. The connection between the erosion sensitivity and the segregation potential could eventually be applied as an input to erosion/ sedimentation models developed by the WP6 team.

Another important focus in the FROST project is investigation of heat transfer mechanisms in granular layers of roads and railways structures. When coarse open-graded materials are used, natural air convection becomes the dominant heat transfer mode and gives favorable ground cooling effect in permafrost conditions during wintertime. The same process in seasonal freezing environment can give an adverse effect. It can increase heat extraction rate and result in extensive frost depth penetration.

PhD student Karlis Rieksts performed several tests by using the large-scale heat transfer box conducted in laboratory of NTNU. This box was designed based on the work done by Norwegian Geotechnical Institute (NGI) and Laval University (Canada).

Northern Research Institute (NORUT) and University of Tromsø - Tromsø

Norut, UiT-The Arctic University of Norway and the Norwegian Water Resources and Energy Directorate (NVE) are since 2013 collaborating for in-situ and remote sensing temperature and kinematics measurements of the Ádjet rock glacier in Skibotn, and the Gámanjunni 3 rockslide in Manndalen, both in northern Troms, Norway.

The Ádjet rock glacier has been documented in the UiT master studies, while H. Eriksen worked with the three-dimensional displacement vectors. From orthophoto comparison, ground- and satellite-based radar velocities exceeding 10's of meter per year have been documented. Temperatures in air and pore spaces and fractures (iButtons) in the active layer of the Ádjet rock glacier have been measured since the summer of 2014. Time-lapse images of the snow cover have also been collected. In summer 2015 a time-lapse camera observing the rock glacier was set up. In August 2016, a snow measurement stick observed by a time-lapse camera and ground temperature loggers were included. During the summer of 2017, all iButton-loggers were exchanged with Geoprecision-loggers, and a rock wall logger was set up. Temperature measurements indicate permafrost conditions, and field observations confirm solid ice cementing large blocks. The measurements are from 2018 managed by the Department of Geoscience at UiT. In addition, displacements of blocks in the rock glacier have been measured using yearly periodic GNSS measurements.

The displacement of Gámanjunni 3 rockslide has been documented by several studies, on cooperation with the Norwgian Geological Survey. Observed displacements from ground- and satellite-based radar are about 5 cm per year in the intact upper part of the rockslide, and much higher in the lateral deposit interpreted as a rock glacier. For the rockslide, temperatures in the active layer have been recorded since 2014 and for the rock glacier since 2013 using iButton-loggers. In addition,

ground and air temperatures have been recorded. All iButton loggers were exchanged with Geoprecision-loggers, and two rock wall temperature loggers set out during the summer 2017. The ongoing measurements are from 2018 managed by NVE. As for the Ádjet rock glacier, displacements of blocks in rock glacier have been measured using yearly periodic GNSS measurements.

Norut started in 2017 the PhD project FrostInSAR "Upscaling the investigation of periglacial landforms in the Norwegian Arctic using Synthetic Aperture Radar Interferometry". FrostInSAR is 4-years project (2017–2021) funded by the Research Council of Norway (Space Programme). The PhD candidate Line Rouyet aims to study the potential of Synthetic Aperture Radar Interferometry (InSAR) to measure the amplitude, the distribution and the evolution of ground deformation related to freeze and thaw. The project focuses on three study sites in Northern Norway and Svalbard in areas with perennial frozen ground (permafrost) or seasonally frozen ground. Rouyet demonstrated in Adventdalen the value of the new European satellite constellation Sentinel-1 to measure heave and subsidence related to ground freeze and thaw. Research will continue to process, analyze and compare the results for the three sites, complement and combine InSAR results with field observation and in-situ measurement, as well as develop explanatory and predictive models relating InSAR deformation to environmental variables. The project includes national collaborations with UiT and the University Centre in Svalbard (UNIS), and internationally with the University of Oulu (UOulu), the ESA GlobPermafrost project via the Austrian Zentralanstalt für Meteorologie und Geodynamik (ZAMG) and the Chinese University of Hong Kong (CUHK).

Norwegian Geotechnical Institute – Oslo

NGI has taken the initiative to upgrade its old boreholes, located in the coastal area in Longyearbyen. The boreholes reach down to 70 m and 10 m, respectively, and were established in 1986. They were measured approximately ten times since then, the last time in 2007. UNIS has been contracted to upgrade the boreholes and maintain them throughout 2018. This includes setting up a new logger and re-connecting the thermistor strings. Logging interval will be every hour on all 32 thermistor strings. This work is ongoing and the first measurements have been read out, but are not fully analysed yet. If you are interested to know more about these boreholes and the measurements, please contact Kjersti Gisnås at kgi@ngi.no.

University of Bergen - Uni Research Climate and the Bjerknes Centre for Climate Research, Bergen

At Uni Research Climate, we focus on biogeochemical cycles towards better gaining more accurate projections of permafrost carbon climate feedback cycles under warmer world. Our strength in permafrost research is in using both in situ observations and Earth System Modeling (ESM) to provide guidance towards reducing the uncertainty.

The field observations are supported by the RCN-funded FEEDBACK project. We established a observational site in northern Norway in the year 2016 that exhibits permafrost thaw and hydrological gradient at a palsa-mire: dry/intact permafrost site to inundated/degraded permafrost site. At this site, we installed automated sampling devices to measure soil CO2 and CH4 concentrations that will provide us with processes involved in aerobic and anaerobic decomposition of rich soil organic matter in permafrost soils. In addition, automated surface soil CO2 flux chambers were installed. In order to gain process level understanding of the shift in aerobic and anaerobic CO2 and CH4 production and oxidation, we installed a network of sensors in different soil profiles such as temperature, moisture, and oxygen sensors.

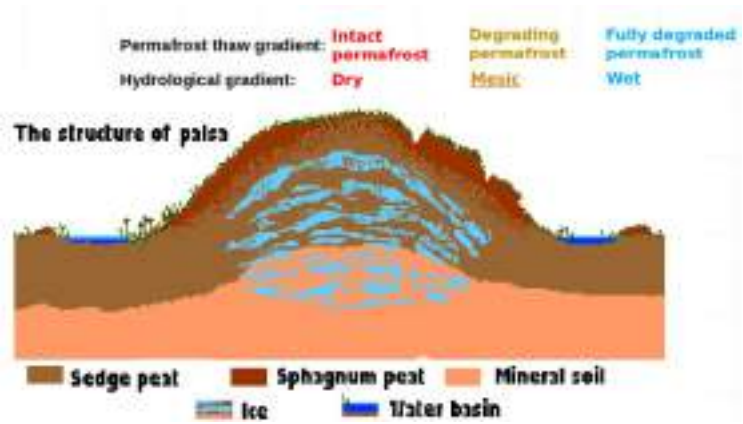


Figure 4: A schematic diagram of the FEEDBACK project site in northern Norway showing the permafrost thaw and hydrological gradient established in a palsa-mire.

The modeling efforts are supported by two different RCN grants: FEEDBACK and PERMANOR in collaboration with University of Oslo-Geosciences. Within the framework of the FEEDBACK project, we focus on evaluating the model with observations. On the other hand, PERMANOR project supports enhancing the processes involved in terrestrial systems within the Earth System Modeling, the nationally funded ESM, Norwegian Earth System Model (NorESM).

Within the PERMANOR project, we focus on developing the missing processes associated to permafrost thaw. Recent developments include dynamic wetlands under permafrost thaw and subsequent land surface subsidence. These new developments will be used in the coupled framework of NorESM to make projections of permafrost carbon climate feedbacks under warmer world.

Poland

Adam Mickiewicz University in Poznań

In summer 2017, the long-term programme of permafrost research in the vicinity of Petuniabukta (central Spitsbergen) that started in 2012 was continued. It is based on the year-round registration of ground temperatures in the profile of raised marine terrace sediments, down to a depth of 1.5 m in two locations comprising wet (floodplain) conditions (2 m a.s.l.) and dry terrace surface (5 m a.s.l.). In both cases, permafrost active layer thickness was measured at the end of the summer season reaching from 1.5 to 2.3 m (measurements were done in accordance to CALM rules). Another borehole for ground temperature profile measurements, down to the depth of 2.2 m, has been operating from 2015 on the raised marine terrace at 30 m a.s.l. The location of this site was selected to observe the spatial variation of active layer thermal conditions, excluding the influence of a proximal fjord coastline. Two other programmes dedicated to periglacial studies and relating to the weathering of various types of rockwalls and the intensity of aeolian processes are continuing in the Ebba valley, and the latter was expanded this year to include measurements of aeolian accumulation on the Ebba glacier.

Gdańsk University of Technology

Scientists from the Gdańsk University of Technology conducted research into the influence of permafrost degradation on water chemistry. In 2017 detailed analyses of the chemistry of water taken from the shore of Bellsund fiord, Hornsund (Svalbard, Arctic) and the western shore of Admiralty Bay (Maritime Antarctica) were done. This work was carried out in cooperation with the Kazimierz Wielki University in Bydgoszcz, the Institute of Biochemistry and Biophysics, Polish Academy of Science (Warsaw), and Maria Skłodowska-Curie University in Lublin. The results are presented in many papers listed at the end of the report.

Nicolaus Copernicus University in Toruń

In 2017 monitoring of the thickness of the permafrost active layer has continued at a few fixed measurement points on the Kaffiøyra Plain around the Nicolaus Copernicus University (NCU) Polar Station. These research points are part of the network of the CALM programme and represent one of the few points in the High Arctic region. The points subject to measurement represent typical Kaffiøyra sites: a sandy beach (*B, Beach*), a tundra plain (*T, Tundra*) and a moraine rampart (*M, Moraine*). The measurements of the size of the ground thawing and the thickness of the permafrost active layer have been performed every 7–10 days since 1996.

Measurements of the temperature of the active layer (ground) were made. For this purpose, automatic temperature loggers were installed at various depths at the measurement points (up to 150 cm). Temperature has been recorded continuously throughout the whole year at the measurement points located on the moraine (*M*) (since 2006), the beach *(B)* (since 2012) and the tundra (*T*) (since 2006).

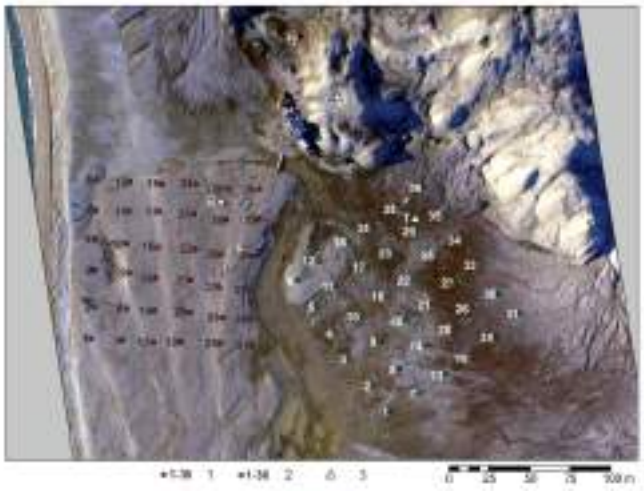


Figure 1. Study area and location of active layer thickness and temperature measurement points: 1 – measurement points in the beach test field, 2 – measurement points in the tundra test field, 3 – permanent measurement points on the beach (B), moraine ridge (M) and tundra (T).

University of Silesia

In 2017, the University of Silesia, in collaboration with the Institute of Geophysics of the Polish Academy of Sciences, conducted research aimed at estimating permafrost changes in front of the Hans Glacier in Hornsund, Spitsbergen due to global warming. For this purpose, a set of multiple seismic methods for permafrost modeling was used, with additional information from ERT imaging. Throughout 2017, field works focused on seismic data gathering.

University of Wrocław

The influence of the depth of the top layer of permafrost (thaw depth) – which determines the level of groundwater during the growing season – on the extent of plant growth was investigated. The results are presented in the paper by Opała-Owczarek et al. (2018).

List of publications:

1. Opała-Owczareka M., Pirożnikow E., Owczarek P., Szymański W., Luks B., Kępski D., Szymanowski M., Wojtuń B., Migała K., 2018, The influence of abiotic factors on the growth of two vascular plant species, Saxifraga oppositifolia and Salix polaris) in the High Arctic. Catena, 163, 219–232.
2. Sobota I., Weckwerth P., Grajewski T., Dziembowski M., Greń K., Nowak M., 2017, Short-term changes in thickness and temperature of the active layer in summer in the Kaffiøyra region, NW Spitsbergen, Svalbard. Catena, 160: 141-153.
3. Szumińska D., Szopińska M., Lehmann-Konera S., Franczak Ł., Kociuba W., Chmiel S., Kalinowski P., Polkowska Ż., 2017, Water chemistry of tundra lakes in the periglacial zone of the Bellsund Fiord (Svalbard) in the summer of 2013. Science of Total Environment, doi:10.1016/j.scitotenv.2017.10.045
4. Lehmann-Konera S., Franczak Ł., Kociuba W., Szumińska D., Chmiel S., Polkowska Ż, 2018, Comparison of hydrochemistry and organic compound transport in two non-glaciated high Arctic catchments with a permafrost regime (Bellsund Fjord, Spitsbergen). Science of Total Environment, *613–614*, *1037–1047.*
5. Szopińska M., Szumińska D., Bialik R.J., Chmiel S., Plenzler J., Polkowska Ż, 2018, Impact of a newly-formed periglacial environment and other factors on fresh water chemistry at the western shore of Admiralty Bay in the summer of 2016. Science of Total Environment, 613–614, 619–634.
6. Kosek K., Kozak K., Kozioł K., Jankowska K., Chmiel S., Polkowska Ż., 2018, The interaction between bacterial abundance and selected pollutants concentration levels in an arctic catchment (Southwest Spitsbergen, Svalbard). Science of Total Environment, 622–623, 913–923.

Report prepared by Rajmund Przybylak (rp11@umk.pl)
Based on reports submitted by W. Dobiński, K. Migała, Ż. Polkowska, G. Rachlewicz and I. Sobota.

Portugal

Portuguese research on permafrost has been conducted by groups from the following institutions: CEG/IGOT – Universidade de Lisboa (led by Gonçalo Vieira), CERENA/IST – Universidade de Lisboa (led by Pedro Pina), CQE/IST – Universidade de Lisboa (led by João Canário) and CCT – Universidade de Évora (led by António Correia).

CEG/IGOT – Universidade de Lisboa

The CEG/IGOT- ULisboa research group continued the long-term permafrost research program PERMANTAR in the GTN-P observatories of the Western Antarctic Peninsula. In the field season the boreholes in Amsler Island and Cierva Cove were upgraded for improving data quality and simplifying the data collection methods, while the sites in Deception and Livingston Islands were also maintained. In the later, the Hurd rock glacier was monitored for surface deformation, a set of activities integrated in the GLOBPERMAFROST project. The field activities were conducted in cooperation with the Portuguese Institute for the Sea and Atmosphere and the University of Alcalá de Henares, Spain. The group also continued the activities in Eastern Hudson Bay (Kuujjuarapik – Umiujaq) where 4 thaw pond areas are being monitored using UAV systems. In August-September, multispectral imagery was collected targeting at analysing vegetation communities and structure, as well as lake water colour. The results are being compared with Sentinel-2, Landsat-8 and WorldView imagery for regionalization. In November the NUNATARYUK H2020 EC funded project started, with the participation of the three teams from the University of Lisbon in tasks associated to high resolution remote sensing and permafrost chemistry.

CERENA/IST – Universidade de Lisboa

The main activities developed at CERENA-IST-ULisboa during 2017 focused on the use of remote sensing to map and monitor ice-free areas of Maritime Antarctica. The field campaign developed in Fildes Peninsula, King George Island (62°S) in January-February 2017, in the frame of PROPOLAR and in collaboration with INACH-Chile, was dedicated to acquiring ultra-high-resolution imagery with an UAV (cm resolution), with on vegetation and patterned ground surfaces. For the vegetation, the imagery allowed building extended and more reliable ground-truthing about the main communities of lichens and mosses, which is greatly improving the classification performance of satellite imagery of WorldView type (metric resolution) and the accuracy on the detection and quantification of multitemporal changes. For the patterned ground, the main focus is on sorted stone circles. The surveys with the UAV at very low heights to acquire images of mm resolution are allowing, together with the DEMs that are derived from pairs of images, perceiving the geometry of the circles in 3D but also of their clasts, and in this way provide an unprecedented characterization of several hundreds of circles.

Figure 1: Permafrost borehole and meteorological station at Cierva Cove, Antarctic Peninsula. Photo: Gonçalo Vieira.

CCT – Universidade de Évora

The research by the Universidade de Évora was conducted under the framework of the project PERMATOMO (Geoelectrical study of permafrost evolution) in the CALM and Papagal sites near the Bulgarian Antarctic Station (Livingston Island) and near the Korean Antarctic Station (King George Island, Antarctica). Field work was carried out in January and February 2017. Near the Korean Station King Sejong several electrical resistivity tomographies were carried out in four locations to try to infer a relationship between ground electrical resistivity distribution and surficial moisture. The main objective of the work was to try to explain the local surface distribution of mosses and lichens as a function of surficial ground water content. In the Bulgarian Station, field work consisted in carrying out electrical resistivity tomographies in the CALM and PAPAGAL sites where, since 2009, the depth and lateral extent of permafrost has been monitored. The main objective was continuing monitoring permafrost time and space evolution at the two sites.

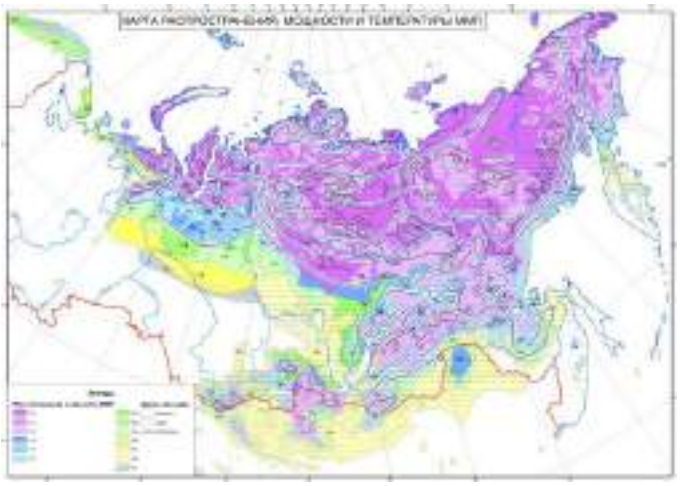
CQE/IST – Universidade de Lisboa

Permafrost research at Centro de Química Estrutural has focused on the chemistry of permafrost degradation using chemical tracers as proxies. Permafrost thaw lakes have been used as study sites and the work has been done in sub-Arctic Canada in collaboration with the Centre for Northern Studies - Laval University. Sediment and soils cores as well as water samples have been collected and analysed for carbon and other trace elements using structural chemistry techniques like NMR or mass spectrometry. Results showed that in permafrost thaw lakes, organic matter degradation occur mainly in the sediment-water interface and in the water column. ssNMR techniques and sulphur biogeochemistry were also found to be excellent proxies to track the degree of organic matter degradation in permafrost soils.

Russia

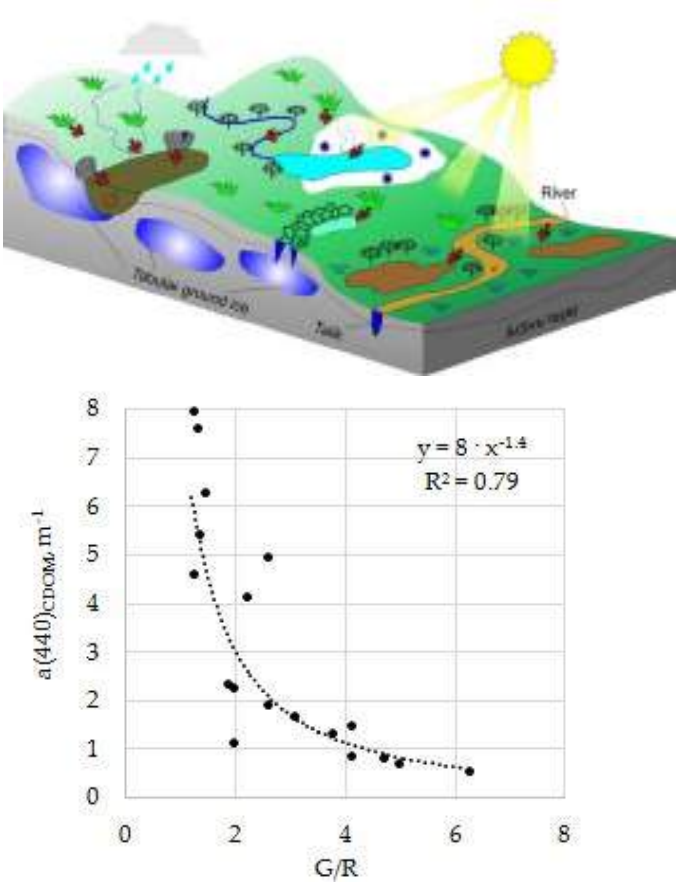
Earth Cryosphere Institute, Tyumen Scientific Centre, Siberian Branch, Russian Academy of Science (ECI Tyumen Scientific Centre SB RAS)

1. The set of geocryological small-scale maps (1: 16 000 000) for the Arctic Region of the Russian Federation and the cryolithozone of Eurasia inclusive the permafrost conditions at the beginning of the 21st century was compiled as a whole. The set was placed in the National Atlas of the Arctic. –Roscartography, Moscow, 2017. - 496 pp.



2. Occurrence of thermocirques in the coastal rim of lakes is the most important control on lake CDOM in the region (Yamal Peninsula). Terrestrial organic matter input from thawed permafrost makes the lakes with thermocirques outstanding compared with other lakes. It remains unclear what would be the lake CDOM of these impacted lakes after the stabilization of thermocirque development. Analysis also shows, that big floodplain lakes connected to the Mordy-Yakha river receive more organic matter, which should be studied further in detail. We didn't find a significant correlation between catchment slope and lake CDOM. But likely lakes significantly incorporated to the terrain through all geomorphological levels can also receive more organic matter due to higher topographical gradient.

Remote sensing and GIS are important techniques for retrieval of lake and lake catchment characteristics and this geospatial data is important as variables to investigate the statistical relationships within "lake – lake catchment" system. In this study we have used high resolution GeoEye-1 and WorldView-2 multispectral satellite images in order to derive a(440)CDOM values. Further application of freely available Landsat-8 and Sentinel-2 images with a sufficient radiometric and spatial resolution can be used for the assessments of terrestrial and water ecosystem interactions in a larger spatial extent. This can also be a source of lake parameters in a lake models. (Dvornikov Yu., Leibman M., Heim B., Bartsch A., Herzschuh U., Skorospekhova T., Fedorova I., Khomutov A., Widhalm B., Gubarkov A. & Rößler S. (2018) Terrestrial CDOM in lakes of Yamal peninsula: connection to lake and lake catchment properties. Submitted to Remote Sensing).



3. A technique for microscopic study of the CO2 hydrate formation and growth in the liquid phase has been developed. Experimental evidence confirmed the possibility of the CO2 hydrate growth from the dissolved gas in the liquid phase is obtained. The rates of lateral growth of CO2 hydrate along the liquid-gas interface and the normal growth of CO2 hydrate in the volume of the liquid phase are measured.

4. A technique for NMR analysis to determine the content of unfrozen water in frozen samples has been developed: the suspension of the microorganism cells which were isolated from permafrost (CMMW), the suspension of the CMMF metabolites and frozen aqueous solution of a high molecular weight cryoprotectant (PVA). It was established for the first time that the metabolites of microorganisms isolated from permafrost contained in frozen aqueous substance, can have a great influence on the content of unfrozen water than the well-known high-molecular cryoprotectants.

5. Development of ecologically clean heat-insulating material from diatomite and recommendations for using this material in adverse geocryological conditions

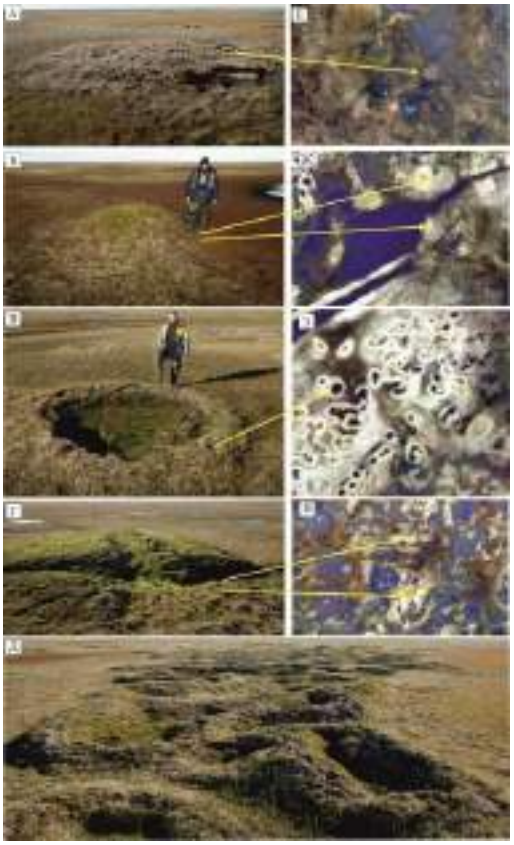
5.1. According to the research on ground frost heaving amount which were protected from freezing with a layer of granular foam-glass ceramics, in comparison with the material used traditionally as a heat insulator (extruded polystyrene foam) and with the ground without a heat-insulating layer, it was established:

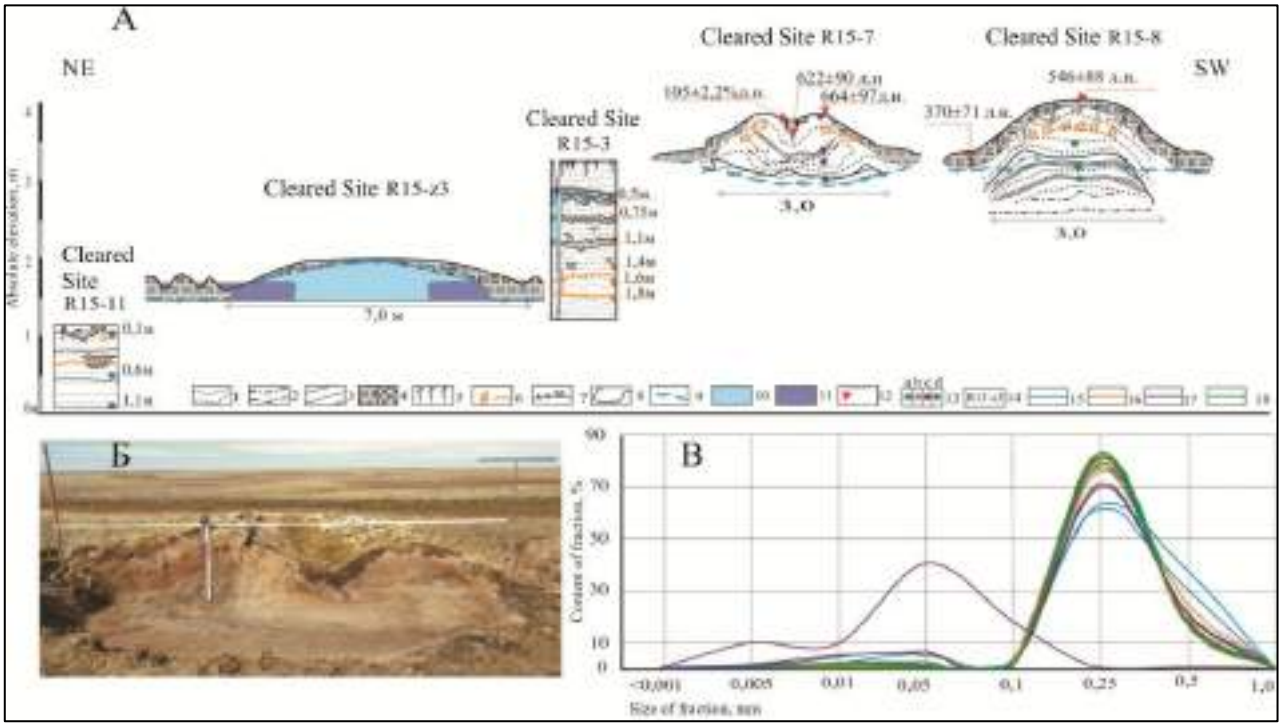
– the use of heat-insulating layers of granular foam-glass ceramics and extruded polystyrene foam gives a similar pattern of temperature distribution in the ground and a reduction in the depth of freezing in comparison with sand without insulation from 26 to 7 cm;

– the deformation of the sand heaving without insulation was 1.65 mm, whereas in the experiments with extruded polystyrene foam and granulated foam-glass ceramics, on the contrary, compression of the ground was observed and the freezing rate of the upper layers is reduced 1.6 times.

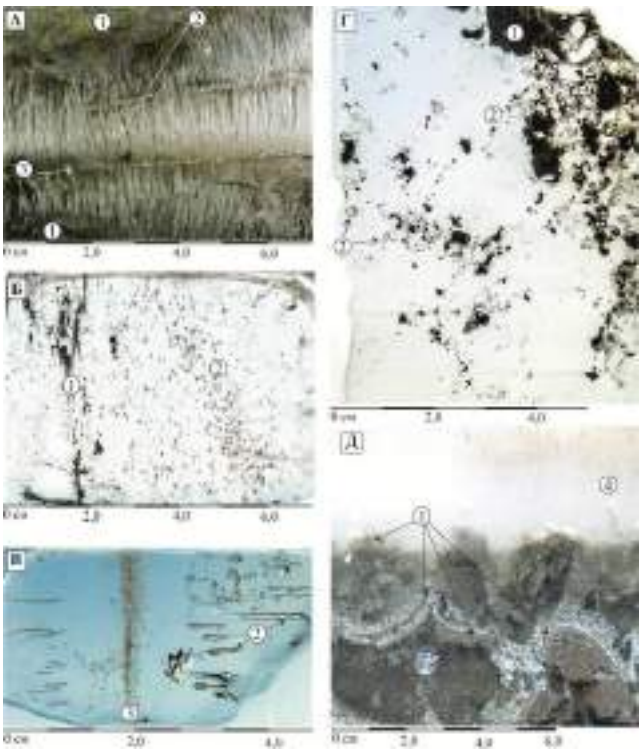
5.2. During the annual monitoring of the experimental section of the motorway: Beskozobovo-Evsino-Lamensky, 47 + 540 km - 47 + 690 km (Golyshmanovsky district, Tyumen region) with frost protection layer made of granular foam-glass ceramics, the depth of ground freezing in the road structure was reduced from 187 up to 100 cm.

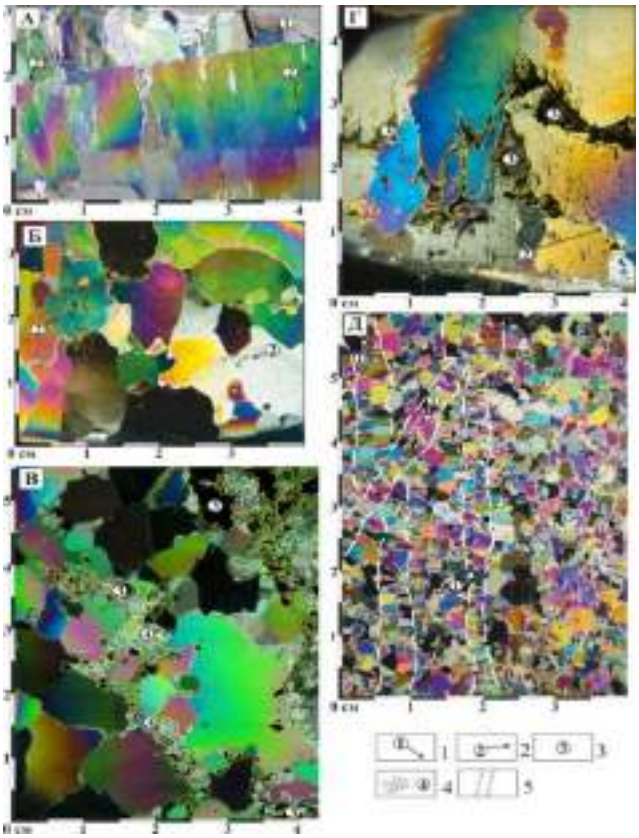
6. The pioneering study of the morphology and structure of frost mounds on Bely Island in the Kara Sea, which also includes radiocarbon dating of peat and determinations of carbon isotope composition of peat and gas inclusions in ice, crystalline structure of ice, and sediment particle size distributions. By their shape, the identifi ed frost mounds are grouped into cone-shaped, toroid-shaped, thaw-weakened frost mounds crosscut by polygonal network, and perennial fl at-topped palsas with ice core. Modern palsas are distributed in laida zones regularly fl ooded by sea waters. Cone- and toroid-shaped frost mounds represent relict permafrost landforms developed in the Late Holocene. Relict frost mounds in Western Yamal and on the Arctic islands can indicate coastal-marine settings of their growth on low elevations in the Late Holocene.





7. The features of texture and structure of new ice formed in the thawing cavities, some cracks were determined. The differences in structure of the late Holocene ground ices and ground ices of the early Holocene and late Pleistocene were defined. The quantitative parameters of the crystal structure can be used to identify closed-cavity ice and crack ice in the composition of massive ice and determine mechanisms and conditions of formation before the Holocene ice wedges.





8. The first time received the data confirming ideas about the shift of typical tundra to the North during the Holocene climatic optimum.

The change of plant species diversity in buried turf of Bely Island reflects changes in the landscape under the influence of climatic conditions. The optimal conditions for the growth of birch - relatively warm and without excessive moisture, were gradually developing between 7820±130 and 5206±97 yr BP. Conditions were deteriorated between 3775±105 and 2924±102 yr BP. In the Atlantic period of the Holocene borders of birch existence were shifted [3], and subzone of typical tundra was moved to the north - on Bely Island.

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

Ice-rich yedoma (ice complex) landscapes, which comprise 335,000 sq. km or about 11 percent of Yakutia, are highly sensitive to climate warming and anthropogenic disturbances. A study by the MPI's Laboratory of Permafrost Landscapes led by A. Fedorov estimated that loss of ice-rich permafrost in central Yakutia ranged from 0.09 m3 in relatively undisturbed areas to 0.57 m3 per m2 in disturbed areas since the early 1990s. The amount of carbon released from these thawing sediments was assessed to range from 0.23 to 1.44 kg per m3. The group conducted physico-geographic regionalization of the permafrost landscapes underlain by permafrost with wedge ice and compiled a 1:1,500,000-scale map of yedoma distribution (Fig. 1).

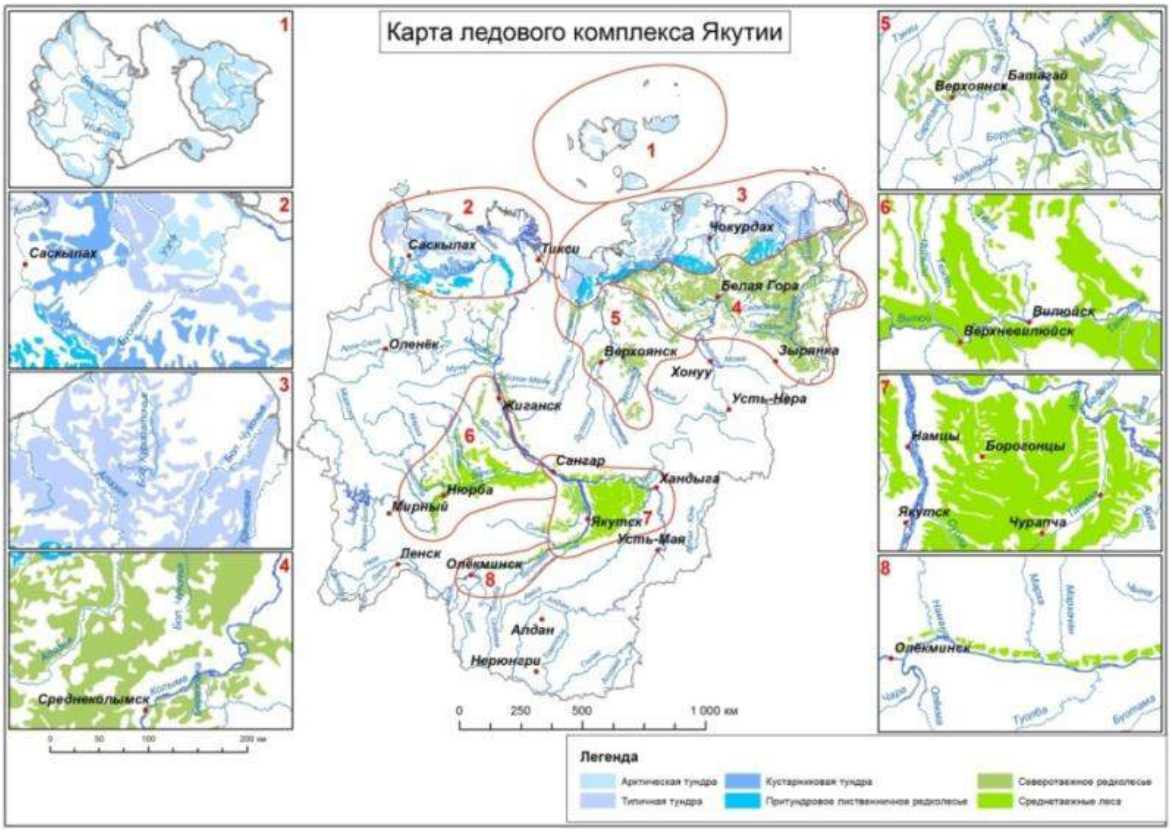


Fig. 1. Map showing the ice complex (yedoma) distribution in Yakutia.

Ulrich M., Wetterich S., Rudaya N., Frolova L., Schmidt J., Siegert C., Fedorov A.N., Zielhofer C. (2017). Rapid thermokarst evolution during the mid-Holocene in Central Yakutia, Russia. The Holocene. doi:10.1177/095968361770845410.

Basharin N., Fedorov A. 2017. Evaluation of thermokarst development in Central Yakutia under changing climate. Cryosols in Perspective: A View from Permafrost Heartland. Proceeding of the VII International Conference on Cryopedology (August 21-28, Yakutsk, Sakha (Yakutia) Republic, Russia). Yakutsk, pp. 16-18.

Drilling from the ice surface of lagoons on the Bykovsky Peninsula in the Russian eastern Arctic (M. Grigoriev and G. Maximov, MPI Laboratory of General Geocryology) revealed the occurrence of unstable permafrost with complex interstratification of frozen and unfrozen ground below lagoons (Fig. 2). In a relatively warm and highly saline environment, both frozen and unfrozen layers are on the brink of changing their state to thawed or frozen condition. Most lagoons are paleolakes which attained a lagoonal regime due to rapid erosion of ice-rich seacoasts.

Grigoriev M.N., Maximov G.T. (2017). The formation and distribution of permafrost under Arctic lagoons. 2017. Proceedings of the Russian National Conference, Environmental Processes in the Earth's Polar Regions in the Global Warming Epoch, Sochi, Russia, 9-11 October, 2017, p. 44 (in Russian).

Angelopoulos M., Overduin P.P., Grigoriev M., Westermann S., Grosse G. (2017): The effects of changing boundary conditions on modelled heat and salt diffusion in subaquatic permafrost offshore, Siberia. CSDMS Annual Meeting, Modeling Coupled Earth and Human Systems. The Dynamic Duo, Boulder Colorado, USA.

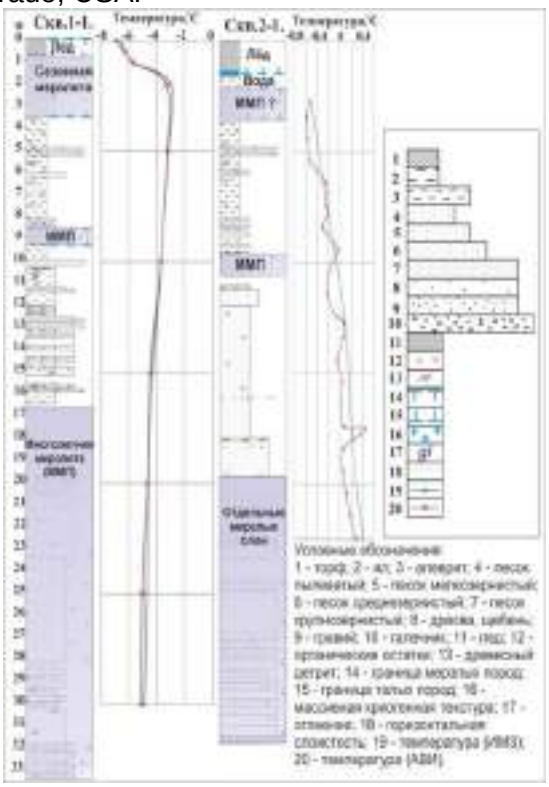


Fig. 2. Geological and permafrost profiles derived by drilling and geophysical surveying, Omulakh-Kel (1-1) and Pestsovaya (1-2) sea lagoons, April 2017.

The Vilyui Station of MPI in Chernyshevsky led by S. Velikin designed a new measurement system to control ground displacements in permafrost (Fig. 3). The system consists of borehole inclinometer probes (accuracy +0.01 angular deg.) and precision temperature sensors (+0.1°C). It has an advantage over standard geodetical and geophysical methods, which can only determine movements that have already occurred, in detecting early stages of ground displacement. Its high sensitivity makes it useful for ground movement control in open pit mines and dams.

Fig. 3. A component of the inclinomter system.

Dr. A. Gorbunov and Dr. E. Severskiy from the Kazakhstan Alpine Permafrost Laboratory of MPI estimated the volumes of ground ice in the Northern Tien Shan, including the Dzhungar Alatau (Table 1). Calculations indicate that the volume of ground ice is 56 km3, comprising about 4.5% of the permafrost and 62% of the volume of glaciers in the Northern Tien Shan (approximately 90 km3). More detailed estimates for the Bolshaya Almatinka River basin (Trans-Ili Alatau) based on the 1:25,000-scale geocryological map show that permafrost contains about 0.6 km3 of ground ice with virtually no change, while the glaciers decreased in volume from 1.1127 km3 in 1955 to 0.3889 km3 in 2008.

Gorbunov A.P., Zhelezniak M.N., Severskiy E.V. (2017). Ground ice in the Tien Shan. Voprosy Geografii i Ecologii, 4: 19-30 (in Russian).

Table 1. Volume of permafrost and ground ice, km^3.

Region	Permafrost			Ground ice		
	Rocks	Coarse soils	Subtotal	Rocks	Coarse soils	Subtotal
Ili, Kungey and Terskey Alatau, Ketmen (Lake Balkhash basin)	366.1	56.84	422.94	5.66	17.05	22.71
Ili and Kungey Alatau (Chu River basin)	143.1	12.84	155.94	1.47	3.85	5.32
Kungey Alatau (Issyk-Kol Lake basin)	160.0	4.5	164.5	1.6	4.8	6.4
Dzhungar Alatau	438.1	57.05	495.15	4.38	17.12	21.5
Total	107.3	131.23	**1238.53**	13.11	42.82	**55.93**

Field Activities

During 2017, MPI conducted wide-ranging field studies in East Siberia, Northern Tien Shan, Altay, and Verkhoyansk Mountains. Permafrost temperature observations were continued at monitoring sites in the Arctic, central and southern parts of Yakutia, in northern Krasnoyarsk region, Kazakhstan, Magadan region and Chukotka. Intensive hydrological, hydrogeological and geochemical studies were performed in Central Yakutia. Environmental and geotechnical monitoring and research programs were continued in support of the major engineering projects.

Field investigations under cooperative programs included:

- field work in the Bykovsky Peninsula under the project "Evolution of coastal and subsea permafrost in the Laptev and East Siberian seas", in cooperation with the Alfred Wegener Institute, Research Centre for Geosciences (Potsdam), Trofimuk Institute of Petroleum Geology and Geophysics (Novosibirsk), Arctic and Antarctic Research Institute (St. Petersburg), and North-Eastern Federal University (Yakutsk);

- a drilling and observation program of the Russian-German expedition Lena-2017 to study the development of permafrost and taliks beneath sea lagoons and coastal lakes, as well as the climate-driven evolution of coastal processes in the Laptev Sea and Lena Delta;

- streamflow studies in Central Yakutia for hydrological modeling with HYPE and HYDROGRAPH models (together with the Swedish Meteorological and Hydrological Institute);

- surface and subsurface water sampling in the Shestakovka River area near Yakutsk for the joint program of MPI, the Swedish Museum of Natural History and Oxford University on the biochemical studies of sub-catchments within the Lena River drainage basin;

- field studies of alas landscapes on the Abalakh and Tyungyulyu terraces of the Lena River, hydrological observations in lakes and streams, ground temperature and active-layer measurements, under the cooperative project with the Geosciences Paris Sud (GEOPS) Laboratory "High-resolution spatial and temporal studies of permafrost degradation in Central Siberia";

- monitoring observations at several sites near Yakutsk (Central Yakutia) and Tiksi (Arctic Yakutia) under the joint MPI-JAMSTEC project "Observational study of permafrost, vegetation,

energy and water in Eastern Siberia towards elucidation of the impact of climate change in the geochemical cycle";

Drilling from the ice surface, Omulyakh lagoon, northern Yakutia.

Following the establishment of the International Research Center for Asian Cold Regions Environment and Engineering, which was officially opened in April 2017, the co-founders - the State Key Laboratory of Frozen Soil Engineering (SKLFSE), Northwest Institute of Eco-Environment and Resources, Chinese Academy of Sciences and the Melnikov Permafrost Institute - conducted a range of joint activities during the summer of 2017. Six young scientists from MPI stayed for a month at SKLFSE in Lanzhou for training and discussions. Together with their potential research partners, they visited field sites on the Qinghai-Tibet Plateau and took part in experimental work. Dr. Alexey Galanin and Dr. Ivan Khristoforov were invited to SKLFSE as visiting scholars under the State Administration of Foreign Experts Affairs (SAFEA) program. A team from SKLFSE, including Profs. Wu Qingbai, Ma Wei, Jin Huijun and Zhang Ze, and from MPI, including Dr. Mikhail Zhelezniak, Andrey Litovko and Leonid Gagarin, conducted a field trip from Yakutsk to Tynda along the Lena Federal Road and the Nizhny Bestyakh–Tynda Railroad to examine the problem sections over ice-rich permafrost in Central Yakutia. The active interaction and idea sharing resulted in four joint project proposals submitted to the RFBR-NNSF Call 2018. If approved, the first joint studies will focus on the effects of zonal and azonal factors on thermokarst, Middle and Late Pleistocene paleoenvironments inferred from syngenetic ice-rich permafrost studies in Asia, permafrost issues of the Lena River bridge site near Yakutsk, and the influence of precipitation infiltration and water vapor condensation on the ground thermal regime.

Meetings

The XI International Symposium on Permafrost Engineering was held in Magadan, Russia on September 5-8, 2017. Organized by the Melnikov Permafrost Institute and its Magadan station in coordination with the State Key Laboratory of Frozen Soil Engineering, CAS (Lanzhou) and the Heilongjiang Province Academy of Cold Area Building Research (Harbin), the symposium provided a forum for over 100 researchers to discuss advancements, ideas and theories in the field of frozen ground engineering research and practice. The participants included researchers from 20 Russian, 1 Byelorussian and 13 Chinese organizations, as well as representatives from business and engineering community. The Symposium involved one plenary and three concurrent sessions with a total of 71 oral and 34 poster presentations. A round-table discussion chaired by Igor Ozimok, Vice Governor of Magadan Province, drew attention to the current permafrost-related problems in the region. A PYRN meeting was organized during the Symposium attended by approximately 40 young researchers.

A book of abstracts (http://mpi.ysn.ru/images/Eng/ISPE/ISPE_2017_Magadan_Abstracts.pdf) was published before the meeting. Selected full papers were published in several journals, including *Sciences in Cold and Arid Regions*, *Earth's Cryosphere*, *Russian Geology and Geophysics*, and *Ice and Snow*. Symposium photographs can be viewed at: https://yadi.sk/d/gm9kYvVR3N38Ff\.

Participants of the XI International Symposium on Permafrost Engineering.

The 21st Northern Research Basins Symposium and Workshop were successfully held in Yakutsk, Russia from 6th to 12th of August 2017 under the theme of “Cold-Region Hydrology in Non-Stationary World”. The meeting organized jointly by the Institute of Water Problems (Moscow) and the Melnikov Permafrost Institute addressed the issues of hydrological research in cold regions, both in fundamental scientific and applied aspects, including the studies of snow, glaciers, permafrost, frozen ground, groundwater, seasonally frozen rivers and lakes. The topics discussed by delegates from Russia, Canada, Sweden, France, Finland and Germany covered observational evidences of change in coupled permafrost-hydrology system; present state and future projections of local, regional and pan-Arctic hydrology; modeling studies representing landscape evolution, dynamics of water storages and permafrost degradation, and impacts of permafrost hydrology changes on local communities. The symposium program included tours to the Mammoth Museum in Yakutsk and a field excursion to the MPI's underground water research site on the Lena River terrace and completed with a cruise to the Lena Pillar Natural Park. The Proceedings of the 21st NRB Symposium and Workshop and the photographs can be downloaded from the Symposium website http://nrb2017.ru/.

MPI Dissertation Council meeting. The Dissertation Council D003.025.01, now consisting of 26 members, was established at MPI in 1984 and authorized by the Russian Ministry of Education and Science's Higher Attestation Committee to award degrees in geography, geology & mineralogy, and engineering (qualification standard 25.00.08 – engineering geology, geocryology and geotechnical engineering). The Council held its meeting on November 28-29, 2017 for a public defense of two dissertations. Igor Syromyatnikov and Nikolay Torgovkin from MPI successfully defended their Kandidat Nauk (PhD) dissertations titled respectively "Structure and Temperature of Permafrost Foundations in Urban Landscapes" and "Geochemical Features of Human Modified Soils in Permafrost Regions", both focusing on the city of Yakutsk.

Cryolithology and Glaciology Department, Geographical Faculty, Lomonosov Moscow State University

In 2017 fundamental studies of changes in the Earth’s cryosphere under the influence of natural factors and technogenesis were carried out at the Department of Cryolithology and Glaciology, Faculty of Geography, Lomonosov Moscow State University.

Rogov V.V. and Konishchev V.N., using the example of the sections of the loess deposits of the Russian Plain and the Loess Plateau of China, shows the promise of the cryolithological method applying for mineral matter analysis. It was shown that, not only within the periglacial permafrost zone, but also under conditions of seasonal freezing in the Pleistocene, processes of cryogenic transformation of sediments took place, which involved the formation of the composition and properties of loesses of sufficiently high thickness (Konishchev and Rogov, 2017).

Rogov V.V. conducted studies of frozen ground and soils structure using the method of X-ray computed tomography (Romanenko et al., 2017). The dynamics of frozen ground and soils structure in freeze-thaw cycles was characterized. The prospects of using X-ray computed tomography in the study of cryogenic processes are revealed.

In the paper «The gas-bearing structures and cryogenic strata of the Yamal peninsula cryolithology provinces» the main geocryological parameters of the cryogenic strata in gas-bearing cuts, dislocated in cryolithology provinces of Jamal peninsula, are shown in the original author classification (Badu, 2017a). Stages of submarine cryolithogenesis development in marine deposits in the Pleistocene, peculiarities its development in a sequential change in facial conditions of sedimentation and freezing bottom sediments of the shelf are shown (Badu, 2017b).

Based on direct observations aimed by Streletskaya I.D. and colleagues, the mean annual temperature of saline sediments is found to be about freezing point in areas where permafrost is subject to degradation, with the depth of zero annual amplitude occurring at 2.5–3.5 m. Permafrost continues to form at low marine laidas, where mean annual temperature of sediments average –3.9 °C. The depth of layer with zero annual amplitude in this area is less than 3–4 m.

Various wedge structures have been studied in detail in sediments of Leningrad region. (Streletskaya, 2017). Primary soil, sand, and ice wedges formed as a consequence of frost cracking 15.5 kyr ago. The obtained disagree with refute the seismic origin of the soil wedges.

The carcass of Mammuthus primigenius named Zhenya was found near the mouth of the Yenisey River in eastern Siberia (Maschenko et al., 2017). It has been dated to 48,000 cal BP. The mineralogical analysis of site sediments revealed that the mammoth's burial in situ took place in the Yenisey River valley seasonally inundated by the river, which together with Fall's freezing temperatures protected the carcass from scavengers.

Commonalities and differences in the relief position and the geomorphic effects of the Yamal (GEC-1) and Gydan (AntGEC) gas-emission crater formations were revealed (Kizyakov et al., 2017a). Digital elevation models were created based on processing very-high spatial resolution stereo pairs

both before and after the formation of the craters formation to characterize the relief changes (Kizyakov et al., 2017b). The morphometric features of mounds–predecessors and craters are revealed, as well as the dynamics of the development of these forms.

Similarity in the isotopic and ionic composition of the crater tabular ground ice and stratified tabular ice of Marre-Sale area was found by Streletskaya I.D., in contrast to the ionic and isotopic composition of surface and atmospheric waters, as well as polygonal ice wedges in the region (Streletskaya et al., 2017). Comparison of the results of the analysis confirms the conclusion concerning the nature of the craters as resulting from the emission of methane accumulated in the upper horizons of frozen rocks and ground ice.

Tumel N.V. and Zotova L.I. performs an updated textbook reveals a number of conceptual provisions for the assessment, forecasting and mapping of the permafrost environment in the northern regions development from the standpoint of the landscapes stability to the manifestation of dangerous cryogenic processes (Tumel and Zotova, 2017).

On the basement of long-term observations, dedicated to thermal regime of the ground basement, activation of cryogenic processes, character of the object deformations, with consideration and analysis of satellite images, done by Grebenets V.I. and co-authors (Shiklomanov et al., 2017), changing trends of permafrost degradation near the largest industrial center in permafrost zone - Norilsk were revealed. Found the common trend of permafrost degradation over the past decade, number of deformed buildings constantly rises. 17 types of the special natural-technogenic geo-cryological complexes, formed on urbanized territories. The analysis showed, that “contribution” in ground temperature increasing (permafrost degradations), in the object basements (10-15%), connected with regional climate warming trends and the negative impacts of technogenesis (80-85%).

International Arctic field courses have been conducted in July 2017 in the North of Siberia. The organizers were department of Cryolitology and Glaciology, Geographical faculty, MSU (Russia) and George Washington University (USA). 24 participants took part in the courses, 9- from MSU, Russia, 15- from USA, Switzerland, Germany, Spain. Objectives of the courses were investigations of permafrost features, pleistocen-holocenic stratas (paleogeographic methods), landscape-permafrost conditions in tundra and forest tundra, depth of ALT in different landscape conditions, thermal regime of permafrost. Important aspects were dedicated to engeneeric-geocryological problems of the territory, geoecological features, methods of rational construction on permafrost. The results of the courses were presented in two volumes.

Field practice for our third-year students have been conducted at first time on Svalbard from July 24 to August 5, 2017. This event was organized within the framework of the agreement on scientific cooperation between Arctic and Antarctic Research Institute «AARI» and the Faculty of Geography of Lomonosov Moscow State University. Students under the leadership of Kizyakov A.I. participated in the permafrost research around Barentsburg area as part of the seasonal group of the Russian Arctic Expedition «Spitsbergen-2017».

As part of an international group of researchers, Petrakov D.A. analyzed the causes of the formation of a catastrophic glacial mudflow in the Ala-Archa basin on July 31, 2012. It is established the high threat of breakthroughs in unsteady glacial lakes in Tien-Shan (Erokhin et al., 2017). Based on the synthesis of field and remote methods, the Catalog of Glacial Lakes of Uzbekistan was compiled, the probability of breakthrough of each of the lakes was estimated (Petrov et al., 2017).

Ground-based radar studies of the largest Caucasus glacier Bezengi were undertaken with participation of Kovalenko N.V. Fundamentally new results on the thickness of ice are obtained, which make it possible to build a map of the glacier thickness and preliminary estimate its volume. The total length of radiosounding profiles was about 75 km, before such studies were not conducted on the Bezengi glacier, only attempts were made.

Fieldwork (Popovnin V.V.) resulted in obtaining data for mass balance estimation for Djankuat, the representative glacier in the Caucasus, and for 3 glaciers (Karabatkak, Sary-tor and Bordu) in Tien Shan, Kyrgyzstan. The reported year turned out quite unfavourable for all of them, so that mass balance was negative, in spite of increased accumulation on Djankuat and Karabatkak Glaciers: ablation exceeded its norm everywhere, while in Kyrgyzstan it represented its absolute maxima for the entire period after the resumption of direct monitoring. Duration of continuous mass balance series at the Djankuat Glacier reached 50 years though exact values for 2016/17 balance year are not calculated yet. Mass balance of the above-mentioned glaciers of Tien Shan came to -1120, -1480 and -1340 mm w.e., correspondingly. These are the most negative values which have ever been registered here since restoration of the measurement program.

References:

Badu Yu.B. The gas-bearing structures and cryogenic strata of the Yamal Peninsula cryolithology provinces // Engineering Geology, № 1. 2017a. p. 39-52.

Badu Yu.B. Gas shows and the nature of cryolithogenesis in marine sediments of the Yamal

Peninsula // Kriosfera Zemli, 2017b, vol.XXI, p.42-54.

Erokhin S.A., Zaginaev V.V., Meleshko A.A., Ruiz-Villanueva V., Petrakov D.A., Chernomorets S.S., Viskhadzhieva K.S., Tutubalina O.V., Stoffel M. Debris flows triggered from non-stationary glacier lake outbursts: the case of the teztor lake complex (northern tian shan, kyrgyzstan) // Landslides, 2017, p.1–16.

Petrov M.A., Sabitov T.Y., Tomashevskaya I.G., Glazirin G.E., Chernomorets S.S., Savernyuk E.A., Tutubalina O.V.,Petrakov D.A., Sokolov L.S., Dokukin M.D., Giorgos M., Virginia R.-V., Markus S. Glacial lake inventory and lake outburst potential in Uzbekistan // Science of the Total Environment, 2017, Vol. 592, p.228–242.

Kizyakov, A.; Zimin, M.; Sonyushkin, A.; Dvornikov, Y.; Khomutov, A.; Leibman, M. Comparison of Gas Emission Crater Geomorphodynamics on Yamal and Gydan Peninsulas (Russia), Based on Repeat Very-High-Resolution Stereopairs. Remote Sens. 2017a, 9(10), 1023; doi:10.3390/rs9101023

Kizyakov A.I., Sonyushkin A.V., Khomutov A.V., Dvornikov Yu.A., Leibman M.O. Assessment of the relief-forming effect of the Antipayuta gas emission crater formation using satellite stereo pairs// Sovremennye problemy distantsionnogo zondirovaniya Zemli iz kosmosa, 2017b, Vol. 14, No. 4, pp. 67-75, doi:10.21046/2070-7401-2017-14-4-67-75

Konishchev V.N., Rogov V.V. Cryogenic processes in loess // GEOGRAPHY, ENVIRONMENT, SUSTAINABILITY, 2017, Vol. 10, №. 2, p.4–14.

Maschenko E.N., Potapova O.R., Vershinina A., Shapiro B., Streletskaya I.D., Vasiliev A.A., Oblogov G.E., Kharlamova A.S., Potapov E., van der Plicht, J., Tikhonov A.N., Serdyuk N.V., Tarasenko K.K. The Zhenya Mammoth (Mammuthus primigenius (blum.)): Taphonomy, geology, age, morphology and ancient dna of a 48,000 year old frozen mummy from western Taimyr, Russia // Quaternary International, 2017, Vol. 455, p.104–134. DOI: 10.1016/j.quaint.2017.06.055

Romanenko K.A., Abrosimov K.N., Kurchatova A.N., Rogov V.V. The experience of applying X-ray computer tomography to the study of micro structure of frozen ground and soils // Kriosfera Zemli, 2017, vol.XXI, №4, p.75–81

Shiklomanov N.I., Streletskiy D.A., Grebenets V.I., Luis S. Conquering the permafrost: urban infrastructure development in Norilsk, Russia // Polar Geography, 2017, p.1–18, DOI: 10.1080/1088937X.2017.1329237

Streletskaya I.D., Leibman M.O., Kizyakov A.I., Oblogov G.E., Vasiliev A.A., Khomutov A.V., Dvornikov Y.A. Ground ice and its role in the formation of gas-emission crater in the Yamal Peninsula // Moscow University Bulletin.Series 5. Geography, 2017, 1(2), p.91-99

Streletskaya I.D. Soil wedges structures in the southern coast of the Finland Gulf // Kriosfera Zemli, 2017, vol.XXI, №1, p.3–12, DOI: 10.21782/KZ1560-7496-2017-1(3-12)

Tumel, N.V. and Zotova L.I. Cryolithozone geoecology: a textbook for undergraduate and graduate students / second edition, revised and enlarged. Moscow: Publishing House Yurayt, 2017, 220 p.

Sergeev Institute of Environmental Geoscience RAS (Moscow)

Monitoring geocryological observations were continued at sites without anthropogenic disturbances in the Torthern Transbaikalia Region. Obtained will be submitted to the international database of GTN-P Project. In cooperation with Institute of Water Problems of the Russian Academy of Sciences, a map of the manifestations of geocryological processes with which economic or economic problems were associated for the period 2000-2015 for the territory of Russia was drown-up. In cooperation with the Geological Faculty of the Moscow State University, the geocryological observatory in vicinity of Vorkuta (European North) were developed with mapping and geophysical works. This observatory was established by professor V.A. Kudryavtsev in the fifties of XX century.

MSU students in the fieldwork in Northern Tansbaikalia (Eastern Siberia). The bond-failure crack at the shore of thermokarst lake is in center of the picture.

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

2017 June 4-8 (Pushchino):
Permafrost Conference «Earth's Cryosphere: Past, Present and Future» was organized by Federal

Agency for Scientific Organizations, Russian Foundation for Basic Research, Institute of Physico-chemical and Biological Problems in Soil Science RAS, OOO «Bioarsenal». Partner of the conference: Earth Cryosphere Institute (ikz.ru) and «Beta Analytic radiocarbon dating lab» (radiocarbon.com). All current information is available at http://cryosol.ru/en/cryoconference2017.html .

Most important publications – 2017:

Shmelev, Denis, Alexandra Veremeeva, Gleb Kraev, Alexander Kholodov, Robert GM Spencer, Wayne S. Walker, and Elizaveta Rivkina. Estimation and Sensitivity of Carbon Storage in Permafrost of North-Eastern Yakutia. Permafrost and Periglacial Processes. 2017. 28, no. 2: 379-390.

Kraev, Gleb, Ernst-Detlef Schulze, Alla Yurova, Alexander Kholodov, Evgeny Chuvilin, and Elizaveta Rivkina. Cryogenic Displacement and Accumulation of Biogenic Methane in Frozen Soils. Atmosphere. 2017, 8 (6):105-124. doi:10.3390/atmos8060105

Spirina E.V., E.V. Durdenko, N.E. Demidov, A.A. Abramov, V.E. Romanovsky, E.M. Rivkina. Halophilic–psychrotrophic dacteria of Alaskan cryopeg—a model for astrobiology. // Paleontological Journal, 2017, Vol. 51, No. 12, pp. 45–57, DOI: 10.1134/S0031030117120036

Organic carbon derived from permafrost can provide a substrate for greenhouse gas production where the buried carbon pool thaws and mobilizes into biogeochemical cycles. Much attention has focused on the permafrost carbon of the Yedoma region of Siberia due to the wide distribution of organic and ice-rich deposits. Here, we present a new estimation of carbon storage in the upper 25m of permafrost in north-eastern Yakutia based on a novel database of total carbon (TC) content, bulk density and ice content of permafrost, and a new map of Quaternary deposits derived from drilling data. The stratigraphic units contain 0.6–2.1% TC, with the highest concentrations in the Holocene cover layer and Late Pleistocene Yedoma superhorizon. The largest carbon pool is found in the Pliocene/MiddlePleistocene Olyor superhorizon. The TC pool of Yedoma is estimated to be 1.5–2 times less than that calculated previously. The TC pool of the study area is 31.2 ± 15.2 Pg C spread across 88 000 km2, with a mean specific carbon content of approximately 14.3 kg C m-3. Carbon storage is estimated excluding the ice-wedge volume and, due to the limited data for Yedoma and Alas deposits, we present a maximal assessment of the carbon pool for the Yedoma region. Refinement of the size of the Yedoma TC pool is critical for quantifying the scale of permafrost feedback to the carbon cycle.

Cryopegs, lenses of hypersaline unfrozen soil or water within permafrost, are a model for astrobiology, since free water can only be present on cryogenic bodies and planets in the form of brine. In this paper the diversity of aerobic halophilic-psychrotrophic microorganisms from an Alaskan cryopeg (Barrow Cape) were studied and described for the first time. This cryopeg is characterized by a constant subzero temperature (–7°C), high salinity (total mineralization is about 120 g/L) and isolation from external influences for a geologically significant period of time. Our study has revealed a large number of microorganisms capable of growth at low temperature (4°C) in a wide range of salinities from 5 to 250 g/L of NaCl, the latter being 3 times higher than the natural salt concentration of the Alaskan cryopeg. The microorganisms identified are comprised of four major phyla: Actinobacteria (genera Brevibacterium,Citricoccus, Microbacterium), Firmicutes (genus Paenibacillus), Bacteroidetes (genus Sphingobacterium), and Proteobacteria (genus Ochrobactrum).

“Earth’s Cryosphere” (“Kriosfera Zemli”) magazine.

The results of fundamental investigations and important results on the research programs of the Earth Cryosphere Institute (ECI SB RAS) and many other Institutes and organizations specializing on permafrost/cryosphere researches are presented in the “Earth’s Cryosphere” (“Kriosfera Zemli”) magazine. It is translated in English since 2014, all the articles are available online for free at the website: 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.

Dvornikov Yu.A.1, Leibman M.O.1,2, Heim B.3, Khomutov A.V.1,2, Roessler S.4, Gubarkov A.A.5Thermodenudation on Yamal peninsula as a source of the dissolved organic matter increase in thaw lakes /DOI: 10.21782/EC2541-9994-2017-1(28-37)

Earth Cryosphere Institute, SB RAS, Tyumen, Russia; 2 Tyumen State University, Russia; 3 Alfred Wegener Institute for Polar and Marine Research, Potsdam, Germany; 4 FIELAX, Bremerhaven, Germany; 5 Tyumen Industrial University, Russia

This paper is devoted to the study of thermodenudation impact on concentration of dissolved organic matter in lake water. We present results of measured concentration of colored dissolved organic matter in water samples collected from the lakes in Central Yamal. We show the difference of colored dissolved organic matter concentration in lakes with thermo-denudational coasts and in intact lakes. Buried peat layers

discovered in thermocirque exposures appeared to have high concentration of dissolved organic carbon. We found average concentration of colored dissolved organic matter 3.5–4.5 times higher in lakes with thermocirques than in intact lakes.

This paper is devoted to the study of thermodenudation impact on concentration of dissolved organic matter in lake water. We present results of measured concentration of colored dissolved organic matter in water samples collected from the lakes in Central Yamal. We show the difference of colored dissolved organic matter concentration in lakes with thermo-denudational coasts and in intact lakes. Buried peat layers discovered in thermocirque exposures appeared to have high concentration of dissolved organic carbon. We found average concentration of colored dissolved organic matter 3.5–4.5 times higher in lakes with thermocirques than in intact lakes.

Manakov A.Yu., Ildyakov A.V., Lipenkov V.Ya*,, Ekaykin A.A.*, Khodzher T.V.** Formation of clathrate hydrates of hydrochlorofluorocarbon 141b in the deep borehole at Vostok Station (Antarctica) in the course of the unsealing of subglacial Lake Vostok / DOI: 10.21782/KZ1560-7496-2017-3(32-40)***

Nikolaev Institute of Inorganic Chemistry, SB RA, Novosibirsk; * Arctic and Antarctic Research Institute, St. Petersburg; ** Limnological Institute, SB RAS, Irkutsk; *** Institute of Earth Sciences, St. Petersburg State University

We have presented the results of a study of core samples which had been recovered from a deep borehole after the second unsealing of subglacial Lake Vostok in 2015 (borehole 5G-3, in which a mixture of kerosene and HCFC-141b densifier had been used as the drilling fluid). The intensive mixing of the subglacial water and the drilling fluid resulted in the formation of a solid plug that filled the volume of the borehole and blocked the access to the lake. We have demonstrated that this solid plug consists of kerosene, ice and clathrate hydrate of HCFC-141b. The obtained data suggests that the drilling fluid presently used at Vostok should be replaced, at least in the bottom section of the hole, by another fluid which does not react with subglacial water.

Sudakova M.S., Sadurtdinov M.R. Malkova G.V. *, Skvortsov A.G., Tsarev A.M. *Application of ground penetrating radar in permafrost investigations / DOI: 10.21782/KZ1560-7496-2017-3(69-82)

Earth Cryosphere Institute, SB RAS, Tyumen; ** Lomonosov Moscow State University, Department of Geology;*** Tyumen Industrial University.

The paper presents results of GPR investigations on the territory of Russia's European North carried out in the areas of different lithologies and permafrost conditions in the upper part of the geological section. The GPR surveys were part of the integrated geological and geophysical studies that also included seismic surveying, lithological differentiation of nearsurface deposits, measurement of active layer thickness, and weight rock moisture determination. The GPR was the most effective for the study of sandy and sand-peat geological sections, whereas in loamy environments its efficiency was low. Providing the upper limit of permafrost occurs at shallow depths (less than 1.5 m), which allows direct measurements, GPR can be used as supplementary method for more detailed description of spatial variability of the active layer thickness and other properties, including volumetric moisture estimates calculated from velocities of electromagnetic waves. Alternatively, with the permafrost table occurring deeper than 1.5 m, the GPR proves to be the main method for determining its position in the section. For more accurate geological and geocryological identification of the boundaries, the GPR data interpretation ought to be constrained by seismic results. Application of the GPR in combination with geocryological and seismic methods is ascertained to be highly perspective for solving various engineering problems, which will contribute to the existing permafrost monitoring frameworks.

Fotiev S.M. Arctic peatlands of the Yamal-Gydan province of Western Siberia / DOI: 10.21782/KZ1560-7496-2017-5(3-15)

Earth Cryosphere Institute, Tyumen

Based on the seminal works of the foregoing researchers, this paper focuses on peat formation processes that occur under the extreme climatic and permafrost conditions of the northern part of Western Siberia. It has been shown that in spite the extreme climatic and permafrost conditions, but more likely because of them, peatlands up to 7.5 m thick reinforced with large ice wedges occupy extensive areas in the tundra zone. Vertical growth of peatlands was found to be most intensive (at a rate 1.5–4.4 mm/year) in a limited time period from 9 to 6 ky BP, which suggests that lower horizons of peatlands up to 3.0–4.5 m thick accumulated in just 1500 years. The three reasons that determined the active vertical growth of peatlands have been identifi ed and thoroughly discussed in this research: huge ice content, abundance of wood residues in peatlands, and intense frost heaving during the freezing of a newly formed peat layer. Premised on our fi nding that birch stands with high bonitet level grew in the tundra only locally, in the areas underlain by insulation-radiogenic taliks, it is proved that in the Holocene, there was no northward shift of 400–500 km in the northern boundary of the forest tundra.

Domanskaya O.V.*, Melnikov V.P.* – ***, Ogurtsova L.V.*, Soromotin A.V.*,

Domanskii V.O., Polyakova N.V., Some features of enzyme activity in different strains of the Bacillus genus isolated from Permafrost / DOI: 10.21782/KZ1560-7496-2017-5(63-71)

Tyumen State University; **Tyumen Scientific Centre, SB RAS;***Tyumen Industrial University

The kinetics of growth and activity of enzymes in bacterial strains of the Bacillus genus isolated from permafrost are studied as a function of incubation temperatures. Viable bacteria were found in permafrost in the area of Tarko-Sale in northern West Siberia. The selected permafrost core samples are Upper and Middle Pleistocene alluvial and lacustrine deposits of marine terrace IV (mIII1, mII2–4). The Bacillus spp. strains change notably in growth kinetics and enzyme activity as temperatures vary from 5 to 45 °C, which is evidence of their adaptation ability. Activity of catalase, dehydrogenase, amylase, protease and lipase enzymes is high at low temperatures in most of the analyzed bacterial strains, which has important biotechnological implications.

South Korea

CAPEC Project (PI: Bang Yong Lee)

The **CAPEC** (Circum Arctic Permafrost Environment Change Monitoring, Future Prediction and Development Techniques of Useful Biomaterials) Project, supported by the Korean Ministry of Science and ICT (MSIT) has been on-going since 2011. The second round (2016-2020) of this project was launched. Through this project, we plan to establish Arctic monitoring nodes to study environmental changes and develop state-of-the-art observation techniques for terrestrial permafrost region. This monitoring project includes atmosphere-pedosphere-biosphere monitoring system with Ubiquitous Sensor Network (USN) and GPS monitoring. The research aims of this project are (1) to understand the correlation between carbon dioxide (CO2) fluxes and soil properties; (2) to estimate the contribution of microbial respiration, and plant photosynthesis and respiration to the CO2 production from soil; (3) to understand the geophysical and mechanical behavior of frozen ground correlated with environmental change. On the basis of the CAPEC project, we conducted Arctic field research and set up new instruments in USA, Canada, Svalbard, Greenland, Iceland, and Russia in 2017.

CAPEC project in Council, Alaska, USA

Scientists and experts of KOPRI with University (Korean and UAF) visited the study site in Council in April and started eddy-covariance measurements to monitor drastic changes of energy/water/carbon fluxes during snowmelt period. A four-component net-radiometer was operated at the site year-round like before. Spatial variation of CO2 efflux was measured using a manual chamber system on 9×9 grids on a monthly basis from July to September. In addition, thaw depths at multiple points were manually measured using a probe once in July, August, and September. Likewise, plant activity was monitored using a camera and NDVI sensors throughout the year. In September, an 8-m long snow-fence and two open-top-chamber were installed at the site together with air/soil temperature and moisture sensors to study effects of snow-depth change.

Long-term continuous measurement of permafrost in the tundra ecosystem is necessary but access to high latitude tundra region is not easily available. To overcome this problem, Wireless Sensor Network (WSN) technology based Ubiquitous sensor network-based remote monitoring system (U-RMS) was used for micrometeorology research. This technology not only presents advantage in overcoming the site accessibility but also many other advantages such as low power consumption, low cost, network reliability, and scalability. With these advantages, U-RMS was used to collect and manage the environmental data on air temperature, relative humidity of the near-surface, soil temperature, soil water contents which play significant roles in the tundra ecosystem as controlling parameters of the carbon cycle. Also, we conducted spatial and temporal analyses of the environmental parameters at the micrometeorological measurement site. To collect and manage the measurements and the image data, two separate application software programs were developed. The application software for the measurement data, post office protocol version 3 (POP3) client, enables the downloading of data to a local PC by converting it through Iridium satellite network (ISN) then Ubiquitous sensor network (USN).

To compare the ecosystem responses to a changing amount of snowfall between dry and moist tundra, we installed 6 snow fences in moist tundra of Council in 2017. A snow fence creates a gradient of snow depth throughout the winter, and plots of control, shallower and deeper snow depths are set up at each fence. Soil core samples were taken for analyzing soil and microbial characteristics, and we also measured CO_2 flux rates (rates of photosynthetic uptake, respiration) in September.

CAPEC project in Cambridge Bay, Canada

For long-term monitoring of CO_2 and energy exchange between the atmosphere and terrestrial biosphere, an eddy covariance flux system together with a net radiometer was operated on an Environment Canada tower about 50 m away from the climate manipulation plots (69°07′48″N, 105°03′36″W) since summer in 2012. Complimentary measurements for soil temperature and soil water content have been measured at a depth of 0.1 m near the tower since July 2014. For quality control of flux data and diagnosis of the impact of a garbage incineration plat southeast away from the flux tower on atmosphere quality, an aethalometer was installed to measure black carbon concentration in a building of upper air station on July, 2013.

For the maintenance of the flux system and additional chamber measurements, two researchers visited the site from June 21 to July 9, 2017. The researchers calibrated the gas analyzers (EC150 & LI7700) with CO_2/CH_4 gas, and water vapor generated by the dew point generator (LI610). Chamber measurements for CO_2 and CH_4 emissions from the soil were conducted at 12 points near the tower and the nearest lake from the tower using LGR

portable gas analyzer with Licor Chamber. For the measurements, twelve collars with a diameter of ~ 0.2 m were installed in the site. In addition, for continuous and automatic chamber measurement of CO_2/CH_4 emission during summer season, we made a small plot 300m away from the tower (Figure 1). Continuous and automatic chamber measurements were conducted from July to September at 2017. Lastly, with the support of Qillaq Innovations, a hut (350 X 220 X 230cm) was put near the flux tower where electricity power is available, which will allow us to measure turbulent N_2O-CH_4 flux from 2018 summer (Figure 2).

Figure 1. Automatic Chamber system near the lake

Figure 2. Hut installed near the flux tower

To investigate the effects of increasing temperature and precipitation in Arctic tundra, we have been conducting the climate manipulation experiment since 2012. This year, from June 16 to September 21, we installed open top chambers (OTCs) to experiment with increasing temperature and watered every week to increase precipitation. We are currently monitoring air temperature, relative humidity, soil temperature, soil moisture content, and NDVI from the climate manipulation plots. We are planning to monitor CO_2 flux and to measure dissolved organic carbon, N mineralization rates, and microbial characteristics during growing seasons in 2018.

The snow manipulation experiment was set up in Cambridge Bay (dry tundra) as a same way in Council, Alaska (moist tundra) in 2017. Soil samples were taken for analyzing soil and microbial characteristics, and we also measured CO_2 flux rates in July. We plan to continue these observations and to conduct electronic and electromagnetic geophysical survey from the onset of snowmelt to the end of growing season in 2018.

CAPEC project in Ny-Ålesund, Svalbard, Norway

The overall main research objective of KOPRI's aerosol research team is to address the question: will future changes of the Arctic climate induce positive or negative feedbacks with respect to DMS-aerosol-cloud interactions? To improve knowledge gaps regarding these issues, we are carrying out in-situ measurement of diverse aerosol-relevant parameters at the Zeppelin observatory in collaboration with POSTECH, Stockholm University, Norwegian Polar Research Institute and Norwegian Institute for Air research.

The Zeppelin observatory is located in the Arctic on Zeppelin Mountain on the island archipelago of Svalbard (79°N, 12°E, 474m: Figure 4). The observatory belongs to a Global Atmospheric Watch (GAW) station, and the unique location of the observatory makes it an ideal platform for the monitoring of global atmospheric change. Currently, we are observing numerous aerosol parameters including cloud condensation nuclei, DMS, size distribution of aerosol particles and sulfur isotope ratio/molecular composition of fine aerosol particles at the observation site. New analytical system for measuring nano-size aerosol particles ranging 3 to 50 nm was installed in 2017. To assure quality and continuity of measurements, we make frequent visits (at least twice per year) to the observation site and provide necessary support for routine maintenance and calibration. Our research activities in Ny-Ålesund are coordinated in the Atmospheric Research Flagship programme as part of the Ny-Ålesund Science Managers Committee (NySMAC) science plan.

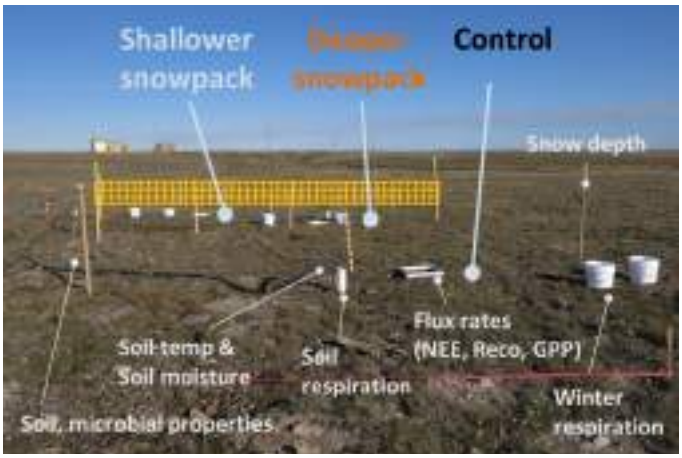


Figure 3. A setup of snow manipulation experiment

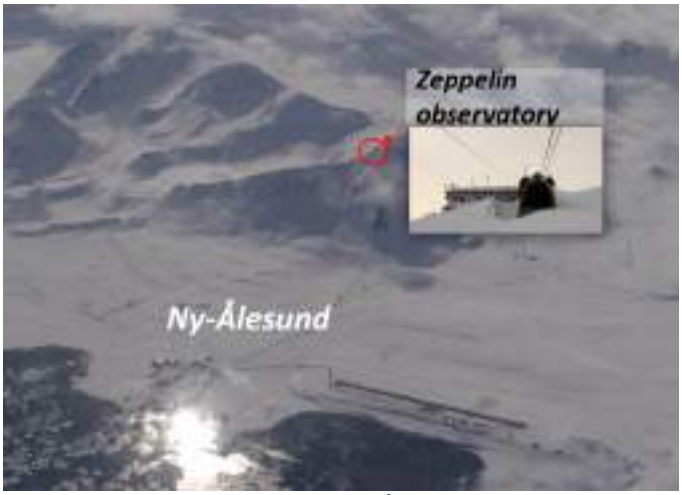


Figure 4. The view of Ny-Ålesund and Zeppelin station taken from an aircraft

CAPEC project in Greenland

Eddy covariance system measuring turbulent heat, CO2 and H2O exchange between the atmosphere and permafrost was installed at a 6-m tower to the south 20 m away from the atmospheric measurement hut at Villum Research Station, Station Nord, Greenland (81° 34.842'N, 16° 38.394'W) on May, 2016. The work was supported by Dr. Henrik Skov at Aarhus University, Denmark. The site is categorized as B1 based on CAVM Team (2003), indicating the site has dry to wet barren landscapes with very sparse, very low-growing plant cover. Complimentary measurements such as soil heat flux, soil temperature, soil moisture and four radiative components were made to better understand the surface energy budget over permafrost with the active layer of a depth of approximately 0.2 m and negligible vegetation effect. The flux system was also operated in 2017 and will be maintained by KOPRI researchers in 2018.

CAPEC project in Storhofdi, Iceland

Dimethyl sulfide (DMS) is a climatically important sulfur compound produced by oceanic biological activities. Storhofdi (Stórhöfði) observatory is one of the Global Atmospheric Watch (GAW) stations located in the southern tip of the island Heimaey, Iceland (63^{o}N, 30^{o}W). The location of the observatory is suitable for the analysis of natural emission of DMS and its linkage to oceanic biological activities. A research project based on the Storhofdi observatory in Iceland has been initiated in November 2016 in a close collaboration with KOPRI-POSTECH and University of Iceland, then, we installed automated DMS analytical system in 2017. KOPRI-POSTECH research team has been carrying out a successful work program with the similar research goal in Ny-Ålesund (79^{o}N, 11^{o}E). Expansion of the research area to Iceland will synergistically enhance current knowledge regarding climate feedback roles of DMS in Arctic environment.

CAPEC project in Russia

To measure turbulent fluxes of energy and carbon dioxide over permafrost at a coastal area of the Arctic sea, eddy covariance system was installed at a 3-m tower to the southeast 1 km away from the Research Station “Ice Base “Cape Baranova”, Russia (79°16′ N, 101°45′E) on October, 2017 with support of AARI, Russia. KOPRI researchers will visit the site and optimize the system in summer, 2018 with Russian colleague. Complimentary measurements will be done such as soil temperature and soil water content. After the system is stabilized, a study on the methane emission will be performed within a few years later.

Sweden

Permafrost-related activities in Sweden spans from baseline monitoring to process-based and applied research, from local to circumpolar scales. This work is carried out by researchers from a range of disciplines based at universities, government agencies or private companies. While much of the fieldwork is carried out during expeditions to other permafrost regions there is also a broad range of studies and monitoring of permafrost in Sweden.

The national adhering body responsible for the Swedish IPA membership is The Bolin Centre for Climate Research at Stockholm University (http://www.bolin.su.se/). The Swedish IPA council member is Dr. Gustaf Hugelius, Stockholm University.

APECS Sweden

Sweden continuous to have an active permafrost young researcher community organized within APECS (Association of Polar Early Career Scientists).

APECS Sweden is now an officially registered non-profit organization. This move will facilitate the operation of APECS Sweden and make it easier to support young polar scientists and organize events.

Members of APECS Sweden have been involved in the IPA action group "Permafrost Comics" that aims to explain permafrost research. The first edition of comics has now been released and are also available in Swedish. More information can be found under: https://frozengroundcartoon.com/

Lund University

At Lund University, there is a wide range of permafrost related research activities, including monitoring and field studies, remote sensing and modelling at multiple spatial scales.

The second phase of INTERACT was funded through Horizon2020 and the project started 1 October 2016. The project is coordinated by Margareta Johansson at the Dept. of Physical Geography and Ecosystem Science, Lund University. The project that networks 79 terrestrial research stations in the Arctic and neighboring high alpine areas will run for 4 years and will among other things provide transnational access to 42 stations in all arctic countries. The second call has been finalized but there will be more opportunities for transnational access in the coming years (www.eu-interact.org).

CALM monitoring in Abisko celebrates 40 years! In 1978, Jonas Åkerman from Lund University started active layer thickness monitoring along a 100 km transect in the Abisko area, northern Sweden. The results from 2017 field work provided the 40th consecutive annual measurements. Nine mires were monitored from the beginning but during the last decade the number has decreased to six as permafrost has completely gone from three of the mires. The active layer thickness has in general increased from ca 50 cm in the late 1970s to ca 90 cm in 2017. The increased active layer thickness has resulted in increased wetness, vegetation change from areas dominated by dwarf shrubs to areas dominated by graminoids (Figure 1).

Figure 1: Permafrost degradation in sub-Arctic palsas in Abisko area have been monitored over four decades.

Dr. Jonas Åkerman is maintaining the project "Long-term monitoring of permafrost and periglacial processes, Kapp Linné, Svalbard (FGFL 2012-2018)". The active layer monitoring in this area that started with 20 CALM sites in 1972 measuring the active layer at various material and levels has been reduced to one site (AL3) which has been maintained with only a minor gap in the series. For 45 years, the research group from Lund University has carried out this active layer monitoring programme. The correlations between the warmer summer temperatures and the depths of the active layer is evident here (Figure 2). Publications regarding correlations between the active layer and periglacial processes are in the pipeline.

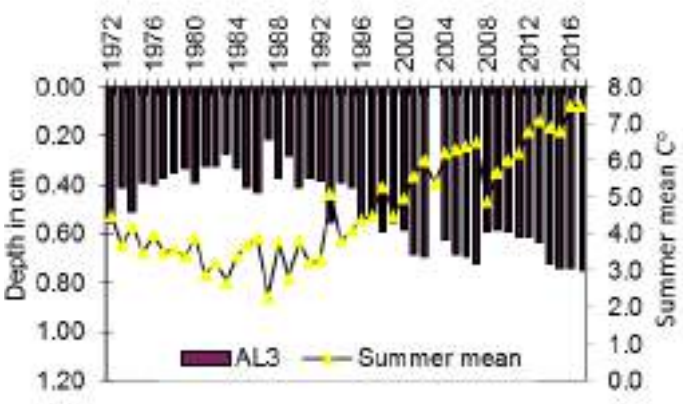


Fig.1 Depth of the active layer compared with the summer temperature at a bog site (AL3) near Kapp Linne' Svalbard, 1972-2017.

In the project NordSpec - a research infrastructure for spectral data collection - spectral measurements are conducted year-round using robust equipment in order to capture seasonal signals from vegetation (https://nordspec.nateko.lu.se/home). This information is used as ground reference information for remotely sensed observations from satellite, and for learning more about the dynamics of vegetation. Such measurements are being conducted of the Stordalen permafrost peat bog near Abisko, in parallel with the long term monitoring of permafrost and studies of ecosystem greenhouse-gas and energy fluxes carried out there. There is also a NordSpec site in the continuous permafrost zone in Zackenberg, NE Greenland.

Frans-Jan Parmentier received funding from the Swedish Research Council for his project "WinterGap". This project will work closely together with a sister project in Oslo, Norway, to improve the way that wintertime processes in permafrost environments are represented in land surface models. The project will start in the second half of 2018, and hire one PhD student in Lund and one in Oslo, funded by the Norwegian Research Council.

LPJ-GUESS is a process-based dynamic vegetation-terrestrial ecosystem model designed for regional or global studies. Models of this kind are commonly known as dynamic global vegetation models (DGVMs). Given data on regional climate conditions and atmospheric carbon dioxide concentrations, it can predict structural, compositional and functional properties of the native ecosystems of major climate zones of the Earth. This model has recently been updated to include basic peatland and permafrost dynamics.

Stockholm University

At Stockholm University, a wide range of permafrost-related research is carried out across several departments and within the Bolin Centre for Climate Research.

At the Department of Physical Geography, monitoring of ground temperatures has continued at Tarfala Research Station (PACE12, 100 m deep, 1550 m a.s.l.) and in peatlands in Tavvavuoma (<6 m deep, 550 m a.s.l.). Tavvavuoma is also the study site for the project Thawing permafrost in subarctic peat plateaus – impacts of climate change, funded by FORMAS (2015-2018) and coordinated by Dr. Britta Sannel, focusing on future permafrost carbon feedbacks. During the August-September field campaign to Tavvavuoma new sensors were installed to measure soil moisture (and ground temperature) along microtopographic gradients. Also a group from the University of Oslo, led by Sebastian Westermann, visited the site to produce a high resolution DEM using photographs taken from a drone (Figure 3).

Figure 3: Field work in Tavvavuoma together with the team from the University of Oslo. Photo: Léo Martin.

Within the framework of the ESF CryoCarb (2010-2014), the EU FP7 PAGE21 (2011-2015), the Nordforsk DEFROST (2010-2016) and the JPI COUP (2015-2017) projects, Prof. Peter Kuhry and Dr. Gustaf Hugelius have led research to update estimates of the northern circumpolar permafrost region soil organic carbon (SOC) pool. We are currently also assessing the northern permafrost region extent and SOC pool at the time of the Last Glacial Maximum (French-Swedish cooperation program, 2013-2016). A Swedish Research Council (VR) project to Dr. Gustaf Hugelius (2015-2017) investigates the role of permafrost soils in ESMs, with a special emphasis on surface organic soil layers and cryoturbation processes.

Ylva Sjöberg coordinates a FORMAS funded project on interactions of permafrost and hydrology in a changing climate, which includes extensive collaborations with the U.S Geological Survey and the Swedish Nuclear Waste Management Company (SKB). This project combines field data from northern Sweden, Greenland and Alaska with numerical hydrology-permafrost modeling. During 2017, field campaigns in Greenland together with SKB focused on measuring groundwater transport of

heat and elements in the active layer during the snow melt season and in late summer.

At the Department of Environmental Science and Analytical Chemistry (ACES) researchers are continuing to contribute to the development of the Max Planck land surface model JSBACH, which includes several high-latitude processes.

The Trace Gas Biogeochemistry (TGB) Laboratory at the Department of Geological Sciences of Stockholm University focuses on how the changing Arctic impacts low molecular weight carbon gas emissions. The TGB has played a role in the establishment of the Stordalen Mire as an ecosystem site in the VR supported Integrated Carbon Observation Network (ICOS-SE), an EU continental wide effort to monitor greenhouse gases.

Researchers from ACES and the TGB also participated in the SWERUS-C3 Arctic Ocean crossing in 2014 collecting a wide range of data, including sediment cores, bathymetric data and continuous, high precision measurements of ambient CH4 and CO2 and the isotopologues of CH_4. The data and samples collected from this expedition is still being processed. This generated several publications during 2017 including papers in a special issue focused on results from this expedition within several EGU open access journals.

Two workpackages within the new EU H2020 Consortia Nunataryuk (Nunataryuk.org) are coordinated by Stockholm University. Nunataryuk will study the Arctic coast and the effects of environmental change. It will include the effects on the natural environment as well as the people living there. Dr. Gustaf Hugelius coordinates a workpackage on Terrestrial permafrost and Prof. Örjan Gustafsson coordinates a workpackage on Subsea permafrost.

Swedish Polar Research Secretariat

The Swedish Polar Research Secretariat's primary mission is to organize and support research expeditions to the polar regions and to manage research infrastructure. The Secretariat also helps to create favorable conditions for polar research that does not involve fieldwork.

In 2017 the Swedish government has appointed Katarina Gårdfeldt as new Director-General of the Swedish Polar Research Secretariat. Katarina is Associate Professor of environmental inorganic chemistry and is currently the Director of Centre for Environment and Sustainability, GMV.

The Secretariat is running the Abisko Scientific Research Station in northern Sweden, about 200 km north of the Arctic Circle at 68°21'N; 18°49'E. The station was founded in 1912 and several long-term observational data series are maintained, e.g. air and soil temperatures, snow and ice data, and phenology. In addition to the main station, there are five minor research huts located in a range of ecological and climatological settings, from high alpine to birch forest. Permafrost has been studied in the Abisko region for many decades.

Abisko Research Station is a part of INTERACT (International Network for Terrestrial Research and Monitoring in the Arctic); SITES (Swedish Infrastructure for Ecosystem Science); and ICOS Sweden (Integrated Carbon Observation System). The ICOS station at Stordalen (SE-Sto) is located on a degrading palsa peatland and has been monitoring greenhouse gas fluxes here since 2013. The Stordalen Mire has hosted multiple projects running greenhouse gas flux measurements since the early 1970s. For more information, please visit http://polar.se.

United Kingdom

Carbon Cycling Linkages of Permafrost Systems (CYCLOPS)

A NERC-funded project, CYCLOPS, involving collaborators from the UK and Canada has found that methane fluxes from two peatlands undergoing permafrost thaw in northwest Canada were driven mainly by anaerobic decomposition of recent carbon inputs rather than from decomposition of previously frozen 'old' carbon. This unexpected finding suggests that changes in surface wetness and wetland area due to permafrost thaw may be more important than decomposition of old carbon in determining methane emissions from northern peatlands. Details are published at DOI: 10.1038/NCLIMATE3328

Past permafrost in the Yana Uplands, northeast Siberia

UK–German–Russian collaboration on past permafrost in the Yana Uplands, northeast Siberia, involved fieldwork at the Batagaika megaslump (Figure 1) and the Ulakhan Sullar section beside the Adycha River. The objectives were to collect ice, organic and sediment samples for palaeoenvironmental analysis and discuss permafrost drilling capability with geologists at Yanageology, Batagay. Thomas Opel and Julian Murton (University of Sussex), Petr Danilov and Vasiliy Boeskorov (North-East Federal University, NEFU) and Kseniia Ashastina (Senckenberg Research Institute, Germany) carried out fieldwork, in a collaborative project with Grigoriy Savvinov (NEFU).

A workshop was held on 22–23 May 2017 at the Alfred Wegener Institute, Potsdam (Germany), to summarise previous research at Batagaika, identify future research priorities and consider potential funding opportunities for collaborative research between the UK, Germany and Russia. A key priority is to scope a project involving deep drilling and analysis of permafrost sediments, with the aim of high-resolution palaeoenvironmental reconstruction of Middle to Late Pleistocene permafrost and associated conditions.

Preliminary results from earlier fieldwork at the Batagaika megaslump are published at doi:10.1017/qua.2016.15

Figure 1: Photograph of syngenetic ice wedges and composite wedges within the upper ice complex and overlying sand unit, Batagaika, 29 July 2017.

Research and cooperation in the Russian Arctic

The NERC Arctic Office organised a workshop on 5th December 2017 at the British Antarctic Survey, Cambridge, to promote research and cooperation between UK and Russian scientists in the Russian Arctic. The event was run by Henry Burgess and Nicola Munro (NERC Arctic Office) and brought together a wide range of UK scientists with interests or experience in working in Russia. Key themes discussed included logistics (e.g. shipping of equipment and samples), research networks and facilities, Arctic terrestrial environments, and funding opportunities.

New book on periglacial geomorphology

Professor Colin Ballantyne (University of St Andrews) has published a new book entitled *Periglacial Geomorphology* (Figure 2; Wiley Blackwell, 472 pp, ISBN 978-1-4051-0006-9; available from 29 December 2017). This text is aimed at senior undergraduate and graduate students taking courses in cold-climate geomorphology, as well as scientists with research interests in high-latitude and mountain environments. The contents can be viewed via the Wiley-Blackwell website (eu.wiley.com), and the book can be purchased via the Wiley-Blackwell website or through Amazon.

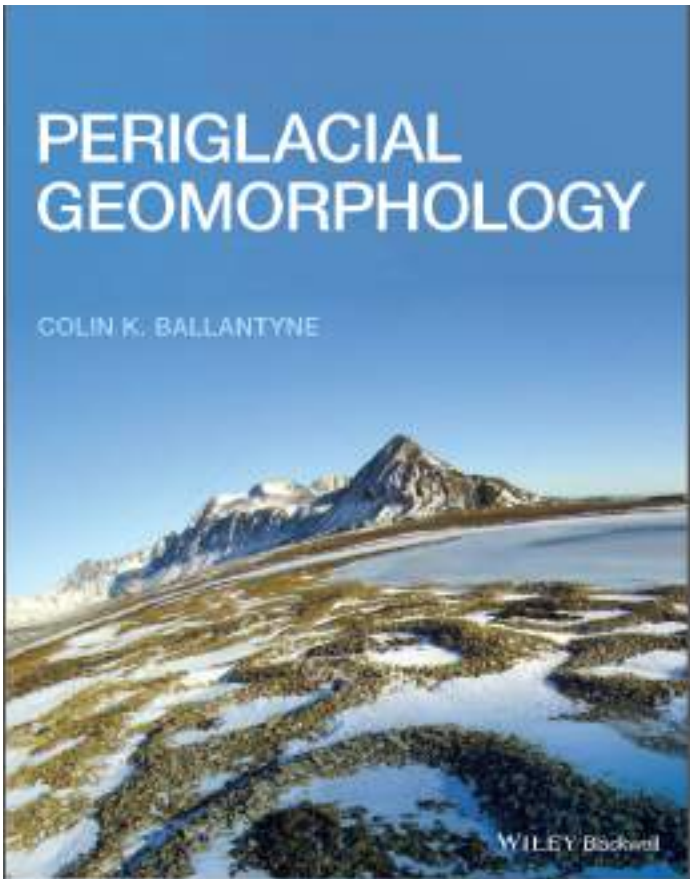


Figure 2: Cover photograph of Periglacial Geomorphology.

New book on periglacial engineering geology and geomorphology

A working party of the Engineering Group of the Geological Society has published a book entitled *Engineering Geology and Geomorphology of Glaciated and Periglaciated Terrains* (Figure 3; Geological Society, London, Engineering Group Special Publication 28, 953 pp, ISBN 978-1-78620-302-1). This is an essential reference text for practitioners, students and academics working in these challenging ground conditions. The narrative style, and a comprehensive glossary and photo-catalogue of active and relict sediments, structures and landforms make this material relevant and accessible to a wide readership. Further information, including free downloads of chapter 1, are available at: http://egsp.lyellcollection.org/content/28/1

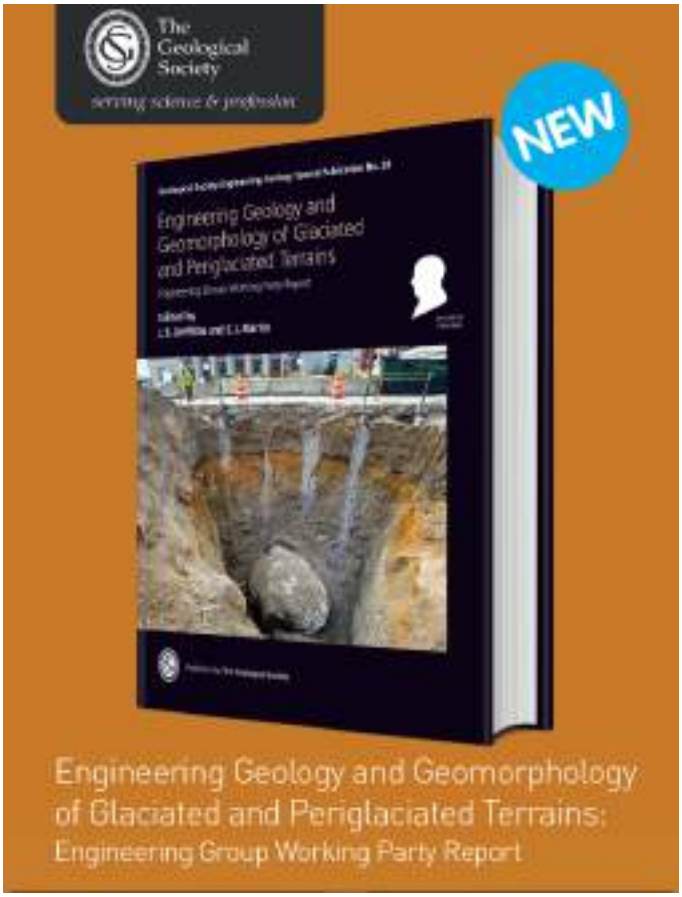


Figure 3: Geological Society Engineering Geology Special Publication 28.

United States of America

US PERMAFROST ASSOCIATION

The annual meeting of the US Permafrost Association (USPA) Board of Directors and a general member meeting was held on December 12 at the 2017 Fall Meeting of the American Geophysical Union in New Orleans, Louisiana. Current USPA membership includes: 20 student members, 45 regular members, 22 corporate/non-profits/lifetime members, for a total of 99 members (including several non-US members). The annual meeting convened at the Howling Wolf and was attended by approximately 150 members and their guests.

Anna Liljedahl became the new President of the USPA. Dmitry Streletsky was elected President-Elect, John Thornley elected Board Member-at-Large, and Molly McGraw re-elected Secretary.

We regret to announce the unexpected death of Andrew Slater in September 2017. Drew was a research scientist at the National Snow & Ice Data Center (NSIDC) in Boulder, CO. The USPA received a generous donation from Drew's family to establish the Andrew Slater Memorial Scholarship for early career Arctic researchers. At the USPA General Meeting, Heidi Rodenhizer (Northern Arizona University) was the first recipient of the scholarship.

The U.S. Permafrost Association, together with the American Geosciences Institute (AGI), provides a Permafrost Monthly Alerts (PMA) on USPA web site (http://www.uspermafrost.org/monthly-alerts.shtml). The AGI GeoRef service regularly scans the contents of over 3500 journals in 40 languages from the global geosciences literature, comprised of approximately 345 different sources. In addition to journals, special publications such as papers in proceedings and hard-to-find publications are provided. Where available, a direct link to the publication is included in the PMA. In 2017 there were approximately 1500 accessions of which 1000 were conference abstracts including all XI ICOP abstracts. See our website for current and past activities: http://www.uspermafrost.org/.

American Society of Civil Engineers

ASCE has reorganized the former Technical Council on Cold Regions Engineering (TCCRE) into the new Cold Regions Engineering Division (CRED). CRED has five technical committees that assess and report on effects of cold regions environments upon engineering design, construction, and operations. Additionally, the Publication Committee of CRED is responsible for editing the peer-reviewed Journal of Cold Regions Engineering published by ASCE. The quarterly Journal publishes practice- and research-oriented articles from any area of civil engineering that is substantially related to cold regions. Topics include permafrost and seasonal frost, ice engineering, construction, environmental quality, snow and ice control, and cold regions materials. The Journal currently publishes 25 to 30 refereed papers per year.

In 2017, CRED was one of the sponsors of the Congress on Technical Advancement held in Duluth, MN on 10-13 September. The theme of the congress was Superior Performance in a Changing Climate and it brought together engineers from the Aerospace Division, Committee on Adaptation to a Changing Climate, CRED, Construction Institute, Energy Division, Forensic Engineering Division and the Infrastructure Resilience Division. Permafrost was a common topic in many of the presentations. A published proceedings was produced and is available through ASCE Publications. The ASCE Cold Regions Engineering Awards were presented at a conference luncheon with Douglas J. Goering receiving the Harold R. Peyton Award for Cold Regions Engineering and Howard P. Thomas receiving the Can – Am Civil Engineering Amity Award. All of the Committees of CRED met at the Conference and the first meeting of the Committee charged with updating the ASCE Standard on Frost Protected Shallow Foundations also occurred at the Conference.

The Environmental and Public Health Engineering Committee of CRED is currently updating the Cold Regions Utilities Monograph that's widely used as a reference by many engineers working in areas of permafrost. This document is scheduled to be published in late 2018.

ASCE is also co-sponsoring the upcoming 2018 Arctic Technology Conference in Houston, TX on November 5-7 to discuss the latest technologies, responsibilities, and practices for responsible exploration and production in the Arctic where permafrost can be a major challenge. The next ASCE International Conference on Cold Regions Engineering is tentatively scheduled for 2019 in Quebec City.

International Association for Engineering Geology and the Environment (IAFG)

IAEG Commission 21: Engineering Geology of Permafrost Regions has been inactive for several years and is currently being re-invigorated. Ed Yarmak from the USA has assumed Commission chair and Dmitry Sergeev from Russia continues as Commission secretary. At the IAEG Council Meeting in Kathmandu on November 26, 2017, the call for new membership of the committee was initiated. The

committee is preparing to produce a white paper to help small communities assess when they need to initiate engineering studies to maintain existing infrastructure on permafrost as the climate warms. The cost of prevention and remediation is generally small compared to the cost of replacement.

Institution Member Activities:

U.S. Army Cold Regions Research and Engineering Laboratory (CRREL)

The U.S. Army Cold Regions Research and Engineering Laboratory reports on a variety of active research and engineering projects. Extensive excavations and upgraded facilities are ongoing for the Permafrost Tunnel near Fairbanks in 2018. The ultimate goal is a three dimensional test bed for geophysical and remote sensed measurements of massive ice features. For the past few years CRREL has conducted a successful permafrost thawing experiment at the Fairbanks Permafrost Experiment Station in collaboration with Lawrence Berkeley National Laboratory where fiber optic cables have been demonstrated to serve as an early detection system for permafrost degradation. Ongoing engineering design and siting for infrastructure at Thule, Greenland has included geological, geotechnical, design and remediation work. Supporting Moose Creek Dam Flood Control Project upgrades, CRREL conducted extensive geophysics to delineate frozen vs thawed zones and identify changes in soil class. Supporting NSF's new development at McMurdo Station Antarctica, CRREL provided review and recommendation of site conditions for infrastructure foundations to be placed on frozen volcanic bedrock. Supporting the Army High Altitude Research Facility upgrade on Pikes Peak Colorado in conjunction with Colorado Springs Colorado, CRREL provided review and recommendation of the site conditions and proposed foundation for new infrastructure to be placed on ice-rich decomposed bedrock. A variety of ongoing and new projects are focused on identifying thermokarst risks and studying habitat-hydrology-permafrost thaw linkages across interior Alaska.

Geophysical Institute Permafrost Laboratory, University of Alaska Fairbanks

The Geophysical Institute Permafrost Laboratory (GIPL) research team led by Prof. Vladimir Romanovsky continued the development of the observation borehole network for the thermal state of permafrost (TSP) monitoring in Alaska, Russia, and Central Asia as part of the Arctic Observing Network project “Development of sustainable observations of thermal state of permafrost in North America and Russia: The U.S. contribution to the GTNP”. As part of “Use of AIEM permafrost module output to assess the permafrost changes in the 21st century” project the GIPL team modeled the permafrost dynamics of North Slope of Alaska through 2100 using Ecotype approach. As part of “Community based permafrost and climate monitoring in rural Alaska” the GIPL team established 18 new ground temperature monitoring stations in the Upper Kuskokwim region of Alaska.

Visit Geophysical Institute Permafrost Laboratory website for further details on the current and past projects, data, reports, publications of all GIPL members, and latest permafrost news, www.permafrostwatch.org.

GIPL Team: Vladimir Romanovsky, Sergey Marchenko, Dmitry Nicolsky, Alexander Kholodov, Reginald Muskett, William Cable, Santosh Panda, Louise Farquharson, Lily Cohen, and Kirill Dolgikh.

George Washington University

Professors Nikolay Shiklomanov and Dmitry Streletskiy continued to manage the long-term NSF-funded Circumpolar Active Layer Monitoring (CALM) Project. In August 2017, a group of GWU, Michigan State University (MSU), and University of Montana (UM) faculty and students continued field work in northern Alaska. This year’s team consisted of GWU undergrads, Patrick Huggins and Emily Evenden; UM graduate student, Brianna Rick; and MSU graduate students, Kelsey Nyland (GWU Alumna) and Clayton Queen.

In July 2017, Drs. Shiklomanov and Streletskiy, graduate student Luis Suter, and 8 undergraduate students participated in an international field course in Western Siberia. Funded through the Arctic Partnerships for International Research and Education (PIRE) grant, the group traveled from Moscow to field sites in Salekhard and Vorkuta.

2017 publications:

Streletsky, D.A., Shiklomanov, N.I., Little, J.D., Nelson, F.E., Brown, J., Nyland, K.E., and Klene, A.E. (2017). Thaw subsidence in undisturbed tundra landscapes, Barrow, Alaska, 1962-2015. *Permafrost and Periglacial Processes* 28(3): 566-572.

Michigan State University and Northern Michigan University

Michigan State University’s (MSU) permafrost group consists of Adjunct Professor Fritz Nelson, Ph.D. student Kelsey Nyland, and M.S. student Clayton Queen. The group is investigating periglacial landforms in the unglaciated uplands of interior and western Alaska. Our specific focus is the origin and age of cryoplanation terraces (CTs), a widespread but under-investigated class of landforms that occur in many parts of Beringia. Research activities include

spatial analysis at local and regional scales, relative age dating across terrace treads, investigating soil and sediment toposequences, evaluating geomorphometric parameters, and mapping geomorphic associations. Nyland and Nelson recently received an award from the U.S. National Science Foundation (NSF) to determine the age of CTs in Alaska's Yukon-Tanana Upland using cosmogenic dating, and to assess whether the features form synchronously with glacial intervals. Nyland and Queen have also received financial support for their work from the Arctic Institute of North America, the Geological Society of America, USPA, and various units at MSU. In July 2017 the group expanded the scope of their investigations into nivation processes at a high-elevation site near Atlin, British Columbia. This component of our work is carried out in association with the Juneau Icefield Research Program. The MSU group is also closely involved in the Circumpolar Active Layer Monitoring (CALM) program (see report from George Washington University). Our research under CALM is funded by NSF through a subaward to Northern Michigan University, where Nelson is a research associate. During 2017 the MSU group also made presentations at meetings of the American Association of Geographers, the Geological Society of America, and the American Geophysical Union.

2017 publications:

Brigham, L.W. and Nelson, F.E. (eds., 2017). Geographical Perspectives on the Arctic. Special issue of *Geographical Review* 107(1): 1-257.

Burn, C.R. and Nelson, F.E. (2017). In Memoriam: J. Ross Mackay, 1915-2014. *Annals of the American Association of American Geographers* 107(4): 998-1010.

Fagan, J.E. and Nelson, F.E. (2017). Sampling designs in the Circumpolar Active Layer Monitoring (CALM) program. *Permafrost and Periglacial Processes* 28(1): 42-51.

Nelson, F.E. and Nyland, K.E. (2017). Periglacial cirque analogs: regional trends of cryoplanation terrace elevation in eastern Beringia. *Geomorphology* 293: 305-317.

Nyland, K.E., Klene, A.E., Brown, J., Shiklomanov, N.I., Nelson, F.E., Streletskiy, D.E., and Yoshikawa, K. (2017). Traditional Iñupiat ice cellars (Siġ-uaq) in Barrow, Alaska: characteristics, temperature monitoring, and distribution. *Geographical Review* 107(1):143-158.

Streletsky, D.A., Shiklomanov, N.I., Little, J.D., Nelson, F.E., Brown, J., Nyland, K.E., and Klene, A.E. (2017). Thaw subsidence in undisturbed tundra landscapes, Barrow, Alaska, 1962-2015. *Permafrost and Periglacial Processes* 28(3): 566-572.

Marine Electromagnetics Lab, Scripps Institution of Oceanography

The Marine Electromagnetics Lab at Scripps Institution of Oceanography has developed a surface-towed electric dipole-dipole system capable of operating in shallow water and deployable from small boats. Our system uses electromagnetic energy from a modulated manmade source to interrogate the underlying resistivity structure of the seafloor. We used this system to map subsea ice-bonded permafrost on the Beaufort Shelf along 200~km of coastline, from Tigvariak Island to Harrison Bay. Research was conducted out of West Dock, North Slope, AK, on the R/V Ukpik over a total of 12 days.

Permafrost is resistive and was found to be anisotropic, likely due to interbedded layers of frozen and unfrozen sediment. Maps of depth to permafrost and its thickness were produced and results compared to borehole logs in the area. We observed elevated resistivity values offshore the Sagavanirktok River outflow, supporting the idea that fresh groundwater flow has a preserving effect on submerged permafrost. This system provides a cost effective method that could be used to further quantify permafrost extent, provide a baseline for measurements of future degradation, answer questions about the relationship between coastal erosion rates and offshore permafrost, and provide observational constraints on pore water salinity to aid in permafrost modeling studies.

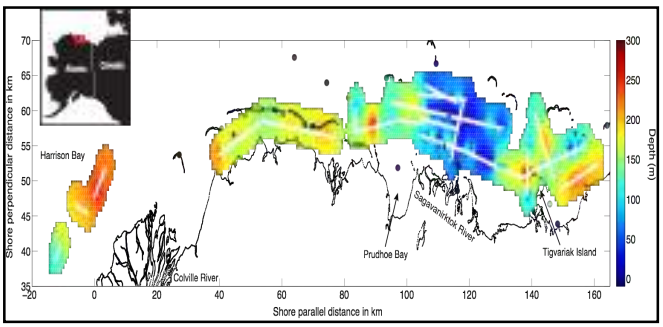


Figure 1: Map of depth to top of permafrost from electromagnetic inversion results. Depths to top of permafrost from boreholes in the area are plotted in circles.

Next-Generation Ecosystem Experiments (NGEE Arctic)

A Systems Approach to Understanding Methane Cycling in the Arctic: Throughout the Arctic, and around the world, scientists are working to understand and model methane emissions from carbon-rich permafrost ecosystems. The Next-Generation Ecosystem Experiments (NGEE Arctic) project is taking a systems approach to predicting carbon cycling in the Arctic, quantifying sources and sinks of methane in tundra ecosystems. Although the

importance of methane is widely acknowledged, its emission from thawing landscapes is highly uncertain. This uncertainly limits our predictive understanding of methane production and our ability to capture seasonal patterns of methane flux in models.

Since 2012, studies at field sites on Alaska's North Slope and the Seward Peninsula have assessed important microbial and geochemical controls on methane cycling in high-latitude ecosystems. Measurements from two atmospheric "flux" towers near Barrow, Alaska revealed large emissions of methane before spring snow melt. These pulses, observed previously but not understood, were linked to unique weather events where freezing rain on snow blocked methane emissions from underlying soils. This pulse is large enough to offset a significant fraction of the Arctic tundra carbon sink and raises questions about processes that may be missing from current models.

Knowledge derived from long-term monitoring and targeted field and laboratory investigations is being incorporated into the E3SM Earth system model being developed by the Department of Energy, Office of Science, Biological and Environmental Research (BER). NGEE Arctic is drawing upon expertise from across DOE, and academic, international, and Federal agencies. The project benefits from regional co-location of sites with the DOE Atmospheric Radiation Measurement program, the NSF National Ecological Observatory Network, and NOAA Climate Modeling and Diagnostic Laboratory, and NASA ABoVE airborne campaigns. Additional information and data products can be found at: http://ngee-arctic.ornl.gov/.

University of Montana

The University of Montana continued to be active in permafrost research in several departments. Anna Klene continued as a co-PI of the CALM IV project concerned with northern and western Alaska, and as co-Chair of the Education & Outreach Committee of the IPA. MS student Brianna Rick participated in CALM's northern Alaska field season, conducted her thesis research, and was awarded an NSF Graduate Research Fellowship to continue on for a PhD. New MS student Ryan Rock joined the group to work on rock glaciers in the northern Rocky Mountains.

John Kimble and the Numerical Terradynamic Simulation Group continued their work on carbon cycle dynamics, surface hydrology, and changes in permafrost landscapes across Arctic-Boreal regions among other projects. Jennifer Watts is now looking at primary environmental conditions regulating the magnitude of soil CO2 released from permafrost affected soils during winter months. In addition, she and UM undergraduate Stephen Shirley, participated in fieldwork at Ivotuk on the North Slope of Alaska, installing new soil moisture and soil temperature sensors. See Research Gate for copies of recent publications.

Individual Member Activities:

Our members were busy this year. USPA Board Member Mark Demitroff, Stockton University, continues work with Franklin & Marshall College on thermal-contraction polygons and periglacial features in Pennsylvania; and has in press an article on the environmental dynamics of railroad-era ethnic settlement as linked to the Pleistocene "badlands" topography of the Pinelands National Reserve.

Molly McGraw, Jerry Brown, and Fritz Nelson chaired three sessions at the 2017 Annual American Association of Geographers (AAG) meeting honoring the late H. Jesse Walker. Walker was a renowned Arctic researcher who specialized in coastal and fluvial geomorphology.

Reginald Muskett, Ph.D., Research Associate, Geophysical Institute Permafrost Laboratory, continues investigations into the changes of the permafrost regions of the Northern Hemisphere. Measurements include the joint mission NASA-DLR Gravity Recovery and Climate Experiment (GRACE), the JAXA Advanced Land Observing Satellite 2 (ALOS2) Phased Array L-band Synthetic Aperture Radar 2 (PALSAR2) and the Global Navigation Satellite Systems (GNSS) coordinated with the International Terrestrial Reference Frame. In computational-engineering adventures all the parts have arrived for a new High Performance Computational Server that Reginald will be assembling and testing in the new year. Thanks to research collaborations with NASA-ABoVE, NGEE-Arctic, USGS Climate Science Center, Go Iwhana, Dmitry Nicolsky and Vladimir Romanovsky.

2017 Publications:

Muskett, R.R. (2017) L-Band InSAR Penetration Depth Experiment, North Slope Alaska. *Journal of Geoscience and Environment Protection*, 5, 14-30. DOI: 10.4236/gep.2017.53002.

D. J. Nicolsky, D.J., Romanovsky, V.E., Panda, S.K., Marchenko, S.S., Muskett, R.R. (2017), Applicability of the ecosystem type approach to model permafrost dynamics across the Alaska North Slope. *Journal of Geophysical Research Earth Surface*, 122 (1), DOI: 10.1002/2016JF003852.

In Memoriam:

Michael C. Metz, Consulting Engineer
Edward J Chamberlain, Jr., USA CRREL

Complied by: Molly McGraw, Secretary, US Permafrost Association (mmcgraw@selu.edu)