RUSSIAN FOUNDATION FOR BASIC RESEARCH RFBR

Soil Cryology Lab

International Conference

«Earth Cryology: XXI Century»

Dedicated to David Gilichinsky

Pushchino, Russia, September 29 – October 3, 2013

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International conference “Earth Cryology: XXI Century” (September 29 - October 3, 2013, Pushchino, Moscow region, Russia). The Program and Conference materials.

International conference “Earth Cryology: XXI Century” brings back the traditions of the Pushchino Permafrost meetings that were held in the 90s – 2000s. Here along with the traditional research areas in the permafrost science, under initiative of David Gilichinsky, arose new research directions such as permafrost microbiology, permafrost-affected soil science and astrobiology.

The main topic of the conference:

- Mountain and volcanic permafrost
- Subsea permafrost
- Subglacial permafrost
- Permafrost on the others planets
- Permafrost processes
- Permafrost modeling and mapping
- Permafrost engineering, constructions on frozen ground
- Permafrost microbiology and astrobiology
- Permafrost hydrology
- Permafrost biogeochemistry
- Permafrost dating and paleoreconstructions
- Permafrost warming and thawing, long-term monitoring
- Permafrost and trace gas exchange

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Russian Foundation for Basic Research
The Scientific Council on Earth Cryology RAS
Earth Cryosphere Institute SB RAS
Institute of Physicochemical and Biological Problems in Soil Science RAS
Laboratory of Soil Cryology

International Conference

«Earth Cryology: XXI Century»

is dedicated to David Gilichinsky,
who was the heart and soul of these meetings in Pushchino for many years

Pushchino, Russia, September 29 – October 3, 2013

International Conference **«Earth Cryology: XXI Century»** organized by:

Russian Foundation for Basic Research
The Scientific Council on Earth Cryology RAS
Earth Cryosphere Institute SB RAS
Institute of Physicochemical and Biological Problems in Soil Science RAS
Laboratory of Soil Cryology

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«…»

__T__he permafrost community has lost one of the great movers of science. David has always tried to bring people together, always proposing new ideas, new concepts, and sharing his knowledge with the rest of the community, colleagues and young scientists alike. David was very active in the International Permafrost Association as chair of the Astrobiology Working Group and as driving force behind many of its initiatives including the Thermal State of Permafrost with David leading temperature monitoring in many parts of Russia and Antarctica. Permafrost scientists all over the globe will be greatly saddened by the loss of a colleague and friend that contributed to shape the face of permafrost science in the 21st century.

International Permafrost Association

…__Н__е одно десятилетие мы постоянно сотрудничали с ним, занимаясь проблемами криосферы, пересекались на многочисленных научных конференциях, встречались в неформальной обстановке. Давид Абрамович отличался глубоким интеллектом, широтой взглядов, умением отстаивать свои позиции. Вместе с тем он всегда был душой коллектива, человеком с тонким юмором. Он создавал новые направления развития увлеченность ищущей личности как магнитом, притягивал к себе молодых исследователей. Мы всегда будем помнить его и как первопроходца, участника полевых экспедиций в Арктику и Антарктиду, объединившего геокриологию и почвоведение и микробиологию.

Академик В.П. Мельников,
коллектив Института криосферы Земли СО РАН

…__H__is home and Pushchino were special to me and many visitors. I always enjoyed your hospitality. We give David tremendous credit for his foresight in organizing these annual conferences in the 1990s, and under such very difficult circumstances. We all benefited from these opportunities to meet Russian colleagues and develop new collaborations. Without these visits to Pushchino many international scientific endeavors would not have flourished. He and the Institute's team also helped us with many administrative and logistical challenges.

Jerry Brown IPA, USA

…За то время, в течение которого нам посчастливилось общаться и совместно поработать, мы почувствовали и оценили его скрупулёзность исследователя, умение доброжелательно выслушать собеседника, стремление объединить коллег в поисках решения принципиально новых научных проблем. К их числу следует, прежде всего, отнести обоснование перспектив новых фундаментальных междисциплинарных исследований на стыке наук о Земле и биологии.

Благодаря усилиям Д.А. Гиличинского Институт почвоведения и фотосинтеза РАН неоднократно распахивал гостеприимные двери для научных конференций российских и зарубежных геокриологов. На этих встречах атмосфера высокой научной требовательности всегда соседствовала с теплой сердечной обстановкой, дружеской заинтересованностью в ознакомлении с достижениями коллег.

Мерзлотоведы ИГЭ РАН, Москва

*… **D**avid, Victor, Vladimir, Dima and I sent a long field season in Antarctic many years ago now and there are many memories from that trip that stay in my mind. Not lease of which was David's constant energy and lack of need to sleep. He could be seen walking the streets of McMurdo at every hour of the day and night. And whenever I asked him if he was doing something, he would always reply with "of course!" in his thick accented English. David and I met many times at international meetings. He was always keen to progress our science plans and enjoy catching up on stories over dinner. But, always he would turn back to the next proposal and plans. I will certainly miss being able to work with him. Please pass on my regards to family and friends and reassure them that David's legacy stretches from the top to the bottom of the world.*

Gary Wilson, University of Otago, New Zealand

***Д**авид Абрамович впервые пришел на кафедру биологии почв почти 30 лет назад с предложением изучить возможность сохранения живых микроорганизмов в мерзлых грунтах. С этого началось новое направление в микробиологии – систематическое изучение древних форм микроорганизмов, сохранившихся в условиях природной консервации, которое разрабатывалось на кафедре биологии почв при тесном сотрудничестве с Давидом Абрамовичем Гиличинским, а в последующем было продолжено и в других институтах. Проведенные исследования вошли в число пионерных работ, фактически положивших начало широким исследованиям в области природной экстремальной микробиологии, микробиологии глубоких подпочвенных слоев. Эти работы сформировали фундамент для развития современной астробиологии. Давид Гиличинский обладал удивительной способностью общаться с широким кругом ученых, убеждать их в необходимости и перспективности таких исследований, завязывать связи с различными институтами и лабораториями по всему миру, добиваться ежегодного финансирования дорогостоящих экспедиций в Арктику и Антарктиду, неизменно осуществлять эти экспедиции. Полученные его группой уникальные образцы глубоко залегающих древних мерзлых осадочных пород анализируются во многих лабораториях мира. Благодаря усилиям Давида Абрамовича и немногих энтузиастов-сподвижников у нас и за рубежом астробиология объединила ученых планетологов, экологов, астрофизиков, астрогеологов, палеонтологов и других единой фундаментальной практической задачей - поиском внеземной жизни в Солнечной системе. Осуществление этой задачи открывает совершенно новые технологические и научные перспективы для человечества. Трудно представить себе, что рядом с нами больше нет Давида - живого, неутомимого, ироничного, полного идей и планов, что мы никогда не услышим в телефонной трубке неизменно завершающее: «**БЕРЕГИТЕ СЕБЯ**».*

Кафедра биологии почв ф-та Почвоведения МГУ

***D**avid was a great person and one of the best scientists I have ever met. His ideas were inspiring and his optimism and sharp sense of humor were truly amazing. Just two month ago, we were standing on a roof of Convention Center in San Francisco, laughing at his jokes…*

Dima Streletskiy George Washington University, USA

Less than a year ago I spent quality time with David and Elizaveta at a Polar and Alpine Microbiology conference in Slovania. David was in top form and provided all at the conference with invaluable information on Siberian permafrost. David wore many hats during his lengthy career-- whether it be Astrobiology, biogeochemistry, or biodiversity, I always respected his input and the fact that he never minced his words. I am sure that his legacy will go on through his numerous publications and through Elizaveta's research. We have lost a great scientist and I have lost a good friend-- one who advanced significantly our knowledge of polar ecosystems.

John Priscu, Montana State University, USA

…Невозможно передать атмосферу тех лукаво-умно-двысмысленно-интересно-поучительно-остроумных монологов и реплик, которые потом еще не раз приходилось мне слышать и в полях и просто в общении с Д.А. Д.А. научил меня ценить главное в жизни своим непритязательным отношением к внешним атрибутам благополучия и порядка на фоне фантастической преданности своему любимому детищу – науке. А какие замечательные люди всегда были вокруг него! Д.А. всегда был тем столпом, на котором держалась огромная область естествознания, он цементировал научные и личные связи между специалистами, обеспечивая ту редкую комплексность изучения природы, без которой наши знания были бы гораздо беднее. Он был новатором и подвижником.

Павел Никольский, ГИН РАН

I began working with David in the summer of 1990, when he led a major international expedition to drill into ancient Siberian permafrost for microbial investigations.

He was quite a phenomenon in the field, operating the permafrost drill nonstop in the 24 hours of polar light. We supported him in rotating crews of three, working mere 10–12 hour shifts. After the drilling, he would relax in the dining tent and engage in wide-ranging discussions on astrobiology and planetary exploration. David was intently focused on determining how microorganisms were preserved in ancient permafrost. To my knowledge, he was the first to develop the methods for drilling in permafrost without the use of drilling fluids, thereby preventing contamination of the core. We learned this approach, as well as David's methods for storing and handling samples, and, with David's help, applied these to new studies in the Canadian Arctic and Antarctica.

David's primary scientific legacy is that he demonstrated to a skeptical science community that the Siberian permafrost contained viable microorganisms that had been immobilized in the ice-cemented ground for up to 5 million years. This was an important discovery and motivated the microbiological study of putative 25-million-year-old ice in Antarctica; it spurred those of us interested in Mars to consider the prospect of life preserved for over 4 billion years on that planet in ice-cemented ground in the Southern Highlands.

David was also active in international science. He actively participated in the International Permafrost Association, and he was eager to involve scientists from all over the world in his field expeditions. In addition, he participated in expeditions in many other countries and Antarctica. His strong yet gentle personality will be missed whenever there is drilling to be done searching for microbial life in ice-cemented ground.

Chris McKay

NASA Ames Research Center, Space Science Division

Moffett Field, CA, USA

***Я** встретился с Давидом впервые в 1986 году, когда он заразил меня идеей добыть живых микробов из мерзлоты миллионнолетнего возраста. Судя по красноречию, убедительности и напору, с каким Давид, будучи м.н.с.-ом, добывал в то время студентов, он, по словам нашего зав кафедрой, Д.Г. Звягинцева, был как минимум заведующим лабораторией. С такой уверенностью кафедра и отпустила меня на дипломную практику, и я поехал с Давидом в экспедицию в Черский. Эта экспедиция останется на всю жизнь одним из самых ярких моих впечатлений - да и научный результат, вошедший с его легкой руки в книгу рекордов Гиннеса, не удалось впоследствии перешибить. А Давид стал действительно заведующим великолепной лаборатории и привлек в науку еще очень много студентов, которые продолжают его дело.*

Сергей Благодатский, ИФХиБПП РАН, Пущино

*… **В** 2001 Николай Никитич Романовский сказал мне, что настоящую мерзлоту я смогу увидеть именно в экспедиции с Гиличинским в Тикси. Эта экспедиция, самая первая, стала и самой успешной за все годы. Слушая рассказы Давида Абрамовича о перипетиях поворота рек, выбуривании вставной челюсти и научных загадках мёрзлотоведения мы часто забывали и про буровую. Его присказки про "...это ещё Ленин писал", "...это - в лигу сексуальных реформ", "...работать шакалы", "...коммунизм построить хорошо, но невозможно" крайне радовали нас, тогда ещё студентов. Его стиль общения притягивал сразу. Главное, говорил он тогда нам, чтобы студент мог послать своего руководителя - тогда есть смысл брать такого студента. Плодотворные дискуссии продолжались у нас до последних дней. Он как бульдозер старался крушить идиотизм существующей системы, придумывал хитрые тактические схемы, и по-детски радовался, когда удавалось одержать победу. Будет не хватать его философского отношения к происходящему вокруг, когда на новость о том, что один из его аспирантов неожиданно предпочёл научным изысканиям путешествия, последовало глубокомысленное "...а пожалуй не каждая лаборатория может похвастать, что её аспирант уехал в кругосветку". Таким он и останется в моей памяти, бросающий вызов устоявшемуся мнению, идущим с буровыми штангами по тундре, выпускающий струю дыма (от этой привычки избавить его было невозможно).*

*И его обязательное **«БЕРЕГИТЕ СЕБЯ!»** на прощанье..*

Андрей Абрамов, ИФХиБПП РАН, Пущино

*....**I** will miss David's contributions to the journal Astrobiology very much. As an Author, he was very demanding of what he required from his co-authors for his publications - and he would not publish prematurely. As Reviewer, he expected from others what he demanded of himself. As a colleague and Regional Editor for Astrobiology, he was always a joy to communicate with - he was enthusiastic anytime I contacted him for help and advice and was very encouraging with new efforts and ideas to grow the field. Many times, he would be out of touch because of field work and poor communication. But he always would re-appear ready to tackle anything I needed from him. Though I only knew him briefly, I found him to be a delightful man and a great friend to the journal Astrobiology. He will be missed.*

S.L. Cady, EIC-Astrobiology, Portland State University

***Е**сть такие люди, о которых даже в самые тяжелые времена, даже зная, что они уже оставили нас, всегда вспоминаешь с улыбкой или даже со смехом. Таким был Давид. Трудную работу он превращал в радостную. Решение им, казалось бы, обычной задачи часто приносило открытие. Потому что это уникальное свойство человеческой души, присущее, увы, далеко не многим, - видеть во всем самое лучшее – давало ему возможность и в жизни, и в работе видеть и понимать самое главное…*

Яков Пачепский,
Лаборатория Микробиологической Безопасности,
Министерство Сельского Хозяйства США, Мэриленд, США

*…**D**avid was a great pioneer in permafrost ecology, a wonderful colleague and a good friend of many of us. His in depth interest in geocryology has built the bridge from Earth-based research towards its application in space research, especially in view of the habitability of Mars. With this, David was an enthusiastic supporter of astrobiology. We will not forget his excellent organising ability and his warm hospitality during the 10th European Workshop on Astrobiology in September 2010 in Pushchino, which he organized, and where we all felt so much welcome. …*

Gerda Horneck, President of EANA, Germany

***В**первые мы познакомились в 1989 г. на V конференции «Теория почвенного криогенеза» в Пущино. Он организовал круглый стол для заслушивания устных докладов молодых сотрудников Института мерзлотоведения, приехавших из Якутска. … я почувствовала искреннюю заинтересованность талантливых и состоявшихся мерзлотоведов, криолитологов. почвоведов - получила поддержку, которой так недостает и молодым и* *зрелым исследователям. В моей памяти он всегда останется добрым другом, неординарным, проницательным и порядочным человеком с ярким чувством юмора. Давид всегда был талантливым исследователем, иногда сумбурно витийствующим, иногда непревзойденно логичным и часто отстраненно задумчивым. Как жаль, что нельзя больше спросить: «О чем ты думаешь?». Как горько, что не собрана книжка под условным названием «Сумасшедшие идеи мерзлотоведения», может она отвечала бы на вопрос: «Куда исследователям мерзлоты идти дальше?»*

Слагода Елена, ИКЗ СО РА,Н г.Тюмень

***D**avis was a very important Geocryologist who made a great difference to Russian Geocryology. His work on survival of bacteria, etc., in permafrost was a major contribution to the science. He was also the organiser of many of the annual international permafrost meetings which were very successful. …*

Stuart A. Harris, University of Calgary, Canada

*…**W**e talked about cryopegs several weeks ago. He always had a lot of humor and great ideas. His lightweight drill rig is wonderful and can go anywhere… I remember his humorous talk about the "Ice Age" movie during the Zurich permafrost conference. We honored him, and I am very lucky to have had a chance to share some experiences with him.*

Kenji Yoshikawa**, **University of Alaska, Fairbanks, USA

*…**К**олыма второй половины 70-х и начала 80-х, статьи о строении рыхлых четвертичных отложениях в районе реки Чукочьей, творческие дискуссии и разработка планов предстоящего полевого сезона на маленькой кухоньке в Пущино, с маленьким Мишей и крошечной Яной или в коридорах и на лестничной, «курительной», клетке 19 этажа Главного Здания МГУ… Поймал себя на мысли, что те из ученых, кто мог бы рассказать о мнс (если не ошибаюсь!) Гиличинском тех лет с буровой (кажется, ПБУ-25) на плечах, ящиками специально изготовленных штанг и образцов, бесконечным количеством загубленных скважин, штанг и буровых «ложек», сопровождаемый толпой студентов-практикантов и поварих – Шер, Архангелов с "бляха-муха"… - не смогут этого сейчас уже сделать. Я мог бы это сделать, ибо сам участвовал в тех экспедициях сначала в качестве рабочего и студента-практиканта, потом инженера Северной экспедиции МГУ, а потом и её начальника…*

Андрей Льянос Мас, Валенсия, Испания

David,

We** are an astrobiology group because of you. Without you, we would not have known each other. You provided two essential components, First and most important, you provided the enthusiasm, the vision, the knowledge, the continuity, the joy and in a clever way the organization to keep us inspired and focused. Second, you provided us the permafrost samples essential to our studies, their special uniqueness made us feel we had a science treasure to study, you also shared your knowledge about the permafrost habitat, its history and the field measurements that we needed to understand the biology we were studying. So, David, without your leadership our lives would not be so rich. For all this, we are indebted and forever grateful. You will always be in our minds, those many experiences and incredible stories we remember from you. You were also very dedicated to students, always thinking of how to better their education and future, students from Russia, US, and everywhere someone had an interest in exploring life in the very cold. We thank you for your contribution to many, many student's careers. **S**everal of the astrobiology students from the MSU NASA astrobiology project when learning of your passing have shared the following memories**:

I remember David's generosity and his fatherly demeanor and good-natured persistence in insisting that I always keep my mind on life for Psychrobacter in the permafrost.

Peter Bergholz

***I** am currently writing a book chapter on Bacterial Diversity in the Permafrost with Corien Bakermans and I have been reading his papers daily. He made such important contributions to the field. He will be greatly missed.*

Shannon Hinsa-Leisure

***F**rom the first time I met David Gilichinsky during his presentation about drilling Antarctic permafrost, I was bewitched by his enthusiasm, broad scientific view, and sense of humor. David had deep impact on my scientific carrier. He believed that different kind of microorganisms were able to* *survive in permafrost and he was right. He brought this belief to Astrobiology and I would not be surprised to find out that he is right.*

Tanya Vishnivetskaya

***D**avid was a very energetic, engaging, and enthusiastic person, it was fun and enlightening discussing research with him, specially about Exiguobacterium. He was also a very helpful and generous not only for providing the permafrost soil for my Ph.D. research, but also writing a recommendation letter for my U.S. green card. I am very thankful for all his help in my personal and professional life.*

Debora Rodrigues

***D**avid was a scientific visionary. His vision drove him to one of the most inhospitable places on Earth in search of life. We owe him what we know now, and for years to come, about life in permafrost.*

Hector Ayala

***D**avid was a pioneering scientist in the filed of microbial ecology who made major contributions to our understanding of microbial life in extreme environments. His passing is heartbreaking. He will be greatly missed.*

Mike Thomashow

***I**n closing, I knew David for 20 years, first meeting him by chance in Pushchino in June 1990, but that meeting turned into a great era for our joint science, friendship and connection with many more Russians, including Liza who we also enjoyed at MSU.*

I know we will never forget David!

Jim Tiedje
Center for Microbial Ecology, MSU, Michigan, USA

***С** самого начала Давид Абрамович заботился о преемственности поколений. Адекватной замены, конечно же, быть не может и не могло. Давид Абрамович – человек, посвятивший себя взращиванию нас. Теперь он в мире грандиозных планов и космического масштаба идей. Это всегда поражало и заражало. С ним актуальность и новизна никогда не вызывали вопросов. … Послушав ход его рассуждений хоть раз, хотелось следовать им и делать что-то великое. Пусть даже и доводить до конца это дело не хватало сил и желания. Тут дело в запале. Поджигается Parliament из припасенного блока, которого всегда хватало даже в самое длинное поле, и Давид начинает вещать, делая нас всех частями Вселенной и тысячелетий. Хватит времени даже записать весь этот продолжительный монолог, но мы пишем на подкорку. Ведь Давид Абрамович очень обстоятельный рассказчик. Из этого рассказа понимаешь всю обоснованность своих на первый взгляд бессмысленных действий. На середине сигареты ты первый в мире, кто делает то, что делает. Последняя затяжка и небрежное тушение в бюкс, и ты, окрыленный услышанным, летишь вершить, а неутомимый Давид продолжает свой многодумный труд. Во многом хотелось брать с него пример. Он и был примером этой обстоятельности и какого-то равнозначного замеса научного познания с жизненной философией…*

Глеб Краев, ЦЭПЛ РАН, Москва

***D**avid Gilichinsky was one of my heroes. A brilliant scientist, unique and irreplaceable. A wonderful person. I will sorely miss him.*

René Demets, ESA Project Scientist Biology

*…**М**не страшно хотелось в Антарктиду, я закидывала удочки и Давид Абрамовичу, получила от него неожиданно суровый ответ – «я жену свою туда никогда бы не пустил, и вам Эля это тоже не надо». Обиделась с одной стороны, с другой было приятно, так как сказано это было искренне и с необычайной заботой. Пробилась, Давид выразил мне свое недовольство, своеобразно, раз уж такая настырная и спрос выше, пока я не оправдала. Вернувшись сейчас, была ужасно горда, что принесла пользы и геокриологии, сняла все данные с логгеров, сделала CALM, предвкушала иронические похвалы Давид Абрамовича на нашем семинаре по окончанию антарктического сезона. Не будет…*

Эля Зазовская, ИГ РАН, Москва

*…**I** was going to meet David for the first time at the Abscicon in Atlanta in April. We had just accepted his abstract for a talk in a session I'm running. I've known of him and his work for years, but we'd never met. In his honor, I'd like to keep his talk in the program. His co-authors on his abstract are N.E. Demidov, V.A. Mironov and A.A. Abramov. If anyone can put me in contact with one or all of these people I would appreciate it. The other thought I am entertaining for his slot is a review of his career.*

Peter Doran University of Illinois, США

... Для бесед и обсуждений, связанных с экспедициями и научными изысканиями, ему совершенно не было жаль времени, как бы занят он ни был... Пример общения с Давидом Абрамовичем ярко иллюстрировал нашу мысль: «чем крупнее учёный, тем более он уважителен к собеседнику, тем менее он скуп в общении, и вряд ли скажет что-то типа «я очень занят»». В мобильнике так и остался сохранённый контакт «Давид Гиличинский»...

Владимир Архипов, ИТЭБ РАН, Пущино

***I** first met Dr. Gilichinsky in Sao Paulo, at the SPASA, in december 2011. He delivered a wonderful talk and later he was very kind in discussing several of his results, specially concerning ice dating. It was just a minuscule glimpse of a notable scientist and man. …*

Jorge Quillfeldt, UFRGS, Brazil

***М**ое знакомство с Давидом Абрамовичем началось 11 лет назад перед экспедицией в Тикси. Запомнилось, что на вопрос, не будет ли там много комаров, услышала, что «Деточка, там так холодно и такой ветер, комары там не живут». Еще помню, мы в той экспедиции плыли на корабле, и нас всех укачало, лежим в койках помираем и я слышу тихий голос Давида Абрамовича: «Мои родители хотели, чтобы я играл на скрипке. Почему я их не послушался?» Это было сказано так проникновенно, но было так смешно представить, что мог бы вместо полевика-ученого вырасти скрипач. Это поле было уникальное, так как до этого Давид Абрамович не брал несколько лет студентов, объясняя это тем, что ему с ними не интересно. «Они говорят о таких вещах, про которые я совсем не понимаю, они хотят быть менеджерами, а я не знаю, кто это такие». И вот ради эксперимента в 2001 году он взял нас и сразу несколько штук. И мы все без исключения после этого поля прижились в его лаборатории, никто не пошел в «менеджеры», потому что за эти 2 месяца он влюбил нас в науку, в тундру, в себя, в конце концов. И уже живя, трудно сказать, работая, в лаборатории мы все стали его детьми, которые всегда чувствовали его заботу и защиту. Сам он мог ругать нас и обзывать самыми страшными словами, но если кто-то чужой задевал его «малолеток», он бросался как тигр нас защищать. …*

Ксения Новотоцкая-Власова, ИФХиБПП РАН, Пущино

***D**avid was a gentleman and a scholar. I found him to be generous with his time and a fine microbiologist. I am sad that I will no longer be able to call on his help.*

Patrick John Webber
Professor Emeritus of Plant Biology, Ranchos de Taos, New Mexico

I first met David in 1993 at an EGS meeting in Wiesbaden, Germany, in a session about extreme longevity of microorganisms, a still controversial topic. Later we organized jointly some sessions at EGU and EANA conferences. He would sometimes ask, with a twinkle in his eye, if I believed - really BELIEVED in my mind, as he phrased it - that those microbes were in fact millions of years old ... combining rigorous science with a humorous approach in his inimitable way.

Helga Stan-Lotter, University of Salzburg, Austria

Давид был яркой, знаковой личностью. Все кто общались с ним, хотя бы мимоходом, ощутили его "средообразующее" влияние. Я встретила Давида первый раз очень давно, в 80 годы, когда студенткой проходила производственную практику в составе колымского отряда МГУ. … Вокруг него постоянно бурлила жизнь и затрагивала всех. Множество девочек-поварих и мальчиков-рабочих из студентов, буровые, палатки, специальный человек, который следил за вертолетами (и мы редко когда застревали в тундре), всем Давид щедро делился с коллегами. …Но это впечатление бурной шумной деятельности было не достаточно полным, пока я не поработала сезон непосредственно рядом с группой Давида около Тикси. Стало ясно, что этот человек, с вроде бы ленивыми движениями и медлительной речью, прекрасный организатор. Все получалось как-то очень быстро и четко. Режим дня - завтрак, обед и ужин по расписанию с точностью до минуты, вечером старшие читали лекции для студентов, все легко, с юмором. В это поле я не слышала ни единого звука нытья, хотя работа была тяжелая, а климат не радовал. Давид сидел за столом в большой кухонной палатке как отец семейства, а прочие внимали его замечательным рассказам и впитывали оригинальные идеи, которые потом служили предметом бурных дискуссий. Например, о захоронении вождей в вечной мерзлоте - ученым объект наблюдения, поклонникам вождя доступ в подземный мавзолей, а экономике полярных районов прибыль от туризма. Креативность была основным качеством мышления Гиличинского, как в научном плане, так и в юморе. …То, что команда пробурила 40 метров мерзлоты как бы без особых усилий, на меня тогда не произвело должного впечатления. Давида все давно знали, его работа казалась привычным делом. А на Юконе, где довелось поработать, дырка в 5 метров считается большим достижением. Про то, как Гиличинский бурит переносной установкой при помощи 4 человек такие глубины, мне сначала не поверили, потом восхитились. Запланировали мы совместные работы и передачу опыта, и вот...

Светлана Кузьмина, University of Alberta, Canada

…Докладов Давида микробиологи всегда ждали и с интересом слушали, хоть это было и не просто: жаргон геолога-четвертичника, многозначительные паузы со вздохами в густые усы и пунктирная логика с несколькими пропущенными звеньями… Я думаю, его пунктир был задуман специально, из осторожности, чтобы не делать скороспелых выводов - и предпочитал докладчика помучить вопросами на кофейном перерыве…

Вклад Давида в науку бесспорен. Пройдет время, безжалостно спрессует тысячи многословных публикаций в скупые строки чистого знания, но там останется имя Давида Гиличинского как первопроходца в биологию вечной мерзлоты. Но есть еще более важная вещь. Цвет общества - ценные образованные специалисты, и их достаточно много. Реже встречаются истинно талантливые люди - ученые, писатели, скульпторы, которых коснулась 'искра божья'. Среди таких талантов есть особенный – быть в гармонии с другими людьми, нравится им, мобилизовать на достойные задачи, разрешать конфликты… Именно таким талантом обладал Давид… Его любили, понимали, ждали и искали встречи, как в России, так и за ее пределами. Это ли не самая счастливая судьба?

Nicolai S. Panikov, Northeastern University, USA

Давид Абрамович был человеком большой души и необыкновенного обаяния. Успех его деятельности определялся широтой научного мировоззрения, беззаветной преданностью делу и умением создавать вокруг себя творческую атмосферу. Его отношения с подчиненными и учениками были совершенно уникальными. Это были отношения равноправного сотрудничества, совместного творчества, глубокого взаимопонимания и взаимообогащения. Охотно делясь знаниями с товарищами по работе, Д.А. Гиличинский сам никогда не упускал возможности поучиться у своих студентов, аспирантов и сотрудников, если они знали то, чего не знал он сам. В его лаборатории каждый занимался, чем хотел, чем считал нужным. И это являлось предметом особой гордости Давида Абрамовича. Он умел не только встроить мысли и достижения каждого в общую концепцию своего научного коллектива, но и найти подход к любому сотруднику, любому человеку, помочь ему раскрыться, поверить в себя и проявить свои лучшие черты. Люди тянулись к нему, учились у него, любили и уважали, в первую очередь, потому, что он сам глубоко любил и уважал людей.
Мы всегда будем помнить Давида Абрамовича - блестящего ученого, неутомимого полевика, прекрасного друга и его обязательное
***«БЕРЕГИТЕ СЕБЯ!»** на прощанье.*

Д. Федоров-Давыдов, ИФХиБПП РАН, Пущино

PROGRAM

of the International Conference

«Earth Cryology: XXI Century»

Pushchino, Russia

September 29 – October 3, 2013

September 28 (Saturday)

15:00 - 21:00	**CONFERENCE REGISTRATION OPEN** **At the hotel "Pushchino"**

September 29 (Sunday)

08:00 - 09:00	**CONFERENCE REGISTRATION DESK OPEN**	
09:00 – 10:00	**CONFERENCE OPENING & HOST REMARKS**	
	Director of Institute of the Earth's Cryosphere, Academician of RAS	**Vladimir Melnikov**
	Director of IPCBPSS RAS, Corresponding Member of RAS, Prof.	**Valery Kudeyarov**
	Chairman of the Local Organizing Committee, PhD	**Andrey Abramov**
10:00 – 10:20	Jerry Brown	**A tribute to David Gilichinsky and the Pushchino Conferences**
10:20 – 10:40	Hans-Wolfgang Hubberten	**20 years of Russian-German cooperation in permafrost research and perspectives for the next 20 year.**
10:40 – 11:20	**Coffee Break**	

Session 1: Subsea permafrost

Chair: Hans-Wolfgang Hubberten	**Co-Chair:** Grigoriev M.N.	
11:20 – 11:40	Vasiliev A.A., Rekant P.V., Oblogov G.E., Shirokov R.S.	**Submarine Permafrost of Kara Sea. Modern View**
11:40 – 12:00	Grigoriev M.N.	**Subsea Permafrost Table Dynamics in the Laptev Sea Nearshore Zone**
12:00 – 12:20	Ogorodov S., Kamalov A., Abramova A., Arkhipov V., Baranskaya A., Belova N., Kokin O., Kuznetsov D., Shabanova N., Udalov L., Vergun A.	**Coastal thermal erosion monitoring at the Pechora and Kara Seas**
12:40 – 14:00	**Lunch Break**	

Session 2: Permafrost hydrology and hydrogeology

Chair: Lebedeva L. **Co-Chair:** Vasiliev A.		
14:00 – 14:20	Zakharov V.G., N.S.Sidorenkov	**The Influence of Lunisolar Tides on Fluctuations of Antarctic Glaciers and Icebergs Runoff**
14:20 – 14:40	Pavlova N.A., Kolesnikov A.B.	**Hydrochemical Characteristics of Intrapermafrost Groundwater in Discharge Areas, Central Yakutia**
14:40 – 15:00	Lebedeva L., Semenova O., Volkova N.	**Detection and modelling of wildfire-induced changes in thermal and hydrological regime of middle scale watersheds in the upper Vitim River basin**
15:00 – 15:20	Oberman N.G., Shesler I.G	**Permafrost and ground waters of Middle Subpolar Urals**
15:20 – 15:40	Campbell R., Mark Bennett	**Presentation of Campbell Scientific, Inc.**
15:40 – 16:20	**Coffee Break**	

Session 3: Permafrost biogeochemistry

Chair: Zubrzycki S. **Co-Chair:** Krivushin K.		
16:20 – 16:40	Zubrzycki S., Kutzbach L., Grosse G., Desyatkin A., Pfeiffer E.-M.	**Carbon and Nitrogen Storages in Permafrost-Affected Soils of the Lena River Delta**
16:40 – 17:00	Maximov T., Kononov A., Maksimov A.	**Long-Term Spatial and Temporal Variations of Climatic and Carbon Parameters of Permafrost-Dominated Ecosystems**
17:00 – 18:00	**Poster session (PS.1, PS.3)**	
18:00	**Conference dinner (at the restaurant of hotel «Pushchino»)**	

September, 30 (Monday)

Session 4: Permafrost and trace gas exchange

Chair: Rivkina E. **Co-Chair:** Serafimovich A.		
09:00 – 09:20	Kraev G. N., Schultze E.-D., Rivkina E. M	**Cryogenic pumping could form methane seeps from permafrost**
09:20 – 09:40	Karelin D.V., Zamolodchikov D.G., Zukert N.V., Chestnykh O.V., Pochikalov A.V., Kraev G.N.	**Interannual changes in PAR and soil moisture during the warm season may be more important for the sign**
09:40 – 10:00	Serafimovich A., Larmanou E., Metzger S., Sachs T.	**Airborne Carbon Dioxide and Energy Flux Measurements in the Lena River Delta**

10:00 – 10:20	Streletskaya I.D., Vanshtein B.G., Vasiliev A.A., Oblogov G.E.	**Isotope and Gas Properties of the Ground Ice as a Proxy of Climatic and Environmental Conditions in West Arctic**
10:20 – 10:40	Rivkina E., Krivushin K., Karaevskaya E.	**Methane and Methane-producing Archaea in the Antarctic Permafros**
10:40 – 11:20	**Coffee Break**	
11:20 – 11:40	Bobrik A., Goncharova O.Yu.	**Carbon Dioxide Production and Water Extractable Organic Matter of Soils in Discontinuous Permafrost Zone of Western Siberia**

Session 5: Permafrost dating and paleoreconstructions

Chair: Schirrmeister L. **Co-Chair:** Gubin S.		
11:40 – 12:00	Gubin S.V., Yashina S.G.	**Paleocryoecological niches in permafrost deposits**
12:00 – 12:20	Spektor V., Kholodov A., Bulygina E., Spawn Seth, Davydov S., Klimova I.	**Yedoma of the Lower Kolyma: a New Insight into Palaeoenvironment**
12:20 – 12:40	Yakimov A.S., Schneider R., Gubin S.V., Vasiliev A.A., Stahr K.	**Micromorphological analysis of structures of Quaternary Sediments**
12:40 – 14:00	**Lunch Break**	
14:00 – 14:20	Kazansky O.A.	**Cryogenic Structure as an Indicator of Climatic Epochs**
14:20 – 14:40	Kienast F., Schirrmeister L., Andreev A., Yoshikawa Kenji	**An early and middle Wisconsin record of vegetation history preserved in the permafrost sequence of the Vault Creek tunnel in Fairbanks, Interior Alaska**
14:40 – 15:00	Blyakharchuk T.A., Ponomareva O.E., Berdnikov N.M., Gravis A.G.	**Radiocarbon Dating of Peatlands and Frost Mounds in the Nadym River Basin**
15:00 – 15:20	Grodnitskaya I.D., Karpenko L. V., Syrtsov S.N., Knorre A. A	**Characteristics of microbial communities functioning in the cryogenic peat soils of boggy larch forests and oligotrophic bog in Central Evenkia**
15:20 – 16:00	**Coffee Break**	

Session 6: Permafrost modeling and mapping

Chair: Marchenko S. **Co-Chair:** Demidova A.		
16:00 – 16:20	Dvornikov Yu. A., Leibman M.O., Khomutov A.V., Heim B., Roessler S.	**Assessment of Organic Matter Transport into Thermokarst Lakes of Yamal Peninsula**
16:20 – 16:40	Eliseev A.V., Demchenko P.F., Arzhanov M.M., Mokhov I.I.	**Transient Hysteresis of Near-Surface Permafrost: the IAP RAS Global Climate Model Simulations**
16:40 – 17:00	Kapralova V.	**Study of Sizes And Relative Position of Thermokarst Lakes By Means of Data of Remote Sensing and Methods of Mathematical Morphology of Landscape**
17:00 – 17:20	Nadyozhina E.D., Pavlova T.P., Stensat A.V.	**Regional-Scale and Local-Scale Climate Change Impacts on the Permafrost Evolution**
17:20 – 17:40	Osadchaya G.G., Zengina T.Yu., Koroleva A.M.	**Landscape Mapping for the Purpose of Geocryological Zonation of the Bolshezemelskaya Tundra**
17:40 – 19:20	**Poster session (PS.4, PS.5, PS.6)**	
18:30	**Round Table:** **«The role of cryogenic, geological and physico-chemical processes in the formation and development of natural and technogenic systems in the cryosphere»** **Chair: Zheleznyak M.N.**	

October, 1 (Tuesday)

Session 6: Permafrost modeling and mapping

Chair: Marchenko S. **Co-Chair:** Demidova A.		
09:00 – 09:20	Demidova A. (Veremeeva).	**Spatial Analysis of IC thawing in Holocene - Remote Sensing and GIS-study, Kolyma Lowland Tundra Zone**
09:20 – 09:40	Smulsky J., Krotov O.	**A new approach for computing insolation of the Earth**
09:40 – 10:00	Zhelezniak M.N., Shipitsyna L.I., Zhizhin V.I., Rybchak A.A., Ots L.A.	**Geocryological Information System (Geocryological Database) of the Siberian Platform. Status and Prospects of its Development**
10:00 – 10:20	Marchenko S., Wisser D., Romanovsky V., Chapman W., Frolking S., Walsh J. E.	**Coupled Hydrological and Thermal Modeling of Permafrost and Active Layer Dynamics : Implications to Permafrost Carbon Pool in Northern Eurasia**

Session 7: Permafrost-affected soils and biosystems

Chair: Lupachev A.	**Co-Chair:** Pastukhov A.	
10:20 – 10:40	Evgrafova S., Grodnitskaya I., Masyagina O., Syrtsov S., Kholodilova V., Vorozhtcova E.	**Methane Soil Surface Flux and Methane-Driving Microorganisms in Central Siberian Boreal Forest**
10:40 – 11:20	**Coffee Break**	
11:20 – 11:40	Ogneva O.A., Matyshak G.V.	**Soils of “Peat Circles” of the Western Siberia**
11:40 – 12:00	Pastukhov A.V., Kaverin D.A.	**Stability of Permafrost Peatlands in Bolzhezemelskaya Tundra (The North-East of European Russia)**
12:00 – 12:20	Moskalenko N.G., Ponomareva O.E., Ustinova E.V., Berdnikov N.M., Gravis A.G., Lobotrosova S.A., Rud M.I	**Change Estimation of Vegetation Cover and Geocryological Conditions in the West Siberia Zone of Sporadic Permafrost Distribution**

Session 8: Permafrost microbiology and astrobiology

Chair: Duarte R., Delgado T.	**Co-Chair:** Kochkina G.	
12:20 – 12:40	Bulat S., Khilchenko M., Dominique Marie, Lipenkov V., Lukin V., Jean Robert	**Bizarre Bacteria at the Uppermost Water Layer of the Subglacial Lake Vostok , East Antarctica**
12:40 – 14:00	**Lunch Break**	
14:00 – 14:20	Duarte R., Delgado T.	**Microbial diversity in permafrost and sea sediment samples from the King George Island, Antarctica, revealed by 16S rRNA gene pyrosequencing**
14:20 – 14:40	Novototskaya-Vlasova K.A., Petrovskaya L.E., Rivkina E.M.	**Characteristic of properties of lipolytic enzymes from psychrotrophic bacterium Psychrobacter cryohalolentis K5T**
14:40 – 15:00	Leushkin E., Penin A., Logacheva M., Kochkina G., Ivanushkina N·, Ozerskaya S., Vasilenko O.	**Population Genomics of *Geomyces Pannorum***
15:00 – 15:20	Shchekinov Yu. A.	**Cryoplanets**
15:20 – 15:40	Vorobyova E., Cheptcov V., Solovyova O., Pavlov A., Vdovina M.	**Microbial Communities of Permafrost and Xerophytic Soils Can Exist Long in the Martian Regolith**
15:40 – 16:20	**Coffee Break**	

Session 9: Permafrost warming and thawing, long-term monitoring

Chair: Streletskiy D.	**Co-Chair:** Leibman M.	
16:20 – 16:40	Romanovsky V.E., Nicolsky D.J.	**Long-Term Permafrost Thawing Under Warming Climate Conditions**
16:40 – 17:00	Shiklomanov N., Streletskiy D.	**Circumpolar Active Layer Monitoring (CALM) program: The Past Present and Future of Long-Term Active Layer and Near-Surface Permafrost Observations**
17:00 – 17:20	Streletskiy D., Shiklomanov N., Nelson F.	**Thaw Subsidence in an Undisturbed Tundra Landscapes**
17:20 – 17:40	Zhelezniak M.N., Serikov S.I., Konstantinov P.Y., Misailov I.E., Gulyi S.A.	**Permafrost Monitoring Network in East Siberia**
17:40 – 18:00	Yoshikawa Kenji, Stanilovskaya Julia, David Palacios, Jose Úbeda Palenque, Pablo Masías Álvarez, Fredy Apaza, Norbert Schorghofer and José Juan Zamorano Orozco	**Tropical mountain permafrost research and update**
18:00 – 19:30	**Poster session (PS.7, PS.8, PS.9)**	
18:30 (Library)	**Round Table:** **«Subsea permafrost: the peculiarities of formation, evolution and influence for oceanic processes and climate»** **Chair: Grigoriev M.N**	
18:30 (Small conf. room)	**Round Table:** **«Modern state of Geocryological mapping: problems, tasks and future perspectives»** **Chair: Rivkin F., Drozdov D., Zheleznyak M.N.**	

October, 2 (Wednesday)

Session 9: Permafrost warming and thawing, long-term monitoring

Chair: Zhelezniak M.	**Co-Chair:** Yoshikawa Kenji	
09:00 – 09:20	Zhelezniak M.N., Serikov S.I., Misailov I.E., Semenov V.P., Kirillin A.R., Zhirkov A.F.	**Temperature Field, Distribution and Thickness of Permafrost in the Elkon Horst**
09:20 – 09:40	Popov K.A., Ukraintseva N.G.	**Active layer dynamics in the forest tundra and southern tundra (Urengoy oil-gas-condensate field)**
09:40 – 10:00	Khomutov A., Leibman M., Epstein H., Walker D.	**Relation between Active-Layer Depth and Vegetation Indices (NDVI and LAI) along the Yamal Transect, Russia**
10:00 – 10:20	Mullanurov D., Leibman M., Khomutov A.	**Ground Temperature Controls and Their Relation to Climate Fluctuations on Central Yamal**

10:20 – 10:40	Galanin A.A	**Glacial-Cryogenic Complexes of Suntar-Khayat Range: Constitution, Age and Reaction on Climate Change**
10:40 – 11:20	**Coffee Break**	

Session 10: Permafrost engineering, constructions on frozen ground

Chair: Rivkin F.	**Co-Chair:** Perlova E.	
11:20 – 11:40	Kondratiev V.G.	**Problems of The Railroad and Highway Embankment on Permafrost**
11:40 – 12:00	Panin V.N., Kuzmin G.P.	**A Temperature Control System of the Permafrost Seed Repository in Yakutsk**
12:00 – 12:20	Perlova E.V., Miklyaeva E.S., Leonov S.A., UkhovaY.A.	**The Producing Wells and Gas Hydrate Saturated Cryolithozone Interaction: Technological Disturbances Categorization and Guidelines for Their Prevention (by the Example of Yamal Region)**
12:20 – 12:40	Gubarkov A.A	**Exogenous Geological Processes on Objects of Infrastructure of the Bovanenkovo-Uhta Main Gas Pipeline**
12:40 – 14:00	**Lunch Break**	
14:00 – 14:20	Shesternev D.M.	**Road Construction Problems in the Russian Permafrost Regions**
14:20 – 14:40	Permyakov P.P., Popov G.G.	**Calculation of Frost-Heave Extent and Settlement of Pipeline Frozen Soil Base**
14:40 – 15:00	Zabolotnik S.I., Zabolotnik P.S.	**Distribution of Taliks Beneath the Buildings Of The Yakutsk CHP Plant**
15:00 – 15:20	Grebenets V. I, Rogov V. V.	**Deformation of Engineering Objects after Creating Peculiar Systems of Combined Natural and Technogenic Character within Developed Areas of the Cryolithozone**
15:20 – 15:40	Dauzhenka T.A., Gishkelyuk I.A.	**Computationally Efficient Numerical Method for Heat Transfer Problems in the Engineering of Foundations Construction on Permafrost Soils**

Session 11: Permafrost processes

Chair: Kizyakov A.I.	**Co-Chair:** Günther F.	
15:40 – 16.00	Golubev V.N., Frolov D.M.	**Mass Exchange In The System of Atmosphere – Snow Cover – Ground**
16:00 – 16:40	**Coffee Break**	
16:40 – 17:00	Sergeev D.	**Geocryological Risk: Conception and Estimation Algorithms**
17:00 – 17:20	Günther F., Overduin P.P., Sandakov A.V., Grosse G., Baranskaya A., Opel Th., Grigoriev M. N.	**Current thermo-erosion dynamics of Ice Complex coasts in the Laptev Sea**
17:20 – 17:40	Kizyakov A.I., Zimin M.V., Leibman M.O., Pravikova N.V.	**New Data on Thermal Denudation and Thermal Abrasion Rate on Western Kolguev Island Based on High Resolution Satellite Images**
17:40 – 18:00	Makarycheva E. M.	**Thermokarst phenomenon typification approaches near south border of permafrost zone**
18:00 – 18:20	Sheinkman V.S	**Glaciation in the Permafrost Area of Siberia as Displaying of Cryodiversity**
18:20 – 19:00	**Coffee Break**	
18:20 – 19:40	**Poster session (PS.2, PS.9, PS.10, PS.11)**	
18:30	**Round Table:** **«Mountain permafrost of Asia»** **Chair: Zheleznyak M.N.**	
19:50	**CLOSING CEREMONY**	

October, 3 (Thursday)

10:30 – 18:30(19:00)	**Excursion:** **Pushchino-Yasnaya Polyana-Moscow (m. Annino)**

POSTER SESSION SCHEDULE

September 29

Poster Session 1: Subsea permafrost		
PS.1-1	**Kneier F., Langer M., Overduin P.P.**	Modeling Degradation of Subsea Permafrost in the Near-Shore Zone of the Laptev Sea Shelf
PS.1-2	**Nicolsky D.J., Romanovsky V.E., Romanovskii N.N., Shakhova N.E., Semiletov I. P.**	Modeling Sub-Sea Ppermafrost in the East Siberian Arctic Shelf: the Laptev Sea Region
Poster Session 2: Permafrost hydrology		
PS.2-1	**Debolskiy M. V., Tananaev N. I.**	Year of Suspended Sediments Measurments on Small Watersheds in Northen Yenisey region
Poster Session 3: Permafrost biogeochemistry		
PS.3-1	**Chizhuk A. L.**	Minor Elements in Bottom Sediments of the Lakes of Yakutsk
PS.3-2	**Schirrmeister L., Strauss J., Wetterich S., Grosse G., Overduin P.P.**	Deep Fossil Carbon - Spatial and Temporal Variability of Organic Matter Pools in Permafrost
PS.3-3	**Motenko R.G., Grechishcheva E.S.**	Oil Contamination Influence on Water Phase Composition of Frozen Sand
PS.3-4	**Hugelius G., Schirrmeister L., Tarnocai Ch., Broll G., Konyushkov D., Kuhry P., Chien-Lu Ping**	The Northern Circumpolar Soil Carbon Database: Current Status and Call for Collaborations
PS.3-5	**Abakumov E.**	Polycyclic Aromatic Carbons in Human Affected Soils of Arctic and Antarctic

September 30

Poster Session 4: Permafrost and trace gas exchange		
PS.4-1	**Makarov V.N.**	The Influence of Climate Warming and Greenhouse Gas Deposition on H^+ Migration in the Geosphere
PS.4-2	**Поденко Л.С., Драчук А.О., Молокитина Н.С.**	Влияние включений переохлажденной воды на устойчивость метастабильных газовых гидратов
PS.4-3	**Поденко Л.С., , Молокитина Н.С. Драчук А.О.**	Устойчивость “сухой воды” к замерзанию/ оттаиванию, образованию/ диссоциации газовых гидратов
PS.4-4	**Perlova E.V., Leonov S.A.**	Potential Resources of Unconventional Gas in Russia and Prospects of their Commercial Development
PS.4-5	**Nesterov A.N., Reshetnikov A.M**	The Influence of Carbon Dioxide Pressure at the Ice Melting Temperature
PS.4-6	**Madygulov M.Sh., Zavodovsky A.G., Nesterov A.N., Schipanov V.P., Reshetnikov A.M.**	Influence of Inhibitors on Induction Time Hydrate Formation
Poster Session 5: Permafrost dating and paleoreconstructions		
PS.5-1	**Badu Yu.**	Cryogenic Strata of the Gas-Bearing Structures of Yamal
PS.5-2	**Belova N., Verkulich S.R., Demidov N., Shmelev D.**	Ground Ice from Larsemann Hills Oasis (East Antarctica): Geological Occurrence, Properties and Genesis

PS.5-3	**Shmelev D.G.**	The Implementation of Cryogenic Weathering Index for Paleopermafrost Reconstruction by Example Late Pleistocene and Holocene Deposits of North-East Yakutia
PS.5-4	**Zanina O.G., Lopatina D.A.**	The Details of Microbiomorphs Spectra from Buried Soils of Kolyma Lowland
PS.5-5	**Opel Th., Meyer H., Dereviagin A.Yu., Wetterich S., Fritzsche D., Schirrmeister L.**	Late Holocene Climate and Environmental Changes in the Eurasian Arctic – Evidence from Glacier and Ground Ice (Eurasian Arctic Ice 4k)
PS.5-6	**Urban A.A., Galanin A.A.**	Lithological and Mineralogical Characteristics of the Kyzyl-Syr Blowing Sand Complex
PS.5-7	**Shpolyanskaya N.A., Korolyova N.A.**	Pleistocene Paleogeography of the Russian Arctic Regions (Shelf-Land) on the Basis of the Analysis of Underground Ices
PS.5-8	**Wetterich S., Rudaya N., Tumskoy V., Meyer H., Opel Th., Schirrmeister L., Andreev A.**	Late Pleistocene Ice Complex and Palaeoenvironments of Bol'Shoy Lyakhovsky Island (New Siberian Archipelago)
PS.5-9	**Larin S.I., Laukhin S.A., Guselnikov V.L.**	Traces of Continuous Permafrost Late Pleistocene in The Southwest of the West Siberian Plain
Poster Session 6: Permafrost modelling and mapping		
PS.6-1	**Bartsch A., Högström E., Heim B., Buchhorn M., Ottlé C., Maignan F., Fily M., Delbart N.**	Remote Sensing and Multi-Scale Integration for Investigating ‘Changing Permafrost in the Arctic and its Global Effects in the 21st Century – PAGE21’
PS.6-2	**Marakhtanov V.P., Radosteva A.V.**	Application of the «Econorth» Program for the Sustainability Assessment of Elementary Natural Regions of One or Adjacent Cascade Landscape Geosystems
PS.6-3	**Semenov V.P., Zhelezniak M.N.**	Permafrost in the Vilyui Basin: State of Geothermal Knowledge and Thickness Estimation
PS.6-4	**Heim B., Buchhorn M., Bartsch A., Dvornikov Y., Epstein H., Ermokhina K., Khomutov A., Leibman M., Walker D.**	Optical Spectral Remote-Sensing Applications: a Case Study in Central Yamal, Vaskiny Dachi
PS.6-5	**Heim B., Bartsch A., Elger K., Buchhorn M., Boike J., Lantuit H., Muster S., Langer M., Duguay C., Soliman A., Rinke A., Matthes H., Klehmet K.**	User Interaction within ESA DUE PERMAFROST: Evaluation of Circumpolar Remote Sensing Products and Their Usability for Models (Permafrost and Climate Modelling)
PS.6-6	**Mikhaylova T.A.**	Cartographical Model of Geocryological and Geoecological Conditions and Dynamics (Yamal Peninsula)
PS.6-7	**Дроздов Д.С., Малкова Г.В., Абрамов А.А., Константинов П.Я., Сергеев Д.О., Романовский В.Е., Холодов А.Л.**	МОНИТОРИНГ КРИОЛИТОЗОНЫ РОССИИ И СОЗДАНИЕ ЕДИНОЙ НАЦИОНАЛЬНОЙ ИНФОРМАЦИОННОЙ БАЗЫ
PS.6-8	**Gishkelyuk I.A., Evlanov D.V., Kovalenko V.A.**	Computer Modeling of an Artificial Freezing of Soils with FROST 3D Software Application

October 1

Poster Session 7: Permafrost-affected soils and biosystems		
PS.7-1	**Lupachev A.V., Abakumov E.V.**	Soil Diversity of Marie Byrd Land, West Antarctica (Russkaya Station Keysite)
PS.7-2	**Zhangurov E.V., Dymov A.A., Kaverin D.A., Zaboeva I.V.**	Mineralogical Composition of the Coarse Fractions in Permafrost-Affected and Long-Term Freezing Soils of the Sub-Polar Urals (Basin of the Middle Reaches of Kozhym River)

PS.7-3	**Torgovkin N. V., Makarov V. N.**	The Snow Cover of the Mountain Landscapes of the Cryosphere In Eastern Yakutia
PS.7-4	**Kaverin D., Pastukhov A.**	Temperature Regime of Tundra Soils and Underlying Permafrost in the European North-East of Russia
PS.7-5	**Dymov A.A., Zhangurov E.V., Starcev V.V.**	Microclimatic Characteristics of Subpolar Ural Soils (National Park Yugyd va)
PS.7-6	**Ananko T. V., Konyushkov D.Ye., Shubina I. G., Khokhlov S. F.**	Soil-Geographic Division of Western Yakutia and Contiguous Territories
PS.7-7	**Dolgikh A., Mergelov N.**	Soils diversity in Thala Hills oasis (Enderby Land, East Antarctica)
Poster Session 8: Permafrost microbiology and astrobiology		
PS.8-1	**Vishnivetskaya T., Layton A., Chauhan A., Williams D., Pfiffner S., Chourey K., Hettich R. L., Phelps T., Lau Maggie C. Y., Stackhouse B., Whyte L., Mykytczuk N., Onstott T.**	Metagenomic and metaproteomic analyses of the High Arctic Canadian permafrost
PS.8-2	**V.S. Soina, L.V.Lysak, A.G. Kudinova, N.A.Manucharova, N.S.Mergelov**	Characterization of Bacterial Community from East Antarctic Oases
PS.8-3	**Kochkina G.A.,Ivanushkina N.E., Vasilenko O.V., Chigineva N.I., Spirina E.V.,Gilichisky D.A., Ozerskaya S.M.**	Mycelial Fungi from Antarctic Active Layer Detected by Different Methods
PS.8-4	**Shmakova L.A., Shatilovich A.V., Mylnikov A.P., Stoupin D.V., Gubin S.V., Gilichinsky D.A.**	Viable Heterotrophic Protists from Soils and Rodent Burrows Buried in the Ice Complex Sediments
PS.8-5	**Ruzova O.V. Domanskii, V.O. Samsonova V.V.**	Activity and Biodiversity of Microbial Biota of Cryosol and Ground Ice Complex of Central Yakutia (Eastern Siberia, Russia)
Poster Session 9: Permafrost warming and thawing, long-term monitoring		
PS.9-1	**Stanilovskaya Yu.V., Yoshikawa K., Sergeev D.O.**	School-based Permafrost Monitoring Project in Russia
PS.9-2	**Leibman M.O., Dvornikov Yu.A., Khomutov A.V., Mullanurov D.R.**	New massive ground ice exposures due to activation of earth flows on slopes in Central Yamal during extremely warm summers of 2012-2013
PS.9-3	**Gilichinsky D., Kholodov A., Fedorov-Davydov D., Sorokovikov V., Davydov S., Abramov A., Demidova A. (Veremeeva), Kraev G., Shmelev D.**	Permafrost Temperature Observation Network in The Northern Yakutia.
PS.9-4	**Gavriliev R.I.**	Catalog of Thermophysical Properties of Rocks in North-Eastern Russia
PS.9-5	**Abramov A.A.**	The state of permafrost monitoring network after the fissure eruption of Tolbachik volcano (FTE-50), Kamchatka

October 2

Session 10: Permafrost engineering, constructions on frozen ground		
S.10-1	**Efremov V.N.**	Detecting Changes in Frozen Ground Condition by Radiowave Surface Impedance Measurements
S.10-2	**Мельников А.Е., Павлов С.С.**	ВЛИЯНИЕ ПРОЦЕССОВ КРИОГЕННОГО ВЫВЕТРИВАНИЯ НА УСТОЙЧИВОСТЬ ЖЕЛЕЗНОДОРОЖНОГО ПОЛОТНА АМУРО-ЯКУТСКОЙ МАГИСТРАЛИ (УЧАСТОК ТОММОТ-КЕРДЕМ)

S.10-3	**Kotov P.I., Tsarapov M.N.**	Impact of Cryogenic Textures on The Deformation Properties
S.10-4	**Остроумова Е.А.**	ДИНАМИКА МЕРЗЛОТНЫХ ХАРАКТЕРИСТИК В РАЗЛИЧНЫХ ЧАСТЯХ Г. ЯКУТСКА
S.10-5	**Topchiev A.G.**	Local Monitoring System for Environmental Studies of Oil and Gas Exploration
S.10-6	**Novikov P.**	Proven Model of Permafrost Thaw Halo Formation around a Pipeline
Session 11: Permafrost processes		
PS.11-1	**Zotova L.I., Dedyusova S.Yu.**	Factors of Geosystems Sustainability within the Boreal and Sub-Arctic Cryolithozone
PS.11-2	**Torgovkin N. V., Makarov V. N.**	Saline Thawed and Frozen Grounds of Yakutsk
PS.11-3	**Andryushchenko F.D., Grebenets V.I., Maslakov A.A., Shmelev D.G.**	The Study of Seasonal Freezing in the Western Moscow Area in a Snowy Winter
PS.11-4	**Bazhenov A. I., Yakimov A. S.**	The Features of Splits Formation in the Peat Layer in Sporadic Permafrost Zone
PS.11-5	**Fedoseeva V. I., Fedoseev N. F.**	Interaction of Some Organic Substances with Surface of Ice Particles
PS.11-6	**Konishchev V.N., Golubev V.N., Rogov V.V., Sokratov S.A.**	Some Results of investigation of the Isotopic Fractionation of Water in the Process of Segregation Ice Formation
PS.11-7	**Zavodovsky A.G., Madygulov M.Sh., Reshetnikov A.M., Nesterov A.N., Schipanov V.P.**	Dicay of Metastable Gas Hydrates by Crystallization Supercooled Water
PS.11-8	**Severskiy E., Gorbunov A.**	Hazards of Geocryological Processes in Kazakhstan
PS.11-9	**Maslakov A. A., Kraev G. N.**	Coastal Dynamics within Built-Up Areas of Chuckhi Peninsula
PS.11-10	**Kasymskaya M.V., Popova A.A., Grechishcheva E.S., Guseva E.S.**	Distribution of Seasonal and Perennial Mounds in the South Tambeyskoye Condensate Field (Yamal Peninsula)
PS.11-11	**Konovalov A.A.**	Mechanisms of Destruction of Frozen Soil
PS.11-12	**Semenkov I. N., Usacheva A. A.**	Current Turbation Identification in Podzols of Western Siberia

ABSTRACTS

of the International Conference

«Earth Cryology: XXI Century»

Pushchino, Russia

September 29 – October 3, 2013

A TRIBUTE TO DAVID GILICHINSKY AND THE PUSHCHINO CONFERENCES

Jerry Brown

Past President, International Permafrost Association, Woods Hole, MA, USA

This 2013 international Pushchino conference on “Earth Cryology in the 21th Century” is a tribute to the life and scientific achievements of our dear friend and colleague David Abramovich Gilichinsky (1943 -2012). Starting in the late 1980s, David Gilichinsky had a profound and continuing impact on scientific cooperation between Russian (Soviet) and Western researchers. The Pushchino conferences were just one manifestation of David’s scientific foresight and leadership.

A total of twelve conferences held in Pushchino from 1992 to 2005 provided unique opportunities for both Russian and Western scientists to meet and discuss advances in geocryology, cryopedology, astrobiology and many other related topic. Scientists and engineersfrom many institutes and departments throughout Russia and the international communities attended. Following the first conference subsequent ones took place in the spring following the long Russian winter. Pushchino provided a welcomed venue to relax in the country among old and new friends. An annual banquet provided added opportunities for celebration. The Scientific Council on Earth Cryology played an important organizational role in the conferences and it held its annual meetings at the close of the conferences.

For many of us the November 1992 conference was our introduction to the Pushchino campus of the Russian Academy of Sciences, and its Institute of Soil Science and Photosynthesis (Institute of Physico-Chemical and Biological Problems in Soil Science). The Institute’s Laboratory of Soil Cryology was founded by Oleg Makeev in 1969 and headed by David from 1989 to 2012. The initiator of the November meetings was the Laboratory of Soil Cryology under David’s leadership and was held in two parts: the First International Conference on Cryopedology (FICC) and a Joint Russian-American Seminar on Cryopedology and Global Change. The FICC was under the auspices of the International Society of Soil Science (ISSS).

The concept for the seminar began in Alaska in June 1991 while David and Stanislav Gubin were attending an US-USSR Beringia Conference. Chien Lu Ping, University of Alaska Fairbanks subsequently received funding from the U.S. National Science Foundation to support travel of some of the eighteen U.S. participants. Representatives from nine other countries who attended the FICC also participated in the seminar. The seminar, divided into seven working groups, provided an opportunity to review a range of soil and climate related topics, provide recommendations and foster future collaborations. The seminar publication (Pushchino 1993) presented resolutions of both the FICC and the seminar and consisted of 38 summary papers. The resolutions provided the basis for establishing Cryosols Working Groups within the ISSS and International Permafrost Association. Recognizing the international importance of Cryosols, the IPA during the 1993 Seventh International Conference on Permafrost in Beijing approved the formation of the Cryosol Working Group and appointed David as it Chair for the following five years.

At each Pushchino conference a book of abstracts and papers was available in English (see attached list). Oral presentations were translated into English for foreign participants. “Roundtables” provided opportunities to plans and discuss progress on joint international programs with Russian colleagues. An early example was the 1992 roundtable on viable microorganisms in permafrost and the publication of a series of papers (Pushchino 1994). Over the years roundtable topics included planning and progress reports on international programs related to active layer (CALM), thermal state of permafrost (GTN-P) and coastal dynamics (ACD). David’s very early contribution to our collective long-term monitoring activities was to obtain the previously inaccessible historical soil temperature data from climate stations throughout the Russian arctic and subarctic regions. David and his colleagues pioneered research on the preservation of microorganisms in

permafrost and presented their results in numerous international conferences and journals. These built on David’s pioneering international collaboration in 1990 to obtain samples and study ancient life from Siberian permafrost. He contributed to the Journal Astrobiology as a Regional Editor and author, and to many international meetings such as the Lunar and Planetary Science Conferences and European Workshops on Exo-Astrobiology. Since 1988, David and his many Russian and international colleagues published in English more than 130 papers.

These collaborations included universities and scientific organizations throughout Europe, North America, and with Antarctic colleagues.

David's life and influence on others are recognized in the many tributes from Russia colleagues and those around the world (http://davidinmemoriam.blogspot.com/2012/02/dear- friends-and-collegues-is-with.html).

Pushchino Conference Proceedings:

Pushchino 1992. Proceedings, 1st International Conference on Cryopedology (Cryosols: the effects of cryogenesis on the processes and peculiarities of soil formation), November 10-14, 1992.

Pushchino 1992. Joint Russian-American seminar on cryopedology and global change, November 15-16. 1992.

Pushchino 1993. Post Seminar Proceedings, Joint Russian-American seminar on cryopedology and global change.

Pushchino 1994. D. Gilichinsky (ed). Viable microorganisms in permafrost.

Pushchino 1994. (conference title).

Pushchino 1995. Evolutionary geocryological processes in the Arctic regions and problems of global changes of the environment and climate in permafrost areas, 24-28 April 1995.

Pushchino 1996. International Conference on Fundamental research of Earth Cryosphere in Arctic and Sub-Arctic (results and prospects), 23-26 April 1996.

Pushchino 1997. The problems of Earth Cryosphere (Basic and applied studies), 21-25 April 1997.

Pushchino 1998. The conference on the problems of Earth Cryology devoted to the 90^{th} anniversary of Academician P.I. Melnikov, 20-24 April 1998.

Pushchino 1999. International Conference "Monitoring of Cryosphere", 20-23 April 1999.

Pushchino 2000. International Conference: Rhythms of natural processes in the Earth Cryosphere, 12-15 May 2000.

Pushchino 2001. International Conference: Conservation and transformation of the matter and energy in the Earth Cryosphere, 1-5 June 2001.

Pushchino 2002. International Conference: Extreme phenomena in cryopshere: Basic and applied aspects. 12- 15 May 2002.

Pushchino 2003. International Conference: Earth Cryosphere as a habitat and object for nature management, in memory of the 95th anniversary of P.I. Melnikov.

Pushchino 2005. International Conference: Priorities in the Earth Cryosphere research, 25-28 May 2005.

Submarine Permafrost of Kara Sea. Modern View

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According to the modern understanding, submarine permafrost (SP) in the Kara Sea shelf can be encountered in the area from the coastline up to the water depth of 120 m, which corresponds to decrease in the sea level during the Sartan cryochron (last glacial maximum of the Late Pleistocene). Potential depth of freezing and corresponding SP thickness could reach 400 to 500 m. Thus, one can presume that SP in the study area is relic. However, during the drilling in the deep-marine shelf of the south-east part of the Barents Sea, SP bodies shaped like ice stocks whose thickness exceeded 100 m and whose temperature was constant with depth were encountered. It was presumed that their formation occurred as a result of rapid degassing and overcooling of initially unfrozen gas-saturated sediments with temperatures close to the freezing temperature. So, SP of the continental shelf of the Kara and Barents Seas is represented by both relic and newly formed permafrost. Besides, modern permafrost formation occurs at low accumulative surfaces (e.g. Sharapovy and Marre-Sal'skiye Koshki).

During the last years, the importance of reliable information on SP formation, distribution, properties, and evolution has increased tremendously due to prospective of development of gas fields of the Yamal continental shelf, first of all, of the Kharasavey and Kruzenshtern gas fields.

Under conditions of lack of direct information on SP (i.e. drilling data), indirect methods of permafrost detection in shelf deposits become extremely important. The most promising method is a high-resolution seismo-acoustic profiling. This recently developed method now is included in a standard set of methods of oceanological research, and a large data base on seismo-acoustic measurements in the whole Kara Sea area has been accumulated. The main obstacle in application of the high-resolution seismo-acoustic profiling for SP identification is related to extremely high gas saturation of the Quaternary deposits within the shelf. Never the less, new methods of the data processing allow detecting of acoustic reflectors which can be interpreted as a permafrost table. Verification of results of seismo-acoustic profiling basing on their comparison with the drilling data was performed in the area of relatively shallow-water continental shelf near Kharasavey and showed a sufficient correlation.

All available results of seismo-acoustic profiling obtained by various institutions have been collected. More than 130000 km of profiles have been analyzed and interpreted. Within 30000 km of profiles, acoustic reflectors which can be interpreted as a permafrost table have been detected. The information on coordinates, sea depth, and permafrost table depth was arranged in a data base which contains approximately 30000 records on SP table locations in the seismo-acoustic profiles. A map of SP distribution in the southern part of Kara Sea was developed basing on GIS-technology. This map can be updated with adding of the new data of seismo-acoustic profiling. Thus, it always represents a current level of our knowledge of SP.

Subsea Permafrost Table Dynamics in the Laptev Sea Nearshore Zone

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Subsea permafrost of the Arctic seas has received very little study. So far there are more questions than answers concerning the problem of its existence and distribution. Neither its thickness nor distribution on the relatively deep shelf is not known still.

An active transformation of ice-rich subsea permafrost in a shallow zone of the Arctic shelf was established. The complicated structure of the subsea permafrost top horizons dependent on local geothermal, hydro-geological and tectonic anomalies is revealed. The limited borehole data from the shallow nearshore zone indicate the great variation in inclination and degradation rate of permafrost table. Permafrost temperatures are relatively "warm" (-1.0 to -1.5°C) within a few kilometers from shore. Inclination of subsea permafrost table in the nearshore zone of the Laptev and East Siberian Seas has been found to average 0.011 (0.62º), ranging from 0.0002 to 0.1. The rate of degradation of the upper part of permafrost decreases off-shore from a few tens centimeters to a few millimeters per year. The degradation rate is controlled by the dynamic regime in the coastal zone, composition and thickness of overlying sediments, temperature and salinity of near-bottom water, and hydrodynamic processes in coastal shelf areas. No evidence of climate-related changes in the degradation rate of subsea permafrost along the East-Siberian Arctic coasts has been found.

One of the main indicators of sub-sea permafrost table inclination at the eroded coastal segments is a coastal retreat rate. Peculiarities of evolution of sub-sea permafrost depend on a number of factors: near-bottom water temperature, water salinity; coastal erosion retreat rates (or rate of accumulation/accretion), shoreface inclination, general coastal morphology and shoreline configuration, coastal and shoreface sediment composition, ice-content of deposits, hydro-lithodynamics.

Practical importance of subsea dynamics studies is connected with changing of bathymetric parameters within a nearshore fairways (for examples, sea floor bottom subsidence because of icy subsea permafrost degradation), as well as development of engineering and exploitation approach on the Arctic shelf.

Coastal Thermal Erosion Monitoring at the Pechora and Kara Seas

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The coastal zone the Pechaora and Kara Seas is highly dynamic due to the contact with the cryolithozone. The coasts of Pechaora and Kara Seas which are composed of dispersive frozen deposits have poor erosion resistance qualities. In natural conditions such coasts may retreat with a rate of 0,5 to 2 m a year. Considering eventual human impact and forecasted climatic change, coastal retreat rate may significantly increase in the coming years. Technogenic disturbances activate trigger mechanisms of wave-induced coastal erosion. Under the conditions of global warming and ice cover reduce this effect is enhanced by the increase of the duration of the dynamic activity period and wave fetch. As a result, local human impact and climate change form synergetic effect due to which coastal retreat rates can double and even triple.

We are presenting here three examples for Pechaora and Kara Seas where human impact has already brought in negative effects. To determine the speed of coastal retreat and shore zone profile deformations, approximately 120 benchmarks have been established at the Varandey (Pechaora Sea) and Kharasavey (Kara Sea) industrial key areas, as well as at the gas pipeline underwater crossing of the Baydarata Bay (Kara Sea) in the 80-90s of the XX century for coastal dynamics monitoring. The benchmarks were attributed to the Baltic-77 (Russian) system of heights. Coastal dynamics monitoring from constant benchmarks is executed by direct measurements and by trigonometric leveling. An additional method of receiving an overview of multiannual coastal dynamics is studying multi-temporal aerial and satellite images of high and extra-high definition.

One of the examples is Varandey Coast of the Pechaora Sea. From 1979 to 2012 a deliberate destruction of the dune chain of a barrier beach by vehicle traffic and beach material removal for construction needs led to quick intensification of the coastal retreat here. And now, storm surges penetrate inland for several kilometers without hindrance.

We also present data from a key area further east to the Kara Sea: the Kharasavey Coast of the Yamal Peninsula. Large-scale extraction of sediments from the coastal slope has resulted in a depletion of the material on the beaches and triggered violent thermoabrasion of the coast in 1982-1985 and 2006-2008.

The third example of the negative impact of human activity has been documented at the sites underwater pipeline crossing on both coasts of the Baydaratskaya Bay, Kara Sea. Designers and builders have not taken into account the negative experience of unsustainable management and sediment removal observed at Varandey and Kharasavey industrial areas. The construction of the pipeline, accompanied by the use of many technical devices and sediment removal from the beach and tide-flat, during the period from 2007 to 2012 led to significant increase in the rate of coastal erosion.

A truly responsible decision making towards the strategy of developing the northern coasts of Russia and constructing new facilities has to be based on integrated knowledge of the ongoing environmental processes, in particular coastal dynamics. The ignoring of this issue may cause irreversible damage to both the coastal geosystems and the facilities themselves, which, once they are destructed, may drag in enormous environmental implication.

Modeling Degradation of Subsea Permafrost in the Near-Shore Zone of the Laptev Sea Shelf

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After the last glacial period, rising sea levels covered large areas of terrestrial permafrost with sea water and created the subsea permafrost present today on the arctic continental shelves. After inundation, the degradation of permafrost is governed by the influence of sea-bottom temperatures, salt infiltration into the flooded sediment and a suite of near-shore coastal processes. Subsea permafrost warming can release trapped methane to the atmosphere and affect coastal erosion rates. Our objectives are to employ meso-scale numerical calculations (from meter to kilometer spatial scales and up to 1000s of years temporal scale) in connection with borehole data from the Laptev Sea to model the transition of permafrost from onshore to offshore conditions. The goal is to identify key processes driving permafrost degradation in the near-shore zone of the shelf and to include quantitative parameterizations based on field observations in the models. Heat transfer is solved numerically and takes freeze-thaw processes into account in a three-phase heat capacity/conductivity model. Sediment composition and initial temperature profiles are derived from field and laboratory analysis of the borehole data. Our approach includes the effect of pore water salinity on phase state and thermal properties in order to show the impact of solute transport mechanisms into the sediment. Measured permafrost temperatures along a borehole transect that extends from an onshore borehole to an offshore borehole that flooded roughly 2500 years ago are compared to the modeled subsea soil temperature evolution following transgression. The degradation of the ice-bearing permafrost table or thaw depth is of special interest due to its direct relation to sediment stability and as the most readily discernible feature in the field observations. This thaw depth is mainly driven by salt contamination and modeled salinity profiles for the different transport mechanisms are compared to profiles from arctic shelf drill sites.

Modeling Sub-Sea Ppermafrost in the East Siberian Arctic Shelf: the Laptev Sea Region

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The present day interest in understanding whether and how methane, preserved in seabed reservoirs, can escape to the atmosphere suggests a need to review sub-sea permafrost observations and to re-examine available sub-sea permafrost models. Currently, the models of sub-sea permafrost evolution significantly vary in employed physical assumptions regarding the paleo-geographic scenario, geological structure, thermal properties, initial temperature distribution, and geothermal heat flux. This work aims to review the underlying assumptions of these models as well as to incorporate recent findings, and hence develop an up-to-date model of the sub-sea permafrost dynamics at the Laptev Sea shelf. In particular, the developed sub-sea permafrost model incorporates the thermokarst and land-ocean interaction theory, and shows that the sediment salinity and a temperature-based parametrization of the unfrozen water content are critical factors influencing sub-sea permafrost dynamics. From the numerical calculations, we suggest development of open taliks underneath submerged thaw lakes within a large area of the shelf.

Session 2: Permafrost hydrology and hydrogeology

The Influence of Lunisolar Tides on Fluctuations of Antarctic Glaciers and Icebergs Runoff

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For the first time the data about tide oscillations of angular velocity of Earth's rotation from 1901 to 2011, connected with lunisolar tides was received in 2008 [2]. In 2009 the influence of lunisolar tides oп dynamics of Antarctic icebergs runoff were investigated. Revealed correlations between oscillatioпs of lunisolar tides and Antarctic glaciers were reported oп IPY Oslo Sciences Conference 2010 and IPY Montreal Sciences Conference 2012 [4, 5].

The amplitude of tide forces oscillations is changed with periods: 18.6; 8.85; 6.0; 1; 0.5 year; month; days; and more short periods. Tide deformations are little oп magnitude but periodically are repeated and acted constantly. They create accumulating effects which are exhibited in transformation of vertical tides displacements in horizontal displacements of terrestrial layers [1, 2]. This effect extends to the horizontal displacements of Antarctic glaciers floating parts (ice shelves and outlet glaciers) [4]. During low tides floating parts lie on rises of bed without moving. When the high tides occur they begin to float, come off away from bed rises and does not exert force of friction oп ground move to the side of oceaп by means of press of ice mass from enter regions of ice sheet. Such mechanism of moving is known as "vibration displacement" [1, 2].

Carried out analysis showed that the connection of Antarctic floating parts fluctuations ([3] and last data) and oscillations of lunisolar tides dispersion were observed clearly in 1893-1910 and 1935-2009. During 75 last years this dependency constantly appeared [4, 5].

It was found that maximum of all advance periods (surges) of Antarctic ice shelves and outlet glaciers corresponds minimum of periods of decrease of tide oscillatioпs Earth rotation velocity amount but the periods of maximum of retreat of margin ice shelves and outlet glaciers in result of icebergs calving correspond maximum of periods of increas of amount of tide oscillations Earth rotation velocity [4, 5].

Correlation analysis of long-term ranges of full Antarctic icebergs runoff (km3 water in year) and dispersion of tide oscillatioпs Earth rotation velocity during 1935-2009 showed maximum correlation equal ¬0.71+O.54 at the shift of the curve of the dispersion by six years back. Periodicity of both considered processes which is equal 18.6 year of variability of lunisolar tide forces was kept

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Hydrochemical Characteristics of Intrapermafrost Groundwater in Discharge Areas, Central Yakutia

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In Central Yakutia, supra-intrapermafrost aquifers are widespread in sediments comprising the middle terraces of the Lena River. Groundwater of this type has been best studied within the Bestyakh terrace. The terrace has a distinct escarpment 25 to 30 m high and a smoothed surface. It consists of fine- to medium-grained sands with gravels at its base, underlain at depths of 20–80 m by Cambrian limestones and Jurassic sandstones. An intrapermafrost aquifer 30-85 m thick lies from depths of 16-50 m below permafrost. It is recharged from precipitation through taliks occurring beneath the lakes, small creeks, and open pine stands on level ground. The aquifer is confined from below by a 100-200 m thick permafrost aquitard. The intrapermafrost groundwater is naturally discharged via the groups of springs concentrated at the foot of the Bestyakh terrace.

In winter, the springs form icings which, along with lateral ground freezing, reduce the cross-sectional area of subsurface flow. The freezing pressure developed in the intrapermafrost talik forces the water to intrude into the overlying warm frozen sands increasing their ice contents. The icings melt out by July-September. Having significant natural resources, intrapermafrost aquifers can be a reliable water supply source.

The largest spring system in the study area is located at the upper reaches of Ulakhan-Taryn Creek. It consists of five groups of springs with a total discharge estimated from long-term data to be 19 × 103 m3/day. In 2000, a well was drilled above one group of springs near the edge of the terrace tread to tap an intrapermafrost aquifer occurring in the sands at depths of 27 to 65 m. The water from the springs and the well is of the calcium-magnesium bicarbonate type with dissolved-solids concentration of 200-300 mg/l.

To understand the long-term changes in intrapermafrost water chemistry, we have examined the data from 50 years of hydrochemical investigations in the Ulakhan-Taryn Creek valley. Water samples were analyzed in the hydrogeochemical laboratory of the Permafrost Institute using standard methods. Starting five years ago, analyses have also been made at the Analytical and Certification Center, Institute of Microelectronics Technology and High Purity Materials RAS, using the mass-spectrometry and atomic emission methods

Our study has confirmed that the springs have highest dissolved-solids concentrations (300-350 mg/l) in March when the icing growth is at maximum. Summer thawing of the ice-rich layer formed near the seeps during the winter results in impoverishment of the intrapermafrost water and lowers the dissolved-solids concentrations in the spring water. Sodium shows greater concentration variability, because of the greater mobility and lower freezing temperature of its salts.

The intrapermafrost water discharged at Ulakhan-Taryn is characterized by a wide array of micro-components and contains more than 50 of 71 measured constituents. In an annual cycle, the contents of lithium increase 1.5-3 times and those of rare-earth elements increase by two orders of magnitude in the end of June – early July. This rise is thought to be related to rapid thawing of the ice-rich sediments frozen during the winter. The meltwater enriched with carbon dioxide is highly aggressive, leaching some elements from the sediments. Furthermore, mass movement on the slopes causes migration of groundwater discharge points, increasing the time of water interaction with the sediments. Seasonal variations in concentration of some minor components are characteristic only of the spring water. The chemical composition of the water from the well remains more stable on an annual and interannual basis. Water samples obtained from the well during five-day pumping at a rate of 380 m3/day also showed highly stable concentrations of major and minor constituents.

In summary, the groundwater chemistry in the discharge area is subject to seasonal variations near the fluctuating boundary of the intrapermafrost talik where intensive water-sediment-carbon dioxide interaction takes place. The long-term stability of the intrapermafrost water chemistry in years with different water availability suggests that the Ulakhan-Taryn springs are mainly formed by suprapermafrost water.

Detection and Modelling of Wildfire-Induced Changes in Thermal and Hydrological Regime of Middle Scale Watersheds in the Upper Vitim River Basin

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The ecosystems of Eastern Siberia are regularly impacted by wildfires. Destruction of vegetation and removal of soil organic layer lead to considerable changes of heat and water regime in permafrost landscapes. They cause both immediate and long-term non-stationary effects, notably the formation of extreme peak floods in rivers, and permafrost degradation.

The aim of the study was to quantify possible changes in active layer depths and hydrological regime of several middle-scale watersheds in the upper Vitim River basin after catastrophic fires using ground observations data, remote sensing products and modelling approach.

Based on the MODIS Active Fire & Burned Area data the fire occurrence in studied area was analyzed and the watersheds affected by extensive (burn area) and intensive (fire severity) fires in recent years were specified.

The Hydrograph, a distributed process-based hydrological model, was applied to quantify the wildfire effect on watershed processes. The advantage of the approach is that observable vegetation and soil properties are used as the model parameters allowing minimally resort to calibration procedure and make use of the Hydrograph model in assessment of environment change impacts on hydrological cycle. The model can use dynamic set of parameters which change in time in case of any directed transformation of landscape characteristics.

To cope with non-stationary conditions we estimated physical characteristics of landscapes (soil and vegetation) in post fire period. The model parameters (ex., albedo, interception capacity, infiltration coefficient, physical soil properties, evaporation coefficient, etc.) were changed in time in a dynamic mode reflecting the vegetation/soil succession in post fire period. Changes in soil heat dynamics, water infiltration, and active layer depths in different part of the watersheds and runoff formation after the fire were assessed.

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Permafrost and Ground Waters of Middle Subpolar Urals

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Geothermal observations in the low-studied axial zone of Subpolar Urals, in the goltsy watershed of Maldynyrd Ridge were conducted in fourteen boreholes. The permafrost temperature at the depth of 20m decreases closer to abrupt and steep slopes with -1 to -4°. Due to lateral cooling of the rocks the geothermal gradient is negative or zero in intervals to 100-175m; deeper - positive: 0.72°/100m. The thickness of permafrost was measured at mark of relief 1293m, in the borehole, which «stood» 162 days after 45 days of drilling. At temperature -1.5° at the depth 433m and specified gradient the thickness of permafrost was 640m. In the borehole with less standing idle time, measured to 386m, the calculated thickness of permafrost was 620m. The former estimations: conjectural – 300m (Baranov, 1977); to measured depth 116m – 490m (Oberman, 1981). The frozen massif are composed of metamorphic rocks (Є3-O1) and detrital deposit. The latest contain ice lenses to 0.5m thick. The ultrafresh ice filling cavities, cracks in bedrocks are marked to the depth of 130m; ice is deeper by geophysical data. Judging by depths of occurrence of ice, the thickness of dry permafrost is 0-15m. The permafrost, occurring deeper, has continuous distribution in marks 1100m and above. Non-continuous permafrost is most developed near the ridge foot, at marks 600-650m.

The sources waters of seasonally thawed layer are fixed from marks near 1200m and lower. In November - December sources are completely exhausted, showing themselves as slope icing with area in tens - hundreds sq.m. The discharge of waters of river-channel, lake taliks is assist by moraines: in crossing of stream with the swell of lateral moraine the icing is formed with the area 70000 sq.m. The module of underground flow, determined by the partition of hydrographs of the river of Balbanyu, directly above and below the lake of Bol. Balbanty, made 2.9 and 5.0 l/sec•km^2. The anomaly of the latter number is caused by subaqual discharge of waters of lake talik, dammed by terminal moraine.

The ground waters are dominated by calcium hydrocarbonates; the dry residue of water 0.01-0.07g/l.

In the mentioned lake, the linear stripe, consisting of eight opening-water (background thickness of ice 1.2-1.5m) with gas streams, presumably nitrogen, was noticed. Considering disposition of this stripe at the front part of regional fault, we believe that here abyssal fluids discharge rising on open talik. The concentration of oilproducts and dissolved organic matter here and in other numerous waterpoints, also located under natural conditions, in faults zones, at marks to 900m, reaches 0.7 and 2.9mg/l accordingly. These components were examined in two laboratories, including accredited Timan-Pechora scientific centre focusing on studies of waters from oil deposits. According to the conclusion of the laboratory chief, Danilevsky S.A., the analyzed tests are natural hydrocarbon mixes of aureole of migration flows of hydrocarbons.

Thus, even in the conditions of thick permafrost of Subpolar Urals the discharge subpermafrost ground waters is fixed on open taliks.

Year of Suspended Sediments Measurments on Small Watersheds in Northen Yenisey region

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Integrated watershed research and sediment budget studies in Krasnoyarsk Region, Russia, started in 2012 and are now running in the scope of I.A.G. SEDIBUD Working Group. Observations were aimed to assess the intra-annual variability of sediment yield in small Arctic catchments, and to relate observed turbidity values with several optical features of the water samples. Four experimental catchments, data from which are employed in this study, are located in the vicinity of the town of Igarka (N67º27', E86º30'), in the lower section of the Yenisei River. This study is representing annual data of turbidity, SSC and water optics measurments on small watersheds near Igarka town.

Session 3: Permafrost biogeochemistry

Carbon and Nitrogen Storages in Permafrost-Affected Soils of the Lena River Delta

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The Lena River Delta, which is the largest delta in the Arctic, extends over an area of 32000 km² and likely holds more than half of the entire soil organic carbon (SOC) mass stored in the seven major deltas in the northern permafrost regions. Around 61 % of the Lena River Delta region consists of true deltaic geomorphic units accumulated in the Holocene. These units are a river terrace dominated by wet sedge polygons covered by a soil complex of Glacic Aquiturbels and Typic Historthels, and the active floodplains covered mainly by sand dominated soils as Psammentic Aquorthels and Typic Psammorthels. The mean SOC stocks for the upper 100 cm of soils on both geomorphic units were estimated at 29 kg m^{-2} ± 10 kg m^{-2} at the river terrace and at 14 kg m^{-2} ± 7 kg m^{-2} on the floodplains. For the depth of 100 cm, the total SOC storage of the Holocene river terrace was estimated at 121 Tg ± 43 Tg, and the SOC storage of the active floodplains was estimated at 120 Tg ± 66 Tg.

The mass of SOC stored within the observed seasonally thawed active layer was estimated at about 127 Tg assuming an average maximum active layer depth of 50 cm. The SOC mass which is stored in the perennially frozen ground below 50 cm soil depth, which is excluded from intense biogeochemical exchange with the atmosphere, was estimated at 113 Tg. The mean nitrogen (N) stocks for the upper 1 m of soils were estimated at 1.2 kg m^{-2}± 0.4 kg m^-2 for the Holocene river terrace and at 0.9 kg m^{-2}± 0.4 kg $m^{-2}$for the active floodplain levels, respectively. For the depth of 100 cm, the total N storage of the river terrace was estimated at 4.8 Tg ± 1.5 Tg, and the total N storage of the floodplains was estimated at 7.7 Tg ± 3.6 Tg. Considering the projections for deepening of the seasonally thawed active layer up to 120 cm in the Lena River Delta region within the 21st century, these large carbon and nitrogen storages could become increasingly available for decomposition and mineralization processes.

Long-Term Spatial and Temporal Variations of Climatic and Carbon Parameters of Permafrost-Dominated Ecosystems

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Almost 65% of Siberian forests and 23% of tundra vegetation grow in permafrost zone. According to our estimate, carbon stocks in the soils of forest and tundra ecosystems of Yakutia (Eastern Siberia, Russia) amount to 17 billion tons (125.5 million hectares of forest and 37 million hectares of tundra in total) that is about 25% of total carbon resource in forest soils of the Russian Federation.

Since the end of XIX century winter air temperatures in Arctic Siberia have risen by 10ºC, and average annual ones – by 2.0-3.5°C. For the last 50 years in Eastern Siberia the average air temperature in January has grown by 7°C, i.e. it was increasing 1.5-2 times faster compared to the first half of the century. Mean annual air temperature has increased by 1.0-2°C. An increase in annual air temperature in the zone of permafrost development is able to cause the activation of biogeochemical processes, and speed up the release of greenhouse gases conserved in permafrost.

Authors established unique International network SakhaFluxNet of series scientific monitoring stations on studying climatic and biogeochemical cycles in a permafrost zone (forest and tundra) in the North-East of Russia.

The measurements of carbon cycle componens were conducted using up-to-date modern equipment – supersensitive systems of eddy-covariance technique with 10 Hz: on CO2 – an infrared gas analyzer LICOR-7500 (LICOR, Nebraska, USA) with a Gill, USA ultrasonic anemometer (Gill Instruments, Lymington, UK); on methane – an infrared LGR Fast Methane Analyser with a Gill, USA ultrasonic anemometer (Gill Instruments, Lymington, UK), and a portable infrared gas analyzer INNOVA 1412 (Photoacoustic Field Gas-Monitor, USA). Soil respiration was measured using a Free University of Amsterdam made automatic system on the base of CIRAS unit (PP Systems, UK) with four chambers, as well as using portable gas analyzers EGM-4 (PP Systems, UK).

For the first time in the conditions of Eastern Siberia an attempt has been made to ground the photosynthetic productivity of plants in terms of physiology, and quantitative parameters of the productive process were obtained. Original data on sink-source relations of plants are stated at the levels of whole plant organism and community. A number of specific results have been got: 1) conclusion was made about high depositing role of the root system of high latitude plants; 2) micrometeorological estimates of carbon balance were done; 3) quantitative dependence of CO2 concentration on the season period, weather condition and forest fire intensity was shown; 4) carbon parameters of forest and tundra ecosystems were investigated; 5) attention was drawn to short vegetative period of plant development – this feature contributes to enrichment of the atmosphere of high latitudes by carbon dioxide.

The growth of wood species in Eastern Siberia during growing season is provided by high rates of photosynthesis and transpiration at relatively low dark expenses on respiration and maintenance. High inter-annual variability of NEE, photosynthesis and dark respiration testifies to high adaptability of wood plants to the specific conditions of cryolithozone.

Minor Elements in Bottom Sediments of the Lakes of Yakutsk

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Lake sediments provide information on climatic and geochemical conditions that is useful in assessing the ecological state of the air and water environments. Many contaminants are accumulated in the lake sediments. Besides being indicators of water quality, they can be sources of secondary contamination. Changes in pH, Eh, temperature and gas composition may cause the compounds fixed in bottom sediments to dissolve, discharged into the water and enter the food chain. Some relatively inert or non-hazardous substances may convert to soluble and toxic forms (for example, transformation of elementary mercury to methyl-mercury).

The author studied bottom sediments of the lakes in the city of Yakutsk to assess the environmental quality and contamination levels of the lakes. The study included both large (Beloe, Saysary, Sergelyakskoe, Ytyk-Kyel) and smaller lakes. Sediments were sampled in the accumulation zone where fine material with good sorptive capacity is deposited, from the 0-15 cm layer. Concentrations of minor elements in bottom sediments were determined by atomic absorption spectrometry and approximate quantitative spectral analysis. In total, 40 sediment samples were collected.

The bottom sediments of the Yakutsk lakes show a large range of salinity, varying from 0.011 to 4.548%. The heavily contaminated lakes, such as Khomustakh and Teploe, have higher salinity values. Most lakes with increased sediment salinity (>0.15%) are confined to the densely built-up areas on the first river terrace. The increased sediment salinity in the lakes of Yakutsk caused both by climatic and anthropogenic factors results primarily from elevated concentrations of chlorine, sodium and magnesium ions which exhibit significant correlations with each other. In contrast, minor elements show no increase in concentration.

Concentrations of most minor elements in the lake sediments are well below the maximum allowable limits. Levels of mostly chalcophylic elements (As, W, Ag, Pb, Mo, Co, Cu, Hg, Zn) significantly exceed the allowable limits. Depleted levels, well below the background values, are characteristic of a complex of chalko- and lithophylic elements, such as V, Ni, B, Li, Ga, Nb, Sn, Cr, Ge, Y. Most chemical elements have about similar levels in the bottom sediments and in the soils, suggesting the transfer from the watershed to the lakes in the solid phase in the form of primary and secondary minerals.

Cd, Ag, W and Sn showed an increase in concentration in the lake sediments during the study period 1998 to 2011 by a factor of 8-19. Concentrations of toxic elements, such as Pb, Cu, Hg and Zn have doubled or tripled over this period.

The ecological geochemical assessment of the lake sediments was made in relation to the allowable limits for soils, because no sanitary standards exist for bottom sediments.

Conclusions. The lakes with increased salinity are mainly located in the densely developed, older parts of the city within the first terrace of the Lena River.

Rapid accumulation of contaminants, Pb, Cu, Zn, Cd, Sn, Ag, Cu, W, in the bottom sediments is observed, the concentrations of which have significantly increased during the last decade.

Sediment contamination levels for most lakes of the city are estimated to be low or moderate. In some lakes, however, contamination levels have reached high or extremely high levels.

Deep Fossil Carbon - Spatial and Temporal Variability of Organic Matter Pools in Permafrost

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The estimation of the carbon pool stored in (sub-)arctic permafrost and its biogeochemical characteristics are essential topics in today's permafrost research. While the uppermost cryosoil horizons are well-studied and already recorded in the Northern Circumpolar Soil Carbon Database (NCSCD), there are still large uncertainties concerning the quality and distribution of deep (i.e. up to decameters) fossil organic carbon stocks.

Well-exposed permafrost sections along the arctic sea coast and river banks in northern Yakutia are excellent objects to study permafrost organic carbon characteristics in connection with cryolithogy, cryostratigraphy and past periglacial landscape dynamics.

Organic carbon occurs in permafrost as large tree trunks, peat inclusions, twigs and root fragments, other solid plant remains, and finely distributed plant detritus. Also fossil mammal remains, insects, aquatic zooplankton and -benthos, and soil microorganisms are significant organic matter sources, and finally the decomposition and metabolic products of all sources in terms of particulate and dissolved organic matter. These different kinds of fossil organic matter were formed, deposited, frozen, thawed and partly degraded, and sometimes refrozen, under different paleoclimatic and paleogeographical conditions of the Quaternary past. Therefore, the deep permafrost organic carbon pool is far from homogeneous and strongly linked to depositional and permafrost dynamics as well as the ecological and climatic history. The archive of specific biogeochemical and cryolithological features of frozen ground is recorded in permafrost sequences of about the last 200.000 years in northern

Yakutia. We present the variabilites of the spatial distribution of organic carbon and organic matter qualities between different stratigraphical units, between correlated stratigraphical units of several sites, and even within stratigraphic units at the same site.

Especially the coverage and composition of the widely distributed late Pleistocene Yedoma horizons and its thermokarst-affected derivatives in alas depressions are of interest to climate modeling, microbiology or biochemistry. There are significant differences to former estimates of the area, thickness of the relevant frozen deposits, ground ice content and finally in organic carbon content that lead to a reassessment of the deep permafrost carbon pools of the northern high latitude Yedoma region.

Oil Contamination Influence on Water Phase Composition of Frozen Sand

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Gas and oil reserves are located mainly in the northern regions, and the majority of them - in the field of dissemination of permafrost. Much of the permafrost zone is occupied by saline frozen rocks [2].

Oil pollution of soils can occur in various ways: in mining, storing it in the fields, also there is a risk of leakage during the transportation of crude oil and petroleum products. During the oil extraction oil contamination often is accompined by salinization of the soil. The sources of salts are stratified fluid, waste water, the contents of barns and other geochemically active substances used for extraction and desalting. In addition, the joint salinity and contamination can occur at the outpouring of oil on the territories where saline soils are distributed.

The object of our research is the studying of combined effect of salinity and oil contamination on soil properties [1,3]. In our report the results of experimental studies of freezing soil temperatures and the unfrozen water content are considered.

The object of the study was fine grained quartz sand (classified in accordance with GOST 25100-2011). For salinization NaCl was used. The samples were prepared with the given values of salinity 0, 0.5, 1%.

Oil pollution was carried out of the West Siberian oil. Contamination was calculated relative to the weight of dry soil. For experimental research samples were prepared with values of pollution 0, 2.5, 8%. In this way the study was conducted with samples of 9 different combinations of salinity and oil pollution.

Investigation of the temperature of the phase transitions was performed by cryoscopic method and the water phase composition – by a combination of cryoscopic and contact methods, the application of which to saline soils has been proved earlier [4].

In the analysis of the results led to the following conclusions: - oil contamination has no influence on the temperature of freezing in a non-saline and saline soil, but has a different effect on the kinetics of the process of thawing of soil;

- thermograms for thawing at temperatures range from -24 ° C to -21.1 phase transition is fixed for saline samples, it is associated with formation of NaCl cryohydrates, due to the increase of pore fluid concentration to the eutectic values during freezing process; oil pollution does not affect on the cryohydrates formation temperature;

- the study of the joint influence of salinity and oil contamination on the water phase composition revealed dominant influence of salinity on all the investigated properties, oil pollution has almost no effect on the amount of unfrozen water in soil.

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The Northern Circumpolar Soil Carbon Database: Current Status and Call for Collaborations

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Global estimates of soil organic carbon (SOC) stocks do not account for pedogenic processes unique to permafrost environments. The Northern Circumpolar Soil Carbon Database (NCSCD) was compiled to address this lack of knowledge of the role of permafrost affected soils in the global C cycle. The NCSCD links 1.778 pedons from the northern permafrost regions to several digitized regional/national soil maps to produce a combined circumpolar coverage. Together these datasets have been used to quantify SOC storage in the topsoil (0–30 cm depth) and down to a depth of 100 cm. Using this database, Tarnocai et al. (2009) estimated SOC mass (SOCM) in the northern permafrost region to be 191 Pg for the topsoil and 496 Pg for the upper meter of soil. Not included into the spatially distributed NCSCD, but in recognition of the key pedogenic processes that transport C to depth in permafrost soils, Tarnocai et al. (2009) provided a first order estimate SOC mass from 0-3 m soil depth of 1024 Pg.

Recently, the NCSCD has been made available through an open access website (http://bolin.su.se/data/ncscd/) in several different file formats suitable for applications in Geographic Information Systems (GIS) and model applications (see Hugelius et al., 2013a for a full technical description of the database). A recent updated version of the database includes an updated pedon dataset for spatially distributed estimates of SOCM between 100–200 cm and 200–300 cm (an additional 524 and 356 pedons, respectively (Hugelius et al., 2013b). Initial analyses of these new datasets confirm the findings of Tarnocai et al. (2009) with estimated high storage of SOC below 100 cm depth, particularly in cryoturbated soils and frozen organic soils.

The majority of the northern circumpolar permafrost zone is located in the Eurasian landmass. Despite this, there is currently a lack of Eurasian soil field data in the NCSCD; only 36% of the pedons available to characterize SOC storage are from this region. The majority of available pedons from Russia are geographically clustered in the Usa River Basin of the European Russian Arctic, the West Siberian Lowlands (organic soils only) and the Yedoma region of Eastern Siberia.

The NCSCD is viewed as a valuable, open access, scientific resource which will be updated and evolve as our scientific understanding of permafrost region soils increases. We invite collaborations with individual researchers or institutions that are interested in sharing feedback, knowledge or field data to further improve the NCSCD.

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Polycyclic Aromatic Carbons in Human Affected Soils of Arctic and Antarctic

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Polar soils of Arctic and Antarctic has been affected by antropic influence during the last 50 years. The main part of this affect is direct contamination by organic and inorganic compounds, which are produced by seasonal or over year stations activity. This activity is mostly expressed in pollution of natural components by the products of diesel stations works. Polar power stations pollute the nature by polycyclic aromatic carbons which are the products of the fuel combustion. Investigations conducted shows that there is an essential accumulation of PAHs in those soils which are situated close to polar stations. This degree of contamination does not exceed the critical level. The amount of individual fractions of PAHs higher in all soils, situated near the polar stations, than in undisturbed soils. Also the content of benzo(a)pyrene is increased in soils and ground of stations in comparison with natural ones. These give an idea that soil pollution is an active process in Arctic and Antarctic landscapes. The dataset on soils pollution in both polar regions discussed in presentation. Data on reference unpolluted soils discussed as well.

Session 4: Permafrost and trace gas exchange

Cryogenic Pumping Could Form Methane Seeps from Permafrost

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Permafrost degradation due to changing climate or other disturbances could result in emissions of gases which were buried in or below the permafrost to reach the atmosphere. Several studies assessed the consequences methane discharge due to permafrost thawing as amplifying the greenhouse effect during Holocene warming. It is generally assumed that the methane originated from decomposition of organic matter which is thawing from permafrost. Here we show that methane is already present and distributed and pressurized in porous material of the permafrost sediment and that this is old methane which concentrated during the permafrost formation processes about 10000 years ago. Thus, high methane fluxes e.g. from the thaw lakes cannot be attributed to modern anaerobic degradation of organic matter, but to the discharge of methane reservoirs being buried within or below gas-impermeable layers of the permafrost. Our findings change the insight of the role of permafrost degradation on modern methane fluxes and their timing.

Interannual Changes in PAR and Soil Moisture during the Warm Season May be more Important for the Sign of Annual Carbon Balance in Tundra than Temperature Fluctuations

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A lot of studies of the global climate change impact on natural plant communities deal with cryogenic ecosystems. Special attention is paid to tundra, since it is characterized with low air temperature and underlying permafrost, both making it extremely sensitive to climate fluctuations. Continuous warming in Northern

Hemisphere reveals more details concerning complex system of relationships, feedbacks, and interactions of the factors of carbon balance. While the set of such factors is currently understood, their relative contribution to C-balance depends on temporal scale of observations and is not constant. The results of field observations and modeling of tundra ecosystems show any one of significant factors can become the leading one at some scale of observations. Even the least significant factor can determine the sign of annual net flux of carbon in tundra ecosystem if contributions of more significant factors offset each other. In the most general situation, the greater the variation of a significant factor during the period of observations is the larger is its partial contribution. The complete set of independent variables of C-balance is not limited by abiotic factors but should include such an important factor as aboveground phytomass, which can be treated as not only the natural product of C-balance but also as its independent parameter.

Airborne Carbon Dioxide and Energy Flux Measurements in the Lena River Delta

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Arctic climate change may lead to thawing of permafrost and the mobilization of carbon pools that have accumulated over thousands of years. Significant amounts of organic material are stored in the upper layers of high latitude permafrost areas. Due to a strong Arctic warming trend, potentially large greenhouse gas emissions from Arctic and sub-Arctic areas are of concern. The Lena River Delta located in north-east Siberia is the largest delta within the Arctic Circle, characterized by wetland ecosystems and wet polygonal tundra environments. These environments are currently thought to be sinks for carbon dioxide and sources of methane.

Tower-based eddy covariance is the most widely used direct method for quantifying exchanges of momentum, energy and trace gases between the surface and the atmosphere. However, they cover a relatively small footprint are constitute point measurements relative to the vast extend of tundra ecosystems. To improve spatial coverage and spatial representativeness of these direct flux measurements airborne eddy covariance flux measurements across large areas are required. We used the helicopter-carried measurement system “Helipod” equipped with a turbulence probe, fast temperature and humidity sensors, and a fast response carbon dioxide and water vapor analyzer to measure turbulent fluxes along two flight transects across the Lena River Delta in August 2012. Our contribution will present an overview of the experiment as well as preliminary results from this first measurement campaign.

In order to cover the whole turbulent spectrum and at the same time to resolve turbulent fluxes on a regional scale, different integration paths were analyzed and validated through spectral analysis. Strong regional differences in turbulent carbon dioxide and latent heat fluxes were detected. This indicates the non-uniform distribution of sources especially in wet sedge-, moist grass-, and moss-dominated tundra. In contrast, the sensible heat flux showed less variability across the investigation area. The obtained results are essential in understanding the Arctic carbon cycle and changes in atmospheric greenhouse gas concentrations.

Isotope and Gas Properties of the Ground Ice as a Proxy of Climatic and Environmental Conditions in West Arctic

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Presented and discussed the new data of gas properties (total gas content and composition) and water stable isotopes of two climatically contrasted Holocene and Pleistocene syngenetic ice wedges (SIW) and two types of tabular massive ground ice (TMGI) near Marre-Sale polar station, West Yamal, Russia.

Our data set also supports the previous assumption that the ice wedges with isotopic signature (-25-23ppm for 18O and -190-180ppm for D) were formed in Pleistocene winters and the ice wedges with isotopic signature (-17-15ppm for ^{18}O and -118-114ppm for D) in Holocene.

For carbon dioxide, all ice wedges mixing ratios are clearly higher than the atmospheric values (0.03pct), the highest values being observed in Pleistocene ice wedges (0.97 pct), in Holocene ice wedges - (0.64 pct). Oxygen shows consistently lower values than the atmosphere (of the order of 4-7 pct), and nitrogen is slightly higher, balancing other constituents.

On the contrary, methane mixing ratios show their lowest values in Pleistocene SIW (0.004%), in Holocene SIW - (0.164 pct). Air bubbles trapped in polar ice provide an almost direct record of atmospheric methane over the last 800 kyr (e.g., Loulergue et al., 2008), methane budget for the periods is known: present (0.167 pct), and Last Glacial Maximum (0.036) (e.g., Josuer Bock et al., 2012) and it is comparable with our data. Different methane mixing ratios in SIW suggest different climatic and environmental conditions. These properties are consistent with SIW developing under relatively warm Holocene conditions and cold in Pleistocene.

Methane mixing ratios in TMGI show highest content (till 1, 37 pct). Isotopic measurements of the 13C -70,5ppm, and D -326ppm in methane are typical for gas formed with the participation of vital functions of bacteria.

Found that the isotopic values 13°C in methane are close to the values of the carbon isotopes of methane horizons at depths of 46-52 and 114-120 m in the Bovanenkovo gas field, West Yamal, and characterized of isotope volume -70.4-76.8ppm.

Source of methane in TMGI could not be methane hydrates, because methane hydrates have a specific deuterium isotopic signature of about -190ppm, versus about -290ppm for mean of other sources.

This pilot study detailed gas content and composition, and water and gas isotope analyses of ground ice sheds more light on the conditions of ground ice growth under changing environmental conditions. Higher temperatures in a Holocene resulted higher methane content in SIW, relatively high carbon dioxide levels. Lower temperatures in a Late Pleistocene resulted lower methane content in SIW.

It is difficult to select potential sources bubbles trapped gas in TMGI. This heterogeneous medium, rich in organic matter, might have favored the anaerobic microenvironmental conditions necessary to explain the maximum methane content levels. Marshy coasts near shallow seas may have contributed to such conditions.

The content of marsh gas in TMGI excludes their glacial origin.

Methane and Methane-Producing Archae in the Antarctic Permafrost

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Compared to the permafrost of the other continents and cryosphere components, permafrost of the Antarctica has not been sufficiently studied. Little is known about its contribution to the global biogeochemical cycle. Unlike Arctic permafrost, Antarctic permafrost has low organic carbon content (0.01%–1.5%) and today its contribution to the greenhouse gas emission is negligible on a global scale. In the future, however, the role of Antarctic permafrost as a source of carbon may become more important as the vast territory is freed off ice and activity of the active layer is increased through colonization by the new plant species and communities of microorganisms as well as the release of the methane deposits conserved in the permafrost.

Our research on the permafrost sediments in the free of ice Antarctic regions has shown presence of methane of biogenic origin in the marine and the lacustrine sediments as well as the sediments of the seasonal waterways near the Bellingshausen station, near the Progress and the Novolazaresvkaya stations, as well as in the Bunger Oasis.

We have also shown the presence of the biogenic methane in the epicryogenic sediments, i.e. Late Pleistocene lacustrine sediments of the Dry Valleys (Miers Valley). Our analysis of the isotopic composition of the subsurface sandstones of the Sirius Formation (Mt. Feather, Dry Valleys) established presence of the non-biogenic methane and its homologs (ethane, propane) and ethylene.

We used 16S rRNA gene based clone libraries to assess the arhaea communities in the marine terrace permafrost sediments near the Bellinsghausen station and the lacustrine sediments in the Bunger Oasis. Our analysis has identified dominant phylotypes closely related to the methanogenic archaea in the permafrost sediments of the marine and lacustrine origin. Marine sediments were represented by a large diversity of the dominant and minor phylotypes of the genera *Methanosarcina, Methanobrevibacter, Methanogenium, Methanolobus* and *Methanoculleus*, and two dominant phylotypes of the Methanomicrobia class. The Archae diversity in the Bunger Oasis sediments was less extensive and was only characterized by two representatives of class Methanomicrobi.

Our analysis of the enrichment cultures from the permafrost sediments in the Miers Valley determined dominant presence of the methanogens of the *Methanosarcina* genus. This research confirms the biogenic origin of methane in the Antarctic permafrost sediments. The role of these sediments as the methane reservoir is yet to be established.

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Carbon Dioxide Production and Water Extractable Organic Matter of Soils in Discontinuous Permafrost Zone of Western Siberia.

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According to the existing world assessments, northern ecosystems represent the main source of carbon dioxide and provide its planetary maximum in the atmosphere.

The research area is located in the north of Western Siberia (Nadym, Yamalo-Nenets Autonomous District, Russia) within the northern boundary of north taiga. It's zone of discontinuous permafrost. It's absent under forest site and bogs, and exist under peatlands. The research was carried out at three sites: the forest site, the frozen peatland and the relic frozen peatland. The forest site represents lichen-pine forest without permafrost in the soil profile. The soil was classified as Podzols. The frozen peatland represents flat and slightly inclined main surfaces of peatlands with cloudberrysphagnum cover. The active layer is peaty horizon with underlying mineral stratum. Permafrost occurs below 80 cm. The following type of soil was identified as Turbic Cryosols. The relic frozen peatland is characterized with locally bare peat spots, sparse vegetation and permafrost from 50 cm in the peat layer. The soil is classified as Cryic Histosols. Regime monitoring of the carbon dioxide emission and concentration in soil horizons, regime monitoring of the temperature were determined in field conditions, and some of general properties of the soil – in laboratory.

Results and discussion.

The carbon dioxide emission are low in this region (115±77 $mgCO_2/m^2hr$), which indicates the low biological activity of research soils. Maximum emissions are characterized by Podzols of forest ecosystem, minimal – Cryic Histosols of relic frozen peatland. Mean emissions are identical for the three years of measurement and placed in the confidence intervals for ecosystems.

Change in the concentration of CO_2 in the soil profile depends on the depth and presence of permafrost and hydrothermal conditions: soils with deep permafrost are characterized by increasing of concentration CO_2 with depth.

The daily dynamics of gas emission and concentration, with a maximum in the afternoon, is associated with the daily air temperature dynamics.

Soils of forest are characterized by the highest biological activity, which related with favorable geo-cryological, hydrothermal conditions in comparison with other objects.

Research ecosystems are characterized with high variation of the total carbon content (37-53%) and very high variation of water extractable organic carbon (0,35-1,65% of C total) in organic profile of the soils. The maximum carbon content found in organic profile of Podzols.

Based on the correlation analysis we revealed a high and significant correlation carbon dioxide emissions with reserves of water-soluble carbon in the upper 20 cm soil layer (ß = 0.899; p-level=0,00) and with geo-cryological conditions - existence of permafrost in the soil profile ß = 0.993; p-level=0.00).

We consider the main factor which determine amount of soil CO_2 production is the existence and depth of permafrost, as it determines the type of ecosystem in such transitional landscapes and organic matter transformation processes.

Underestimation of the spatial heterogeneity of soil and vegetation cover in the region of discontinuous permafrost can lead to substantial distortion of estimates of the total emissions.

The Influence of Climate Warming and Greenhouse Gas Deposition on H^+ Migration in the Geosphere

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The migration of H^+ (pH) in precipitation, lake waters and land cover was studied in the area of Yakutsk in the long-term ecological and geochemical monitoring of the environment (Makarov, 1985, 2007). During the study, a comprehensive geochemical assessment of the migrating and depositing environmental components -

air, snow, soil, surface water and groundwater - was carried out.Human activities (burning of fossil fuels) emit greenhouse gases into the atmosphere. They affect the energy balance of the Earth, which in turn can affect the temperature. Most climate scientists relate the observed warming to the increasing concentration of carbon dioxide in the atmosphere. For this reason, during the last century, the average global temperature has increased by 0.6°C.Climate (temperature) change and increased atmospheric concentrations of greenhouse gases are also observed in local areas. Monitoring of atmospheric greenhouse gases performed by the Melnikov Permafrost Institute (N. F. Fedoseev) in the vicinity of Yakutsk since 1997 has shown a consistent increase in concentration of carbon dioxide in the near-surface air from 363 ppm in 1997 to 398 ppm in 2011, with a steady positive trend of about 2 ppm/year Yakutsk has experienced significant warming over the last three decades. Y. B. Skachkov's (2012) data indicate an increase in mean annual air temperature of 0.7°C over this period. We have studied the migration of H^+ (pH) in precipitation, lake water and soil of Yakutsk associated with increased atmospheric carbon dioxide and climate warming. CO_2 is a natural agent that exerts the greatest influence on the presence of free hydrogen ions - H^+ in atmospheric water, because the concentration of hydrogen ions in the water depends on the content of carbon dioxide. Other conditions being equal, the more CO2 is contained, the more the hydrogen ion concentration and the smaller the pH.The relationship of the hydrogen ion level to the concentrations of other ions in precipitation (neglecting the contribution of weak organic acids) is expressed as:$(H^+) = 2(SO_4^{2-})+(NO_3^-)+(Cl^-)-2(Ca^{2+}) - (K^+) - 2(Mg^{2+}) - (Na^+) - (NH_4^+) +2.5\cdot10^{-6}$.The remainder term in this expression – $2.5 \cdot10^{-6}$ mol/l - corresponds to the H+ concentration in the equilibrium aqueous solution (pH = 5.6) at an average atmospheric carbon dioxide of 330 ppm and a temperature of 20°C. This value generally corresponds to unpolluted rain. In the process of long-term monitoring of atmospheric precipitation in Yakutsk dynamics of the H^+ concentration (pH) in precipitation was traced. In the last 20-25 years there has been a steady increase in the concentration of carbon dioxide in the atmosphere, which is accompanied by a steady decrease in the pH of precipitation, their transition from slightly acidic to slightly alkaline (pH_{1989} = 8.0; pH_{2012} = 6.66). The atmospheric H^+ deposition to the surface increased nearly sevenfold (pH_{2000} = 0.14; pH_{2012} = 0.97g/m^2/year) from the beginning of the twentieth century to 2012. The increased deposition of H+ cation from the atmosphere to the ground surface is accompanied by an increase in soil acidity in the city. During the period of our observations, the average soil pH at Yakutsk changed from the alkaline values - 8.10 in 1982-1984 to 7.51-7.56 in 2008-2011. The areal extent of acid soils with pH<7 increased from 0-2% in 1982 – 1984 to 8% in 2008 and 10% in 2011. Highly alkaline soils with a pH above 8.5 virtually disappeared from the territory of the city, and in some areas there were soils with acidity less than 6.8, to pH=5.6. Under the influence of acid-forming substances, the soils become depleted of exchange bases, and the weak natural acids (hydrocarbons) are displaced with man-made sulfates and nitrogen compounds, resulting in lowering the pH of water. Maximum acidification occurs on the soil surface and in the seasonally thawed layer at a depth of 1-2 m no acidity changes are observed. The increased H+ cation deposition from the atmosphere and soil acidification has caused a change in the acidity of lake water in the city. The average pH of lake water lowered from 8.1-8.8 in 1986-2003 to 7.6-7.8 in 2009-2012. Possible adverse effects may be associated with the occurrence of acid geochemical barrier in places of the increasing acidity of ground water. Moreover, the barrier may also occur under alkaline conditions when the strongly alkaline medium is changed to slightly alkaline. Anionic components - silica, molybdenum, selenium, and others whose mobility is reduced in an acidic medium – are concentrated at the acidic barrier. Elements forming easily soluble anionic and carbonate complexes in alkaline medium - B, V, Mo, As, S, Cr, can significantly extend the range of migration. Soils with neutral pH values are favorable For the majority of plants and further increase the acidity can lead to degradation of vegetation in the city.

Potential Resources of Unconventional Gas in Russia and Prospects of their Commercial Development

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The prospects of commercial development of unconventional gas resources are the subject of wide speculation in mass media, professional community and governmental authorities recently. The significance of the study of unconventional gas resources is evident and resulted from several fundamental reasons.

Unconventional gas has wide distribution in the Earth crust and huge resource potential, which far exceeds those of the conventional natural gas. The competitive ability of any uncon-ventional gas approaching the conventional one due to its resource depletion, structure deterioration as far as smaller fields remote from unified gas supply system are put into production.

An additional point is that the research of unconventional gas resources is important when planning external economic activity, because of an opportunity to react swiftly to changes in export-import balance. For example, more than 50% of internal gas production in USA comes from unconventional gas sources and their share is increasing. In connection with an advance in unconventional gas resources exploration in USA, many countries, which are traditional markets for Russian gas (West Europe, China and etc.), show great interest in using of American experi-ence for exploration their own unconventional gas resources.

Business value of unconventional gas development will be determined by the balance of the following factors of different nature: geological (permeability, free gas proportion, depth of occurrence), technological (density of resources, gas flow rate, wellhead pressure), as well as economical (distance to consumer, price for gas etc.) and environmental. The business value of some unconventional gas resource cannot be categorically determined at this stage of investiga-tions since new data and new technologies may shift key points. However the general trend of the competitive ability of any unconventional resource type approaching the conventional one can be clearly tracked.

The survey of world experience of prospecting of unconventional gas (gas hydrates, coal-bed methane and shale gas), as well as tight gas and gas of deep reservoirs and also prospects of their commercial development in Russia in view of geological-economic conditions are consid-ered in the report.

The Influence of Carbon Dioxide Pressure at the Ice Melting Temperature

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Possibility of CO_2 sequestration in a gas hydrate form within permafrost is studied actively at the present time. Due to presence of the gas hydrate stability zone, permafrost is considered to be a promising environment for CO_2 storage [1,2]. As this take place, it should take into consideration that good solubility of CO_2 in water decreases the ice melting tempera. As a result, the coordinates of the Q1 quadruple point of water-ice-hydrate-gas equilibrium are changed.

This paper presents experimental data on determination of the Q1 quadruple point for CO_2 hydrates, as also the data on phase equilibrium for water(ice)-hydrate-gas and water-ice-gas. The data were obtained using visual observations and PVT measurement.

Distilled water and CO_2 gas (99.9 mol%) were used in our experiments. To study the behavior of the samples, method of visual observations using optical microscopy was chosen. Visual observations were supplemented by pressure and temperature measurements. A detailed description of the experimental setup, as well as the methods of producing hydrates and study of their dissociation is given in [3]. The main element of the setup is the high pressure reactor. On the lateral surface of the reactor there are viewing window for visual observation of the processes inside the reactor. The reactor is placed in the Teledor thermostat controlled room. Monitoring of the processes taking place inside the reactor is done using cathetometer B-630. The cathetometer eyepiece is fitted with a digital camera.

In the experiments on the determination of ice melting point under pressure of CO2, ice was prepared by freezing of small water droplets sprayed on a transparent Plexiglas plate cooled to a temperature of 253-258 K. The plate with frozen water droplets was mounted inside the reactor. After evacuation, the reactor was slowly charged with CO2 at a fixed temperature up to pressure when the melting of ice was observed. The melting of ice was judged from the appearance of smooth liquid phase on the rough surface of frozen water droplets.

In experiments on ice(water)-hydrate-gas equilibrium, bulk samples of hydrate obtained from ground ice were used. The sample was cooled to the temperature of the experiment after that pressure was lowered for hydrate dissociation. Due to hydrate dissociation, pressure increased. The pressure which was not changed during two hours was chosen as the equilibrium pressure of gas hydrate dissociation. Then the sample was heated to the new chosen temperature and the equilibrium pressure of hydrate dissociation at this temperature was determined.

As a rule, the Q1 quadruple point is determined by the intersection of the equilibrium curves ice-hydrate-gas and water-hydrate-gas. The literature data on Q1 quadruple point for CO_2 hydrate have are scattered. Using the method of visual observations, we obtained the curve of the ice melting temperature versus pressure up to 271,15 K. Intersection of the equilibrium curve of hydrate dissociation and the ice melting curve allowed us to determine the Q1 quadruple point of CO2 hydrate.

The obtained experimental data allowed us to define more accurately P, T coordinates of quadruple point of Q1 for CO_2 hydrates. According to our data, the coordinates of the quadruple point are P= 1.03 MPa T=271,65 K. So CO_2 has a greater influence on melting temperature of ice as compared with hydrocarbon gaseous. As results of this, the dissociation of CO_2 hydrates into water and gas starts at temperature 271,65K. This is 1.5 K below the melting temperature of ice.

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Influence of Inhibitors on Induction Time Hydrate Formation

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One of the problems faced by the oil and gas industry in the areas of permafrost is the formation of gas hydrates. To date, for preventing hydrate formation in Russia widely used is methanol. Methanol is classified as thermodynamic hydrate inhibitors, biasing a line of three-phase equilibrium of gas-water-hydrate at lower temperatures. The main disadvantages of methanol is its high rate (20-50%) and toxicity [1]. Search alternative methanol 90s led to the discovery of a new class of materials - kinetic hydrate inhibitors. This is basically watersoluble polymers with a relatively environmentally friendly low flow (0.25-1%). Kinetic hydrate inhibitors compared with thermodynamic inhibitors have limitations on temperature and time inhibition [2,3]. These limitations constrain their use in permafrost areas. To date being actively search for and development of new environmentally friendly kinetic hydrate inhibitors.

To study the influence inhibitors on hydrate formation process we have developed and built high-pressure reactor with mixing device that simulates dynamics of flow in processing lines. Hydraulic test conducted showed use reactor up to 20 MPa and 233K. Testing of the reactor to determine the induction period is estimated based hydrate of distilled water. The sample temperature in experiments was 274 K and a pressure of 390 ± 10 kPa. Formation of gas hydrate produced on basis of technical propane (composition in wt. %: C1- 0.0165, C2-1.2350, C3-96.5817, iC4-2.1196, nC4-0.0471). In the course of experiments showed that induction period beginning hydrate substantially depends on speed mixing components. So at 1080 rev / min induction period beginning hydrate is 90 minutes, and a smaller number mixing have been not recorded formation of hydrates within 3 days. For determine the effect inhibitors on kinetic hydrate period beginning was used a solution of 0.1% polyvinylpyrrolidone (PVP). Experiments were carried out at 1080 rev / min during which validated increasing induction time beginning hydrate to 512 min.

Studies showed good reproducibility results. The experimental results confirmed influence PVP on increase induction time hydrate formation. Further studies suggest determination of the effect on the induction period of the beginning of the kinetic hydrate inhibitors synthesized based on polyesters.

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Session 5: Permafrost dating and paleoreconstructions

Paleocryoecological Niches in Permafrost Deposits

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Wide group of viable organisms from permafrost deposits was described and investigated during the last decades (aerobic and anaerobic bacteria, green algae, fungi, yeast, protea, mosses and grasses). Viable tissues of *Silena stenophilla Leded*. with age of 32 kyr that were found in buried burrows of ground squirrel (*Citellus undulates Pall*.) in permafrost at the depth of 40 meters gave shoots and then fertile plants gave new generations. Moss' spores from frozen samples of MIS2 and MIS3 deposits have shown their possibility to grow in the yedoma material without any special conditions: high temperatures or additional nutrition.

The analysis of number and structure of biological objects (including viable organisms) allows us to distinguish a number of cryopalaeoecological nishes – spatially detached volume of frozen deposits, ice forms or buried biological objects that can be characterized by similar genesis, structure, features and organization of biological material, similar way and time of burying. These characteristics determine viability of organisms that are cryoconserved here. The examples of such niches are the buried soils and peat volumes, alluvial layers, buried burrows, bodies of Pleistocene animals, big wood remnants, ice wedges with flora detritus, seeds, spores and pollen etc.

Some of these cryopalaeoecological niches are extremely rich with palaeoecological information. Buried rodents' burrows with age of 15-20 kyr may contain hundreds of thousands of plant seeds that have been preserved so well that they can be specified at the level of specie. We obtain here well-preserved mammal bones and bodies, hairs of mammoth fauna animals, feathers, eggs, insects etc. This material is also enriched with spores and pollen. So, this complex and be used in aims of palaeoreconstruction of given habitat.

Buried burrows show much higher viability of mosses than buried soils or yedoma deposits. The same thing with viable protea. This fact allows us to suppose that frozen burrows is one of the best cryobank of viable Pleistocene biota.

The analysis of conservation features of palaeobiological material in buried ground squirrel burrows (n = 70) shows that viability ratio may vary significantly. We suppose that there are buried burrows and other cryopalaeoecological niches with viable organisms that are preserved so well that they can be brought back to life in natural conditions.

Possibility of impact of Pleistocene biota on modern fauna and flora has to be proven. But our results show that ancient microorganisms, spores, protea and other organisms can be reconserved after tens of thousands of years. These facts bring new light on the issues of microevolution, ice age refugiums, plant cover genesis etc.

Yedoma of the Lower Kolyma: a New Insight into Palaeoenvironment

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In 2012, a complex study of two permafrost cores obtained by drilling on the Kolyma Lowland in scopes of the Polaris Project was conducted. The study is focused on investigating environments during and after formation of Late Pleistocene ice complex/yedoma.

BH 12/1 (15.1 m in depth) was drilled in the vicinity of Chersky (N68˚44' E161˚23', 60 m a.s.l.). It recovered homogeneous icy bluish-grey coarse silts with poor sorting. Average characteristics are as follows: gravity water content 40-50 %; bulk density 1.5 g/cm3; loss of weight on ignition 3%; chemical content from water extracts hydrocarbonate-calcium; minerlization 100-200 mg/l, pH 7, Eh 370 mv, 13˚C -25.8. Association of heavy minerals is biotite-epidote-amphibole. Association of light minerals is either chlorite-quartz-feldspar, or quartz-feldspar-chlorite. The considerable amount of light fraction represents clay-mica aggregates. AMS 14C dates obtained from the depths 2, 5, 9, 12, 15 m vary between 42 to 45 kyr. BP, that is MIS 3 or the Karginian horizon. The palynocomplexes reflect the cold and humid climate with domination of gramineous and mixed herbs associations in the deeper section, changing upward to phytocenoses of open forest with shrub vegetation. The upper most section part belongs to Holocene with predominance of tree-shrub associations. A new method applied is a determination of enzyme activity in permafrost soils by Phenol oxidase (POX), Beta glucosidase (BG), Phosphatase (PHOS), and Leucine-Aminopeptidase (LAP), normalized to organic material and DOC in silts. The biggest liability belongs to POX which shows the greatest values, between ca. 700 to 1500 µmol gOM-1 h-1 along the whole section getting the maximum 13900 at the depths less than 2 m.

BH 12/2 (13.4 m in depth) was drilled in the Pleistocene Park (N68˚30' E161˚30', 2.5 m a.s.l.) on the high floodplain terrace. The section is represented by fine sands (12.5-13.4 m), coarse silts (12.5-1.3 m), peat (1.3-0.6 m) and the uppermost floodplain clayey sediments forming the soil layer. Average characteristics are as follows: gravity water content 30 %; bulk density 1.7 g/cm^3; loss of weight on ignition 4%; chemical content hydrocarbonate-calcium; mineralization less than100 mg/l, pH 7, Eh 370 mv, 13C -26. Association of heavy minerals is pyroxene-epidote-amphibole. Association of light minerals is chlorite-feldspar-quartz. A considerable part of light fraction is composed of clay-mica aggregates. AMS 14C dates collected at the depths 5, 8, 11, and 13 m were ca. 18, 28, 46, and 45 kyr, correspondingly, that is relating to MIS 3 & 2, or the Karginian and Sartan horizons. The palynocomplexes characterize the change of climates as relatively warm and humid (13 m), cold and humid (11 m), cold and dry (10 m), warm and humid (7 m). The deposits are characterized by predominance of tree and shrub pollen indicating the distribution of birch-larch open forest with subdued landscapes of meadows, steppes, bogs, and stony tundra. Enzyme activity of LAP, BG, varies insignificantly. POX shows the most significant variation, with min 204000 to max 2305000 µmol gOM-1 h-1. The most active phases of enzyme activity are associated with climatic optima.

Micromorphological Analysis of Structures of Quaternary Sediments

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Investigations of structures of the quaternary sediments of 3 marine terraces of the Western Yamal Peninsula (northwestern Siberia, Russia) have been established on the macro and microscale by field and laboratory measures. The main focus was set on the development and transformation of the landscape as well as the sediments and their structures. The data allow one to reconstruct the changes of environmental conditions within the last 70 thousand years.

It may be noted that the most representative characteristics of the different sediments are based on the structure of basic mass, plasma, new formations and shapes of the organic matter. The quaternary sediments occur subsequently and represent three primary genetic types: marin, lagoonal and terrestrial. The structure of the marine sediments indicates calm conditions during sedimentation. The macro- and microstructure of the lagoonal sediments indicate more dynamic natural conditions during that period with swelling–drying-cycles. The deposition of the terrestrial sediments occurred at the final stage of the territory formation and it is currently in progress. The complex subtrate transformation is related to exogenic processes like cryogenic, aeolian, fluvial and pedogenetic alterations. A transitional zone between the lagoonal and terrestrial sediments was found implicating very unstable conditions while landscape changed from sea to land. So two major changes of the natural conditions are revealed during the Upper (Late) Pleistocene and Holocene.

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Cryogenic Structure as an Indicator of Climatic Epochs

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The cryostructural method for reconstruction of paleo-permafrost conditions was developed by the author in 1990. It is based on the physical-mechanical model of freezing fine-grained soil. The method is used to estimate the upper boundary temperature conditions during the formation of lenses or beds of segregated ice at different depths.

This paper presents results of the calculations of mean annual temperatures at the top of permafrost and in the air, as well as growth rates of segregated ice at times of formation of thick ice lenses and beds at different depths in glaciolacustrine deposits in the Norilsk area. Conversion from the mean annual temperature at the base of the active layer to air temperature is made by quantitatively incorporating the thermal effects of the main surface heat exchange factors.

The widespread occurrence of segregated ice beds in the Norilsk area is explained by the presence of confined groundwater which easily moves through the sandy soils and fissured rocks and by slow freezing of the deposits. These conditions provided a ready supply of water to the growing ice lenses and beds.

The calculations have shown that at the time of formation of segregated ice at 15 m depth, the temperature at the top of permafrost was -0.9°C, while the air temperature was 1.5°C lower than today (-9.0°C). The water flux to the ice lens at the groundwater head of 10 m was 2.4 • 10-10 m/s, and it took 434 days for a 1 cm thick ice lens to form. The calculated results analyzed with the history of the area suggest that freezing of the sediments occurred under conditions not much more severe than today.

An early and middle Wisconsin record of vegetation history preserved in the permafrost sequence of the Vault Creek tunnel in Fairbanks, Interior Alaska

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The permafrost sequence of the Vault Creek (VC) tunnel in Fairbanks, Interior Alaska, deposited during the early and middle Wisconsin period was studied using plant macrofossils.

Over most of the time span represented by the Vault Creek permafrost sequence, boreal coniferous forests largely resembling modern vegetation existed at the study site. The tree layer was dominated by spruce, mainly black spruce (Picea mariana). Also the other detected tree species such as gray alder (Alnus incana ssp. tenuifolia), birch (Betula cf. neoalaskana) and tamarack (Larix laricina) are regular constituents of modern vegetation in the study area. Most of these tree species and also the majority of herbaceous plants are characteristic of wet habitats like lake shores, muskegs, bogs, and peatlands. The pollen record of the VC tunnel indicates relatively warm climate conditions with the occurrence of Abies and Tsuga in large parts of the spectra. The presence of Tsuga or Abies could, however, not be confirmed by plant macrofossils.

Only one cold stage interval with a very few and poorly preserved plant remains could be found representing tundra steppe vegetation and very dry climate conditions. Among them, Phlox hoodii is characteristic of sagebrush and mountain grassland communities and occurs at dry, open, rocky, gravelly, or sandy sites. The plant is not able to withstand shading and therefore avoids forested vegetation. The other tundra steppe indicator plant in the assemblage is Kobresia, which is characteristic of dry, open, in winter snowless habitats in grasslands and tundra. Both taxa together clearly indicate a cold stage with cool and very dry climate conditions unsuitable for tree growth.

Above this cold stage interval, the preserved remains of spruce (Picea), wetland sedges (Carex sect. Phacocystis) and high northern buttercup (Ranunculus hyperboreus) reflect again a wet coniferous forest resembling modern vegetation around Fairbanks. The assumed paludification detected by the pollen record can be reproduced by plant macrofossils through the increase in the number of wetland sedges (Carex sect. Phacocystis, several hundred nutlets) including water sedge (Carex aquatilis) and spruce muskeg sedge (Carex lugens). During the time of deposition of that sample, the (dwarf) shrubs Betula glandulosa/ nana subsp. exilis, Empetrum nigrum, Salix sp., and Ledum palustre ssp. decumbens occurred in the shrub layer of a spruce forest, the existence of which is indicated by spruce needles.

In the uppermost studied sample, only Betula glandulosa/ nana subsp. exilis, Luzula sp. and Carex sect. Phacocystis could be detected indicating again wet habitats under boreal climate. Even though fossils of tree species could not have been proven, their existence cannot be excluded due to the incompleteness of the preserved plant macrofossil record in this sample.

Radiocarbon Dating of Peatlands and Frost Mounds in the Nadym River Basin

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Peatlands and frost mounds, occupying more 80 % of the area in the Nadym River basin, are involved in modern frost heaving and thermokarst, therefore peatlands and frost mounds are objects of our researches since 1970. Researches allowed us to establish the modern dynamics of these processes. For reconstruction of full chronology of development of processes of frost heaving and thermokarst we analyzed original and literature radiocarbon dates from peat and buried wood. Samples collected from outcrop and borehole in frozen peatland have been analyzed by palynological method (T.A.Blyakharchuk).

Radiocarbon dating had shown, that peat and buried wood in frost mounds are younger than 9800 years, and, hence, these formations are of Holocene age, that consists with Y.K. Vasilchuk conclusion (2012). Moreover it was found, that upper part of the frost mounds is frequently composed by peat older than 3000 years. After this time boundary, apparently, there was a suspension of peat accumulation at tops of frost mounds because of it appeared rather well drained. Now at the tops of many frost mounds took place a destruction of vegetation cover and formation of limited by area spots with bare peat deprived of vegetation cover. We assume that temporal recovery of vegetation on these spots can occur during humid years; therefore we organized an observation network on several spots.

The age of the peat from peatlands in flood plain of tributary of the Nadym River (from 3450 up to 6945 years BP) corresponds to the mentioned above time frames, but in general it is little bit younger, than age of peat of frost mounds on III lacustrine-alluvial plain.

The peat of flat peatlands, also, of Holocene age not older than 9000 years. However the upper part of peat thickness here is younger, than on frost mounds. It evidences that the suspension of peat accumulation marked earlier (during last 3000 years) on frost mounds has not been caused by global climatic changes, but rather by local processes.

The detailed palynological analysis of the upper two meters of peat in frozen peatland with age 4560+-120 years has revealed 7 phases in development of a vegetation cover, which differ from each other either by dominance of a treelike birch, or spruce, or pines (*Pinis silvestris* and *P. sibirica*). Change in abundance of local components in pollen spectrums (pollen of sedges and dwarf shrubs and also spores of Sphagnum) has shown, that freezing of peat thickness has taken place on a boundary of new era about 2000 years ago when the climate became drier and colder after period of humidification in second half of third millennium before present. Palynological markers (maximums of spores of Sphagnum and pollen of *Pinus sibirica*) specify more short episodes of freezing of the peat thickness, which took place about 3000 and 4000 years before present

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Cryogenic Strata of the Gas-Bearing Structures of Yamal

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Gas-bearing structures in cryolithosphere occupy a significant part of the incision Ceno-zoic of sediments. On the main characteristics of the cryogenic strata, situated above the produc-tive horizon structure (temperature gradients, the position of the isotherm 0 C, the power of the frozen part of the cryogenic strata, etc.), compiled overview of the permafrost zone for Western Siberia. In the middle- and fullscale mapping these characteristics are used for the interpretation of the cryogenic sections and interpolation in areas outside of the position gas-bearing struc-tures.

Gas-bearing structure is neotectonic formation in lithosphere. In the geological composi-tion the horizon of unconsolidated Pleistocene and Paleogene sediments cover the thick com-pacted sediments of the Late Cretaceous, that overlie the productive gas-bearing horizon of Early Cretaceous. During the Pleistocene on the roof of the degraded Last Cenozoic sediments had ac-cumulated sediments of Early and Middle Pleistocene, and the sediments of the Last Pleistocene suites formed the surface relief of many structures.

Geomorphological unit surface of the gas-bearing structures is different for shallow, up to 500-800m, gas bearing surface of the dome. In the shallow part of the underwater shelf slope (where the depth of the sea is about 100-120 m) are located Rusanovskaya and Leningradskaya structures. Sedimentation and relief forming in the hard climate conditions were connected by active synchronous freezing of the marine late Pleistocene sediments and epichronous freezing of more ancient underground strata. The ground moisture, which soaked up marine sediments, was fixed by freezing in singenetic and in epigenetic parts of the frozen strata. The whole history of sedimentation in the Late Pleistocene was directly connected with the synchronous and epichronous underground iceformation: ice-cement, segregated ice, polygon vedge ice, massive ice, gas-hydrate ice.

The upper part of the gas-bearing structure is occupied by the cryogenic strata. The posi-tive temperature gradient from the low boundary of the cryogenic strata to productive horizon showes thermal influence of the dome to the bottom, as it is known from a number of works G.B.Ostriy, V.V.Baulin, V.T.Balobaev a.o.

The capacity of the cryogenic strata is different and diverse in the gas-bearing structures with various geomorphologic device surface, geology composition of the above-dome part of the sediments, the depth of the gas bearing dome, depth of deposits of varying salinity.

Features of the cryogenic strata gas-bearing structures are shown in the series of geologi-cal cuts, accompanied by the stratigraphic working scheme, in a series of geocryological sections and maps of capacity. Most of them are published in volumes 1 and 2 of the publication «Cryosphere oil and gas condensate fields on the Yamal Peninsula».

Ground Ice from Larsemann Hills Oasis (East Antarctica): Geological Occurrence, Properties and Genesis

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Geological crossection of quaternary deposits 15 m depth in Larsemann Hills oasis was studied with the use of drilling rig and complex laboratory analyses of cores. Lower stratigraphic unit was interpreted as lacustrine-marine sediments 37820-17860 years BP meaning that relative sea level during MIS3-MIS2 period was at least 30 meters higher than present sea level allowing lagoon-type deposition. Upper stratigraphic unit was interprerated as end morain which marks the position of last glaciation which moved so far to the north during pre-Antarctic Cold Reversal glaciation 14 Ka BP or some minor Holocene surges.

Two different types of ground ice were observed in these deposits. The upper layer of ground ice is allocated on the contact between morain and lacustrine-marine deposits or in the upper meters of lacustrine-marine sediments. It is mostly clean transparent ice, sometimes with admixture of gravel and sand. The lower layer of ice lays into lacustrine-marine strata quite close to the aquiclude, which is presented by rock foundation; it is composed by laminated icy sediments with narrow-meshed inclined ice schliers 1-2 cm thick. Both ice layers were found in boreholes near the margin of Lake Reid at the quite close depths interval – 33-37 m a.s.l. for upper layer and 24-26 m for the lower layer.

We present results of complex analysis of the ice core including detailed characterization of ice structure, texture and contacts with host sediments. The isotopic analysis of ice is also currently carried out. This data allow us to make a choice between several theoretical possibilities of ground ice origin including sea or lake ice, glacier, firn snow, injection or segregation ice.

The work has been supported by RFBR, projects No 12-05-31442 mol_a and 12-05-31125 mol_a.

The Implementation of Cryogenic Weathering Index for Paleopermafrost Reconstruction by Example Late Pleistocene and Holocene Deposits of North-East Yakutia

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The investigation of the composition, structure and properties of the Late Pleistocene and Holocene deposits of North East Yakutia has been done. Ice Complex of Late Pleistocene (IC) and Holocene cover layer deposits in Bykovskiy peninsula and Cherskiy (Kolyma region), alasses and IC - cape Chukochy have been studied. Cryogenic weathering and permafrost acted the great role in the time of deposit sedimentation. For paleopermafrost reconstruction Cryogenic Weathering Index (CWI) has been calculated. It has been found that the least sever permafrost condition was in Kolyma region, for Bykovskiy peninsula and cape Chukochy it were similar. The increasing of cryogenic weathering over a period of Ice Complex formatting have been shown, the most sever permafrost conditions were in boundary of Late Pleistocene and Holocene (end of IC formatting and cover layer sedimentation). Alasses complex (lake-boggy and taberal thicknesses) formed in the soft condition, thawing and long-term period in thawed state were shown in more small values (<1) of CWI, than for adjacent IC.

The Details of Microbiomorphs Spectra from Buried Soils of Kolyma Lowland.

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Researches were conducted in Lower course of Kolyma, where ice complex deposits distribution. Pedogenesis was one of leading processes of thicknesses formation in a Pleistocene. The four paleosol profiles different age from deposits of stage of MIS 3 were object of our research.

Soil is open information system. It constantly receives and keeps information (including microbiomorph complexes) about factors of formation during long intervals of time. The microbiomorphs in buried soils are various. There are spore and pollen, detritus, phytoliths, sponge spicules, shell of diatom algae, amoebas shell.

Features of microbiomorphic complexes of buried soils are analysed. In material from paleosoils the big quantities of detritus is noted, the remains of epidermis of herbs, lignified shrubs tissue meet. The soil materials contain a lot of various phytoliths. Phytoilths various graminoids from which the Festuca group is distinguished are met. Phytoliths of carex, horsetail, dycotiledon herbs are found. A conifer remains and parts of dwarf steppe xerophytes flora, hydrophilic flora are rare. The remains of testate amoebas which are usually living in plant litter, peaty horizons of soils and peat often meet in a material of the top horizons

Content of pollen and spore in profiles of buried soils is estimated as average and high that it is enough for environment reconstruction. It is established, that the far transferable pollen (mainly trees and bushes) are dominated. This group of pollen can't be as indicator local phytocenosis, but with success can be used for comparison of palynological diagram even-aged paleosols in region, being at considerable distance from each other. The extra-local elements of spore-pollen spectrum indicate local features phytocenosis. This group of pollen has subdominated position in ranges (10-20%). Because in severe climate conditions part of plants passes to vegetative reproduction. It distorts conceptions about vegetable cover, received on the basis of the palynological analysis. Pollen of anemophilouse herbs meets in spectra often, entomophilous is rare. These different are caused by pollination mechanisms.

Microbiomorphic researches of paleosols supplement available palynological data and allow us to detail caracteristics of vegetable asociations of local places of soils formation. Microbiomorphic researches of paleosols supplement available palynological data and allow detailed characteristics of vegetable associations of local places of soils formation.

The studied ranges of complexes of paleofossils from Late Pleistocene soils show that they were formed in open landscapes with domination of herb associations with grass, sedges, sagebrushes, plant of Cruciferae and Caryophyllaceae family and participation of dwarf shrubs and moss in vegetable cover.

Late Holocene Climate and Environmental Changes in the Eurasian Arctic – Evidence from Glacier and Ground Ice (Eurasian Arctic Ice 4k)

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The Arctic as key region for the global climate system is more affected by ongoing climate change than most other regions and has experienced a strong warming in the recent decades. A better understanding and assessment of recent Arctic climate dynamics from a longer scale perspective requires detailed information on past changes and their causes from climate archives. Of particular interest is the natural climate variability in the Mid to Late Holocene. This period is characterized by relative stable boundary conditions of the climate system and by a negligible anthropogenic influence in the preindustrial period.

The research project “Eurasian Arctic Ice 4k”, funded by German Research Foundation (DFG), aims at the reconstruction of Late Holocene climate and environmental changes in the Eurasian Arctic using glacier and ground ice as climate archives, mainly by means of stable water isotopes. Whereas ice cores are known as one of the best climate archive, the analysis of ice wedges as mid-resolution winter climate archives is a relatively new approach.

Our study sites are so far located in the Laptev Sea region: (1) the ice core from Akademii Nauk ice cap (AN; Severnaya Zemlya; 80.5°N, 94.8° E), (2) ice wedges from the first Lena River terrace in the central Lena

River Delta (around 72.5°N, 126.5°E), (3) ice wedges at the top of the Ice Complex of Muostakh Island (71.4°N, 130.0°E) and (4) ice wedges in a huge Alas at the Oyogos Yar coast of the Dmitry Laptev Strait (72.7°N, 143.5°E). This dataset will be complemented by additional field campaigns and other available ice-core and ice-wedge data from the Eurasian Arctic.

The combination of ice-core and ice-wedge records will provide new insights into the Late Holocene climate dynamics of the Eurasian Arctic, into their causes and into the moisture generation and transport patterns between the varying impacts of the Atlantic and Pacific Oceans.

Here, we introduce the research project and present stable-water isotope records for all study sites and put them into the context of temporal, spatial and seasonal aspects of Late Holocene climate variability in the Eurasian Arctic.

High resolution AN ice core δ18O data as proxy for Western Eurasian Arctic annual temperatures reveal significant changes on different timescales. A long-term decrease, coinciding with a decreasing summer insolation, does not solely reflect climate cooling but probably also the growth of AN ice cap. Several abrupt decadal-scale warming and cooling events are a marked feature of this record and lead e.g. to the coldest period around AD 1800 followed by the exceptional warming to the absolute maximum around AD 1930.

Contrary, centennial scale ice wedge δ18O records from all study sites based on 14C AMS dated ice-wedge samples indicate a general Late Holocene winter warming trend, consistent with an increasing winter insolation and characterized by a marked variability. This long-term warming trend culminates in the recent maximum reflecting ongoing Arctic warming.

Additionally, both ice-core and ice-wedge d excess records exhibit distinct variability reflecting substantial changes in the moisture generation and transport patterns.

Lithological and Mineralogical Characteristics of the Kyzyl-Syr Blowing Sand Complex

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Blowing sand complexes, called tukulans in the Yakut language, are unique permafrost-related landscapes occurring in Central Yakutia. They cover extensive areas and consist of parabolic dunes of different orders characterized by variable composition and combination of alluvial and eolian sand deposits. Several hypotheses for the origin of tukulans in Central Yakutia have been proposed. Some authors believe that the tukulans are products of eolian transport of the originally alluvial deposits. G.F. Lungersgausen and V.V. Kolpakov assert that the tukulans are distinct genetic accumulations of eolian origin resulting from transport of sand material by strong winds. S.S. Korzhuev adds that they continue to be deposited under present-day conditions. Despite many studies, the origin of tukulans remains open to question.

We performed a comprehensive lithological and mineralogical analysis of the deposits in order to differentiate them by origin and to interpret their depositional history. Our findings indicate that the depositional environment varied considerably throughout the Quaternary. The lower part of the section was accumulated under periodically changing conditions. Sand particle transport occurred alternatively by suspension and saltation depending on the hydrodynamic conditions. The upper unit suggests relatively stable depositional conditions. In summary, the study has shown that the upper part of the section is composed of eolian sands. The middle and lower parts consist of alluvial sands of riverbed facies and sands of glacial origin with signs of modification by water action. These findings have confirmed that glacial and alluvial deposits contributed to the formation of tukulans, later on subject to wind action.

Pleistocene Paleogeography of the Russian Arctic Regions (Shelf-Land) on the Basis of the Analysis of Underground Ices

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On the basis of the genetic analysis ground ices unequal geological development and an unequal transgressive-regressive regime of western and east sectors of the Russian Arctic regions in Quarternary period is shown. Prevalence in the western sector of submarine massive ice beds specifies on mainly sea sedimentation during Pleistocene and transgressive regime during this epoch. Possibility of formation of a permafrost with massive ice beds directly in sea conditions is shown and the mechanism freezing of bottom deposits is offered. Prevalence polygonal-wedge ice in east sector specifies in a continental regime during almost all Pleistocene. Spatial regularity of ground ices take up a question on the reasons of fluctuation of level of the Arctic basin. Fluctuations, apparently, are a little connected with glacial eustasy, and caused by regional tectonic. The bottom of the Arctic ocean is the rift zone and is settling down on a joint Eurasian and Amerasian lithospherian plates. It has generated two isolated enough diverse tectonic areas: western with an oceanic crust and active tectonic processes, and east with a continental crust and less dynamical processes. One more conclusion from the analysis of ices – the limited distribution in Pleistocene of glacial covers in the Russian north, and their absence on plains of the Russian Arctic region and Subarctic region.

Late Pleistocene Ice Complex and Palaeoenvironments of Bol'Shoy Lyakhovsky Island (New Siberian Archipelago)

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Paleontological proxy data and cryolithological information from East Siberian Arctic permafrost preserve records of late Quaternary climate and environmental conditions in West Beringia and their variability which results from interglacial-glacial and interstadial-stadial dynamics. A key site for late Pleistocene Ice Complex is situated at the southern coast of Bol'shoy Lyakhovsky Island (New Siberian Archipelago, Dmitry Laptev Strait) where coastal outcrops expose frozen sediments, ground ice, and fossil remains.

A 15 m long sequence of Ice Complex permafrost accumulated continuously between >55 and 27 kyr BP in an ice-wedge polygon reflecting the palaeoenvironmental history from the end of the MIS4 stadial to the end of the MIS3 interstadial (Oyogos and Molotkov horizons of the Oyogosskaya Suite). The late MIS4 stadial (>55 to 52 kyr BP) record shows a quickly developing polygon tundra while harsh cold and dry summers are reflected by sparse grass-sedge tundra-steppe and high amounts of redeposited conifers. During the early MIS3 interstadial (52 to 48.5 kyr BP) pollen records show higher Artemisia percentages within a grass-sedge tundra-steppe vegetation that supported dry conditions. The MIS3 interstadial optimum between 48.5 and 37 kyr BP promoted low-centered polygon tundra with shallow water in polygon centers. Moister conditions in the landscape than during the previous late MIS4 stadial are assumed while the general summer climate conditions likely remained dry, but slightly warmer as reflected by higher Salix abundances. Warmer summer air temperatures and moister conditions on landscape scale during the MIS3 optimum are revealed mainly by Salix and green algae findings in the palynological tundra-steppe records. A late MIS3 cooling trend in summer air temperatures between 37 and 27 kyr BP can be deduced from disappearing Salix pollen. The stable water isotope composition of an ice wedge (mean values of -31‰ in $\delta^{18}O$ and -243‰ in δD) point to stable cold winter conditions. Changes in the accumulation conditions are indicated at the end of the MIS3 in transition to the MIS2. The Last Glacial Maximum (LGM) period has been rather poorly represented in East Siberian permafrost records. However, present pollen, sediment, and ground-ice stable water isotope data obtained from coastal exposures on Bol'shoy Lyakhovsky Island mirror the coldest conditions during the MIS 2 stadial (Sartan horizon of the Yanskaya Suite) period between about 26 and 22 kyr BP. The pollen record reveals a cold tundra-steppe vegetation with characteristic predominance of grass pollen over sedge pollen while the stable isotope ice-wedge data indicate extremely cold winter temperatures with mean values of -37 ‰ in $\delta^{18}O$ and -290 ‰ in δD.

By the use of combined cryolithological, sedimentological, geochemical, geochronological, and palaeontological proxy data, stadial-interstadial environmental variability in arctic West Beringia was elucidated at millennial resolution.

Traces of Continuous Permafrost Late Pleistocene in The Southwest of the West Siberian Plain

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It is known (Aubekerov, 1990, Gorbunov et al., 1998 and others) that permafrost during last (sartan) glaciation spread from Northern shelf of West Siberia to mountains on Kazakhstan south. Only in belt ~500-470 N it is proposed discontinion and, may be, sporadic character of permafrost (Velichko et al., 2009). On the rest of territory permafrost was continious. Relief traces of cryogenic genesis on West Siberia south-west were noted by I.Krasnov, M.Boitsov, M.Gorodetskaya, V.Tarnogradskyy and many others. Pseudomorphs on ice or ice-ground wedges for this territory were published very rarely. With it, to south from 50^{o}N usually single, rarely pair pseudomorphs were described (Aubekerov, Chelykhyan, 1974; Aubekerov, 1992 and others). Big difficulties arise during definition of permafrost evolution, traces which are reflected in relief. Pseudomorphs on ice and ice-ground wedges can take to sartan time, more or less, indisputable, which occur in upper part of 1st over flood-plain terraces. Relict cryosphere relief on ii-iv "terrasing plains" of SE Western Siberian lowland and also polygons of relict alas basins bottoms to west from Omsk (Tarnogradskyy, 1966), most likely are more ancient, than sartan time. Polygonal relief traces, which are observed on cosmic photo and, less clearly, on 1st over flood-plain terraces levels and low divides (below than "II-d terracing plain") conventionally can compare with Late Pleistocene plain.

During fieldworks on SW Western Siberia traces of polygonal relief were observed in many points on low levels. On papers, interpretation cosmic photo and field observations on territory with coordinates 57^{o}12'-53^{o}55'N and 62^{o}56'-73020'E numerous areas with manitictations macro-polygonal, linear-polygonal, low-polygonal (cellular) relief. Earlier on SE Western Siberia Late Pleistocene polygons of dimension were marked only till 70 m (Gorbunov et al., 1998). We observed polygons more 100 m. Such big polygons are typical for marine coast (Garagula et al., 2001). They were observed by us on distance more than 1500 km from sea, but in region spreading saline lakes. Grade of expressive and conservation of polygonal relief noticeable differ. Most distinct traces of such relief are showing on cosmic photo, which were made in autumn of late spring on lots, which were occupied by ploughed field in moment of surveing. Block-polygonal relief with polygons mainly of square form is good visible on these cosmic photo. During fieldworks in under-taiga and forest-steppe zones of Prytobolye we investigated more 60 quarries and series of outcrops in valley of Tobol and series sections were made known Late Pleistocene end – postglacial age of permafrost traces for its outerops can be proposed on geomorphological and stratigraphical disposition. Kyshtyrlinsky quarry is most informative. It is disposed in 40 km from Tyumen, 56^{o}55'N and 65^{o}49'E, elevation 54-57 m, on outlier of 1st(?) over flood-plain terrace of right coast valley of Pyshma. Most good traces of paleocryogenesis are marked above NE part of quarry. Here polygonal net with numerous pseudomorphs (148-290-390 cm) on ice wedges are uncovered. Layers adjacent to pseudomorphs have bend down. Contacts of pseudomorphs with incloseing sediments usually are had ferruinginization. Distance between pseudomorphs are 18-23 m. Possibility, it is most eastern field of polygonal network of ice-wedges Late Pleistocene end ice-wedges on South-East of Western Siberia.

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Assessment of Organic Matter Transport into Thermokarst Lakes of Yamal Peninsula

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This paper presents the results of water sample tests on concentration of dissolved organic (Colored Dissolved Organic Matter, cDOM), collected out of the lakes in Central Yamal. The relation of cDOM to climatic characteristics and the depth of seasonal thaw in 2011-2012 are analyzed. We take into consideration the distribution of the chlorophyll-A concentration index in tundra vegetation within lake catchment areas as calculated using remote sensing data. It is established that a combination of factors, including a significant increase in average summer air temperature, and the associated increase in the depth of seasonal thaw in a key area in conjunction with an increase in the summer rainfall, affected the inflow of more organic matter into lakes of the Central Yamal, resulting in an increase in the concentration of cDOM in 2012, which was warmer compared to 2011.

During field expeditions of the Earth Cryosphere Institute SB RAS, 7 thermokarst lakes in Central Yamal were examined and 25 samples were collected. A laboratory analysis of the samples for obtaining information about cDOM concentration was produced. The results were compared with each other as well as with the values of chlorophyll-A (Chla) concentration indexes on the catchment areas of these lakes. The Chla index calculation is based on the knowledge that the vegetation absorbs waves of red spectrum for the maintenance of the photosynthesis process. The Chla index is calculated using the satellite image GeoEye-1.

It was found that cDOM concentration has a very high correlation with the average value of the Chla index in catchments ($r = 0.89$). It was therefore concluded that this type of vegetation covering the basin’s area, and that its species composition are one of the elements that form the concentration value of dissolved organic matter in the lake. Because the water samples were collected in the field seasons of 2011 and 2012, it was possible to trace a dynamic of changes in the concentration of dissolved organic matter in the studied lakes. The results of the analysis for 2011 and 2012 demonstrate a rather large difference in values. To explain the differences in the values of the cDOM concentration we analyzed the influence of climatic factors. Mean monthly air temperature was examined during the summers of 2011 and 2012, and it was found that in 2012 mean monthly air temperature in summer (according to the weather station Marre-Sale records) was much higher than in 2011 (an average of 5 degrees). This led to the observed significant increase in active layer depth in the study area (as measured by the CALM project). The active layer depth values in 2012 were significantly higher than in 2011, and this may therefore increase the flow of dissolved organic matter to the lakes from catchment areas. Additionally, the organic matter flow may be related to the amount of precipitation infiltrated into the active layer. The comparison showed that during the period from May to October 2012, much more liquid precipitation fell compared to the year 2011 (according to the weather station Marre-Sale).

Transient Hysteresis of Near-Surface Permafrost: the IAP RAS Global Climate Model Simulations

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Estimates of changes in near-surface permafrost (NSP) area Sp relative to change in globally averaged surface air temperature Tg are made by using the global climate model developed at the A.M. Obukhov Institute of Atmospheric Physics RAS (IAP RAS CM). For ensemble of runs forced by scenarios constructed as return-to-preindustrial continuations of the RCP (Representative Concentration Pathways) scenarios family, a possibility of transient hysteresis in dependence of Sp versus Tg is exhibited: in some temperature range which depends on imposed scenario of external forcing, NSP area is larger, at the same global mean surface air temperature, in a warming climate than in a cooling climate. This hysteresis is visible more clearly for scenarios with higher concentration of greenhouse gases in the atmosphere in comparison to those in which this concentration is lower.

Hysteresis details are not sensitive to the type of the prescribed continuation path which is used to return the climate to the preindustrial state. The multiple-valued dependence of Sp on Tg arises in the regions of extra-tropical wetlands and near the contemporary NSP boundaries due to dependence of soil state on sign of external climatic forcing. To study the dependence of permafrost hysteresis on amplitude and temporal scale of external forcing, additional model runs are performed. These runs are forced by idealised scenarios of atmospheric CO_2 content. It is shown that the above-mentioned hysteresis is related to the impact of phase transitions of soil water on apparent inertia of the system as well as to the impact of soil state on atmospheric hydrological cycle and radiation transfer in the atmosphere.

Study of Sizes and Relative Position of Thermokarst Lakes by Means of Data of Remote Sensing and Methods of Mathematical Morphology of Landscape

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More than 25% of Earth is within a permafrost zone. Accordingly problems of permafrost and related exogenous geological processes are very important. Thermokarst is one of geocryological processes especially sensitive to anthropogenic intervention and climatic changes.

Many researches study thermokarst processes, but statistical methods are less studied, in particular we may tell it about analysis of quantitative aspects of thermokarst processes.

Within the framework of this work an attempt has been made to solve 2 problems:

- analyze regularity of spatial pattern and dynamics of the morphological structures associated with thermokarst;
- compare results with other studies of lakes distribution.

In our work we use a method of mathematical morphology of a landscape - a branch of landscape science, investigating quantitative laws of landscape mosaics and methods of the mathematical analysis of these mosaics.

Theoretical basis of mathematical morphology of a landscape is formed by mathematical models of morphological structures – the quantitative dependences describing the basic properties of morphological structures.

Mathematical models of thermokarst lakes are based on the following assumptions (Viktorov, 1998):

- The process of origination of new depressions is probabilistic and proceeds independently on disjoint areas.
- The probability of origination of one depression on a sample area depends only on area size and on time interval. Also, this probability is much greater than the probability of origination of several depressions.
- Growth rate of depressions due to thermal abrasion occurs independently from each other, it is directly proportional to the heat stocks in a lake and inversely proportional to the area of a lateral surface of the lake basin under water level.

After data analysis, the probabilistic mathematical dependences reflecting the most essential geometrical properties of a pattern for territories with thermokarst processes have been developed by A.S. Viktorov (1998, 2006).

We performed the model approval in several test districts. We selected the districts based on morphological homogeneity and availability of remote sensing data.

The model shows that at a particular moment of time lakes areas should follow a lognormal distribution. Using a specially developed "Vectorizator" (by A.A. Viktorov) software we digitized the lakes in the selected district.

We found good conformity between theoretical and experimental data. This implies that for the selected parcels a lognormal distribution of lake areas is acceptable.

The model also shows that at a particular moment of time in a randomly selected area the lakes must be located according to Poisson distribution. The researches were performed in the same reference parcels. Most of the obtained results correspond to the Poisson distribution at the significance level of 0.95.

Also we analyze other studies of lakes distribution. As it follows from one of them, distribution of average sizes of the lakes should be normal. Another investigation shows that diameters of lakes obey the exponential distribution.

The analysis showed that the model in which the growth rate of lakes is in direct proportional to its sizes results to be the most suitable for considered districts.

Regional-Scale and Local-Scale Climate Change Impacts on the Permafrost Evolution

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The climate projections have to provide prediction of ground- and site-specific permafrost evolution. The problem of obtaining local-scale information from global climate model (GCM) and regional climate model (RCM) is not trivial. In the literature one can find the examples of both dynamic and statistical downscaling. We have used the multi-scale simulation on the basis of model system consisted of GCM, RCM, meso-scale model of the atmospheric boundary layer and ground heat transfer model to evaluate the permafrost evolution during the 21st century. The multilevel one-dimensional model of the heat transfer in the ground was used, taking into account water phase transformation, snow cover and vegetation effects, The model was constructed vertically on the expanded grid, The active layer depth and ground temperature at various depths were assessed under the canopy in the forest, at the shore of Arctic marginal seas and internal reservoirs.

The results of numerical experiments are presented in comparison with observational data if it was possible. The local features of permafrost at the end of 20th and in the first decade of 21st century in the permafrost regions of Russia were simulated quite satisfactory. The global scale climate change evaluation was provided by the output data of CMIP5 (Coupled Model Intercomparison Project Phase5). The permafrost evolution projections were analysed and compared with the results of other investigations.

Landscape Mapping for the Purpose of Geocryological Zonation of the Bolshezemelskaya Tundra

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Geocryological zonation shows itself in regular changes of the permafrost parameters of the territory. There are significant discrepancies in approaches to the geocryological zonation of the Bolshezemelskaya tundra that require clarification of the boundaries of geocryological zones and subzones.

In this study, medium-scale topographic maps (predominantly of 1:100000 or 1:200000 scale), field research, and remote sensing data the main source of information were used to specify and update the boundaries between geocryological zones and subzones within Bolshezemelskaya tundre. The multispectral images LANDSAT-7\ETM+ with resolution 30 m were applied for the thematically oriented RGB-synthesis and for receiving color images in pseudo-colors. In addition, we used ASTER/Terra images with resolution 15 m, images of submeter resolution, including images presented on portals Google-maps and Google Earth etc. Information was processed using the ArcView-3.2, ArcGIS-9.2, GlobalMapper-11 software and specialized software IDRISI.

Geocryological zones within the Bolshezemelskaya tundra conditionally correspond to zonal landscapes: tundra subzone (mostly southern shrub), southern and northern forest-tundra and extreme northern taiga for which correspond four geocryological subzones. The northern cryolithozone matches with tundra and forest-tundra subzones and is characterized by continuous and discontinuous permafrost. The southern cryolithozone with massive-island and island permafrost corresponds to southern forest-tundra subzone and to extreme northern taiga northern part. Most important indicators of geocryological zonation are the local landscapes. Therefore, our work was based on the method of large- and medium-scale landscape mapping and landscape-indication interpretation.

In the first place the local (in the stow rank) landscape-indicators were determined on maps and satellite images. The analysis was conducted in four main groups of stows: forest, bog, peatlands and tundra. Further main groups of the stows-indicators were determined for the each geocryologycal subzone.

Practically universal group of indicators is the group of peatlands stows. The dome-shaped peatlands or palsa are being used as indicators for carving the southern boundary of the cryolithozone, and for allocating the boundaries between discontinuous and continuous permafrost. The flat-topped polygonal peatland or peat plateau is not present in the island permafrost subzone. Polygonal and flat peatlands with many lakes are typical for the discontinuous permafrost zone. The hasyreys (the local name in West Siberia for the thermokarst depressions) are allocated in the northern cryolithozone.

Opposite, it appeared difficult to use the bog stows group for indication. Only the string bogs are typical for the island permafrost subzone, though they may be present in southern part of the subzone of its massive-island distribution.

The group of tundra stows can be used as indicators for carving apart northern and southern cryolithozones (by particular relief forms). The tundra stows can be rather conditionally used for distinction of the island and massive-island permafrost areas by using the degree of the tundra sites distribution. The indicator for allocating boundaries between continuous and discontinuous permafrost can be tundra stows with gently undulating relief with single trees.

The forest stows are indicators of the boundary between northern and southern cryolythozone (by forest continuity character), of the continuous and discontinuous permafrost boundary (by the presence of the forest and open woodlands sites). As a rule pine forests do not grow north of the island permafrost subzone.

No less significant characteristic when using stows-indicators for the geocryological zonation is the cryogenic relief. For the southern cryolithozone first of all it is the modern hillocky relief (basically the mounds in the growth stage), for the northern – ancient residual-poligonal relief. Both of them are allocated good enough by use of the remote sensing data with high resolution. The result of this work is a small-scale map of the Bolshezemelskaya tundra geocryological zonation.

Spatial Analysis of Ice Complex Deposits Thawing in Holocene, Kolyma Lowland Tundra Zone

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Yakutian coastal lowlands are the landscapes, formed as a result of thawing Late Pleistocene ice-rich Ice Complex (IC) deposits in Holocene. The climate warming in the end of Pleistocene – beginning of the Holocene contributed to the activization of thermokasrt, which has become the leading relief-forming factor during the Holocene. Of particular relevance of the study of these areas have acquired in recent years in connection with the assessment of the influence of modern climate change. Knowing the spatial patterns of thermokarst development is important for the understanding of the development of the territory in the future and assessment the content of organic matter to predict the emission of greenhouse gases. The advent of new techniques – GIS-study and remote sensing make it possible to implement spatial analysis of the relief to the next level, which will clarify and supplement the existing conception about its development in the Holocene.

Study area is the tundra zone of the Kolyma lowland on the right bank. The main relief form are the watershed remnants of the Late Pleistocene surface formed by IC deposits (Yedoma), thermokarst-lake basins (alases), and the river valleys. For the receiving the map of areas, occupied by lakes the classification on the allocation of lakes by satellite images Landsat ETM+ of 2000 and 2001 years was carried out using the ENVI software. The allocation of Yedoma formed by IC deposits performed manually using aforenamed satellite images and topographic maps of 1:200000 scale. The construction of maps, overlay operations were done in ArcGIS software. The map of the distribution of thermokarst and thermoerosion dissection of Yedoma depth was made. It was received by subsrtaction of the absolute heights of Yedoma surface and thermokarst lakes and rivers' shore line using the data of 1:200000 scale topographic maps. The map of the areas occupied by lakes and Yedoma in percentages were construct.

The receiving data show the general structure of the research region. According to the satellite images data Yedoma occupy about the 15 % of the whole territory. For comparison the same parameter according to the Quarternary deposits map of the 1:1000000 scale is 41 %. Two-thirds of the region are the alases (63,5 %). The area occupied by thermokarst lakes is 13,5 %. The river valleys and coastal marshes areas is about 8 %. Significant areas of Yedoma saved along the river valleys and in the regions of the tectonic uplifts, where their area is about 40 % and more. In most parts of such territories thermokarst lakes occupy less than 15%. In the some regions of southern tundra subzone the high lakes area (more than 40%) is observed. Mostly the high thermokarst lakes area typical for the vast depressions, where the Yedoma preserved in small areas and occupied less then 15 % of depressions. The surrounding areas more elevated regions differs by lower lakes areas (less than 20 %).

The analysis of thermokarst and thermoerosion dissection of Yedoma depths distribution shows the IC deposits thickness so as the dissection depth is the function of the deposits thickness (Kaplina at al., 1986). Average depth of Yedoma dissection received by mapping is 24-28 m which is comparable to the known thickness of IC in the research region: from 10-15 m to 30-40 m (Arkhangelov at al., 1979; Kaplina at al., 1981). Smaller depth of Yedoma dissection (less than 24 m) corresponds to the tectonic uplift regions and for the Bolshaya

Kuropatochya river valley. The dissection depths of more than 29 m are observed in all other river valleys and in depressions where few Yedoma remnants have preserved.

A New Approach for Computing Insolation of the Earth

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The Earth's insolation in the theories of paleoclimate is calculated by the method of M. Milankovitch. It is enough complicated approach, and some of its features are not clear for some researchers. Therefore the insolation is calculated by approximate methods in town planning, climatic and other researches.

At calculating insolation the main difficulty is caused by motion of the Sun above the Earth's surface, which is defined by the Sun's longitude. In the new method the longitude is defined on the basis of the exact solutions of two-body problem. In addition, the method is designed for computer technology. In the methodology of M. Milankovitch a series of tasks about insolation is solved for the certain time intervals by approximate analytical method. The computer technology allows solving these tasks by sampling the daily insolations in these time intervals.

The paper discusses the highlights of the two-body problem, the geometric characteristics of insolation, the distribution of solar radiation on the Earth's surface and in dependence on the Sun's position. The algorithms are given for computing of the daily insolation for each day of year, for one year, for the caloric half-year, and also the algorithm is given for computing insolation in equivalent latitudes. All components of insolation are computed in concrete examples by the methodology of M. Milankovitch and by the new method, and are obtained their coincidence.

The method is realized in the MathCad software and is submitted for free access. It allows researcher to define kinds of analyses of insolation, and do not limited by those that have been developed at creation of the method. By new approach the dynamics of insolation of the Earth's surface is computed at different latitudes for 100 years from epoch 1950. The results of computing represent a detailed structure of small changes of insolation. It is necessary for research of the reasons for short-periodic changes of the natural processes caused by insolation. These results testify of ample possibilities of the method. They allow carrying out researches, which could not be executed earlier.

Geocryological Information System (Geocryological Database) of the Siberian Platform. Status and Prospects of its Development

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Geological, geophysical and geocryological data collected during more than a hundred years of resource development and scientific research are spread across dozens of different organizations. This could not, but affect their integrity, quality and accessibility. Modern information technologies, including database development, provide means for safe storage, organization, processing and analysis of available data.

Currently, there are no completed geocryological databases (GDB) in Russia or abroad. In early 1990, the International Permafrost Association launched the initiative aimed to create the Global Geocryological Data (GGD) system, and the Russian National Permafrost Committee supported this decision. In 1995, the SB RAS Permafrost Institute started the development of a geocryological database's structure. In accordance with the prepared provisions, a three-level architecture was proposed [Balobaev et al. 1996]. Within the framework of the pilot project, the Geothermics Laboratory of the Permafrost Institute of SB RAS started the creation of the third level, i.e. the base of actual data comprising structured permafrost and geothermal information. New solutions and changes in the database's architecture came to life during the work. Currently, the creation of the geocryological database on the Siberian Platform that can become an example or working model for the development of the Global Geocryological Data system is being completed (Zhelezniak, 2011).

The Siberian Platform Geocryological Database builds on the geological-structural approach. Based on the tectonic units identified (up to the fourth order), it contains information on boreholes, terrain conditions, ground temperature regime, and rock thermophysical properties for 246 sites (2050 boreholes with depths ranging from 50 to 2000 m).

The Siberian Platform database was created using the multi-functional system DELPHI and the database processor Borland Database Engine (BDE). The Structured Query Language (SQL) is used as a standard language. The Delphi special component TQUERY is designed to implement the queries. It has a series of features and methods that allow to use all advantages of SQL queries in operations with the data. This enables operations with large information retrievals.

The data input system allows one to enter detailed information, including borehole information, terrain conditions, permafrost thickness, ground surface temperature, groundwater level, depth of annual temperature variation, snow, and vegetation. An important field is details of the organization that collected and contributed the data. The database also contains data on thermophysical properties of soils and rocks, such as thermal conductivity, thermal diffusivity, dry unit weight, moisture content, temperature at the depth of zero annual variation, and geothermal gradient. Maps and geothermal cross sections may be entered into the database, and exogenous geological processes and resulting landforms can be shown. Borehole data may be accompanied by photographs for illustration purposes.

For spatial representation and visual analysis of data, the database is connected to ArcGIS making the use of maps of any scale possible. In future, the widespread use of ArcGIS will enable unified storage formats and rapid data exchange with other permafrost communities. The system for automated construction of permafrost-geothermal cross sections from borehole data is to be completed soon.

The database allows the systematic addition of new data, view in table and graphic forms, data retrieval by geomorphological conditions, statistical processing, and analysis of permafrost temperature trends by geological structures and geomorphological provinces. The database will help improve the reliability of permafrost parameter assessments and reveal regional patterns and general relationships. The database will be useful in modeling and predicting changes in the state of permafrost. In future, it will help solve complex engineering problems in Russia, where 70 percent of the land surface is underlain by permafrost.

The Siberian Platform Geocryological Database will serve as a prototype for the development of geocryological databases for the Nepa-Botuoba High and the Anabar-Olenek High. These databases planned under the project 'Earth's Temperature Distribution and Permafrost Evolution in Northern Asia' will be also based on the geological-structural approach.

The database is managed by the Permafrost Institute. The metadata will be made available soon at the MPI website.

Coupled Hydrological and Thermal Modeling of Permafrost and Active Layer Dynamics : Implications to Permafrost Carbon Pool in Northern Eurasia

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Recent observations indicate a warming of permafrost in many northern regions with the resulting degradation of ice-rich and carbon-rich permafrost. Permafrost temperature has increased by 1 to 3 deg C in the Northern Hemisphere during the last 30-40 years. To assess possible changes in the permafrost and the active layer dynamics we developed a robust coupling of a GIPL (Geophysical Institute Permafrost Lab) transient model and modified version of the pan-Arctic Water Balance Model (P/WBM) developed at the University of New Hampshire. Through explicit coupling of the Permafrost Model with the Water Balance Model we are able to simulate the hydrological budgets, temporal and spatial variability in soil water/ice content, active layer thickness, and associated large-scale hydrology that are driven by contemporary and future climate variability and change. Coupling of the GIPL model with a suitably-scaled hydrological model captures thresholds and highly non-linear feedback processes induced by changes in hydrology and the temperature regime over the pan-Arctic. Input parameters to the model are spatial datasets of mean monthly air temperature, snow properties or SWE (Snow Water Equivalent), prescribed vegetation and thermal properties of the multilayer soil column, and water content. The climate scenario was derived from an ensemble of five IPCC Global Circulation Models (GCM) ECHAM5, GFDL21, CCSM, HADcm^3 and CCCMA. The outputs from these five models have been scaled down to 25 km spatial resolution with monthly temporal resolution, based on the composite (mean) output of the five models, using the IPCC SRES A1B CO_2 emission scenario through the end of current century. The model takes into account the geographic distribution of organic soils and peatlands, vegetation cover and soil properties, and is tested against a number of permafrost temperature records for the last century.

We estimated dynamics of the seasonally thawed volume of soils within the two upper meters for the entire North Eurasia using a coupled, large scale, grid-based water balance/permafrost model. The model results indicate 1,200 km^3 of seasonally unfrozen soils within the two upper meters across 10,800,000 km^2 of northern Eurasian permafrost domain during the last two decades of the 20th century. Our projections have shown that unfrozen volume of soil within two upper meters increases to 3,500 km^3 by 2050 and to 9,500 km^3 by the last decade of the 21st century due to active layer deepening. According to this specific climate scenario, the area of permafrost with active layer shallower than 2 m in depth could decrease from 10,800,000 km^2 in 2000 to 9,000,000 km^2 by 2050 and to 6,000,000 km^2 by the end of current century. Despite the slower rate of soil warming in peatland areas and a slower degradation of permafrost under peat soils, a considerable volume of peat (approximately 20% of the total volume of peat in Northern Eurasia) could be thawed by the end of the current century. The potential release of carbon and the net effect of this thawing will depend on the balance between increased productivity and respiration, and will be mitigated by peat moisture.

Remote Sensing and Multi-Scale Integration for Investigating 'Changing Permafrost in the Arctic and its Global Effects in the 21st Century – PAGE21'

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PAGE21 (ENV.2011.1.1.3-1, www.page21.eu) aims to understand and quantify the vulnerability of permafrost environments to a changing global climate, and to investigate the feedback mechanisms associated with increasing greenhouse gas emissions from permafrost zones. This research will make use of a unique set of Arctic permafrost investigations performed at stations that span the full range of Arctic bioclimatic zones. As part of the project remotely sensed data will be integrated with in situ measurements for improved process understanding and model validation. A wide range of Earth Observation datasets at model scale are available for this purpose, but there is a lack of representation of heterogeneity and dynamics, in particular. This needs to be addressed, as well as the actual suitability of the available data, by incorporating state-of-the-art approaches regarding surface cover distribution and the dynamics of biogeophysical properties, for all observation sites and across all scales.

Landsurface temperature (LSCE, LGGE).

Microwave radiometers will be used to assess land surface temperature diurnal variations at regional scale (25km) for all the Arctic region. Thermal infrared measurements will helped to downscale the data to the kilometric scale for all the observations sites. The downscaling procedure uses a priori land surface temperatures estimated with a land surface model, to constrain the inversion process. The methodology under development at LSCE, will be presented.

Landsurface Hydrology (TUW).

ERS and Metop scatterometer derived soil moisture (25-50 km resolution) is combined with ENVISAT ASAR data (150 m - 1 km resolution), and Sentinel 1 data if it becomes available, for periods with unfrozen conditions for across scale assessment of land surface hydrology. The potential of data from these active microwave sensors for high latitude land surface characterization will be discussed.

Phenology (UPD).

A remote sensing methodology has been developed to measure the timing of ecosystem green-up, closely related to the timing of leaf appearance, based on medium spatial resolution optical sensors (NOAA/AVHRR and SPOT/VGT). This methodology allows us to analyse the inter-annual variations of this key functionnal trait of arctic ecosystems. The comparison of these time series with those obtained with active and passive microwave remote sensing, that detects timing of key events such as the freezing or defreezing of soil, snowmelt and snowfalls, will permit an assessment of artic ecosytems functionning at scales that are not accessible by ground observations only. Moreover, the analysis will be completed by a comparison by the remote sensing products of surface temperature.

NDVI_tundra, fAPAR_tundra, LAI_tundra (AWI).

Remote sensing algorithms for the Normalized Differenced Vegetation Indices (NDVI), Leaf Area Index (LAI), fraction of Absorbed Photosynthetically Active Radiation (fAPAR) all use the NIR spectral bands. Due to low NIR reflectances from low-growing biomes, NDVI, LAI and fAPAR values for tundra fall into low ranges. Within the further preprocessing for models (permafrost/climate) the low values are falsely parametrised as large areal contributions of barren soil. Spectro-radiometrical field investigations at various Arcitc sites representing a range of tundra landscapes with varying moisture regimes and vegetation structures shall provide ranges for fAPAR_tundra, LAI_tundra.

Application of the «Econorth» Program for the Sustainability Assessment of Elementary Natural Regions of One or Adjacent Cascade Landscape Geosystems

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In order to meet the urgent needs of a developing society, modern geography must focus on production of the information that allows us to make reasonable constructive decisions about our impacts on environment. In this situation the specialized computer programs, that are made for a wide range of users, including non-specialists, and takes into account all possible diversity of the results of natural and technogenic systems interaction are perspective. The last feature makes great difference between such programs and traditional tools (e.g. evaluation maps), that provide static and often badly-founded picture that is not really convincing for non-professionals. The first step on the way to user-friendly programs is «Econorth», developed by Vadim Marakhtanov in the Laboratory of Geoecology of the Northern Territories, Faculty of Geography, Lomonosov Moscow State University.

In daily practice specialists often evaluate the impact of the objects which construction influences not 1 -2 elementary natural regions but the whole catena or more, e.g. in mountain regions. For this reason, the aim of our research is to estimate the usability of the «Econorth» in dissected relief conditions. The model region is the Cancun hydroelectric power plant surrounding (South Yakutia).

The inundated area is projected in Aldan and partly Neryugrinsky municipal regions, in uninhabited area, so the construction will cause different techogenic impacts.

«Econorth» allows not only to examine the sustainability of nature regions and give it quantitative description but also to analyze it with respect to processes of different types: thermal, mechanical, chemical. The most important feature is the opportunity to mark up the types, that cause negative consequences, by placing the information about each natural region and the type of the impact in the analysis matrix. In addition, users can compare sustainability in different absorption types and choose the most suitable.

We have chosen for our research such impacts as frequent transport movement, surface planning, mining, snow removal, disposal of liquid wastes.

According to the calculations, the frequent transport movement and the snow removal that causes thermokarst, swamp formation and frost cracking are the most harmful for the study area. The complex of processes, for example, groundwater ponding, caused by surface planning, can trigger thermoerosion. The area in general is quite sustainable to technogenic impacts. Nevertheless, it is important to pay attention to subhorizontal surfaces and slopes susceptible to solifluction and cryogenic earth flows. Drained slopes, made of disperse icy matter, are unsustainable, which is quite strange and can be determined as an error of generalization. We also compared two absorption types.

«Econorth» is very useful for accurate analysis of impacts, user-friendly and helps the user to make recommendations for each type of impact and examine each natural region. Therefore, the user should choose what to study: processes or natural regions. Moreover, the program is suitable for visualization of the decision-making process for politicians etc. However, the user cannot find a place for each natural region that can lead to some mistakes. Therefore, it is more reliable to work with bigger natural regions, on the catena’s parts scale.

Permafrost in the Vilyui Basin: State of Geothermal Knowledge and Thickness Estimation

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The Vilyui Basin is one of the most important regions of Russia due to the wealth of hydrocarbon and mineral resources and their economic value. Hydrocarbons and minerals occur in and below permafrost. It is therefore important to understand its distribution and parameters.

The earliest evidence of permafrost and first estimates of its thickness and temperatures in hydrocarbon deposits were obtained in the course of deep exploration drilling conducted in the early 1970s by the VNIGRI, Yakutia Geological Survey, North Yakutia Oil Exploration Expedition, and Yana Geological Exploration Trust. In 1971-1980, a team from the Laboratory of Geothermics, Permafrost Institute, consisting of V.T. Balobaev, V.N. Devyatkin, A.I. Levchenko, B.V. Volodko and V.G. Rusakov performed geothermal measurements at some of the geological exploration sites [Melnikov, 1972, Balobaev et al., 1983, 1991]. Much of the data were collected from boreholes not yet in thermal equilibrium, resulting in the estimated values for geothermal parameters.

In 2009-2011, geothermal investigations were resumed in the region by the Permafrost Institute as part of the program 'The Temperature and Permafrost Patterns in the Siberian Craton' and covered eleven exploration sites. All existing data sets maintained by the Permafrost Institute and the Yakutia Geological Foundation have been compiled and synthesized to produce an electronic permafrost database of the Vilyui Basin. The development of this first full collection of geothermal data for the region is now near completion. As a result of these studies, new data on permafrost thickness, distribution and temperatures to 1200 m depth have been obtained. The studies have shown the regional northward and westward increase in permafrost thickness within the Vilyui Basin. Significant local variations in permafrost thickness occur in the Middle Vilyui and Middle Tyung areas, from 500 to 630 m and from 580 to 680 m, respectively. The geothermal heat flux in the unfrozen ground below the permafrost is 30-34 mW/m2 greater than that in the permafrost. The estimates have shown that the lower boundary of the permafrost is degrading at a rate of 1.7 to 2.5 cm/yr.

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Optical Spectral Remote-Sensing Applications: a Case Study in Central Yamal , Vaskiny Dachi

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The YAMAL2011-expedition of the teams from the Earth Cryosphere Institute Siberian Branch of Russian Academy of Sciences (ECI SB RAS), RU, and the Alfred Wegener Institute for Polar and Marine Research (AWI), DE, took place during the period from August to September 2011. This expedition was part of the AWI-project 'hyperspectral Arctic VEGetation Indices' (hy-Arc-VEG), which is a component of the Environmental Mapping and Analysis Program (EnMAP), a German hyperspectral space mission with an expected launch date in 2017. Hy-Arc-VEG focuses on spectro-radiometrical field measurements of tundra landscapes to technically explore the potential of multispectral to hyperspectral satellite data for applications in the low-growing arctic tundra. Representative ground data need to come from well-described sites of a homogenous surface type. Since 2007, the NASA Yamal Land Cover/Land Use Change (NASA Yamal-LCLUC) team has established field sites in northwestern Siberia (Yamal Peninsula) to sample homogenous surface types that can be used for upscaling to the footprint of the satellite sensor's. The ECI had established the Circumpolar Active Layer Monitoring (CALM) site at Vaskiny Dachi on the Yamal in the early 1990s. Vaskiny Dachi has been revisited every year for late-summer measurements of active layer depth and other system properties. The sites on the Yamal Peninsula represent a range of tundra landscapes with varying moisture regimes and vegetation structures. Vegetation serves on one hand as an insulation ground cover (moss, lichens), and as an entrapment for snow (shrubs), and on the other hand vegetation indicates drainage conditions (sedges for wet environments, lichens for dry ones, mosses and shrubs for mesic).

For the Yamal2011-expedition, Yamal-LCLUC sites were revisited in August 2011: two at Laboravaya, southern Yamal, close to the Polar Ural Mountains, and three at Vaskiny Dachi, central Yamal, and along with the ECI CALM site at Vaskiny Dachi. New measurement plots were established along a 1.5 km transect (Tr11) crossing different permafrost regimes and vegetation communities. Main vegetation complexes affecting permafrost were subdivided into main classes, such as barren surfaces, shrub-dominating, moss-dominating and sedge-dominating communities.

With respect to spectro-radiometry, the main research goals of the Yamal2011 investigations are:
(i) remote sensing algorithms for spectral narrow-band and broad-band vegetation indices (VI): Normalized Differenced Vegetation Indices (NDVI), Leaf Area Index (LAI), fraction of Absorbed Photosynthetically Active Radiation (fAPAR). The results on NDVI-tundra, fAPAR-tundra, LAI-tundra will be incorporated into the PAGE21 project (Changing permafrost in the Arctic and its global effects in the 21st century, www.page21.eu);
(ii) spectral analyses were performed to extract surface classes: surface waters, barren surface, shrub-dominant, moss-dominant and sedge-dominant communities.
(iii) anisotropy studies on spectral reflectances using the in-house (AWI) developed portable field spectro-goniometer (EyeSight).

The spectro-radiometrical multi-zenith, multi-azimuth measurements simulate the viewing geometries of wide-angle looking satellite sensors such as AVHRR, MODIS, MERIS, or sensors with technical side-looking possibilities such as the EnMAP sensor.

The first results of the field measurements and the analyses of vegetation indices are presented and discussed.

User Interaction within ESA DUE PERMAFROST: Evaluation of Circumpolar Remote Sensing Products and Their Usability for Models (Permafrost and Climate Modelling)

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The ESA DUE Permafrost project (2009-2012) developed a suite of remote sensing products indicative for the subsurface phenomenon permafrost: Land Surface Temperature (LST), Surface Soil Moisture (SSM), Surface Frozen and Thawed State (Freeze/Thaw), Terrain, Land Cover, and Surface Water. Snow parameters (Snow Extent and Snow Water Equivalent) are being developed through the DUE GlobSnow project (Global Snow Monitoring for Climate Research, 2008-2011). The final DUE Permafrost remote sensing products cover the years 2007 to 2011 with a circumpolar coverage (north of 50°N). The products were released in 2012, to be used to analyze the temporal dynamics and map the spatial patterns of permafrost indicators. Further information is available at www.ipf.tuwien.ac.at permafrost.

Since the beginning, scientific institutions and the International Permafrost Association (IPA) were involved in the science plan. Interactive workshops took place in 2010 at the Technical University of Vienna, Vienna (AT), and in 2011 at the International Arctic Research Center (IARC), Fairbanks, Alaska (US). The final User Workshop was held 2012 at the Alfred-Wegener-Institute for Polar and Marine Research (AWI) in Potsdam. It brought together a multidisciplinary permafrost community working on satellite-derived products, in-situ field validation and modelling. About 60 participants from Austria, Canada, Finland, France, Germany, Italy, Japan, Norway, Poland, Russia, Sweden Switzerland, UK, and USA participated and gave oral and poster presentations.

The involvement of the user communities and the ongoing evaluation of the indicators derived from remote sensing data for high-latitudinal permafrost regions make the DUE Permafrost products trustworthy for the permafrost and the climate research community. Ground data is provided by user groups and global networks. A major part of the DUE Permafrost core user group is contributing to GTN-P, the Global Terrestrial Network of Permafrost (IPA). Its main programmes, the Circumpolar Active Layer Monitoring (CALM) and the Thermal State of Permafrost (TSP) has been extended during the last International Polar Year (2007-2008) to provide a true circumpolar network. Ground data ranges from active layer- and snow depths, to air-, ground-, and borehole temperature data as well as soil moisture measurements and the description of landform and vegetation.

The adaption of the remote sensing products for the permafrost and climate modelling is experimental. For a few years already, the Geophysical Institute Permafrost Laboratory (GIPL), University of Alaska Fairbanks, US (http://www.gi.alaska.edu/research/snowice permafrost/Permafrost) has successfully demonstrated the value of using LST derived from remote sensing data for driving its permafrost models. Further experimental testing of the use of DUE Permafrost products for the permafrost-modelling and climate-modelling communities will range from (i) the evaluation of external data of the models, with modifying or providing new external data (e.g. tundra land cover, surface water ratio, soil distribution), to (ii) new drivers for regional models derived from remote sensing data (e.g., LST), to (iii) the evaluation of the output data from the models (e.g. spatial patterns of moisture and temperature).

Cartographical Model of Geocryological and Geoecological Conditions and Dynamics (Yamal Peninsula)

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Cartographical model of the geocryological and geoecological conditions and dynamic has been made on the landscape basis. The landscape indication method is widespread in geocryology and engineering geology, and involves the use of a landscape map as a basis for grouping, statistical analysis and extrapolation of the geolgical parameters.

A cartographic - mathematical analysis of heterogeneity landscapes morphological structure has been done to assess of spatial distribution and heterogeneity of geocryological conditions. The analysis is based on Ivashutina L.I. and Nikolaev V.A. method. The frozen ground types, which are characterized by a set of geocryological factors: permafrost extent, the ground temperature and ice content, a peculiarities of the ground ice distribution spread, complex of exogenous geological processes, are corresponded to geosystems types. Therefore, the characteristic of landscapes morphological heterogeneity could be used to assess the geocryological conditions heterogeneity.

The cartographic -mathematical analysis of the landscapes morphological structure allows us to estimate this heterogeneity and express it using quantitative coefficients. The coefficient of landscape heterogeneity (Kln) indicates the complexity rate of geosystems structure characterized by set and spatial extent of their different parts. In accordance to the calculated values of Kln, the classification of the geosystems was carried out: highly heterogeneous, heterogeneous, relatively homogeneous and homogeneous. One of the most heterogeneous geosystem (Kln> 0,85) is hilly termodenudation geosystem with circular low area on the first, second and third marine terraces. It is characterized by ground temperature 2… 7 C°, volumetric ice content 0,2-0,6, and the depth of the seasonally thawed layer 0,25-1,6 m.

The homogeneous geosystems (Kln <0,45) are lake-peat on the fourth marine terrace, with ground temperatures below -5 C°, volumetric ice content 0,4, the depth of the seasonally thawed layer 0,3-0,8 m. Basing on the Kln values the zoning of the territory was made and correspond map was created showing the spatial distribution of landscape and geocryological heterogeneity. This information is very important for linear plotting construction and the optimal way of pipeline routs installation.

The method of landscape mapping is also widely used for the assessment of geoecological conditions. As an example of such assessment, based on the landscape mapping, we could present an assessment of high willow distribution – the distribution of the best summer reindeer pastures. It is known that high willow widespread in typical tundra is controlled by two major factors: near-surface occurrence of saline soils and active landslides.

The map of high willow distribution for the period of the late 70 - 80's was created using GIS-mapping on a landscape basis. Current satellite imageries allow to evaluate the willow area reduction, associated with the active landslides. Up to 2010 the high willow summer reindeer pastures reducing is about 10%.

Computer Modeling of an Artificial Freezing of Soils with FROST 3D Software Application

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The application of FROST 3D software for the computer modeling of freezing and thawing processes in soils is considered. The forecasting of the processes of freezing and thawing of soils is highly demanded in various practical problems:

Geotechnical justification for the constructions design on permafrost soils with respect to available technical solutions for thermal stabilization of soils.

Analysis of permafrost shields, which are employed at construction of tunnels and mines of various destinations on unstable soils, at the construction of foundation pits for dams, electrical stations buildings, docks and other buildings.

Mathematical solvers of FROST 3D allow the following possibilities:

Solution of non-linear heat equation with temperature dependent thermal conductivity and heat capacity.

Ability of assigning boundary conditions as temperature, heat flow and heat exchange by Newton's law.

Parameters of boundary conditions can be set time dependent.

Ability of creation of complex geometries and land reliefs.

Heat sources and drains of arbitrary forms can be introduced both inside the modeling region and on the boundaries.

Convective heat transfer, solar radiation and snow are taken into account.

Availability of including cooling devices for ground thermal stabilization.

To summarize, the FROST 3D software can be effectively used for design of beds and foundations in permafrost soils, so as also in other problems related to artificial freezing of soils. The key advantage of FROST 3D software is the ability of three-dimensional computer simulation of large-scale problems (regions with linear sizes of hundreds of meters, meshes with millions of nodes) and non-linear thermal processes for long time periods (of the order of years) spending a reasonable computation time (about several hours) on common personal computers.

Session 7: Permafrost-affected soils and biosystems

Methane Soil Surface Flux and Methane-Driving Microorganisms in Central Siberian Boreal Forest

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One third of the global carbon pool is stored in ecosystems of the northern latitudes (Tarnocai et al. 2009). This globally significant carbon reservoir is vulnerable to climate warming through permafrost thawing and may thus become a future source of a large amount of CO_2 and CH_4 to the atmosphere (Zimov et al., 2006). The degradation of permafrost and the associated release of climate-relevant trace gases from intensified microbial turnover of organic carbon and from destabilized gas hydrates represent a potential environmental hazard.

Results of the methane flux from soil surface for Central Evenkia ecosystem are presenting. Using closed chamber method (Wagner et al., 2003) we estimated the methane released daily from soil surface of south-exposition slope as well as north-exposition slope. The mid-vegetation season mean flux rate from south-exposition slope was 7.5 ± 2.6 mg CH_4 m^{-2} d^{-1}, and the mean flux rate from north-exposition slope was 7.8 ± 2.8 mg CH_4 m^{-2} d^{-1}. The CH4 production in the upper soil horizons of both slopes was very low (0.20 ± 0.06 nmol CH_4 m^{-2} d^{-1} for south-exposition slope; and 0.31 ± 0.13 nmol CH_4 m^{-2} d^{-1} for north-exposition slope). The CH_4 oxidation rate of the upper soil horizon of south-exposition slope was 0.14 ± 0.06 nmol CH_4 m^{-2} d^{-1}; and of north-exposition slope was 0.13 ± 0.07 nmol CH_4 m^{-2} d^{-1}. The data obtained shows that there is no difference between soil methane-driving microbiocenosises of contrast slopes despite of sufficient disparity their (slopes) active layer thickness, soil moisture and temperature.

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Soils of "Peat Circles" of the Western Siberia

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The considerable part of mire ecosystems in the territory of the Western Siberia develops in the conditions of permafrost. In this location such mire complexes as peat plateau are widespread. There are unique peat formations - "peat circles" diagnosed by the extensive spots of bare peat, the vegetation on which is completely absent.

The purpose of this work - studying the features of formation and functioning of "peat circles" soils. The area of researches is located in the north of Western Siberia (Yamalo-Nenets Autonomous Okrug, 65°78'26") in a zone of discontinuous permafrost. "Peat circles" are located on the top parts of slopes and at the tops of peatlands, have an oval form, diameter ranges from 1 to 5 m, and their surface is covered with the seared peat crust with a peculiar structure. The soil of peat circles is described as the peat oligotrophic destructive (Shishov, 2004).

During 2011-2012 more than 20 "peat circles" were studied. The following features were noted: the minimum thawing of the active layer unlike typical soils of peatlands (Typic Histoturbels); peat profile is thicker and homogeneous; "peat circles" are characterized by high degree of decomposition of organic matter; dark-brown color. The horizons of oligotrophic peat were found in all soil pits.

During field works experimental sites were put on "peat circles" and on areas with a vegetative cover adjoining "circles". It was established that on sites with bare surface emission of CO2 is lower, than on sites under vegetation, (74 mgCO2/m2 in hour, 175 mgCO2/m2 in hour, respectively), at the same time concentration of CO2 at depths 10, 40 and 60cm had inverse correlation and was higher (0,18, 0,49, 055 % and 0,2, 0,25, 0,41 %, respectively). An average annual temperature of "peat circles" soil is considerably lower than under vegetated surface (-1,12°C and - 0,01°C, respectively at the 20-40cm depth)

The analysis of chemical properties revealed essential difference of "peat circles" soils to surrounding area soils. Peat horizons of "peat circles" have higher total contents of carbon (5-10 %) and nitrogen (at 5-10 times). "Peat circles" have the lower content of such biophile elements as potassium (4,6 mg/100g and 37,3mg/100g respectively) and phosphorus (1,5mg/100g and 2,5mg/100g respectively), also the lower content of exchange forms of iron (37,6 mg/100g and 89,7 mg/100g, respectively) . It was established by laboratory trial, that indicators of intensity of initial growth of plants (defined by a sprouting method, such as total length of root system and of green sprouts) for 20-30 percent are lower for "peat circles" samples compared to surrounding soils (0,74 and 1,36 cm for sprouts and 0,48 and 1,13 cm for root system).

Our results show that "peat circles" are widespread in the area of researches, they are specific landscape of peat plateaus with essentially different chemical properties and features of functioning. Apparently, similar specific is caused by soil development in the extreme conditions inhibiting vegetation (a wind and snow erosion), also a peculiar genesis of investigated peat and the lack of a number of biophile elements.

Stability of Permafrost Peatlands in Bolzhezemelskay a Tundra (The North-East of European Russia)

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Monitoring and preservation of permafrost peatlands are important, because huge natural reservoirs of soil organic carbon (SOC), conserved mostly in upper permafrost, Therefore, the actual environmental impact of the permafrost degradation in peatlands has to be estimated and whether to expect an accelerated mineralization of SOC previously being in the frozen state.

Field studies were conducted in the Bolshezemelskaya tundra in B. Rogovaya and Seida River Basins, in a peat plateau complex, complicated with thermokarst formations and alluvial terraces. The basis of this complex is Histosols (Tundra residual-peaty soil of mounds and fenny upland peat soils (TmOTBvm).

Mostly rounded peat mounds are composed of peat deposits up to 2.3 and more meters thick, the diameter of 5-15 m. Peat mounds and many small thermokarst lakes are surrounded by narrow sedge-sphagnum unfrozen fens (from 15 to 30 m2) serve as water conduits in the partly frozen terrain. Peat in mounds is mainly dark brown, well-decomposed, alternating with layers of weak-decomposed wood peat. The mound core is composed of bluish-brown sandy loams and loams.

Soil properties were determined up to 2 m depth. Soil pH is 3.5-4.6, the lowest values of the actual and exchangeable acidity are common for sphagnum and wood layers. In fens peat consists of sphagnum, it is acid and of various degree of decomposition. Peat of the uppermost 10 cm soil profile in the mounds and fens has minimal ignition loss, C/N ratio is up to 50-65. In the mounds, below 20 cm, C/N ratio is relatively stable - 16-23. The decomposition degree of the 9 peat is about the same in all the peatlands of the European North-East (not only shown in the abstracts).

Reducing the bogs surface under the influence of erosion and thermokarst processes is one of the main reasons of peatlands formation. Mounds are considered as outliers former bogs and fens surface which are not damaged by erosion and thermokarst (Pyavchenko, 1955). SOC has been formed in the peatland from 9-7 thousand years to the present, however the degree of peat decomposition and humification is slightly changed down the profile. Peat deposits are initially and primarily accumulated under unfrozen mesotrophic and eutrophic bogs. Permafrost aggradation initiated erosion processes 2000-3200 years ago, resulting to peat mounds formation (Becher, 2011). Thus, studied peatland remains to be frozen during relatively short period of its development (approximately 22-36%).

Currently, a lot of scientists claim that the so-called sub-zero temperatures inhibit mineralization of SOC stored in permafrost. Permafrost thaw will lead to a rapid remobilization and mineralization of organic matter that occur during the decades (Schuur, Abbott, 2011). However, due to the insulating properties of dry peat, active layer will be very slow deepening in the mounds. Scenarios for the SOC release under permafrost thaw were described by Hugelius et al. (2012). They suggest that further disintegration of the thawed SOC will depend not only on the increase thaw depth, but on changes in the hydrothermal soil regime resulting in water logging, thermokarst lakes expansion. Conducted by Knoblauch et al. (2013), model experiment with Holocene and Pleistocene permafrost peat deposits in northeastern Siberia revealed that even under permafrost thaw the release of greenhouse gases, i.e. mineralization occurs much more slowly than previously considered. Their obtained that during 100 years 15.1% of all SOC has been mineralized under aerobic conditions in the form of CO2 and 1.8% under anaerobic conditions as CH_4.

Thus, to inhibit organic matter decomposition, the presence of anaerobic conditions is the most important issue, rather than permafrost occurrence.

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High Resolution Palaeo-Ecological Studies of Ice-Wedge Polygon Mires in the Indigirka-Kolyma Lowlands (NE Siberia, Russia)

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Ice-wedge polygon mires are typical features of the Arctic zone, where climate change has been and will be particularly intense. Little is known to what extent polygon mire dynamics are controlled by climate change and to what extent they result from polygon internal feed-back processes.

Two ice-wedge polygon mires in NE Yakutia, a low-high center polygon near Chokurdakh (Lhc11) and a collapsed polygon complex near Chersky (Mnp12), were subject to intensive studies. Actuo-ecological research included mapping of vegetation and height of ground surface and frozen soil in a grid of one meter resolution and high resolution palynological surface studies of the relation between actual vegetation and pollen deposition. Palaeo-ecological studies are carried-out on closely-spaced peat sections in order to reveal short-distance differences and changes in peat formation.

First results indicate that the polygon ridge of Lhc11 migrated inwards from its original position that is now occupied by a trough. 210 contiguous 0.5 cm thick samples of a current wall section have been analysed on pollen, macrofossils and various abiotic parameters and provide the currently most detailed palaeo-record of the entire Arctic, with the base dating at ca. 4000 calendar years B.P.

Soil Diversity of Marie Byrd Land, West Antarctica (Russkaya Station Keysite)

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Authors summarize soil data of one of the hardly accessible and less visited areas of Antarctica – the Marie Byrd Land. Leptosols and Leptic (Turbic) Cryosols dominate in a soil cover here; the majority of soils have lithic contact within a profile; upper layers of permafrost are rarely ice-cemented, visible ice is only obtained below soil profiles on shallow slopes and closed depressions of relief.

Rocklands are with extremely sparse vegetation and spots of very shallow Lithic Leptosols (SOC=0,3-1%; pH=5,0-6,0; fine earth content 1-10%). Soil and vegetation cover becomes more closed at flat watersheds and shallow slopes. Vegetation cover, primarily of *Usnea antarctica* forms the combination of Leptosols and Leptic Cryosols (SOC=0,5-2%; pH=5,0-6,0; fine earth content 5-20%). Leptosols dominate here due to the lack of liquid water and shallow thickness of debris that prevents cryoturbation processes from active development. The depressions of relief are occupied with moss-lichen associations. Soils here are much more provided with melt water, debris thickness here is relatively higher (but still with lithic contact within 100 cm of profile). According to WRB for Soil Resources these soils are also Leptic (Turbic) Cryosols (SOC=1-8%; pH=4,0-5,0; fine earth content 15-30%). Turbic Cryosols dominate here. Lithic Leptosols Ornithic occur near the sea shore on the relatively elevated sites with ice-cemented permafrost at the bottom of soil profile (SOC=5-20%; pH=6,0-7,5; fine earth content 5-20%).

The human impact presented with fuel spills and soil disturbance by vehicles. Disturbed soils contain 3-10 times more of As, Pb, Cd and Cs than soils in the background. They also accumulate petroleum products – from 150 to 600 and even more than 2200 mg/kg (average background concentration of CH-groups in soils is 40-60 mg/kg).

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Mineralogical Composition of the Coarse Fractions in Permafrost-Affected and Long-Term Freezing Soils of the Sub-Polar Urals (Basin of the Middle Reaches of Kozhym River)

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In the mountains the cryogenic processes significantly impact on soil formation, their influence expressed as features of specific patterned ground microtopography, cryoturbation, thixotropy, suprapermafrost water stagnation, gleying, cryogenic ferrugination, specific aggregation formation of mineral mass and ice segregation (cryogenic structures). In the studied region of the Sub-Polar Urals (Maldynyrd ridge, 65° 20' N, 60° 42' E), these features are of different intensity and specifity and expressed to the maximum extent in the high-altitude mountain tundra zone. In the mountain forest belt the soil cryogenesis is weaker developed due to leveling of micro-climatic conditions under forest canopy.

The aim of the study is to examine the profile redistribution pattern of minerals in coarse fractions (1.0-0.25 mm, 0.25-0.1 mm) in permafrost-affected and long-term freezing soils of the Sub-Polar Urals.

The study area belongs to the zone of massive-island and sporadic permafrost, which are widespread along gentle slopes of the piedmont plains (350-450 m a.s.l.). The objects of the study are two profiles filled in mountain forest belt (pit 22-09) and in mountain tundra (pit 25-09).

Pit 22-09. Mountain forest belt. The vegetation is dominated by larch (Larix Sibirica). Profile structure: O (0-6 cm)-E (6-14 cm)-BF (14-30 cm)-CRM (30-37 cm)-BCcrm (37-55 cm), BC (55-70 cm). Soil – Fe-illuvial svetlozem. The soil is underlained by quartz-sericite schists and rhyolites from a depth of 70 cm. According to morphological structure, specific cryogenic aggregation is clearly expressed at a depth of 30-55 cm: fragile lenticular-layered tiles are disintegrated to angular-lumpy (nuciform) aggregates. The mineral composition of coarse and intermediary sand fractions is represented by micaceous -feldspar-quartz mineral association. In the composition of heavy residue (0.25-0.1 mm) hematite (80-85%) and leucoxene (15-20%) predominate. In cryogenic-structured horizons (CRM and BCcrm) epidote sporadically occur (1-2%) as well as tourmaline, rutile (up to 5%), sphene, zircon, anatase and andalusite.

Pit 25-09. Mountain shrub-lichen tundra. Profile structure: O (0-8 cm)-BG (8-22 cm)-BCg (22-45)-Cg⊥ (45-70 cm). Soil – Fe-cryogenic permafrost-affected gleezem. Under shallow weakly decomposed peaty litter (5-8 cm) there are series of mineral gley horizons of different color intensity. In the upper soil the gley horizon BG has a bright blue (often bluish-brown) color with brownish ocher-thin margins. Middle gleyic horizons BCg-Cg are bluish-brown with rusty spots up to 1-2 cm, the horizons enclose small lenses of pure ice. Permafrost table, which represents watertight stratum, underlies at a depth of 40-45 cm. Thus, the soil profile is waterlogged and thixotropic.

In studied gleezem the cryogenic structure analysis revealed that active layer is directly underlain by ice-rich permafrost where stratified cryogenic structures dominate. According to mineral composition of coarse sand fraction, quartz (40-55%), Mn and Fe hydroxides (10-25%) and feldspar (5-10%) dominate. Feldspar content is increased down the profile up to 30% in the fraction of intermediary sand.

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The Snow Cover of the Mountain Landscapes of the Cryosphere In Eastern Yakutia

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To clarify the different characteristics of snow cover, a better understanding of the role of snow cover in the Arctic climate system, and a more reliable estimate of the chemical composition and the amount of snow in the cryosphere, monitoring snow surveys were conducted within the boreal and mountain landscapes of Central and Eastern Yakutia (2010-2012).

During the field studies snow depth was measured using snow stakes, snow water equivalent was determined using a cylindrical cover sampler of 0,005 m2 in cross section, the hardness of the snow surface was measured with the help of a durometer, snow type and size was measured using agrain gage. For a chemical analysis of dust, ions, and stable isotopes of water samples were taken with a clean cutter at the full depth of the snow cover and were placed in a clean sealed plastic bag. When melted, the samples were poured into clean airtight bottles made of polypropylene or glass.

The height of snow cover is small due to anti-cyclonic weather regime. In the mountainous landscapes of the Indigirka River basin it is 28 cm, in the middle boreal landscapes in the basin of the Lena River it is 50 cm.

A characteristic feature of the snow cover in the region is its low density. Snow falls very dry and is little compacted during the winter. By the beginning of snowmelt, its density ranges from 0.160 g/cm^3 inmiddle boreal landscapes to 0.138-0.154 g/cm3 in mountain landscapes.

The volume concentration of dust particles tends to decrease in the mountainous landscapes and increases in the relatively populated middle boreal landscapes.

During the observation period a steady increase of the water reserve in the snowpack of cryogenic middle boreal and mountainous landscapes was observed, its value for the two years having increased by almost 60%, from 41 mm in 2010 mm to 66 mm in 2012. Exceptions are mountainous deserts, where a decrease of water reserve is observed. This situation largely determined different water content in rivers during flood.

Geographical position and atmospheric processes in the western (the Lena River basin) and eastern (the Indigirka River basin) parts of the route determine the differences in the chemical composition of snow. The eastern, more mountainous part of it is located in a region where with a flow of oxygen-rich moist polar air from the Pacific Ocean. In the Lena River basin, with mainly middle boreal and mountain boreal landscapes a lack of oxygen is observed, which is characteristic for the anticyclonic regime in Central Yakutia.

The chemical composition of snow cryogenic landscapes regardless of elevation has remained relatively constant, hydrocarbonate chloride-bicarbonate or sodium calcium typical for the background areas of Yakutia with very low level of anthropogenic pressure.

An increasing role of nitrogen compounds, mainly ammonium form, a sharp decrease in salinity and acidification of water in snow mountain landscapes can be noted. At the altitudes above 2000 m the chemical composition of snow becomes hydrocarbonate mixed composition of cations with ammonium prevalence.

In the future, it is planned to continue the monitoring system with the constant selection of snowmonoliths for the complex study of various parameters of snow cover typical for cryogenic landscapes.

Temperature Regime of Tundra Soils and Underlying Permafrost in the European North-East of Russia

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Temperature regimes in 7 permafrost soils formed in mineral and peat soil-forming deposits in various landscapes of the southern tundra In the discontinuous permafrost zone of the European North-East of Russia. The parameters of annual, winter and summer temperature regimes have been relatively studied. Seasonal and long-term temperature dynamics in active layer and permafrost beneath has been characterized.

The differences are caused by the winter temperature indicators: thickness of snow cover, landscape position, etc.

On peat and mineral mounds cold permafrost-affected soils occur with harsh winter temperature conditions, the FDD range on the surface of the soil -1036 ... -2508° C, the DDT range of active layer 0.8 ... -4.8° C. The relatively low MAT of the upper permafrost vary from -2.3 to -4.4° C with their shallow active layer (40-50 cm) indicated the relative stability of permafrost peat mounds.

Soils of shallow slopes and depressions are a group of warm profiles with relatively mild winter and annual temperature regimes. Surface FDD are -171 ... -1264° C, active layer DDT are 1,1 ... -1,9 ° C. Loamy soils of this group are underlain by warm permafrost, particularly sensitive to climate change. Sustained positive MAT of the active layers of peaty- gley soil confirm and mark permafrost thawing observed at the site during the last two decades.

Summer temperature indicators in the upper horizons (0-20 cm) of the investigated soils are relatively aligned. Differentiation In the deeper layers is due to the different depth of permafrost level. Large heat losses in seasonal thawing, the presence of permafrost cooling screen and partly thick organic horizon prevents the penetration of biologically active temperature (MAST>10° C).

Microclimatic Characteristics of Subpolar Ural Soils (National Park Yugyd va)

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Recent studies have shown that the vast territory of the Subpolar Urals with a strongly dissected relief is characterized by the great diversity of the terrestrial and water ecosystems (Biodiversity…, 2010). However, this unique territory remains insufficiently studied with respect to its climatic characteristics. In relation to the problems of climate change and the budget of greenhouse gases, data on the microclimatic features and also pools of carbon and nitrogen stored in the soils of mountain regions are of great importance. Also, the territory of the Subpolar Urals is the southernmost territory with permafrost in the East-European sector of the Subarctic (Oberman, 1998).

The aim of our work was to characterize the microclimatic regime (temperature of ogranogenic soil horizons, temperature of air, solar radiation level) at dominated landscapes of mountain-tundra and mountain forest belts of Subpolar Urals for understanding soil forming and humification processes.

The measurement was carried out by temperature logger Ibutton and Hobo micrometeostation. The field diagnostics of the studied soils and the determination of their classification position were performed according to the Field Guide on Russian Soils. Morphological and physicochemical properties of investigated soils were presented at our article (Dymov et. al., 2013). The studying of temperature regime was beginning at 2010. Litter temperature to a considerable degree repeated to air temperature. But mostly temperature of soils depend on landscape position and vegetation belt location. Disposition and altitude of plots play major role at microclimatic characteristic of studied soils. The minimum temperature of soil organogenic layers are located at 600-730 m a.s.l. are minus 18 °C, but minimum soil temperature at similar organogenic horizos at soils are located at 400-450 a.s.l. minus 7 - 10 ° C. Maximal average daily temperature during summer season at tundra soils vary from plus 7 up to 21 °C at dependence on landscape position. Temperature of organogenic horizons at mountain-forest belt is some higher than tundra soils - minimal value at winter season is minus 4 °C. The maximal average daily temperature of litter at forest soils at summer season is 24 °C. Forest cover is influence on amplitude of diurnal temperature. Daily temperature amplitudes during summer season at forest soils are 10-12 °C, while the daily amplitudes at tundra-mountain soils some higher - 17-20 °C. The average daily temperature below zero are observed at soils mountain-tundra soil during 200-240 days per year, at mountain-forest soils - 145-208 days per year. Solar flux level incoming on surface of soils dependent on altitude of study sites, maximal value were determinate at june. More inclement conditions of mountain-tundra lead to forming humus substances with their composition reflects the specificity of the soils' humus forming. At soil of mountain-forest humus substances are more aromatic, while humic substances of mountain-tundra are characterized by increase of periphery part of biopolymers.

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Soil-Geographic Division of Western Yakutia and Contiguous Territories

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The map of soil-geographic regions of western Yakutia and contiguous territories of Krasnoyarsk region and Irkutsk oblast has been developed on the basis of the State Soil Map (1 : 1 M) (map sheets P-48-49, Q-48–51, R-49–51) and satellite imagery. Detailed descriptions of climate, vegetation, relief, parent materials, and soils are given for each of the regions. The division of the territory into regions differs from the classical schemes of zonal (subzonal) and provincial division. It is entirely based on the analysis of soil cover patterns as displayed on the soil maps. Information about the factors of soil formation plays a supplementary role. The leading factors specifying separation of soil regions differ in dependence on the particular environmental conditions.

Thus, differentiation of soil regions in the area of the Anabar shield composed of the Archean quartzite gneiss and granitoid rocks is specified by the absolute height of the territory. The highest positions (600-900 m asl) are the areas of predominant stony rock outcrops with peat-mucky cryozems and podburs. Palevye (pale) soils of stony polygons predominate on leveled interfluves at 400-600 m asl; rock outcrops and peat-mucky cryozems are developed on slopes under tundra vegetation; Combinations of peat-mucky cryozems and raw-humus pale soils under sparse larch taiga are formed on lower parts of the slopes.

To the east and south of the Anabar Plateau, vast Olenek–Anabar (250-350 m asl), Olenek-Markha (350-450 m asl), and Vilyui (600-700 m asl) plateaus composed of the Late Proterozoic, Cambrian, and Ordovician calcareous rocks are found. These plateaus differ in the composition of surface deposits serving as parent materials. Thus, surface sandy loamy deposits with a relatively low ice content predominate in the Olenek-Anabar Plateau, clayey ice-rich deposits of the Eikskaya suite are widespread on the Olenek-Markha Plateau, and numerous intrusions of mafic rocks complicate the lithology of the Vilyui Plateau. The difference in lithology is the major factor of the soil cover differentiation in these areas. Slightly gleyed mucky cryozems forming hummocky complexes with peat soils of cryogenic fissures predominate in the areas with sandy loamy sediments on leveled surfaces. Thermokarst is poorly developed in these areas. Gleyed peat and peat mucky soils and residual-calcareous mucky cryozems are formed in the areas with clayey parent materials. Thermokarst is active. The areas with mafic rocks and their derivatives on the Vilyui Plateau are occupied by the raw-humus gravelly pale soils amidst the calcareous cryozems. Within lithologically homogenous areas with calcareous bedrock, the particular relief and drainage conditions play the major role in the soil cover differentiation. Within the northeastern margin of the Siberian Platform (in the Lower Lena reaches), Jurassic and Cretaceous sandstones, siltstones, and slates come to the surface. They are covered by the loamy Quaternary sediments. The subdivision of these territories is specified by the climatic factor: mucky and peat-mucky cryozems with peat soils of cryogenic troughs predominate in the northern part; raw-humus pale soils and pale-cryozemic soils, in the southern part.

Soils diversity in Thala Hills Oasis (Enderby Land, East Antarctica)

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The area of the coastal Thala Hills oasis (Enderby Land, East Antarctica) is twenty square kilometers, it consists of two sections (Molodezhnaya and Vechernyaya). Thala Hills oasis should be considered as Mid Antarctic snowpatch barrens (Goryachkin et al, 2012). Organo-mineral soils (first centimeters depth) with micro profiles on fine earth under algae, lichen and moss are well represented. Soils with macro-profiles are associated with the receipt of the organic material from the ocean («ornithogenic» и «post-ornithogenic») and from lakes - «amphibia» soils (Abakumov, 2011). Wet valley oasis should be regarded as the closest analogue of the wet valleys oasis "Larsemann Hills“ (Mergelov, 2011). The most important factor of soil formation in the valleys is the additional surface wetting due to the active melting of snowpatches in the warm season. Maximum vegetation in oasis is found in the wind shelters on eluvium in the rock baths. It creates thick moss and lichens cover; the organo-mineral soil with peat and raw humus horizons (Histic Leptosol) is formed. This soil can be preliminary classified as the Spodic Histic Leptosol.

Session 8: Permafrost microbiology and astrobiology

Bizarre Bacteria at the Uppermost Water Layer of the Subglacial Lake Vostok, East Antarctica

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The objective was to estimate microbial content of accretion ice originating from frozen water of the subglacial Lake Vostok buried beneath 4-km thick East Antarctic ice sheet as well as first samples of the lake water (RAE57) with the ultimate goal to discover the life in this extreme icy environment. As a result, the DNA study constrained by Ancient DNA research criteria along with cell enumeration by flow cytometry has pointed out that the deepest closest to the ice-water boundary accretion ice (3764m) contains the very low microbial biomass generating no reliable DNA signals in PCR and is comparable with background contamination level (a few cells per ml). The comprehensive analyses of the first lake water (mixed with a drill fluid at ratio 1:1) sample froze on a drill bit at 3769.3m depth upon the subglacial Lake Vostok entry (February 5, 2012) are finally got finished. The cell concentrations in the sample showed 167 cells per ml (counted by flow cytofluorometry) coming up with several bacterial phylotypes identified by sequencing of several regions of the 16S rRNA genes. Amongst them all but one were considered to be contaminants (in our contaminant library, including drill fluid findings). The remaining phylotype successfully passing all contamination criteria is proved hitherto-unknown type of bacterium (group of clones, 3 allelic variants) showing less than 86% similarity with known taxa. Its phylogenetic assignment to bacterial divisions or lineages was also unsuccessful despite of the RDP has classified it belonging to OD1 uncultured Candidate Division. Archaea were not detected nor in deepest accretion nor in the lake water sample. Thus, the unidentified and unclassified bacterial phylotype for the first time discovered in the uppermost water layer in subglacial Lake Vostok seems to represent ingenious cell populations in the lake. The proof will (and further discoveries may) come with analyses of several new cleaner lake water (frozen-in-borehole) samples that will be available shortly.

Microbial Diversity in Permafrost and Sea Sediment Samples from the King George Island , Antarctica, Revealed by 16S rRNA Gene Pyrosequencing.

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Microbial responses to environmental changes are still uncertain, mainly because little is known about the species composition in most habitats. These responses are of particular interest in climatic sensitive regions such as the Antarctic Peninsula. Biological and environmental parameters were studied in Permafrost samples collected on mid-summer of 2009 near the Russian Antarctic Station “Bellinsgauzen”, in King George Island, Antarctica. Five permafrost samples were selected from a borehole drilled 4 to 9 meters below the surface (P13=4.6 mbs; P14=5.8 mbs; P15=6.9 mbs; P16=8.1 mbs; P17=9.2 mbs). Initial analysis of the samples indicated they represent Antarctic marine sediments frozen up to 7,500 years ago. In addition, a "modern" marine sediment from Maxwell Bay (sample B2) was collected in order to compare the past and present microbial community structures. Total microbial DNA was extracted from 10 g of each sample using PowerMax Soil DNA kit (Mo Bio, USA), and then amplified with barcoded primers U519F and U1068R, which correspond to the V4-V6 regions of Escherichia coli 16S rRNA gene. Amplicons were sequenced in 454 GS FLX Pyrosequencing (Roche), resulting in 63,610 sequences. A high abundance of Unclassified sequences (49% in average) was found in the Antarctic permafrosts, similarly to previous studies using massive sequencing approaches on permafrost samples from Canada and Eastern Asia. The remaining sequences were assigned to 19 different Bacteria phyla and varied significantly across all samples. The most abundant phyla included Proteobacteria, Actinobacteria, Bacteroidetes, Cyanobacteria, Acidobacteria, Firmicutes and Verrucomicrobia, which are groups ubiquitously found in soils. The modern marine sediment was dominated by Proteobacteria (73%), Bacteroidetes (13%) and Verrucomicrobia (6.3%). The uppermost permafrost sample P13 revealed high abundances of Proteobacteria (49.9%), Actinobacteria (20.7%) and Firmicutes (17.1%) . P14 and P15 showed higher abundances of Proteobacteria (respectively 88.7% and 55%), Firmicutes (6.4% and 20.3%) and Actionobacteria (2.3% and 13.7%), while P16 showed a surprisingly high abundance of Proteobacteria (98.9%) followed by a few sequences classified as Firmicutes (0.46%) and Cyanobacteria (0.42%). Finally, the deepest permafrost P17 showed Proteobacteria (56.9%), Firmicutes (20.1%), Cyanobacteria (14%) and Chloroflexi (5%) as more abundant phyla. Overall, the results revealed significant changes in the microbial community structures in the permafrost, which could be related to past environmental changes in the Antarctic Peninsula over the past 7,500 years. Also, the high abundance of unclassified sequences indicates the presence of microorganisms with less understood or even yet unknown ecological roles in the Antarctic permafrost.

Characteristic of Properties of Lipolytic Enzymes from Psychrotrophic bacterium Psychrobacter cryohalolentis K5T

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50% territory of Russia is occupied by permafrost, which poses unique challenges to its resident biota: low temperatures, low content of organic matter, small amounts of liquid water and etc. Siberian permafrost contains the unique microbial community adapted to these specific conditions. It is inhabited by bacteria, green algae, yeasts, mycelial fungi. One way of survival for these microorganisms is the expression of cold-active enzymes including coldactive lipases. Goal of our study was to search for coding sequences of lipolytic enzymes in the genomes of bacteria isolated from the permafrost, and the study of their properties. Analysis of the genome of Psychrobacter cryohalolentis allowed to detect the presence of the lipolytic system in this bacterium including coldactive esterase EstPc and coldactive lipases Lip1Pc, Lip2Pc. The expression systems of these genes in E. coli were constructed and an efficient protocols for purify recombinant enzymes and in vitro refolding of lipase Lip2Pc in the presence of the truncated chaperone were developed. In the study of the properties of recombinant lipolytic enzymes of P. cryohalolentis following results were obtained. The optimal temperature for enzymatic activity of EstPc was 35° C, and for Lip1Pc and Lip2Pc - 25 ° C, while their activity at temperatures below the optimum was 70-90% of maximum. Unlike most of the enzymes, EstPc and Lip2Pc have shown a relatively high thermostability, they retained their activity on the level of 40-100% after incubation at temperatures above 70°C. For Lip1Pc was shown a typical for coldactive proteins instability at elevated temperatures. Obtained results for the use of proteins of substrates with different length of hydrocarbon chain showed that EstPc is esterase with maximum activity toward C4 substrate. Lip1Pc and Lip2Pc showed higher activity toward substrates with relatively long hydrocarbon chain. Maximum activity was shown to Lip1Pc using C12 substrate and Lip2Pc - C16, respectively.
The results of these studies suggest that the permafrost is a promising source of enzymes, particularly with lipolytic activity at low temperatures.

Population Genomics of *Geomyces Pannorum*

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Analysis of the diversity of filamentous fungi from the Arctic and Antarctic active layers and permafrost, showed that Geomyces pannorum (Link) Sigler et J.W. Carmich., psychrotolerant anamorphic fungi which can reproduce at temperature -5°C, occupy a special position among the isolated fungi. These everytopic micromycetes are not only widely distributed in low-temperature regions, but also have the great number of propagules. For example, the ability to survive in conditions of high salinity and low temperature is responsible for their abundance in the Antarctic cryopegs (75% of all isolates obtained).

High adaptive capabilities of G. pannorum allowed them to maintain the viability in the samples with the age of thousands or even millions of years.

Starting from the paradigm of basal importance of genomics and genomics-based approaches for comprehending evolutionally derived adoptive properties of living organisms, we present here the results of the whole-genome sequencing of the 14 specially selected G. pannorum strains. Five strains were isolated from permafrost (age 1,8-3 million years), three ones from Arctic active layer, one strain from Arctic cryopeg (age 100-120 thousand years), and the rest ones from temperate environments (midland Russia, Sweden, Germany, USA and Mongolia).

The comparative analysis of genome sequences reveals very high nucleotide diversity among G. pannorum isolates. The typical distance between two isolates is dS≈0.5, this is near the same as the distance between G. destructans Blehert et Gargas (well-known pathogen of bats) genome sequence and each any of newly sequenced G. pannorum genome sequences.

The strains extracted from permafrost do not form a separate phylogenomic clade, although they are considered completely isolated of temperate environments for the last 2-3 million years. Namely, each permafrost isolate has relatives from temperate environments. This indicates that either the varieties of G. pannorum diverged much earlier than the isolation had started or the permafrost did not provide enough isolation for G. pannorum population. Moreover, mutation rate and mutation patterns for permafrost isolates are indistinguishable from those for temperate strains.

Consistent with the hypothesis of asexual reproduction of G. pannorum, we observed clonal structure for >99% of genome sequences. However, there are certain short (~100-10000 nt) regions which demonstrate phylogenetic pattern strikingly different from the rest of the genome. These regions are most likely to be the result of horizontal transfer of the genetic material between different varieties of G. pannorum.

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Characteristics of Microbial Communities Functioning in the Cryogenic Peat Soils of Boggy Larch Forests and Oligo-Trophic Bog in Central Evenkia

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The microbial activity of cryogenic peat soils was studied in oligo-mesotrophic bog and boggy larch forests formed by the Larix gmelinii Rupr., located in the basins of the Kochechum and Nizhnaya Tunguska rivers in Central Evenkia. Formation of a thick moss–lichen cover is typical for waterlogged soils of Evenkia and promotes to the slow thawing of the active soil layer during the vegetation period. The level of permafrost depends on microrelief (microhigh or microlow), orientation of the microhigh slopes and amount of precipitation.

Peat soils of boggy larch forests and the transitional bog are characterized by the simple and thin (30–50 cm) profile underlying by permafrost. Boggy larch forests (B1 and B2) are forming after the fires; the composition of peat changes from the woody peat in the lower layers to sphagnum peat in the middle and upper parts of the profile. The effects of fires on vegetation have not been found in the oligotrophic open larch forest (B4), where the peat was composed of S. fuscum. Degree of decomposition of the upper moss layer and the peat is lower than in B1 and B2 plots. The thickness of the peat soil profile in transitional bog (B3) varies from 25 to

35 cm. The botanical composition of the peat is rich and diverse. The degree of decomposition of the peat varies from 20 to 45%. The acid reaction in studied peat soils changes from strongly to moderately: in the TO horizon pHKCl varies from 2.7 to 3.1 and in the T1 and T2 horizons - from 4.3 to 5.3. The soils have very low ash content: in the moss horizon on the microhighs varies from 1.62 to 3.16%; in the microlows - from 2.80 to 8.90%. The carbon content in the soil profiles of all studied plots varies slightly (48–49%). It is known that peat decomposition depends on the microbial activity. The representatives of the bacterial complex (Proteobacteria) predominated among microbial population in the soils of all plots. The abundance of the microbial population gradually decreased to deep of soil profiles and reached its minimum in the boundary of the permafrost layer.

The intensity of the microbiological and biochemical processes in the peat soils of B1–B4 plots is different; the maximum values were recorded under the boggy larch forests (B1); lower values were obtained for plots B2 and B3; the lowest activity was recorded on plot B4 (B1 ≥ B2 > B3 > B4). ANOVA and the correlation analysis revealed significant effects of pH and soil temperature on the activity of the main microbial ecotrophic groups and the MB ($p < 0.05$) at all the plots. The values of the integral criterion of the microbiological activity (QR) at all the plots evidence of the functioning of microbial communities in the studied soils is within the limits of the natural variability, which points to the ecological stability of the studied ecotopes.

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Cryoplanets

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Recent observations of gravitational microlensing towards globular clusters and the Galactic centre have brought information of a completely new class of objects in our Galaxy: the planets liberated of their host stars and floating free in the interstellar space -- so-called free-floating planets. Estimates show that their amount can be upto four-five orders of magnitude higher than the number of stars in the Galaxy. This conclusion has been confirmed by a recent near-infrared detection and spectroscopic study of such a free-floating planet of 4-5 jupiter mass, aged of 20-500 Myr, and with surface temperature of 650-750 K. In general though the existence of free-float exoplanets in a very wide range of ages (ranging from hundreds of Myrs upto 10-13 Gyr) can be expected in our Galaxy, with the corresponding surface temperature from hundres to 3-10 K, respectively. I esttimate and briefly discuss the following characteristics of free-floatting planets: i) the mass, age and temperature distribution functions, ii) expected chemical composition and physical conditions on their surface, iii) emissivity of very cold (3-30 K) planets induced by external radiation and cosmic rays, iii) expected fluxes in infrared and prospectives for their photometric and spectroscopic study with current and ongoing telescopes.

Microbial Communities of Permafrost and Xerophytic Soils Can Exist Long in the Martian Regolith

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The study of microbial resistance in extreme habitats suggests that the protective role of the natural environment can be a factor that significantly corrects the theoretically predicted maintenance of cell life sustaining in alien ground and in the meteorites.

The purpose of this study is to investigate the viability of terrestrial microorganisms and natural microbial communities in soils and rocks under conditions simulating the space environment and Mars regolith, to estimate the duration life sustaining in the Martian ground.

We conducted the irradiation of frozen rocks and arid soils (as the models of Martian regolith), and pure cultures of bacteria by gamma radiation (dose gradient 1Gy - 10 kGy) at different temperatures (+50°C, 0°C, -50°C) and a pressure of 0,1 mbar. We also studied the influence of strong oxidants presence (peroxides and perchlorates at concentrations up to 10% and up to 15% by weight respectively) in the soil. In our research we investigated the combined effect of all these factors.

It was found that bacterial communities of the extreme Earth habitats (Xerophytic arid soil and permafrost sediments of Eastern Siberia and Antarctica) are able to withstand, without significant loss the space conditions and simulated Martian environments: ionizing radiation at doses corresponding to 5-50 thousand years on the Martian surface, the presence of oxidants, low pressure and low temperature, maintaining metabolic and reproductive activities. The perchlorate presence exacerbates the impact of radiation on microorganisms under vacuum and low temperature. However, the damage to communities and the cells were not catastrophic. The concentration of peroxide up to 15% in the soil and atmospheric saturation by and hydrogen peroxide vapors are not critical to the viability of the borrowing mechanisms disorders natural microbial communities. Most of the cell pass into uncultivated state, keeping the possibility of reparation after damages and maintainance of the cell pool potentially ready for reproduction.

The high viability of pure bacteria cultures (Kocuriar osea, Arthrobacter polychromogenes, Micrococcus roseus, Micrococcus luteus, Bacillus sp., Cellulomonas sp., Sphingomonas.sp.) isolated from the permafrost and arid soils was found us in the Martian model. Certain strains have an increase in reproductive activity and an improvement in functional status undercertain modes, and the positive impact of short-term (2 h) impact of vacuum on the crop condition was found.

Thus, the expectation of a high concentration of oxidants in the soil of Mars or the lower layers of its atmosphere, combined with the impact of other extreme factors such as radiation and low pressure – do not contradict to the terrestrial microbial communities and fundamental possibility of adaptation and long-term survival in the soils of Mars.

Activity and Biodiversity of Microbial Biota of Cryosol and Ground Ice Complex of Central Yakutia (Eastern Siberia, Russia)

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The activity of microbiocenosis defines ecosystem functions of contemporary permafrost soils and permafrost rocks. The investigation was focused on microbial biota of thermocirque ecosystem, which develops in the ice complex, located on the left bank of the Aldan river under the influence of cryogenic processes, destructing permafrost depositions of upper Pleistocene-Holocene age of the Mamontova mountain outcrop.

The samples were taken in June, 2012 from the thermocirque wall for studying diversity and number of microorganisms, as well as enzymatic activity depending on the humus content, temperature, humidity, pH, soil and ground composition. The area is described by extreme climatic conditions. In the permafrost soils the microbial biota activity is season determined, limited by a very short warm period of the year. The microorganisms in the permafrost soil are in the latent state. At thawing of rock ice complex and failure of the walls at the average speed of 5-15 м for the summer season the soil and permafrost microbial biota first finds oneself in the thaw basin, and then to the bank and inside the body of the Aldan river together with thawed deposits.

A considerable decrease of microbial biota in number is traced at transition from permafrost soil (1, 00×10^7 CFU/g) towards permafrost (8, 60×10^6 CFU/g). the following bacterial prevail: *Bacillus*, *Acinetobacter*, *Psychrobacter*, *Phenylobacterium*. The coefficient of microbiological mineralization in the permafrost soils is 0.54, and 0.90 in the permafrost and correlates with the humus content (r=0.64). The permafrost soils and permafrost rocks in terms of invertase activity are estimated as poor, at that all the investigated samples were enriched with invertase. The invertase activity has a strong positive correlative relation (r=0.95) with the number of microorganisms, either in permafrost soils and in permafrost rocks.

The permafrost biological activity is not less than the permafrost soils activity. The diversity of contemporary microbiocenosis increases by means of cryogenic processes with the help of relict bacteria.

Metagenomic and metaproteomic analyses of the High Arctic Canadian permafrost

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Permafrost thawing and the resulting microbial decomposition of previously frozen organic C represents a significant potential positive feedback from terrestrial ecosystems to the atmosphere. Comparative metagenomic and metaproteomic analyses of microbial ecosystems in low-carbon Arctic cryosols and upper permafrost layer were undertaken to understand the effect of temperature increase on the changes in community composition. Twenty, well-characterized, 1 meter long, intact cores consisting of active-layers and permafrost, collected from an ice-wedge polygon located near the McGill Arctic Research Station on Axel Heiberg Island, Nunavut, Canada were used in a long-term thawing experiment. The cores were thawed under saturated conditions (receiving artificial rain), under natural hydrological conditions with light input (drained cores) and with no light input (dark cores), and without thawing (control cores with permafrost maintained at 70 cm depth). Gas composition in the headspace (H_2, CH_4, CO, O_2, N_2, CO_2, and $\delta^{13}C$ of CO_2) and pore water chemistry (including dissolved gases) at 4 different depths were analyzed weekly. The cores were sub-sampled along 4 depths at 0, 0.25, 6 and 12 months for metagenomic analyses. Shotgun metagenome libraries for samples before and after thawing were sequenced using 454 and Illumina platforms yielding >300 Gb of raw data. Taxonomic and functional characterization of the metagenomes indicated specific microbial community differences between the upper active layers and the lower permafrost layer. Potential CH_4 cycling pathways primarily consisted of CH_4 oxidizers in the upper layers with a paucity of methanogenic archaea in the lower layers. Other differences in carbon cycling pathways with depth included aromatic ring oxidation and CO_2 fixation potential in the uppermost layer, and carbon reduction pathways in the permafrost layer. Nitrogen-cycling pathways also differed by depth with nitrogen fixation occurring in the upper layers and nitrification in the permafrost. Metaproteome profiling of the samples revealed modest increases in the cellular activity of the microbial consortia upon thawing. The metagenomic sequences generated during the study are currently being co-assembled to generate a high quality database in order to understand the relationships between metabolic potential of microbial communities and ecosystem gradients.

Characterization of Bacterial Community from East Antarctic Oases

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Antarctic permafrost is the regarded model for solving several important issues such as life evolution and soil-forming factors in extreme habitats on Earth and possible life preservation in extraterrestrial environment. Subsoil sediments are the most constant and stable environment among other extreme habitats, where microbial communities survive several millions of years. Nevertheless, Antarctic soil seems to be no less attractive as a model for study of life on the surface of Antarctic rocks and influence of living forms on soil development under extreme conditions. Detailed soil investigations are concentrated mainly on soil genesis, development of relatively detailed soil maps and molecular-genetic analysis of microbial components in such soils. Molecular-genetic methods showed the diversity of bacteria in Antarctic soils, but these results don't reveal biological activity, physiological status and stability of microbes in external environment. A combination of culture - depended and – independent techniques were used to characterize bacteria community in earlier not investigated soils in the oases of Larsemann Hills (East Antarctic Coast). The samples of ahumic soils and barren rock with endolithic soil-like bodies in interhill 'wet valleys' area were examined. The total number of bacterial cells counted by staining with acridine orange was rather high for Antarctic habitat and varied in the range of 107-108 cells/g dw. Using Live/Dead (L7012) pigment stain it was shown that 60% of detected total number cells has undamaged cell membranes that testify for their viability and stability to extreme environment.

The considerable number among viable cells (70-80%) were nanoforms with cell diameter not higher 200 nm, that exceed such indexes in temperate soils and represent the specific pool of antarctic bacteria. The viable cell count of heterotrophic bacteria varied significantly (0-10 5 cfu/g dw) and correlated with organic C content in microhorizons. This can testify that the most important part of organic matter is rather mobile and available for bacteria, but weakly connected with mineral matrix and poorly humified. Application of Fish method (Fluorescence in situ by hybridization) allowed determining the representatives of Actinobacteria, Planctomyces, Acidobacteria. Examined soils were characterized by significant discrepancy between indexes of total and viable number of cells, as well as high irregularity in horizons of developing soils, that is rather common in Antarctic sediments. As a general rule, it can be explained by specification of physical and chemical processes in permafrost or permanently frozen habitats, both by imperfection of microbial isolation techniques. Our data indicate additionally the importance of taking into account in Antarctic investigations the microbial biofilms, where microorganisms are intimately associated with each other and mineral particles through binding and inc lusion within exopolymer matrix. These biofilms may play leading role in soil development, modify the metabolism of the component cells and favor the cells to obtain high stability to external factors that require special techniques for reactivation of bacteria from such extreme environment.

Mycelial Fungi from Antarctic Active Layer Detected by Different Methods

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To identify Antarctic fungi the conventional microbiological methods and (or) the metagenomic analysis of the samples are commonly used. A characteristic feature of these studies is that the lists of taxa recovered by different methods often don’t yield an overlap (Margesin, Miteva, 2011; Kochkina et al., 2013).

The present study was conducted to investigate the genomic DNA of 2 samples of active layer Novolazarevskaya station (hole FDG-09-03, 70°45'45,3"S, 11°46'50,2"E). By sequencing of amplification products, 84 OTUs (operational taxonomic units) of the ITS2 region were obtained from these samples. Only 19 OTUs belonged to Kindom Fungi. The obtained OTUs included a great number of those belonging to mosses, green algae and ciliates.

All received fungal OTUs relate to phylum Ascomycota. 5 fungal sequences found in the surface sample (0.5-2 cm) were similar to those available in the GenBank for 3 fungal species (Geomyces pannorum, Herpotrichia juniperi и Tumularia aquatica).

14 fungal OTE in the subsurface sample (2-6 cm) could be referred to 10 taxa. They were represented by both anamorphs and teleomorphs of Ascomycetes. Among the teleomorphs there were two species (Thelebolus microsporus and Antarctomyces psychrotrophicus) commonly found in Antarctica.

The black snow mold pathogen frequently occurring in the Alps (Herpotrichia juniperi) and the aqueous fungus often found in the cold waters of Alpine springs (Tumularia aquatica) were common for both samples.

In parallel, culture-dependent method with using of different temperatures of thawing (Kochkina et al., 2001) was used for isolation of fungi from the same samples. As a result of studying the Antarctic samples by culture-dependent and culture-independent methods, different lists of the taxa were obtained, which coincided only in the two dominant species: Geomyces pannorum and Phoma herbarum. However, complex studies are extremely informative and allow to obtain a more complete picture of biodiversity in Antarctic sediments.

Culture-dependent method for fungal diagnostics may lead to problems in identification because of:

1) having morphology of strains isolated from low-temperature habitats reduced and variable; C than contemporary isolates of the same species;□

2) some psychrotolerant fungi prefer lower temperatures and grow more slowly at 26

3) the presence of a large number of sterile mycelia.

Therefore, in our study we used a molecular-biological analysis for the identification of sterile mycelia and for the diagnosis of some freshly isolated strains with unclear morphological peculiarities.

Thus, a strain named anamorph Ascomycetes has been identified to the level of genus (Teberdinia sp. - 99% homology). Difficulties of this strain identification were related to the lack of growth at temperatures above 15°C, whereas the description of this genus was carried out at a temperature of 18°C (Sogonov et al., 2005).

Strain of dark sterile mycelium had cultural properties similar to those of the species Epicoccum nigrum, but identification was impossible because of absence of reproductive structures. Molecular-biological analysis has confirmed that the isolate belongs to this species with 100% homology.

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Viable Heterotrophic Protists from Soils and Rodent Burrows buried in the Ice complex Sediments

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To identify viable protists were investigated permafrost sediments of north-east Arctic by different age, composition and origin (Shatilovich et al 2005, 2010). We analysed 230 samples of permafrost and found that the most rich and diverse fauna of the ancient protozoa is contained in buried soils and in the contents of ground squirrel (Citellus undulatus) burrows.

The number of samples of buried soils and burrows containing viable protists reached up to 90% of the investigated, while in mineral blocks of ice complex only 36% of the samples contained protists. Ice Complex is composed from loam sediments with powerful ice wedges. It was formed in the process in a constant supply of precipitation on the surface in the process of syncryogenes.

However, during the formation of these sediments have been more warm periods when the precipitation did not arrive so intensely. The soil with well-defined genetic horizons was formed on the surface. Then, these soils were buried in permafrost. Age of buried soils was dated is 32-35 thousand years (Zanina et al 2011). Burrows of ground squirrels located in the mineral layers. They contain a rich and varied material. Rodents brought it from the surface (Zanina et al, 2005). In addition, we assume that the physical conditions in soils saturated with organic residues, as well as in the litter burrows are more favourable for cryopreservation viable objects compared with ice-rich sandy loam of mineral blocks.

Heterotrophic protists of three groups: the naked amoebae (representatives of the three genera), ciliates (7 species of 3 taxonomic groups), flagellates (32 species and form of 12 taxonomic groups) and one species of heleozoa were identified from samples of buried soil and from material of burrows.
Samples were taken from outcrops Stanchikovsky yar and Duvanny yar in the 2000- 2003 field seasons. In most cases, the detected species is universally common organisms in the soil ecotopes. Thus, the buried soils and burrows of rodents are the most promising objects for biodiversity studies of protists have retained viability a long time.

Session 9: Permafrost warming and thawing, long-term monitoring

Long-Term Permafrost Thawing under Warming Climate Conditions

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Climate warming of the last half of a century resulted in many changes in all other components of the Earth’s system. One of the most impacted components was the Cryosphere. Permafrost, as an important part of the Cryosphere, has also been strongly affected. However, according to our data, a wide range of permafrost reaction has been observed. Typically, a much more significant warming has been observed in cold permafrost and much less in warm permafrost. At many sites where the permafrost temperatures are within 0.5 C from the freezing point of water, almost no measurable changes in permafrost temperature during the last 25 to 30 years were recorded. Also, while the warming of relatively cold permafrost was observed practically for the entire Northern Hemisphere permafrost domain, the permafrost thawing was much more restricted and mostly observed in mountain permafrost and at the sites where surface disturbances (natural or human-induced) have occurred and where isolative organic layer was reduced or removed from the ground surface.

In our previous publications and in the publications of our colleagues, the lower rates of changes in relatively warm permafrost were correctly related to the unfrozen water presence in frozen fine-grained earth material. However, we believe that a more in-deep explanation of this phenomenon is warranted especially now when the changes in permafrost and specifically the rate of permafrost thawing were designated by the last IPPC report as one of the major uncertainties in future climate projections.

The major driving force of permafrost warming and/or thawing is a long-term (one year or multi-years) imbalance in incoming and outgoing heat fluxes at the upper boundary of permafrost (permafrost table) integrated over a one-year time period. If more heat is coming in than going out, permafrost will be warming and eventually thawing. If the opposite is true, permafrost will be cooling and the active layer could be converting into permafrost from the permafrost table up.

For some reasons that will be discussed in this presentation, this heat imbalance at the permafrost table is very difficult to measure directly. Therefore, to investigate and explain the mentioned above phenomenon we used both in situ precise temperature measurements and numerical modeling. The permafrost temperature reanalysis technique which was developed in our Permafrost Lab was used in this study. Results of this effort show that, depending on a specific shape of the unfrozen water content curve in soil, active permafrost thawing and a talik formation triggered by atmospheric warming may be delayed by tens and even hundreds of years in fine-grained soils (both organic and mineral) if compared with mineral soils of coarse-grain texture, such as sands or gravels. The presence of massive ice of any type, structure or origin in the upper part of the permafrost layer may further decrease the rate of permafrost thawing and substantially delay the formation of a talik. We believe that any representation of permafrost in global or regional climate models should include the thermal effects of unfrozen water in soils. Otherwise, the rates of permafrost thawing and degradation produced by these models will not be realistic.

Circumpolar Active Layer Monitoring (CALM) program: the Past Present and Future of Long-Term Active Layer and Near-Surface Permafrost Observations

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Global climate change has serious impacts on natural and human systems in permafrost regions. The uppermost layer of seasonal thawing above permafrost (the active layer) is an important regulator of energy and mass fluxes between the surface and the atmosphere in the polar regions. Active layer monitoring is an important component of efforts to assess the effects of global change in permafrost environments. The Circumpolar Active Layer Monitoring (CALM) program, established in the early 1990s, is concerned with observing the response of the active layer and near-surface permafrost to climate change at multi-decade time scales. CALM and its companion borehole temperature program, Thermal State of Permafrost, are closely coordinated international observational networks devoted to permafrost (together, they comprise the Global Terrestrial Network-Permafrost, or GTN-P). The present active-layer network represents the only coordinated and standardized program of observations designed to observe and detect decadal changes in the dynamics of seasonal thawing and freezing in high-latitude soils. In recent years substantial efforts have been made to develop CALM in the permafrost areas of the Southern Hemisphere (CALM-S). Overall, the CALM network involves 14 participating countries and is comprised of 230 sites distributed throughout the Arctic, parts of Antarctica, and several mountain ranges of the mid-latitudes. Direct active-layer measurements are conducted on standard rectangular grids ranging from 10 x 10 m to 1 x 1 km. The locations of sites were selected to represent generalized surface and subsurface conditions characteristic of broad regions. The size of each grid reflects the level of local geographic variability. Active-layer observations and auxiliary information from the CALM network provide a circumpolar database, which has been used extensively by the broader scientific community in biochemical, ecologic, geomorphologic, hydrologic, and climatic research. This presentation is intended to provide discussions on observational strategy, data availability, dissemination, and data use for CALM in the Northern Hemispheres. The main purpose of this report is to initiate the discussion on future development of CALM observational program.

Thaw Subsidence in an Undisturbed Tundra Landscapes

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Thaw penetration into ice reach permafrost is a common process in tundra landscapes. Associated changes of the surface affect radiation balance, surface hydrology, vegetation and cryogenic processes. Differential subsidence initiated by man-made or natural disturbances characterized by relatively fast and substantial changes of surface elevation over relatively small areas. However, over larger areas subsidence can be relatively slow process which can be attributed to changes in climatic forcing alone. Despite the importance of frost heave/subsidence, field measurements of the process are quite rare and available only at point locations which may not be representative of diverse landscape conditions of even small areas. Recent advances in remote sensing allowed to monitor surface deformations over large geographic areas using SAR interferometry. However, field measurements are essential in validation of the remote sensing data and in scaling local observations to larger areas.

To asses changes in daylight surface due to frost heave and subsidence at the North Slope of Alaska two monitoring plots were established in 2001. One site was chosen to be characteristic of the Arctic Coastal Plain and the other of Arctic Foothills physiographic province (detail site descriptions are available under the CALM webpage for sites U5 and U32a at www.gwu.edu/~calm). The sampling design at each site represents hierarchically nested spatially distributed network of 32 points over 1 ha area. Monitoring of changes in surface elevations was performed at least annually at each of the points using DGPS Fast Static surveys.

The results show that net subsidence of 0.11 and 0.14 m occurred at both sites over the period of measurements. The net subsidence occurred due to domination of subsidence over frost heave in most years. The maximum subsidence occurred in the summer of 2004, which was exceptionally warm allowing thaw penetration to melt segregation ice the bottom of the active layer. Linear fit between the square root of Degree-Days of Thawing and active-layer thickness is commonly used to evaluate sensitivity of permafrost landscapes to climatic forcing. Introduction of thaw subsidence to this equation improves best linear fit and increases the coefficient of determination by about 10% at both sites showcasing importance of subsidence in development of the active layer.

The results indicate that relatively slow subsidence may occur over large areas due to changes in climatic forcing even without initiation by man-made or natural disturbances. This low magnitude relatively slow subsidence is referred to as isotropic subsidence to distinguish it from high magnitude differential subsidence associated with initial disturbances and commonly leading to development of thermokarst terrain. Integration of radar interferometry and ground based DGPS measurements of thaw subsidence in the future may provide assessment of isotropic thaw subsidence over large geographic areas. This will help in better understanding of reaction of active-layer and upper permafrost on changing climatic conditions.

Permafrost Monitoring Network in East Siberia

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Temperature characterizing the ground thermal conditions is a key assessment criterion for controlling the state of permafrost. Development of predictive models, their adaptation and reanalysis require reliable data that can only be provided by permafrost monitoring networks. Significant climate changes towards warmer temperatures observed recently in various parts of the Earth increase the importance of establishing such networks. Over the last ten years, the world permafrost community has been undertaking activities to develop thermal monitoring networks within the framework of the Thermal State of Permafrost (TSP) project.

The Melnikov Permafrost Institute has been conducting observations on the thermal state of permafrost over more than thirty years in Central Yakutia, Magadan Oblast, Chukotka and northern Krasnoyarsk Krai. During the last fifteen years, automated systems (dataloggers) have been used at the observation sites, allowing monitoring to be performed with better quality and fewer observers. In 2007, the Institute with support from the TSP project developed a program to establish a permafrost monitoring network across East Siberia. Over 40 observatory sites have been established during the last five years in central, southwestern, western and southern parts of Yakutia, in Magadan Oblast, in the Anadyr lowland on Chukotka, in the Chara Basin, and in the foothills of the Kodar Range. Monitoring sites have been in operation for the last two years in the southern Verkhoyansk Mountains (Lazurnyi). In 2012, twelve sites were instrumented with datalogger systems representing a variety of terrain conditions within the North-Eastern Federal University Geological Field Camp area in the southern Verkhoyansk. Five or six more sites will be established here in 2013.

The permafrost monitoring network in long-term operation will make it possible to obtain reliable information on the thermal state of permafrost needed to predict and prevent adverse consequences associated with permafrost response to climate change and anthropogenic impacts.

Tropical Mountain Permafrost Research and Update

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This project's objective understands the current permafrost state and to establish long-term permafrost monitoring sites at tropical high mountains along the equator between 23.5 ° N and 23.5 °S. Presence of the permafrost strongly affects local hydrologic regimes and the impact of natural disasters. Also this will greatly increase global cryosphere structure and local knowledge and to aid science education.

The tropical high mountain climatic system plays an influential role in the global climate system. The borehole data that result from this study will provide a quality spatial-resolution data set from tropical mountains for the first time then connecting between Arctic and Antarctic cryosphere. The presence of permafrost in tropical mountains has been determined and some borehole data has been obtained, but further/deeper research is needed to gain a greater understanding of climate signals. The additional data gathered from the proposed research will aid the research community in the understanding of today's thermal state of permafrost and encourage science education in the younger generation. This project offers great opportunities for both the science and education communities.

This project will contribute much-needed data to several working groups in the international science community, also provide unique and valuable opportunities for field experience and education to generally underserved groups in rural and predominantly Hawaiian, African and Latin American communities, including isolated communities along the Altiplano, Peruvian and Bolivian Andes. In addition, the project will represent a successful collaboration between the science/research and education communities, and offer valuable insight into difficult thin-air drilling operations. Thus far, we have had promising success in this difficult fieldwork. The data resulting from this research will remain a useful record for future climate studies.

Temperature Field, Distribution and Thickness of Permafrost in the Elkon Horst

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The Elkon Horst is situated in the northern part of the Aldan Shield and consists of a set of raised blocks composed of Archean, Paleoproterozoic and Mesozoic metamorphic and igneous bodies. The region has a middle altitude, heavily dissected mountainous relief. The areal extent and thickness of permafrost, as well as its temperature field are controlled by the complex geology and geomorphology of the Elkon Horst.

In 2007-2011, permafrost and geothermal investigations were carried out by the Laboratory of Geotermics, Melnikov Permafrost Institute, in designated resource development areas within the Elkon Horst. Temperature measurements were made in 120 boreholes ranging in depth from 10 to 1200 m. In the laboratory, thermophysical properties were determined for main rock types. Based on the results obtained from these studies, the region was subdivided into three zones differing in permafrost distribution, temperature regime and thickness:

the northern zone is underlain by unfrozen ground with isolated masses of permafrost; ground temperature ranges from -1.0 to +2.5°C and permafrost thickness varies from a few meters to 80 m;

the central zone is underlain by discontinuous permafrost; ground temperatures range from -2.0 to +2.5ºC and permafrost thickness varies form a few meters to 150 m; and the southern zone, comprising about 90% of the region, is underlain by continuous permafrost with some areas of discontinuous permafrost; ground temperatures generally range from +0.5 to –2.5ºC and permafrost thickness is 30-50 to 330 m. The maximum thickness is estimated to be as much as 450 m in the Kurung and Bileberda watersheds.

In the lower parts of west- and north-facing slopes and in the debris cones, patches of relic permafrost up to 70 m thick occur below depths of 20-30 m from the surface.

The ground temperature regime within the depth of annual temperature fluctuation depends on slope aspect. On north-facing slopes, ground temperatures range from +2.5 to –3.5°C. Ground temperatures are positive on south- and southwest-facing slopes, ranging from 0.5 to 1.8°C. On south-eastern slopes, 69% of the boreholes had positive temperatures, while 31% had zero or subzero temperatures.

No permafrost was found to occur within the flat watersheds where ground temperatures at 10 m vary from 0.1 to 2.5°C. On the Pre-Aldan Plateau, the fissured rocks of Fedorov suite are highly permeable, favouring intensive percolation of precipitation and surface water. The associated thermal effect prevents perennial freezing. Here, areas of unfrozen ground have relatively high temperatures ranging from +1.5 to +2.5°C.

First determinations of the thermophysical properties of the Elkon Horst main rock types were made during the study. Thermal conductivities were found to vary from 1.47 to 4.20 W/(m•K) and dry densities to range from 2236 to 3235 kg/m3.

Using the geothermal measurements and borehole log data, the subsurface temperature field was characterized within the depth of 1500 m. The direct measurements and calculations indicated that ground temperatures at true vertical subsea depth of 500 m vary from -1.0 to +5.2ºC. The geothermal gradient in the subpermafrost zone below 600 m varies from 1.66 to 2.20 ºC/100 m depending on rock type. The geothermal heat flux in the Elkon Horst was estimated to be 44 mW/m2.

Active Layer Dynamics in the Forest Tundra and Southern Tundra (Urengoy Oil-Gas-Condensate Field)

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In 2008, in the frame of CALM program (Circumpolar Active Layer Monitoring) the Earth Cryosphere Institute SB RAS has established 2 study sites which are located on the left bank of the river Pur within the Urengoy oil-gas-condensate field: UKPG-5 – in the southern forest-tundra and UKPG-15 – in southern tundra. The main task of the research is to estimate of the impact of soil and vegetation on the thickness of active layer and permafrost conditions in the ecosystems of the different natural zones. Location of the study sites was made on the base of the theory of the "ecosystem-driven" and "climate- driven ecosystem-modified" permafrost, respectively, for the southern discontinuous nonstable high-temperature cryolithozone and the northern continuous low-temperature cryolithozone [Shur Y. L., Jorgenson M. T., 2007]. Ecological-geochemical studies (determination of overground phytomass of the dominant species) were made using landscape pattern mapping with GIS technology by scale of 1:5 000 for the every site.

In southern forest-tundra the CALM-site is placed at the IV lacustrine-alluvial plain composed of loamy-sand deposits. Landscape pattern at the CALM-site in the southern forest-tundra is mosaic: forest, hilly tundra, ravines with shrubs, peatlands, bogs. The overground phytomass reached 3 kg/m2. Active layer depth (Dth) is accompanied by thickness of organic soil horizon (Mt). At peatbogs – Mt = 0.5-3 m, Dth = 0.3-0.5 m; at hummock tundra – Mt = 0.2-0.4 m, Dth = 0.7-1.2 м; in the ravines with shrubs – Mt = 0.05-0.4 m, Dth = 1.0-1.6 m. Sandy valleys are covered by sparse larch-lichen forest. Permafrost table decreases up to 3-8 m, active layer depth ranges from 0.8-1 to 1.4-1.6 m [Ukraintseva et al., 2010, 2011]. In southern tundra the site UKPG-15 is located at III marine plain composed mainly of loam. Grass-shrub-moss-lichen tundra with rare sorted circles is the dominant landscape there. The phytomass decreased to 1.5-2.5 kg/m2, the thickness of the organic soil horizon is rather uniform and reached 4-10 cm. Southern tundra vegetation is less motley than in the southern forest tundra, biodiversity of the dominant ecosystems is decreased to the north [2]. Thus, in the southern forest tundra with diverse and mosaic vegetation, the total impact of soil and vegetation play the significant role in active layer dynamics and position of permafrost table. This is due to "ecosystem-driven" permafrost. The role of the soil-vegetation cover in tundra is substantially reduced and "climate-driven ecosystem-modified" permafrost is formed [Shur Y. L., Jorgenson M. T., 2007].

Analysis of temperature regime using data of the meteorological stations Novy Urengoy (southern forest tundra) and Tazovskiy (the southern tundra) was made on the base of Student t-test for dependent samples. Statistically significant differences were obtained for the period from March to August, there are no significant differences for the period from September to February. Thus, differences of air temperature which in mainly determine the thermal state of permafrost of the northern and southern parts of the Urengoy field appear only in spring and summer. This study was supported by grant SS 5582.2012.5 from the Grant Council of the President of the Russian Federation. It was carried out as part of integration programs of the Presidium of the RAS Siberian Branch, as well as international projects TSP and CALM, (USA), grants from the Russian Foundation for Basic Research and SB RAS. Additional logistic support was provided by Gasprom Dobycha Urengoy Ltd.

Relation Between Active-Layer Depth and Vegetation Indices (NDVI And LAI) Along the Yamal Transect, Russia

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Analysis of relation between active-layer depth and vegetation indices data was carried out within the framework of IPY projects (CALM and GOA). Normalized Difference Vegetation Index, Leaf Area Index and active-layer depths (ALDs) were measured at four grid locations along the Yamal Transect from bioclimate subzone E (Laborovaya) in the south through to bioclimate subzone B (Bely Island) in the north. At each location, we sampled both sandy and clayey sites, which differed in vegetation and permafrost features.

NDVI on sandy (clayey) plots decreases from Laborovaya to Bely Island from 0,64 (0,73) to 0,45 (0,59). NDVI at Kharasavey (Subzone C) on the sandy sites (0,59) was greater than the expected zonal value and closer to the value found at Laborovaya (0,64). This is likely caused by a dense vegetation mat at Kharasavey on the flatter and poorly-drained sandy surfaces. NDVI at the Bely Island at clayey site (0,59) was also slightly greater than the expected zonal value. This is likely related to very high moisture content of the soils and a well-developed vegetation mat on lower elevation terrain compared to continental Yamal. NDVI at clayey sites were in general greater than on sandy sites due to greater vegetation biomass

LAI on sandy (clayey) plots decreases from Laborovaya to Bely Island from 0,29 (0,86) to 0,0 (0,41). For sandy sites this trend is consistent, but for clayey ones an important deviation is on Bely Island where LAI is close to that at Laborovaya (0,84), again due to low topography, while LAI at the Kharasavey clayey site is only 0,41.

Rated maximal ALDs on clayey plots decrease zonally northward from 84 to 63 cm on average. On sandy plots at both Vaskiny Dachi (Subzone D) and Bely Island the active layer is considerably deeper than expected zonal values for sand (123 cm at Vaskiny Dachi and 117 cm on Bely Island compared to 110 cm at Laborovaya, and 92,5 cm at Kharasavey).

It is well known that active-layer depth mainly depends on soil composition and moisture content, vegetation mat thickness, and air temperature. In its turn, vegetation as an active layer control depends on the same zonal and local factors. In the similar soil conditions provided by separate analysis of sandy and clayey plots, variability of vegetation indices is not fully correlated to the ALD variability. Nevertheless, shallow active layer on sandy plots at Kharasavey corresponds to increased NDVI. At the same time, increased values of indices on clayey plot of Bely Island did not provide small values of ALD. Probably, this is connected with high wetness.

Generally, the zonal pattern of vegetation indices and ALDs from south to north exists on both sandy and clayey sites. Deviations from zonal trends are related to local features, such as lithology, drainage, and topography. Vegetation cover on sandy surfaces of flat terraces at Laborovaya and poorly-drained watersheds at Kharasavey is well developed, yielding shallower active layer compared to Vaskiny Dachi and Bely Island. At Bely Island high vegetation indices on clayey sites do not prevent deep thawing, possibly due to high soil moisture content.

Ground Temperature Controls and their Relation to Climate Fluctuations on Central Yamal

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Basic factors which influence ground temperature regime in the upper part of the geological profile on Central Yamal are considered. The aim of the research is to determine proportion of various natural controls of ground temperature formation and estimate climatic impact as a major control. The controls include: vegetation cover (moss), the sum of precipitation and air temperature. Observations were carried out on Vaskiny Dachi geocryological polygon in 5 boreholes up to the depth of 1.5 m within the last 5 years. Boreholes are located within different geomorphic levels; one borehole is located on slope. Snow survey carried out in the end of March 2013 showed snow redistribution by wind depending on the landform. Thus, snow thickness on the flat watersheds does not exceed 0.11 m, on the convex tops snow is almost fully blown off; on slopes snow thickness could be more than 2 m. The field research and data processing revealed the following. The moss cover thickness near boreholes located on the flat surface of VD-1 and VD-2 sites is 0.06 and 0.03 m respectively. Snow thickness on these sites does not exceed 0.11 m. The same temperature regime in these conditions formed on both grids. At 0.25 m depth average annual temperature varies from -3.4°C to -6.8°C from year to year (2008-2011).

The third thermometric borehole is located on the flat surface of VD-3 site. Moss thickness is 0.02 m. Average annual temperature at 0.25 m depth varied from -2.9°C to -6.8°C from year to year.

The borehole on the convex top of a hill (VD CALM site) is characterized by 0.03 m thickness of the moss cover and 0.035 m thickness of snow cover. Value of average annual temperature is -5.3°C, -5.0°C and -4.2°C at the depths 0.25 m in 2007, 2008 and 2011 respectively.

The fifth borehole is located on slope where moss thickness is 0.1 m and snow cover thickness reaches 0.83 m. Average annual ground temperature up to the depth 1 m is above zero (from +0.1°C to +1.4°C).

Therefore, snow cover shows the highest impact on ground temperature regime formation as a heat-insulating factor. In the boreholes with snow thickness up to 0.11 m average annual ground temperature at different depths correlate with average annual air temperature with coefficient not less than 0.9. In the borehole located on slope with 0.83 m snow thickness correlation coefficient between average annual ground and air temperatures is no more than 0.78. Average annual ground temperature variation pattern on the sites where snow thickness is under 0.1 m replicates average annual air temperature variation pattern. On the site where snow thickness is 0.8 m and higher ground temperature variation pattern slightly differs from that of the air temperature with the phase shift of 1 year.

Glacial-Cryogenic Complexes of Suntar-Khayat Range: Constitution, Age and Reaction on Climate Change

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The term glacial-cryogenic complex is used here to refer to a suite of different age icy-debris formations, consisting of a source area, glacier bodies, prefrontal moraines, terminal and lateral moraines, rock-glaciers, etc. The study of glacial-cryogenic complexes of Suntar-Khayata is a logical continuation of the research started by M.M.Koreysha in 1957-1959. This gives a great opportunity for comparative analysis of glacier shrinkage and permafrost change during the last 60 years. The studied key site is situated in the upstream of the Burgaly River on the northern slope of Mus-Khaya Mountain (2959 m a.s.l.). It includes glaciers # 29, 30, and 31 and their ice-cored moraines of different ages.

Our study is based on field geomorphologic mapping carried out in 2012-2013, as well as on geospatial analysis of multi-temporal high resolution (1-0.6 m) aerial and satellite imagery. The estimation of the Last Glacier Maximum (LGM) was fulfilled with lichenometry and Schmidt Hammer Test (SHT) followed approaches of Shakesby et al. (2004, 2006), Winkler (2000, 2005), and Goudie (2006).

The glaciers' terminal positions have risen on average from 2052±102 to 2226±114 m a.s.l. after 1945 aerial photography. The termini of Glacier # 29 and Glacier # 31 have retreated approximately by 500-650 m, while the ELA has risen by 61±38 m, from 2346±56 to 2407±55 m a.s.l. The total glaciated area has reduced in size by approximately 36%. The surface of Glacier # 31 has lowered by 50-70 m in its terminal part due to ablation. The estimated glacier shrinkage is valid only for the exposed ice area, since the large amount of glacier ice is buried in ablation moraines, glacier-derived rock glaciers and other glacial-cryogenic landforms. Some ice-cored rock glaciers are 30 to 80 m in thickness.

Lickenometry and SHT methods show that LGM occurred between 2500-2000 kyr. In LGM the glaciation was only 5-7% larger in extent compared to the 1945 photography. The glaciers were relatively stable till the 1850s-1900s, then started to shrink slowly. The most catastrophic decline in glacier area began after 1960 and continues to the present. A surface ice flow velocity has decreased 5-6 times compared to the 1957-1959 values. A 45-m-deep geothermal borehole drilled in the middle of Glacier # 31 in 1958-1959 has completely melted away and its mouth shifted 150 m down the glacier surface. The drilling equipment of 1958 is now on the top of a steep 70 m-high rock wall which was entirely covered with ice before 1958. This obviously reflects the magnitude of glacier shrinkage. However, despite the rapid retreat of glaciers, the size and position of foots of rock glaciers have not changed over the past 60 years. This shows the difference between glaciers and rock glaciers in morphoclimatic niches as well as in reaction to current climate change.

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School-based Permafrost Monitoring Project in Russia

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The objective is to establish long-term permafrost monitoring sites in appropriate and convenient sites near communities and schools in Russia. Permafrost conditions are one of the important indicators for the future climatic change. Permafrost strongly affects local ecosystems, hydrological regimes and natural disasters. The design of the long-term permafrost observation not only fits our science objectives but also involves rural villages and schools and provides an important linkage to schools and communities across the Russia. Most of these villages depend on a subsistence lifestyle and are directly affected by climatic and permafrost changes. At the same time, there is colossal interest of the northern native villages and people from those living in non-permafrost areas. The monitoring sites collect temperature measurements at different depths in the permafrost, and also record the length and depth of the active layer (the layer above the permafrost that thaws during summer and freezes again during winter).

In addition to extending our knowledge of the environment of the cryosphere, this network involves school-age students in hopes of inspiring a new generation of scientists to continue this study. Our project involves drilling boreholes at the villages/schools and installing the micro data logger with temperature sensors to measure permafrost temperatures in Russia. The trained teachers at the schools will download data every summer and discussing the results with students in the classroom. The teachers at the schools can demonstrate and compare with the other villages' data. This is an important science project for these remote villages that have limited exposure to science.

The intellectual merit of this research is that it will advance our knowledge of the climatic system and the thermal state of permafrost. It will provide more insight of a complex process that is spatially and temporally quite variable in an area where little data are available. The Arctic climatic system imparts an important influence on global climate. Monitoring of the thermal state of permafrost using boreholes temperature will be the one of the methods that increases our understanding climatic trends and spatial and temporal distributions of the climatic signals. The broader impacts of this project are: 1) to provide opportunities for field experience and educational participation at levels ranging from elementary school to high school. 2) to provide high resolution spatial distribution of the thermal state of permafrost using the same protocol as in North America. 3) to improve the general knowledge of the polar climatic patterns and provide an opportunity for younger generations to take part in enhancing our understanding of the climatic systems. This project will make clear connections between permafrost and the arctic and subarctic climate system as well as establish a strong outreach program supporting village science education and a great knowledge base by which we can document future changes.

New Massive Ground Ice Exposures due to Activation of Earth Flows on Slopes in Central Yamal during Extremely Warm Summers of 2012-2013

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Our previous studies in Central Yamal laid a basis for a theory of cryogenic landsliding. Subdivided were 2 main types of cryogenic landslides differing in mechanisms and triggers: (1) translational landslides, and (2) earth flows. In contrast to other predictions of process activation in the Arctic plains, we suggested that cryogenic translational landslides resulting from accumulation of ice at the active layer base will not become more active because of climate warming as they depend on reduction of the active layer thickness in a sequence of years. At the same time, earth flows/mud flows related to the thaw of ground ice within permafrost should activate with the deepening of the active layer when massive ground ice get involved in thawing. This theoretical assumption got its verification in 2012 and especially in 2013 when extremely warm summers resulted in substantial deepening of the active layer (average values on the experimental grids were the highest in 2012-2013 (102-103 cm) compared to previous years (76-97 cm in 1993-2011). As a result, a number of new landslides appeared, only very few being translational landslides (active-layer detachments). Most landslides were earth and mud flows.

While translational landslide events are separated by decades of centuries and form landslide cirques, earth/mud flows form thermocirques which once being triggered, develop until either ice is exhausted, or insulated by landslide bodies from further thaw. Single translational landslides and earth/mud flows are found as well. Usually single earth flows are located on slopes far from the impact of streams or lakes, while thermocirques are rather related to lake coasts. Several thermocirques exposed walls of up to 15 m high and hundreds of meters long. The rate of scarp retreat reached several tens of meters a year since discovered in 2012.

Field studies in 2012-2013 at the Research Station Vaskiny Dachi in Central Yamal revealed extraordinary for the area huge exposures of buried polygonal ice wedges invading into tabular ground ice. Buried peat several meters thick is also exposed in the sections building polygonal blocks in between the ice wedges. Such exposures are very unusual for this inland area. They are mostly observed and described at the sea and river exposures. Ice wedges do not have manifestations on the surface except for subdued polygonal relief at the hill edges. It is for the first time since Yamal was under such a close study that such sections are found inland.

Thus, (1) activation of cryogenic landsliding in Central Yamal proved the theory of cryogenic landsliding which suggests that earth flows are landslide forms to extend over the territory with massive ground ice due to climate warming; (2) new exposures of Late Pleistocene-Holocene ice wedges and tabular ground ice should be subject to thorough study to obtain new data on Quaternary history of the area.

Permafrost Temperature Observation Network in The Northern Yakutia

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Our research team started systematic permafrost temperature observation in the North-Eastern Yakutia in the 1980s. Until the 2006 temperature in 15 to 50 m deep boreholes was measured occasionally (once per year of every other year). Since 2006 most of existed boreholes available for observation and all new boreholes were equipped with instruments fro continuous measurements in the frame of International Polar Year project “Thermal State of Permafrost” initiated by the International Permafrost Association. We use HOBO U12 (4-channel) and HOBO U23 (2-channel) data loggers with TMC-HD thermistors designed and produced by “Onset Computer” Corp. as standard equipment. The high resolution and accuracy (±0.02ºC) of this equipment allow us to obtain precise temperature records and to register even slight changes in permafrost temperature that are very important for a short period of observation.

Currently observation network consists of 15 boreholes located in the different climatic conditions and natural zones. Boreholes characterize 3 main types of terrain typical for this area: tundra; boreal forest and river floodplain. We try to establish new boreholes next to the historical drilling site in order to compare recent results with historical data.

Comparison of modern observations and published data shows permafrost temperature increasing at the all observation points. But rate of this process is different in various ecosystems. The most significant changes in permafrost temperatures took place within the tundra zone on the Kolyma Lowland. Permafrost temperature increased here by 1.5-2°C since 1980. At the same time, the thermal state of permafrost in the western part of the region did not change until the recent years. However, as observations show, temperature here is rising now by hundredths to tenths of a degree Celsius per year at the most of monitoring sites. At the some of observation sites permafrost temperature now as high as -2.7ºC, that is close to the range of phase transition in fine-grained deposits.

Catalog of Thermophysical Properties of Rocks in North-Eastern Russia

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In order to present a large volume of factual data collected during the last forty years, a systematized catalog of measured thermal conductivity, moisture content and dry density of rocks has been compiled. It contains information for 167 sites spread across various geological structures in the north-eastern part of Russia. Measurements of thermophysical parameters, moisture content and dry density were performed by the thermal property research group of the Laboratory of Geothermics (now the Laboratory of Geothermal Physics and Prediction), Melnikov Permafrost Institute. The catalog collects together data on physical characteristics of over 3000 rock samples measured in the laboratory.

The samples were selected to represent all types of igneous, metamorphic and sedimentary rocks from the variety of studied sections and covered the stratigraphic interval from the Early Achaean to the recent.

The data have been assembled in the form of aggregate tables. The tables give geological structure, site name, laboratory number assigned, borehole number and sampling depth interval, as well as site location maps for ease of site identification. From the drilling logs, geological indices and sample descriptions by rock type are given to show sample position in the geological section. The physical parameters – thermal conductivity, moisture content, and dry density – are given with the accuracy of test measurements. The thermal conductivity values are given for saturated samples representing in situ conditions.

For the sake of compactness, the primary material was generalized for each study site with identification of main varieties of sedimentary rocks and indication of occurrence of metamorphic and intrusive rocks.

The representation of measured thermal conductivities by borehole with sampling depth interval is convenient for geothermal calculations, because the depths of sampling points and temperature measurements are strictly tied.

The catalog contains no discussion of cause-effect relationships between rock thermophysical properties and environmental factors, as it was made earlier in Gavriliev [1998, 2004]. This catalog is thought to be valuable in that it presents the original, primary data.

The data presented in the catalog can provide a foundation for mapping efforts to reflect the regional distribution of rock thermal properties and physical parameters.

The catalog is intended for use by permafrost scientists, geothermal researchers, thermal physicists, geologists, geophysicists and other researchers interested in the upper layers of the continental earth crust.

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The State of Permafrost Monitoring Network after the Fissure Eruption of Tolbachik Volcano (FTE-50), Kamchatka.

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The monitoring network consists of surface and ground (installed in the boreholes 2-25 m deep) temperature sensors and marked grids for active layer measurements (in the frame of CALM project) were established in the Klyuchevskaya volcano group area during 2002-2012. At the end of 2012 there was 4 boreholes equipped with ground sensors, 11 points equipped with surface sensors and 3 points equipped with air sensors for year-round monitoring of temperatures in operation.

During the Fissure Tolbachik Eruption named by 50 anniversary of Volcanology institute (FTE-50), started at 27 of November 2012, more than 20 km^2 was covered by lava flows up to 30-50 m thick. The initial temperature of lava was about 1100-1200° C. The active cone of eruption (named by Naboko) is situated near our CALM grids (R30A and R30B), which were covered by lava, the borehole 8-03(06) was situated at R30A grid and was covered by lava too. The air and surface loggers at 500 m a.s.l. is under lava, but at 950 m a.s.l. the lava stopped just 5 m near the installed logger.

According to the field observations, the permafrost was affected by this eruption only under the lava flows, and in the very narrow area around. For better understanding of changes in temperature field under the lava the drilling from the surface of fresh lava flows would be necessary, the important point is, that we can compare the existing ground temperatures with one, observed by ground sensors in boreholes before the eruption. At the vicinity of 8-03(06) borehole, the thickness of lava is about 5-6 m, and drilling a new borehole here looks possible.

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Problems of The Railroad and Highway Embankment on Permafrost

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The history of railway and highway construction in permafrost zones in Russia, USA, Canada and China has extended more than 110 years. Nonetheless, no one has ever been able to build a railway track not subject to deformation caused by subsidence resulting from ice-rich subgrade soils thawing. This paper presents data on the roadbed state in the Transbaikalian and the Baikal-Amur Railways as well as the Federal Highway “AMUR” Chita-Khabarovsk. It also covers the possibility of roadbed stability maintenance using methods based on the reduction of the mean annual ground temperature and roadbed preservation in a permafrost state by means of the natural cooling and heating factors ratio regulation resulting in a reduction of the heat generation in the roadbed and the adjoining area accompanied by an increase of heat consumption.

A Temperature Control System of the Permafrost Seed Repository in Yakutsk

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Plant seeds can remain viable for long periods at certain subzero temperatures and low humidity. There are currently a number of long-term seed storage facilities around the world which use refrigeration equipment or natural cold with further artificial cooling to maintain desired temperatures. Their disadvantages are high power demands and the risk of collection loss due to power failure. An alternative, less costly and more reliable, strategy is to use the natural sources of cold to maintain optimal temperatures in seed repositories.

Investigations carried out by the Institute of Biological Problems of the Cryolithozone (IBPC) suggest that temperatures of -6° to -10°C are optimal for maintaining the viability and genetic integrity of seeds. Such low ground temperatures are only found in the arctic and alpine areas, and additional cooling to reduce permafrost temperatures is required elsewhere.

The Federal Permafrost Seed Repository, Phase I was completed in Yakutsk by reconstructing an underground laboratory of the Melnikov Permafrost Institute. The enclosing frozen ground has a natural temperature of -2.3°C. To maintain the optimal temperature year round, the repository is equipped with air convection cooling devices in which the flow of cold air is driven by natural drag. For summer stabilization of the repository temperature, an innovative method based on the phase lag of ground temperature fluctuations is used. The new technology allows the required temperature to be maintained in the repository throughout the warm season.

This paper describes the main requirements to the use of the new temperature stabilization technology for underground structures in permafrost by natural-climatic conditions of construction areas. Schemes and main parameters of the repository and cooling devices are given. Results of the first year of observations on the performance of the cooling devices and the temperature regime of the repository and surrounding permafrost will be presented.

The Producing Wells and Gas Hydrate Saturated Cryolithozone Interaction: Technological Disturbances Categorization And Guidelines for their Prevention (by the Example of Yamal region)

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The effective gas fields development at Yamal region depends significantly upon consideration of extremely complicated and varied geocryological conditions and forecast of cryolithozone's gas hazard. Usually, at northern gas fields development, cryolithozones section (depths up to 500 m and deeper) is not paid great attention. The geocryological studies usually focused on upper 10-20 m of permafrost section and they will not suffice for safe operation of gas producing industry units at the region. The experience of construction and exploitation of producing wells at the north part of Nadym-Pur-Taz region shows a possibility of accident conditions at all stages of field development in permafrost areas. Evolution of geocryological processes and phenomena, thawing and refreezing of icy and saline rocks, caving formation, intrapermafrost gas hydrates dissociation and other negative processes associated with producing wells and permafrost interaction are developing during the whole period of field exploitation.

These challenges will come in full force during exploitation of gas fields at Yamal region. Yamal peninsular and contiguous shelf of Kara sea are characterized by extremely complicated geocryological conditions: wide spread occurrence of geocryological processes and phenomena, presence of ground and repeated-wedge ice, icy and saline section, presence of permafrost and cooled rocks at the shelf and etc. Also there are a wide spread occurrence of relic gas hydrates at Yamal peninsular, which are especially sensitive to natural and anthropogenic influence.

It should be noted that development of gas fields at Yamal region goes on against the backdrop of natural climate warming in Arctic. This may entail intensification of all above-described negative processes associated with complicated geocryological conditions and gas hydrate saturation of cryolithozone of Yamal peninsular.

The first step towards minimization of negative effects during gas fields development at Yamal region is generalization and systematization of negative experience, gained during exploration of northern part of West Siberia. The causes and effects of accident situations and process upsets at drilling, exploitation and conservation of wells in northern regions are considered in the report. Also guidelines for prevention and minimization of negative effects of long-term interaction between producing wells and gas hydrate saturated cryolithozone are presented.

Exogenous Geological Processes on Objects of Infrastructure of the Bovanenkovo-Uhta Main Gas Pipeline

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Yamal refers to the zone of continuous distribution permafrost. All exogenous geological processes territory is characterized by the flat processes. Cryogenic processes are the most active among them. During the construction and operation of industrial and civil projects most cryogenic processes are unfavorable or dangerous.

Detailed engineering-geological research of the regiont Baidaratskaya Bay perfomed in the 80's of last century in connection with the gas pipeline construction of the Bovanenkovo-Ukhta. In 2004 engineering-geological researches are continued again. In connection with complexity of geocryologic conditions and activity of cryogenic processes three times the axis of the route of the gas pipeline was changed.

In 2006 near Baidarata Bay researches of cryogenic processes are conducted in a natural environmental conditions. In the summer-autumn period in 2006 field route, regime and aerovisual researches are conducted. In this period conditions and characteristics of cryogenic processes and their current status were identified. The most active processes in 2006 were the channel processes, termodenudation, termoabrasion on the banks of thermokarst lakes and deflation.The surface with the absence of active cryogenic processes predominate in the surveyed area. But in all parts of the relief with large ice inclusions in the permafrost, there are parts of the manifestations unfavorable or dangerous cryogenic processes.

In 2008, in the observation network includes four construction objects. The temporary construction camps located on a flat watershed area on the second sea terrace. The strew by sandy ground platform prevents mechanical and warming impact on the permafrost. The base of storage is located on flat water separate place. The low-inclined surface adjacent to the gullies and ravines network and river valleys. The impact on the surrounding area is the result of obstructed flow of water from the sewage lake, sliding and scour the sides of drainage ditches.

The quarry of sand and the clamping platform located on the watershed area of small rivers Sidyapelyatose and Hurehotarka with gently sloping and steep banks. In developing the quarry of sand occurred most significant impact on the geological environment. The soil-vegetation and peat layers are removed and opened seasonally thawed and permafrost soils. As a result of actively developing the termodenudation, a thermokarst, cryogenic sliding, a thermoerosion.

Ice storage area for pipes exposed to the least human impact. Because the work carried out on it in the winter, the land cover slightly disturbed, therefore, does not occur higher-layer thawing and development of cryogenic processes.

Cryogenic processes have the greatest activity in the quarry of sand, due to a number of natural factors and characteristics working-out of soils. The quarry is located between the small rivers. Sides of valleys have sufficient biases for development of cryogenic slope processes of various activity under natural conditions. Opening and clamping of soil of a seasonal thawed layers, transitional layers, intermediate layers and permafrost leads to an active drain of water and a thermoerosion, soil streams, cryogenic landslides of a current, and also a termodenudation. Quantity of thermoerosive gullies and cryogenic landslides of a current in 3-5 times more, than on other objects of monitoring.

Road Construction Problems in the Russian Permafrost Regions

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Changes in the areal extent, thickness, cryogenic structure and ice content of seasonally and perennially frozen ground are observed in recent years due to global climate change. This results in deterioration of the engineering properties of soils on which integrity of infrastructure, including motor roads, largely relies on. Furthermore, it becomes increasingly difficult to predict the kinetics and mechanics of the development of adverse cryogenic processes and phenomena (alternating seasonal deformations, perennial heaving, frost jacking, thermokarst, settlements, and icings) and engineering-geological processes (paludification, land sliding, gully erosion, etc.). The impressive impact of these processes acting singly and in combination was observed during the reconnaissance survey conducted in 2012 on the Lena, Amur, Vilyui and Kolyma roads with a total length of over 8,000 km.

Where the Lena Road transverses the floodplains and terraces of temporary and permanent streams, permafrost conditions reduce or may reduce the efficiency of road maintenance and operation. The survey has shown that such sections of the Lena Road total no less than 100 km in length. On the Vilyui and Kolyma Roads, the length of critical sections is still greater.

Investigations at 18 key sites along the Amur Road have demonstrated that the main causes for embankment deformation and pavement damage are:

- degradation of the underlying permafrost characterized by complex cryolithology and high ice contents;
- development of trough-shaped thaw bulbs in the roadbed and attendant oversaturation;
- differential settlement of the embankment and underlying permafrost layer;
- cuts in the ice-rich permafrost promoting additional saturation of the thawing soils.

In our opinion, primary measures to prevent deformations of the roadways on permafrost were to have been considered and implemented at the design, or at least, the construction phases. However, geotechnical investigations were of such poor quality that they failed to fully comprehend the real geocryological conditions. Moreover, no prediction was made for interaction of different roadway designs in the context of global climatic change.

A possible solution to the existing roadway construction and maintenance problems in the permafrost regions is to:

- establish research and testing sites in different road-climate zones to develop new construction technologies using innovative techniques and materials;
- develop site-specific and standard designs and technologies for each road-climate zones in Russia;
- promote research on experimental sites to adapt the conventional technologies used in non-permafrost regions;
- develop regional packages of construction codes and regulations for the entire project cycle, from route selection to maintenance and possible abandonment;

- develop codes and regulations which would take into account not only the administrative division of Russia, but also the unified zonation of road-climate conditions and their changes resulting from the natural cyclic variations in climate over the service life of roadways.

Calculation of Frost-Heave Extent and Settlement of Pipeline Frozen Soil Base

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Cyclic freezing and thawing of grained grounds are often accompanied by deformation (raising and settling) of the surface, i.e. by heave and settlement of ground surface. At the industrial development of an area the particular danger for engineering structures is not the absolute value of these deformations but their non-uniformity in area.

The formula to estimate the amount of heave and settlement in freezing-thawing grounds is presented. The formula derivation is based on the assumption that the expansion (compaction) of ground volume occurs vertically (toward the ground surface) due to the increase of pore materials by transformation of water into ice, i.e. without the possibility of lateral expansion as it is assumed in the problem of compression soil compaction. The proposed equations are closed by the system of simultaneous equations of heat and moisture exchange.

Two-dimensional nonlinear equations taking into account the iteration are split into one-dimensional problems and implemented by the method of directional differences. The initial data for the numerical calculations are taken from local weather stations and engineering survey works of concrete objects. The numerical experiment of water regime of grounds has been carried out taking into account the quantity of pore solution of carbonate rocks, precipitations and evaporation.

The numerical experiment found that the process of film and capillary moisture migration plays a major role in the formation of frost heave. The value of heave steadily grows during the wintertime due to the migration of pore water to the freezing level. In May the sharp increase (swelling) of upper layers of the active layer is observed due to water from melted snow. During summer months (June-August) when the intense evaporation takes place due to the drying of upper layers of soil, the active layer is settled. The autumn rains (September) stop the process of settlement from drying out. The all above mentioned process is repeated cyclically every year. The amplitude of the seasonal fluctuations in the active layer surface is equal to 5 cm.

The seasonal shaking" of the main laid at a depth of 1 m compared with the surface of ground is little slow. The amplitude of seasonal fluctuation is equal to 3.8 cm. The peak meanings of shaking are observed at the end of May (maximum) and in the beginning of November (minimum). The general course of this numerical experiment coordinates well with the data of field observations.

The general settlement of oil-pipeline operated in positive regime consists of two terms. The first term takes into account the relative subsidence of icy deposits without load. The second expression is calculated at different values of ground compressibility and external load. From the numerical experiment it has been found that the process of pipeline settlement is increased without insulation, i.e. the presence of thermal insulation significantly decreases the heat distribution around the pipeline. In the process of 35-years operation of the pipeline without insulation the bowl of thawing with a depth of 11.7 m is formed. This is accompanied by the maximum settlement of a pipeline by 0.45 m. And with insulation at the end of 35 years of operation the bowl depth of thawing is equal to 7.6 m, and the value of maximum settlement is 0.37 m. To stabilize the deformation state of the pipeline it is necessary also to conduct the arrangements against thermokarst.

Distribution of Taliks Beneath the Buildings of The Yakutsk CHP Plant

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The Yakutsk Combined Heat and Power (CHP) Plant is located in the north-eastern part of Yakutsk on the bank of a branch of the Lena River. It is situated on an alluvial terrace which is 9-10 m above the low-water level and about 3 km wide. According to N.I. Saltykov's data, permafrost in the area was 180-200 m thick prior to construction, and the mean annual ground temperature at 15 m depth ranged from –3 to –5ºC at the construction site.

The Yakutsk CHP was put into operation on November 7, 1937. It was the first large industrial facility in the USSR built on permafrost using the passive construction method, i.e., maintaining the supporting ground in its frozen state. Special foundations (pillars with casing shoes and solid concrete plates under the process equipment) were developed based on frost heave analysis and an air space for winter ventilation was provided.

During the 75 years of the plant's operation, stability problems occurred now and then due to partial thawing of the underlying permafrost. This was mainly caused by leakage of warm process water into the foundation soils and along the conveyance lines from drainage pipes, sewages and other utility lines.

As a result, thaw zones developed beneath the plant's buildings. In order to reestablish the natural ground temperature regime, Gapeev seasonal cooling devices were installed at problem sites. The operation of cooling devices, as well as other measures, such as ice removal from the ventilated air space and continuous leakage control of the utility lines, resulted in partial ground re-freezing and talik reduction. However, taliks have persisted to the present.

The highest temperature (up to 12°C) and thickness (up to 23 m) was observed in a talik near the circular pump station. The talik extends around the pump station for 25-30 m and into the southern corner of the main building.

A talik beneath the hot-water boilers building is 17 to 20 m thick with mean annual ground temperatures of less than 2.5°C. Permafrost around this part of the building has thawed down to 12.0 to 19.5 m and the mean annual temperature of the thawed layer is 1.7 to 1.8°C.

From the boilers building, the talik extends in a narrow strip to the carbon dioxide department (CDD) and underlies its eastern part. Its thickness is not known yet. In 2012, boreholes drilled around the CDD to the depth of 10-15 m failed to reach its bottom. Ground temperatures within the talik were measured to vary from +0.9 to +1.5°C.

Around and beneath the eastern part of the chemical water purification unit, the thawed ground had refrozen from top to 7.0-8.2 m by 2009. A thaw layer has preserved below with a temperature of 1.0-1.5°C at 10-11 m depth.

In spite of the large number of taliks, the soils are in a perennially frozen state over much of the Yakutsk CHP site. Beneath the main building, annual ground temperatures in the depth interval 4–10 m varied from near 0ºC to –3.9ºC. In recent years, the taliks have slightly decreased in extent, indicating that the foundation soils are gradually restoring their thermal regime.

The current permafrost conditions at the Yakutsk CHP site are quite complicated. However, the engineering solutions used during site preparation, construction and service have provided such a long term of its failure-free operation.

Deformation of Engineering Objects after Creating Peculiar Systems of Combined Natural and Technogenic Character within Developed Areas of the Cryolithozone

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Economic development of the cryolithozone creates a new pattern of geocryological conditions, different from natural parameters. This pattern is characterized, firstly, by drastic landscape transformation, promoting changes in the conditions of heat and mass turnover within the permafrost/atmosphere system, and, secondly, by engineering and technical influence upon the frozen ground, leading to alteration of its physical, thermal and mechanical properties. In the northern cities this causes ground temperature rising and intensification of hazardous cryogenic processes in areas under engineering development, reducing hereby stability of geotechnical environment. For example, facility deformations in Norilsk district, Northern Siberia, in the last 15 years, became much more abundant than these revealed throughout the previous 50 years. By the beginning of XXIst century up to 250 large buildings in the local towns were deformed considerably due to worsening of geocryological conditions, ca. 100 objects were revealed to function in emergency state, and almost 50 nine- and five-storeyed houses, built in the 1960-80s, have undergone laborious dismantling recently.

Increase in accident risk for facilities (water and oil pipelines, industrial enterprises, etc.) enhances the technogenic pressure on permafrost of the territories under development, leading to the new milestone of changes in perennially frozen grounds, i.e. to creation of "another reality" of geocryological conditions. Factors of natural and social geography cause the cluster distribution pattern of industrial units in the cryolithozone. Cryogenic processes within the urban cryolithozone are seldom similar with these under the natural conditions: they either run more intensively or, vice versa, attenuate under technogenic impacts, whereas sometimes new cryogenic processes and phenomena occur, which have not been typical for a given region hitherto. Then possibility of origin, activity, intensity, reversibility, geographical distribution, formation of paragenetic chains and other features of cryogenic processes differ considerably from natural conditions or are unprecedented at all. Peculiar natural-technogenic geocryological complices (NTGC) are formed in the urban territories, which are remarkable by the vector of permafrost evolution, by the set of cryogenic processes, by temperature trends and the other characteristics. NTGC types depend on initial natural settings and on kinds, intensity and duration of technogenic pressure. For instance, field reconnaissance of permafrost and geological conditions resulted in 17 NTGC types in Norilsk industrial area, 11 types in Yamburg gas condensate field, Taz Peninsula, and 32 types along overground and underground gas and oil pipelines in the north of Western Siberia. NTGC dynamics, depending on the scale of urban system, on the set of its elements and on duration of impact upon nature as well as on degree of stability of natural permafrost, attracts the particular interest. A key point here is assessing the direction of climate change (in terms of influence on the engineering of the permafrost environment) in different areas of the cryolithozone.

Computationally Efficient Numerical Method for Heat Transfer Problems in the Engineering of Foundations Construction on Permafrost Soils

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The long-standing problem of constructions engineering on permafrost soils is reviewed and the relations between effects accompanying the seasons of thawing and freezing of active layer are revealed. The fact that temperature is the most actively changing physical parameter leads to the necessity of determination of temperature field around the constructions foundation for the whole period of exploitation. In practice, this determination is realized via calculations and requires the use of sophisticated scientific software, where appropriate numerical methods are implemented.

We have both developed and implemented an alternating directions implicit method (ADI method) that permits to solve the Stefan problem and to take into account convective heat transfer in large-scale 3D systems – i.e. in permafrost soils. The stable calculation algorithm is constructed and successfully applied to the nonlinear transient heat equation solution in typical three-dimensional domains of permafrost soils. The physical properties (such as thermal conductivity and heat capacity) are assigned separately for the thawed and frozen phases of different soil structures, thus permitting to consider sets of soils layers with purely thawed, frozen or intermediate, so-called frozen fringe, states.

The proofs of convergence of the developed numerical algorithm are obtained by using both generalized Galerkin's method and Brezis theorem for maximally monotone operators. The stability criterion (constraint on the relation between the values of time step, space discretization steps and the values of physical properties of soil) is derived using Samarskiy's and Gulin's approach to the study of stability of difference schemes. The estimated computational complexity of the developed algorithm is O(N), where N is the number of nodes in a mesh. We argue that our numerical ADI method specially designed for permafrost soil heat transfer problems shows good performance in terms of time consumption and accuracy. The numerical results will be presented for some typical configurations of initial-boundary values and soil domains.

Mass Exchange in the System of Atmosphere – Snow cover - Ground

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The input of the sublimation to the snow cover balance was estimated. The relation of snow and ice sublimation intensity on snow density and heat conductivity was experimentally established (from 42•10-8 kg/m^2s for ice and 40•10-8 kg/m^2s for snow with density 500 kg/m^3 to 32•10-8 kg/m^2s for snow with density 160 kg/m^3). The moisture distribution in the pore space of snow and soil and the possibility of vapor migration from snow to ground was considered (relative concentration of water vapor in snow pore space Csnow/Cover_ice varies from 1.,14 at temperature -20°C to 1,06 at -5°C). The experimental results on mass transfer under isothermal condition and with the temperature gradient are presented. The combinations of temperature and temperature gradients, which allows water vapor migration from ground to snow, thermo dynamical equilibrium or migration from snow to ground was characterized. The water vapor flow from snow to ground had the rate 1-

2,5•10-8 kg/m^{2}s on the contact snow/sand at temperature -13 or -4°C and zero temperature gradient. The water vapor flow from ground to snow had the rate 8-39.3•10-8 kg/ m^{2}s on the contact snow/sand or snow/clay at temperature -5 - -8,3°C and temperature gradient 24-91 K/m.

Detecting Changes in Frozen Ground Condition by Radiowave Surface Impedance Measurements

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The results of surface impedance observations in the frequency range from 20 to 900 kHz on experimental sites near Yakutsk, consisting from sandy frozen grounds, are presented. The observations revealed that in the study area the surface impedance of frozen soils is most closely correlated with upper 4-m temperature, structure and strength properties in the frequency range of 500 to 900 kHz.

The period of ground seasonal cooling detected by the surface impedance of the active layer is subdivided into the freezing zone (November - February) and the zone of stable frozen condition (March - April). The period of seasonal warming of the active layer is subdivided into zones of intensive thawing, moderate thawing and stable thawed condition. The sizes of these zones differ in time between forested and open sites. Changes in the periods and zones can be used as a measure of permafrost response to climatic changes.

The temperature dependence of effective electrical resistance of frozen soils has been determined experimentally which is obtained from surface impedance. The lowering of frozen ground temperature from -5 to -8oC has resulted in an over four-fold increase in effective resistance. The variations in mean effective electrical resistance of frozen soils correspond well to the variations in mean annual temperature data from meteorological observations for the same year.

The module of surface impedance at the forested site can decrease in summer more than twice as a result of the increased conductivity of frozen soils of the active layer caused by melting of ice and occurrence of thawed water. The phase angle of surface impedance in the forest can decrease by 45o in the 864 kHz frequency due to the formation of a thawed layer on the surface (active layer, intrapermafrost taliks) and increase by 20o for the 171 kHz frequency due to the formation of an additional thawed layer at depth (intrapermafrost taliks).

The study indicates that joint observation of surface impedance and its phase angle provides a non-contact means for detecting changes in structure of frozen ground caused by the formation of a seasonally thawed layer, as well as suprapermafrost and intrapermafrost taliks.
Moreover, surface impedance parameters can be used to detect variations in moisture content and volumetric ice content of frozen soils.

Impact of Cryogenic Textures on the Deformation Properties

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Deformability of clayey soils during thawing varies widely, because it depends on many factors. Most important ones are density, moisture content, strength structural bounds and type of contacts between the particles, mineral and grain size, the nature of the pore space, the orientation of the structural elements, etc. But the effect of cryogenic structure of clay soils is poorly studied.

The research aims to the investigation the effect of cryogenic structure of clayey soils on their deformation and physical properties under compression tests. Studies were conducted to silt (a IIIkr) and clayey silt (la IIIkz). Soils were selected near pipeline from Pyakyakhinskoye field (Russia, Yamal-Nenets Autonomous District). These soils can be thawed at surface and subsurface pipelining.

Deformation characteristics of clayey soils are determined by various field and laboratory methods. But the field method is quite time-consuming and costly, so soil tests are conducted primarily in the laboratory.

Average values of density and moisture content were obtained by field studies. Then we prepared artificial clayey soils (height 35 mm and diameter 71 mm) with a massive cryogenic and layered texture. Cryogenic texture had two versions. The first was with a one layer of ice (the size of ice layer - 2,1 mm), and the second - with three layers of ice (the size of one ice layer – 0,7 mm). But all soil had the same physical properties (density and moisture content).

Thawing of clayey soils was carried out under two loads 0,025 MPa 0,1 MPa and then step by step applied load – 0,05 MPa. Each next step was applied after stabilization of deformation and altogether there were 4. We had two condition of thawing soils: one-dimensional or three dimensional.

After thawing and compaction we studied the change of density and moisture content of the soil. We also investigated the effect of cryogenic structure on deformation characteristics – thawing and compression coefficients. These characteristics are necessary for the calculation of settlement during thawing under its own weight or load of engineering construction.

We obtained the following results. Most deformation and change of physical properties occurs during thawing (more than 80% of total settlement, the initial density and moisture content). The values of moisture content after thawing for all clayey soils 2-5% higher than plastic limit. The largest change in the density and moisture content are typical for soils with massive cryogenic texture.

Different cryogenic textures affect the values deformation characteristics soils during thawing and consolidation. So thawing coefficient of clayey soils are greatest in samples with a massive cryogenic texture. Thawing coefficient in all studied soils is higher during three-dimensionals thawing. In addition, this difference for various soils did not exceed 10%. Compression coefficient depends on condition thawing and type of soil. Thus, different cryogenic structure, soil type and conditions of thawing can affect the calculations of settlement frozen soil during thawing and consolidation.

Local Monitoring System for Environmental Studies of Oil and Gas Exploration

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The most complicated stage of any environmental investigation is field survey, because collected data define the accuracy of further results. Nowadays the researches use remote sensing data collected from space to shorten time wastes. The technological development in this sphere has got us images with high resolution, but even they are not completely suitable for some purposes. Moreover some territories are not available to be sensed from the space, because it's the high level of cloudiness there. Another lack is a variety of data interpretation, so the results can differ greatly.

We suppose that there is the way to solve the problems described above. It is the airborne system serving for local range monitoring. Its name is "Biosphere-TM" and it was developed by a group of specialists from Lomonosov Moscow State University, "Biosphere TNK", Moscow Institute of Physics and Technology, Gubkin Russian State University of Oil and Gas and Moscow State Technical University of Civil Aviation. Local range monitoring system is the unique technique and technology which provides data collection from low heights and automatically processing via GIS-technologies.

The main idea of local range monitoring system (LRMS) is "from particular to general". It means that accurate and overall information about petroleum industry can be received by summarizing data about its principal parts. Investigation of each object or principal part will be local, but the number of particular results got by one technology can be combined into one geodatabase and present the general vision. By this way we perform data collection and data can be used further for the wide range of tasks because of high positional accuracy, high resolution and multispectral sensing.

As it was said the system is aerial and it is used Ultralights as the carrier (Figure 1). The carrier is equipped by navigation system GPSMAP 76CS. It provides flight navigation and data positioning with sufficient precision. Optimum height for the carrier is 100 – 3 000 meters and optimum speed is nearly 100 km per hour. There were constrained the special airborne system to control, manipulate, rotate the platforms that carry the sensors.

General view of "Biosphere-TM".

All the sensors can be divided into primary and additional. Primary equipment includes high resolution digital photographic camera, thermal sensor and professional camcorder. Additionally the system can be upgraded by aerial camera with focal length 140 mm and microwave radiometer.

There are some spheres of activity where LRMS was utilized and yielded the sufficient result.

These spheres are: environmental management, environmental and technical monitoring, geodetics, mine surveying and topographic maps creation, rights of ownership verification, land management for oil&gas objects, flow detection for pipelines, detecting geohazards.

Proven Model of Permafrost Thaw Halo Formation around a Pipeline

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Heat released from buried pipelines transporting warm hydrocarbons progressively thaws surrounding permafrost forming a permafrost thaw halo around the pipeline. Due to the non-uniform distribution of soil properties and massive ice deposits in the permafrost, differential settling of soil under the pipeline is likely to occur. This differential settlement results in bending strain in the pipe's wall which could lead to overstress and possible damage to the pipeline.

This work is dedicated to the prediction of permafrost thaw halo formation around a pipeline. A reasonably accurate predictive model of pipeline thermal interaction with permafrost is difficult but realizable if detailed data on all of the relevant factors influencing this interaction are available. But today obtaining full and precise information about these factors is quite difficult.

The aim of this work is to develop a predictive model that provides sufficient accuracy in estimating thawing halo dimensions in comparison with actual thawing halo. In order to achieve this aim we solved the following problems:

First, we constructed a list of factors (temperature of the transported hydrocarbons, soil properties, geometry of the trench, etc.) that possibly influence permafrost-pipeline thermal interaction and from this list we developed a model that predicts interaction with a pipeline and thaw halo extent.

Second, we measured the permafrost thaw halo around the oil pipeline located in Eastern Siberia, Russia. Measurements of thaw halo extent were taken for two sections of the pipeline after 3 years from the start of its operation. In addition, we collected all information as accurately as possible about local conditions that affect permafrost-pipeline thermal interaction.

Third, we predicted the thawing halo formation around the pipeline using our model and conditions recorded at the pipeline. We compared calculated halo dimensions with measurements of the thawing halo for each of two sections during June and October in the third year of the pipeline's utilization. The good agreement between calculated and measured results was demonstrated

Finally, we conducted a series of numerical studies to evaluate the individual influence of each factor on permafrost thaw halo formation, allowing us to estimate the requirements for input condition.

In conclusion, we have developed and tested a predictive model of permafrost thaw halo formation that provides sufficient accuracy of calculated thawing halo dimensions. According to the results of the numerical studies, the dimensions of the thawing halo are most sensitive to the temperature of the transported hydrocarbons, thermal conductivity of frozen soil and the initial temperature field of permafrost within the region of the pipeline's thermal influence. This model can be used as a basis for further investigations of the stress state of a pipeline in the conditions of soil subsidence.

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Geocryological Risk: Conception and Estimation Algorithms

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The approach of geocryological risk estimation is considered. The irreversible change of geocryological conditions is the content of the stochastic component of the risk. Depending of the situation, scale and accuracy of investigations, other specifications the special accent in geocryological situation diagnostics is choosing. These accents are the cryostratigraphy, the ground temperature regime and the geocryological processes' dynamics.

The change of geocryological conditions leads to engineering structure damages, disturbances of sustainable economical development, loss of natural resources or violation of environmental laws.

The engineering structure damages are linked with direct effects of geocryological processes (thermokarst, icing, frost heaving, etc.) or with indirect impact with changed landscapes that are located outside of engineering structure allotment (fires, swamping etc.). The economic loss is linked with assurance of technological safety of the engineering structure. E.g. the thermokarst development under the railroad embankment leads to complete reconstruction of the railroad within the distance of the settlement.

The disturbances of sustainable economical development are linked with non-forecasted losses due to abnormal exploitation of engineering structure. E.g. the thermal erosion along the pipeline leads to permanent works on the gullies filling-up by the ground.

The loss or deterioration of natural resources is significant for the society. E.g. the permafrost evolution affects the forest recreation and water resources stability.

The violation of environmental laws leads the surcharges and penalties for the above-standard exposure on the environment or the protected territories.

In all above mentioned cases the charge of the special survey and scientific investigations must be added to general economical losses. These investigations are the base for the revision of geocryological forecast and recurrent risk assessment.

The spatial and temporal factors must be taken into account in risk estimation procedure.

The spatial factors are:

Insufficient geological information about location of ice-rich and saline grounds.

Heterogeneity of ground structure and cryolithological content due the history of landscape evolution.

Insufficient information about geocryological processes' activity (where and when the geocryological processes accelerate after the climate fluctuation and human impact).

Uncertainty of future areas of human activity.

The temporal factors are:

Anomalous climate events (years and seasons with abnormal characteristics and single weather impact).

Permanent and repetitive periodic and non-periodic typical human impact that is linked with determined nature management.

Long-term climate and landscape change.

Long-term changes of the human impact intensity in the different stages of the engineering structure's life-cycle.

The anomalous climate events and typical human impact demand the statistical analysis of the empirical data. On the contrary the long-term change of climate and human activity need the development of the prognostic scenario for the risk assessment.

The principal task for permafrost professional is the determination of two principal risk factors: the first one is from spatial factors and the second one is from temporal factors. These two factors set the specifications for geocryological forecast. The predicted probability of the irreversible change of geocryological conditions is corresponded to the economical loss during the period of the forecast. The product of mentioned probability and loss is the desired geocryological risk estimation.

The stated approach is valid for different scale and different types of human-nature systems. Particularly it was tested in different permafrost condition with long distance structures (railroads, trunk pipelines) and structures of oil-gaz exploration.

Current Thermo-Erosion Dynamics of Ice Complex Coasts in the Laptev Sea

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Thermo-erosion causes 74% of the continental coastline in the Laptev Sea region that consist of unconsolidated permafrost deposits of Ice Complex type to continuously retreat during the short time window of the subarctic summer. Insights into past and future landscape dynamics depend on understanding the spatially and temporally variable intensities of coastal erosion and its interaction with endogenous and exogenous forcing factors. Coastal thermo-erosion includes two related processes that work temporally and quantitatively differently together. Cliff top erosion (thermo-denudation) and cliff bottom erosion (thermo-abrasion) are coupled, since the entire coastal cliff profile is super-saturated with respect to ice, largely due to thick syngenetic ice wedges. These erosion types result in annual land loss of up to 0.5 hectares per kilometer of coastline and mobilize deep permafrost organic carbon, in response to seasonal environmental changes in the Arctic. Thermo-abrasion and denudation vary in intensity according to the seasonal cycle. Thermo-abrasion is only active during the open water season, while thermo-denudation can proceed throughout the summer. In order to systematically analyze these seasonal thermo-erosion dynamics, we use a set of contemporary very high resolution satellite imagery, repeated geodetic surveys in the field and historical aerial photographs. Particular emphasis in our change detection study was put on stereophotogrammetric digital terrain modelling and subsequent ortho-rectification in order to enable accurate coastline position change measurements over multidecadal to seasonal time scales and to provide current and historical quantifications of planimetric land loss and volumetric coastal erosion. Across a variety of study sites well distributed along more than 200 km of the Laptev Sea mainland coast, observed recent erosion rates for the last 1 to 4 years were almost twice as rapid as the long-term mean of around 2 m per year. Based on normalization of diverse seasonal and interannual erosion rates, our findings at Muostakh Island demonstrate that the currently higher intensities of coastal erosion are controlled at least in part by the increasing open water season and summer air temperatures. We found that under current hydrometeorological conditions, as seasons lengthen and permafrost warms, thermo-abrasion and thermo-denudation are increasingly coupled, increasing the effective mass flux resulting from erosion. Our results also suggest that higher rates were accompanied by a higher frequency of the thermo-erosion cycle that causes coastal cliffs to pass various stages of morphological evolution, which in turn have different impacts on eroded volumes and subsequent mass displacement in the coastal zone.

New Data on Thermal Denudation and Thermal Abrasion Rate on Western Kolguev Island Based on High Resolution Satellite Images

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INTRODUCTION. Destruction mechanisms and dynamics of the Arctic coast, including the western sector of the Russian Arctic, where is our observations took place, are studied in detail, including the use of remote sensing methods. However, data on thermal abrasion and thermo denudation of Kolguev Island is quite limited. Some estimates are presented in article M.A.Velikotsky (1998). Determination of a speed of thermo denudation breaks in the key area near the mouth of the river Sauchiha for the period 1948-2002 years was done by the authors earlier (Kizyakov& Perednya, 2003; Perednya et al., 2003).

To obtain data about the modern (after 2002) shoreline retreat rates and growth of thermal cirque a high resolution remote sensing data are involved in our research.

METHODS AND KEY-SITE. Part of the western coast of Kolguev Island was inspected in field work conducted on 2002 by ECI SB RAS, together with VNIIOkeangeologia. The object of research was the part of coast, including a group of three coastal thermal cirques. In 2012, within the project "Geoportal of MSU" operational satellite imaging was done by satellite FORMOSAT-2. High resolution satellite imagery provides ample opportunities for visual interpretation of coastal landforms.mAerial photographs (1948, 1968), surveying materials (2002), satellite images (2009, 2012) became a basis to study the dynamics of the coast.

RESULTS. Calculations for key area:

retreat rates of the edge of the coastal terraces and thermal cirques for the periods 1948-1968, 1968-2002, 2002-2009, 2009-2012;

retreat rates of the foot of the coastal terrace for the periods 2002-2009, 2009-2012;

volume of the material enters the coastal zone by the thermal abrasion for one linear km of a coast.

Average long-term rates of retreat of the coastal terrace during: 1948-2012, 0.7-2.4 m/year; 2002-2012, 1.7-2.4 m/year. Identified rates are distinctive for the part of coast from the mouth of Krivaya River to the curve of coastline near the mouth of the Gusinaya River, a length is 60.5 km.

Averaged growth rates of the thermal cirques: 1948-2002, 2.4 m/year; 2002-2012, 2.6 m/year. The maximum growth rates on some sections in 2009-2012, 14.5-15.1 m/year. The cause of the abnormally high rates is an increase the annual amount of positive air temperatures, which in 2011-2012 were 1.4-1.5 times higher than the long-term average.

The determined rates of the development of thermal cirque can be extended to the north from the key area to the mouth of Gusinaya River a total length of 32.3 km.

CONCLUSIONS

1. Modern rates of thermo denudation and thermal abrasion were obtained by using very high resolution satellite imagery. Averaged growth rates of the thermal cirques: 1948-2002, 2.4 m/year; 2002-2012, 2.6 m/year.

2. The maximum growth rate: 2009-2012, 14.5-15.1 m/year. These rates are the highest for the previously recorded in the western sector of the Russian Arctic.

3. Average rates of retreat of the coast without thermal cirque: 2002-2012, 1.7-2.4 m/year. These rates are in 1.1-1.5 times lower than average rates of retreat of thermal cirque edges which are connected with melting of massive ice deposits.

Thermokarst Phenomenon Typification Approaches Near South Border of Permafrost Zone

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The development of thermokarst processes leads to negative landform generation. Morphology, vegetation characteristics and watercut of negative landform depend on geotechnical conditions, activation trigger and stages of process development.

Thermokarst phenomenon of wide south territory of Eastern Siberia was analyzed throughout more than 2500 km length. Thermokarst phenomenon was investigated not only in pipeline affected zone but also under natural conditions. The object was constructed using one construction technology throughout all the pipeline. This enabled to estimate a degree of technogenic impact on the development thermokarst processes in different landscapes and under varied climate conditions.

Initial data for researching were helicopter visual observation materials using special equipment. We got more than 7000 images every year within last three years.

The problems of thermokarst phenomenon identification by images were solved. Thermokarst phenomenon typification near south border of permafrost zone was made on the basis of generalized analysis of typification approaches which were published in Russian and world literature. The regularities of thermokarst process distribution, the dependence of the phenomenon morphology and a morphometry from a structure and a genesis of the territory, and a source of thermal influence underlie this typification.

The distribution regularity analysis of thermokarst phenomena allowed all the phenomena to be divided into two classes by their confinedness to elements of a relief and a complex of quarternary deposits. The first class, i.e. the phenomena having a natural genesis includes: confinedness to fluvial deposits of the rivers valleys, the dead arm of river and drain hollows, or sedentary deposits and moraine of watersheds.

At the development of thermokarst process on fluvial deposits, morphological and morphometric characteristics of the phenomena have distinctions depending on the form of a relief and landscape type, and as a result, structures of the territory and a source of thermal influence. Within the territory studied, five thermokarst phenomena on types fluvial deposits were as follows: thermokarst expansions of river arms or drain hollows, a thermokarst on drain hollows, a thermokarst on dead arms, on mound peatland in valleys of the rivers, hypocrateriform low in river valleys.

At the development of thermokarst process on sedentary and moraine deposits of watersheds, obvious dependences of morphology and a morphometry of the phenomena on type of underground ices and landscape types are traced. The total of the allocated types is leveled to four: thermokarst within suffruticose mari, a thermokarst on mound peatland, a thermokarst on ice-wedge casts, close-meshed thermokarst on watersheds.

The thermokarst phenomena whose genesis is connected with human impact belong to the second class. They are not occasional to forms of a relief and quarternary deposits complexes. The phenomenon factor development of the second class is the type human impact. Within the studied territory, groups of the phenomena whose development is connected with violations of a vegetable cover and the phenomenon connected by influence of engineering objects are found. Thus, in the second class of the phenomena two types are distinguished: thermokarst on an arable land and on the sites of violation of heat exchange.

To each of the eleven distinguished types of the thermokarst phenomena the description of a form, approximate depth, sizes, character of the coastline, water cutting, character of vegetation in a form and existence of modifications in character of the vegetation, a landscape containing a form were fefined. Additionally, forms with activation signs as a result of human impact of the territory were denoted.

Allocated type analysis allowed to find a stadiality sign existence of the process development inside the studied territory. The allocated types of the phenomena are characterized by various development time and the intensity of process course that results in the necessity of development of individual protection measures for each of them. The developed typification can be applied to other areas of permafrost zone.

Glaciation in the Permafrost Area of Siberia as Displaying of Cryodiversity

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In respect to the cold world, at present it has been mapped out, on the base of system knowledge, a wide perspective of cryological researches. It requires first to integrate available data into a system of scientific views in all range of phenomena which have been yielded by cold and covered by the concept of cryodiversity (Melnikov et al., 2013). However cold is an anthroposensory concept. There is not such a quantity in physics, but it has been constantly required to operate with it in permafrost studies. So, it is possible to be guided by the meaning of the Greece word "cryos" (*χρνος*) that has become the terminological base in those studies. It means as "cold, frost", also "ice", because the Greece language has been born in subtropics where the words determining cold and frost are usually associated with such a phenomenon yielded by them as ice. The analogous occurs in other languages in subtropics. For example, the Hebrew word "kor" (קור) means "cold", and the derived from it "kerakh" (קרח) means "ice", and the further derived word "kerkhon" (קרחון) means "glacier".

In point of fact, the concept "cold" implies a state of environment under negative temperature, and in such a meaning it already became actually operated in terminology, because the well-established term "cryogenesis", as a set of different processes going under negative temperature and leading to the development of formations of frozen ground, means literally "the yielded by cold". However, in respect to glaciers such associations are not unambiguous.

The source substance of glaciers is snow that is a product of cryogenesis in atmosphere. However after it falls on the ground, accumulation of ice developed of snow is able to form as in the permafrost area, also outside it. At that, it has been historically turned out that glaciers yielded by the second way became to be studied earlier, and on such a base it has been formed a stable view that antagonism between formations of snow and permafrost genesis exists. As a result it is so far unaccustomed to consider glaciers as a product of cryogenesis which covers them also on the earth surface, even if they are in the permafrost area. Though it means only displaying of cryogenesis in respect to geological bodies of initially specific frozen rocks, that is to say – of snow and ice yielded of snow. All the more so that another form of surface glaciation – icing – consists of snow and ice, but it has been attributed as of a permafrost phenomenon. Barely, the glacier body is a result of sedimentary-metamorphic ice-formation, whereas the icing body is a result of mainly congelation ice-formation.

In Siberia all glaciers occur in the field of cryolithozone (Sheinkman, 2012). That is to say the glaciation is here a product of cryogenesis both in atmosphere and lithosphere. Being an object of the science about glaciers, it becomes also the object of the science about frozen rocks. So, such an object should be analyzed from the position of system knowledge of Earth cryology, as according to which all ice bodies represent the displaying of cryodiversity, and they should be considered in their interaction as cryogenic geosystems (Melnikov et al., 2010). In order to show the situation in a specific case, when glaciers are in the permafrost area and become the main element of cryogenic geosystems, it is reasonable to add to the name of the geosystems the word "glacial" and lead the conversation in respect to glaciation as of specific cryogenic-glacial system (Sheinkman, 2011).

Cryogenesis covering not only the source substance of glaciers in atmosphere, but also their bodies on the earth surface, attaches to them and to their geological work specific features. However taking in account of all of this became possible only during the last decades, when necessary representative data have been appeared. Earlier for a long time there was a prevailed opinion in respect to antagonism between formations of snow and permafrost genesis. Nevertheless, as displaying of cryodiversity (Melnikov et al., 2013) in frames of cryogenic-glacial system, development of glaciers as a component of cryolithozone has been quite appropriately, and their study in such an aspect allows better to understand many of cryogenic processes.

Factors of Geosystems Sustainability within the Boreal and Sub-Arctic Cryolithozone

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Potential geosystems stability in permafrost - is their ability to resist cryogenic processes activation. To assess this lithocryogenic stability you must select factors, the number and range of which depends on the regional specificity and scope of research. The procedure for their selection and evaluation is considered as an example of test objects located in different climatic conditions. The first three are located in the West Siberian tundra within the Bovanenkovo, Yamburg and Kharvuta gas fields. The others - in "forested" cryolithozone, Central Yakutia along the route of the railway Tommot-Yakutsk.

Within the sub-Arctic cryolithozone, to estimate the cryogenic processes intensity using five factors:

-annual mean permafrost temperature;

- permafrost ice content in rocks to a depth of 10 m;

-protective vegetation properties– heat-insulating properties of the topsoil cover and the fixing properties of the plant root system;

-ground composition, which the seasonally thawed layer thickness change depends on;

–vegetative cover self-recovery potential.

In some cases, we add "regional" terrain parameters - slope dissection degree and steepness or the dispersion of sediments which was introduced into the evaluation scale of the Kharvuta test site for strengthening of the weight of hazardous thermo-erosional processes (earthflows).

According to this factors each geocomplex assigned some marks for further checking and obtaining the total index for ranking. In all cases expert marks are traditionally used. They are simply summed up or arithmetic mean values are calculated. The calculation-statistical method of miltifactorial correlation analysis can also be used to identify the factors communication with each other, to select the leading factors and reject the secondary ones.

Found that on the West Yamal minimal resistance was found in landscapes with high annual ground temperature, high ice content, maximum protective properties of vegetation and its slow and incomplete recoverability, with the largest change in the depth-layer after the surface mechanical breaches.

In the boreal taiga zone within the test objects in Central Yakutia it has been selected the following factors:

- relief position, the genesis;

- permafrost ice content;

-change in the seasonally thawed layer (ratio of the actual thawing depth to the maximum possible);

- shading of tree crowns;

-insulating properties of the topsoil cover.

Found that a high risk of cryogenic processes manifestation in Central Yakutia occurs on relatively steep slopes and within the areas between alases , with the ice content over 0.47, when the seasonally thawed layer below 0.35, crown cover of the stand above 0.6, with moderate and significant heat- insulation properties of the topsoil cover.

Comparative evaluation of geosystems stability within the north and south cryolithozone showed that a universal factor is ice content of frozen ground, other factors have regional implications. For example, in Western Yamal tundra are the leading self-healing properties and the rate of vegetation. In Central Yakutia - insulating properties of ground cover, shading, and changes in the seasonally thawed layer as a result of the surface disturbances.

Saline Thawed and Frozen Grounds of Yakutsk

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Saline frozen soils possess special geotechnical properties that define the low bearing capacity and instability to anthropogenic influence. The authors analyzed the results of geocryological and geochemical monitoring carried out on the territory of Yakutsk.

Soil salinity in the city (as opposed to natural) has no areal distribution. Salinity of soils (depth 0,10 - 0,20 m) varies in a wide range from non-saline (0.021% / 100g) to highly saline (0.98% / 100g), mainly in the old part of the town, where large lithogeochemical anomalies developed with salinization exceeding 1% / 100 g. The chemical composition is variable; salinity may be chloride, sulfate, and carbonate.

The active layer (depth 3.2 m) is characterized by predominant chloride-sulfate salinity with the ratio of anions SO_4^{2-}>Cl^-> HCO^{3-}. Salinity also varies in a wide range from non-saline (0.017% / 100g) to strongly saline (0.96% / 100g)

In permafrost (depth 5-6 m) soil salinity decreases. The salt composition is dominated by bicarbonates and sulfates, but in the old urban areas anomalies of heavily saline soils with concentrations of up to 1% / 100g are observed.

The maximum concentration of salts and the greatest depth of penetration and distribution of saline soils are noted in the old part of the city, where the duration of anthropogenic effect ranges from 150 - 200 to 300 years, also having the majority (70%) of damaged buildings and structures. The minimum soil salinity is observed in relatively new areas of the city with the duration of technogenesis less than 80 years.

In the city, the depth distribution of saline soils is usually about 6 am, however, a number of areas of saline rocks reach the depth of 9.0 - 10.0 m and 14.0 m. As a rule, these are the areas of existing or frozen taliks under lakes or oxbows. With the interpretation of aerial photographs of the old city area (1946), and comparisons with modern satellite images the location of fully or in partially buried lakes in the central part of the city was determined and their position on a modern map of the city was found.

The freezing point of soils, saline chlorides and sulfates of magnesium, sodium and calcium comprises -2.3 ° C at the depth of 2-5 m and -1.1 ° C at the depth of 6 m. The transition of saline soils from the plastic-frozen to the frozen condition occurs at low temperatures. Therefore, saline frozen soils are characterized by reduced strength and low values of shear resistance along the surface of the freezing with the foundation. They are distinguished by increased corrosive effect on foundations.

Salinization of soils and soil causes direct and indirect damage to the urban economy, threatening the stability of structures, causing accidents and destruction of residential buildings, industrial sites and transportation routes, emergency situations, and environmental problems (in particular, hampers the urban landscape gardening).

Change Estimation of Vegetation Cover and Geocryological Conditions in the West Siberia Zone of Sporadic Permafrost Distribution

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In West Siberia northern taiga the long-term monitoring observations have been carried out in Nadym area. Landscape and geocryological researches started here since 1967, have allowed to track changes of ecosystems both in natural conditions, and on the sites disturbed by a lining of the Nadym-Punga gas pipeline and fires. Observations were carried out on permanent transects and plots established in natural and disturbed conditions.

On data of Nadym weather station for 1970-2012 the trend of increase of air mean annual temperature has made 0.040°C in a year. The steady increase in active layer thickness in all natural complexes and rise in permafrost temperature is connected to rise in air temperature. The rise in air and permafrost temperature and increase in active layer thickness were accompanied by appearance on peatlands of tree species (*Betula tortuosa, Pinus sibirica, P. silvestris*), earlier not characteristic for these natural complexes, and increase in frequency, coverage, height of shrubs *(Ledum palustre, Betula nana*).

In northern taiga on boggy sites under impact of increase of atmospheric precipitation amount hummocky open woodlands with pine cloudberry-wild rosemary-lichen-peat moss cover were replaced by andromedacotton-grass-sedge-peat moss bogs. Hummocky settled, and the lenses of permafrost under the hummocks thawed. All aboveground biomass, characteristic for wood communities, decreases from 2316 up to 1715g/m^2 in bog communities.

On cloudberry-wild rosemary-peat moss-lichen flat peatland on which the vegetation cover has been removed, the surface and the permafrost table has lowered with the development of thermokarst and bogging and it is covered with cotton grass-peat moss bog community. This bog are kept and in 40 years after disturbance in connection with increase in an atmospheric precipitation amount last decades. This bog radically differs from the initial peatland in appearance, structure, frequency, coverage of dominant species and geocryological conditions (downturn of permafrost table up to 3,5m and rise in permafrost temperature).

On the sites, undergone to a fire, recovery of a vegetation cover goes faster, than in territory with the removed vegetation, and recovery of the vegetative cover close to initial plant communities is more often observed. For example, on frost mounds with *Pinus sibirica*- wild rosemary-peat moss-lichen open woodland in 35 years after a fire were formed *Betula nana*-wild rosemary-peat moss-lichen community with *Pinus sibirica* in height 2m. The participation of lichens sharply decreased after a fire, within 16 years has considerably increased.

Thus, the carried out monitoring of ecosystems has allowed revealing impact of climatic changes and human-induced disturbances on a vegetation cover and permafrost. The increase in air temperature and in amount of atmospheric precipitation in the north of Western Siberia caused process of bogging on flat poorly drained surfaces of plains. As a result of it hummocky open woodlands with lenses of permafrost on the hummocks are replaced by thawed bogs.

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The Study of Seasonal Freezing in the Western Moscow Area in a Snowy Winter

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Winter period in 2012-13 in Western Moscow area differed from previous periods by increased snowiness: the average thikness of snow on watershed reached 54cm (in previous years 20-47cm), and cold: the sum of negative-temperature hours was 17455 (the average – 14350).

The combination of these factors led to the formation of features in progress and to the seasonal freezing spreading. The research of these peculiarities in different landscape conditions were in the Zvenigorod (55°42`00`` N; 36°43`21`` E).

The expedition was held in several stages (the start, middle and finish of winter). The main observation plots were chosen, there were held landscape descriptions, measuring of snow layer depth, soil samples collecting, the cryogenic structures were investigated and the depth of the seasonally frozen layer was determined. Noted the diversity of soil and ground composition: from fine-grained silty sands to sandy-loamy differences. Using data loggers provided data on temporal variability of the temperature field in freezing soil.

During research it was found that the maximum depth of seasonal freezing occurs on the edge of the ravine, coming to the floodplain of the Moscow River, and is 54 cm (with a depth of snow - 35cm). The minimum values of the depth of the active layer (or absence thereof) are confined to areas with high altitude snow (more than 75cm) or wet soils: water-logged low floodplains, the bottom of ravines, poorly drained areas with powerful logging herbaceous cover, in which a young tree and shrub vegetation plays stop-snow role during snowstorms.

The depth of the active layer in the watershed ranges from 0 to 44 cm, depending on the type of vegetation, soil composition and moisture content, the provisions of sections in the relief and the degree of anthropogenic pressure. For example, cover layer (soil, litter and vegetation) may provide temperature difference between under and above cover – 6-7^{o}C. The other side of cover – temporal heterogeneity of seasonal freezing (in autumn period we can observe up to 7 cycles freezing-thawing). Characterized by high differentiation depth of seasonally frozen layer in dissected relief, where there is a significant redistribution of snow and runoff of soil moisture on the slope.

Especially interesting to study the influence of the anthropogenes seasonal freezing of ground, activating their frost heave, bulging lightly loaded objects and the destruction of the roadway. Noticeable the increase in the active layer thickness on dirt roads and trails (with seal or absence of snow), 8-year observations have shown that there is power at 30-100% higher than the average for the territory. For example, in cold and relatively little snow winter of 2005 06 on the frozen dirt road 98cm (snow had a thickness of up to 5 cm) on average this winter - 45cm, after the "abandonment" of the road in winter 2012-13 frost depth was 41 cm (with a thickness of 32cm of snow).

Up a number of observations (from winter 1999 to 2000.) on the actual freezing of soils of different compositions in different winters in Central Russia. Increased pre-winter snow accumulation and prevent water logging of soil freezing, which can cause its absence in the suburbs, even in the cold of winter. The combination of "relatively low temperatures and low power cover" at the beginning of the cold period (as in December 2012.) has led to an excessive (in comparison with a long-term supervision) frost heaving of soils, the development of strains that commonly observed in the region in late winter. Variations in the thickness of the active layer (the same thickness of snow) are connected, first, with micro landscape conditions, and only in the second - with litho genetic parameters.

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The Features of Splits Formation in the Peat Layer in Sporadic Permafrost Zone

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The work was carried out on Nadym's polygon ECI SB RAS (Tyumen Region, Yamal, Nadym district). Subject of cracks research was flat-hilly peat-lands. As a result two types of splits were developed: frost-shattered and dehydrated.

Frost splits are widespread on the peat-land. An example is a split in a section with coordinates N 65 ° 18 '; E 72 ° 51'. The section is confined to small-hilly peat-land which is divided by lows on isometric forms (polygons). Diameter of polygons is 0.5-3 m and relative altitude is 0.1-0.2 m in places up to 0.4 m. Width of interpolygon lows is 0.2-0.7 m. Distinguish ability of polygons is complicated by overgrowing of lows with dwarf shrubs. Peat on the surface of polygons is denser than peat in lows. In lows area permafrost tapes at a depth of 0.2-0.3 m, on adjacent polygons permafrost tapes at a depth of 0.5 m. Examined splits do not have any signs of syngenesis with splits of dehydration.

Splits of dehydration are localized on the plots without plant cover. Diameter of such plots is 5-7 m. Often it is drained slopes of southern exposition. Several splits were developed on a plot without plant cover which is located on a flat slope of flat-hilly peat-land wit coordinates N 65°17'; E 72°53'. Splits of dehydration (width 3 cm) divide surface on small blocks which are observed to the depth of 0.15-0.2 m in open section.

Research of peat layer cross-section in places of pronounced dehydration splits does not indicate on development of frost-shattering but points on process of freezing and thawing with intensive moisture migration and substance volume alternation. Main role in peat processing in upper part of section plays dehydration and freezing-thawing.

Studied formations which are consequence of split formation underline the climate contrast and variety of landscape cover in research area. Frost splits and dehydration splits develop in different seasons so in theory they can develop one on another. Nevertheless landscape conditions of plots with one type of splits impede development another type of splits.

Interaction of Some Organic Substances with Surface of Ice Particles

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E. M. Katasonov (1954) pointed out that the change of cryogenic structure of permafrost is bound up with changes of the content of organic matter in the soil. Similar observations were made in the laboratory by freezing of soils treated with various lubricating preparations (Yarkin, 1981). Ground water is enriched with various substances, dissolving the products of decomposition of organic residues.

Formation of frozen soils with different cryogenic structure is possible by the freezing of moist soil, depending on the content of organic matter. If they can be adsorbed on the surface of ice particles, it is able to influence on the number of nuclei that are formed during the crystallization water, their size and shape. Thus, the study of the interaction of organic substances with the surface of the ice particles is important both from a theoretical and practical point of view.

When organic substances interact with the surface of the dispersed ice from their solutions in the indifferent organic solvent, the decrease in the concentration of substances in solution should be due to its passage in liquid-like film existing on the surface of ice. Sorption capacity of substance (Nechaev Fedoseeva Fedoseev, 1981) correlated with the its distribution coefficient between water and organic solvent at ambient temperature. Bulk aqueous layer appeared with increasing concentration of such substances in the system. Sorption isotherm is concave relative to the axis of the equilibrium concentrations.

Behavior of o-bromo-benzoic acid in sorption experiments differed from that described above. First, the shape of the sorption isotherm is convex and obeyed the Langmuir adsorption equation. Secondly, the shape of the isotherm did not change with the change of temperature. It is evidence of interaction between the molecules of the acid and the surface of ice particles. These results suggested that o-bromo-benzoic acid may be used to estimate surface area of ice particles. Confirmation of this was obtained in the study of adsorption o-bromo-benzoic acid on snow samples, selected from different according to the temperature and humidity conditions sites (Makarov, Fedoseev Fedoseeva, 1990). In the following, a method of estimating the specific surface area of dispersed ice was used to study the dynamics of migration of solutes on the border of snow with underlying substrate.

The distribution pattern of o-bromo-benzoic acid between surface of ice particles and the acid solution was maintained during the transition from solution in an organic solvent to solution in water. The energy of adsorption interactions in aquatic systems was markedly higher.

Some Results of investigation of the Isotopic Fractionation of Water in the Process of Segregation Ice Formation

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Study of the isotopic content of the ice formations in the cryoshere, such as ice sheets, glaciers and massive ice, became one of the main methods of obtaining information on the climatic conditions in the past. The structure-forming ice is studied much less than the other forms of ice and, despite the difference in the mechanisms of the ice formation, the same approaches are normally applied to the interpretation of the isotopic content of both the structure-forming ice and the ice formed from the atmospheric moisture (Michel, 2001; Derevyagin et al., 2012). The principles of the creation of the structure-forming ice need to be known for understanding the construction of its isotopic content. However, the data on the difference or similarity in the isotopic content of free water or in the water taking part in the moisture migration is not in existence. Nevertheless, it can be assumed that the water, taking part in the moisture migration and creating the segregation ice and ice-cement has different characteristics than those of free water and thus can have the isotopic content differing from those of the free water. In addition, it can be assumed that the concentration and distribution of the stable isotopes of oxygen and hydrogen in the structure-forming ice should change as the result of the phase transitions.

The external medium for the ground moisture is the ground itself. The degree of its influence on the moisture distribution and on isotopic content of the moisture depends on the mineral composition, dimensions of particles and specific of the phases interactions with the mineral particles. The characteristics of the mineral particles are the factors responsible for the specific surface and the surface energy of the mineral matrix, as well as for the quantity of the volumes of supercooled water, unfrozen in the ground at temperature below the freezing temperature. The properties of such water, which is interacting with ions, atoms and molecules of a ground particle surface, are different from the properties of bulk water. This allows possibility to have different quantity of the molecules with heavy isotopes of hydrogen and oxygen in the supercooled water, than in the bulk one. However, the crystallization of such water, possibly, once again allows the change in the ratio between light and heavy isotopes, similar to such change with freezing of the bulk water.

To prove such a hypothesis, the authors conducted experiments on the samples of the kaolinite ground of the Prosyanovskoe deposit. The samples with set moisture content and known isotopic content of the ground water were unidirectionally refrozen in special device under set temperature gradient. The water for isotopic analysis was extracted from the samples in another device, allowing vaporization of whole the ground water in hermetically closed volume. The isotopic analysis provided the following conclusions: The water from unfrozen part of the kaolinite sample (presumably the bounded water not taking part in the migration) had the isotopic content “heavier” in oxygen and “lighter” in hydrogen than the original isotopic content of the water filling the sample. This result is in agreement with the data of Yu.A. Federov (1999). The water, which formed the ice-cement in the frozen part of sample with massive ice-structure, had the isotopic content “heavier” than the original one both in oxygen and in hydrogen. The water, which formed the second in size from the top of the sample ice schliere (7 mm-thick) had the isotopic content “heavier” both in hydrogen and in oxygen relative to the original water, but “lighter” than in the massive horizon. The maximal difference of the isotopic content from the original water in the direction to “heavier” was in a thin ice layer with massive structure positioned right below this schliere. The regularity in the isotopic content distribution in an upper, not such thick (3 mm) schliere and below it was similar, though less extreme

The obtained data allow expecting that mainly isotopically “lighter” moisture participates in the migration to the freezing front. The migration is most active in the contact area of a forming ice schlieres. Since this “light” water is forming a schliere, the “heaviest” water remains under the schliere, forming the massive ice structure. The “light” migrating water takes part in the schliere formation, but the fractionation during the phase transition results in heavy isotopes enrichment almost back to the content of the original water. Besides that, the noted effect of isotopes differentiation shows dependence on the speed of freezing and on the activity of schliere growth. The less is the first factor and the more is the second one, the more pronounced is the differentiation.
The results allow stating of existence of intensive and rather complex structure of the differentiation of the isotopic content of bounded moisture in the process of segregation ice formation. That is why; the interpretation of the isotopic data from the structure-forming ice for paleo-climate reconstruction should be based on the other principles, than those applicable for the interpretation of isotopic data from the ice of the atmospheric origin.

Dicay of Metastable Gas Hydrates by Crystallization Supercooled Water

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Metastable states of gas hydrates are realized into the region of *P-T* the parameters, limited on the phase diagram by equilibrium lines "ice-hydrate-gas" and “supercooled water-hydrate-gas ” [1]. It is assumed that a condition of translation of hydrate into region of metastable states is absence of its direct contact with the ice crystals [2].

In this work is investigated by *P-T* method the stability of metastable hydrates Freon-12 and propane to external influences. Found that the crystallization of water initiates the dissociation of the metastable hydrate on an ice and gas. Into *P-T* experiments testify to it downturn of temperature of the sample and growth of quantity of pressure which eventually to equilibrium line "ice-hydrate-gas" asymptotically approaches (Figure).

Empirically shown that stability of gas hydrate in the region of metastable states in many respects is defined by lifetime of supercooled water contacting with its surface. With downturn of temperature metastable hydrate to become is less stability since it increases the activity nuclei of heterogeneous nucleation and shortens the lifetime of the supercooled water. It is established, that the increase in velocity of pressure decline of gas within the limits of metastable region raises probability of crystallization supercooled water, and, accordingly, probability of hydrate dissociation.

In turn, the translation of the metastable hydrate through the line of equilibrium "supercooled water - hydrate - gas" is accompanied by its decomposition with the formation of liquid water. The reverse translation of hydrate region of absolute instability in the region of metastable states, if in the process of transition in the sample does not form ice. It is established, that at the same temperature for more stable hydrates of Freon-12 than hydrates of propane.

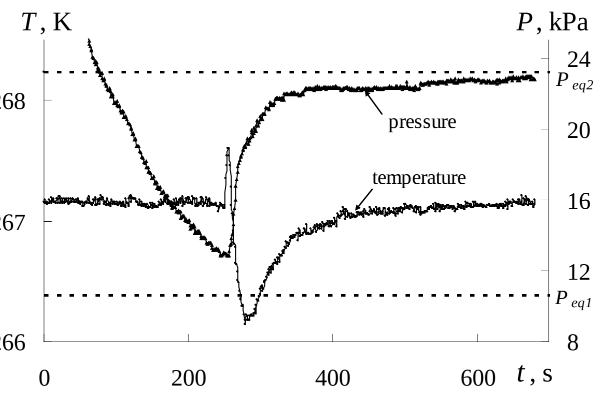

Fig. Decay of the metastable gas hydrate Freon-12 as a result of crystallization of supercooled water. P_{eq1}, P_{eq2} - corresponding pressure equilibrium "supercooled water-

Further studies are assumed to be similar to the use of a broad class of hydrate forming gases.

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Hazards of Geocryological Processes in Kazakhstan

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Qualitative and quantitative estimation of degree of danger of the main geocryological processes and phenomena of mountain and extensive flat territories of Kazakhstan is done. On the plains and in intermountain depressions in the conditions of seasonal freezing of soils and grounds the most widespread processes are frost heaving and cracks formation. As a result of these processes thufurs, frost-shattered cracks and polygonal relief are formed. Extremely rarely aufeis are observed here. The quantity of dangerous exogenous-geological processes and phenomena including geocryological sharply increases in the mountains and essentially complicates development of these territories. Laws of distribution of geocryological processes and phenomena here depend on latitudinal positions of mountain region and in the region from the absolute height. That is reflected in regional structures of altitudinal geocryological zonality. The most significant geocryological processes developing in the conditions of long-term and seasonal freezing of soils are the following: frost heaving, thermokarst, solifluction, frost cracks formation, aufeis formation. Large and most dangerous cryogenic formations are rock glacier, corroms, cryogenic landslides and landslips and glacial

In the mountains of Central Asian region climate change became the reason of considerable reduction of land glaciation. It leads to essential reorganisation of periglacial environment of high mountains and frequently accompanied by activation of postcryogenic permafrost geological processes and phenomena including of destructive character. All geocryological processes and phenomena are united in groups by one-two leading factors: cryogenic-gravitational, cryogenic and water-cryogenic.

The quantitative estimation of danger of geocryological processes and phenomena allowed to systematize and tot allocate three categories of natural and technogenic geocryological processes and phenomena by degree of danger of their occurrence - low-hazard, middle hazard and hazard.

For the first time hazard geocryological processes and phenomena in Kazakhstan were mapped on the map of «Hazard of geocryological processes in Kazakhstan» (scale 1:5 000 000). It was made on the base of geocryological map (scale 1:5 000 000) in which the main characteristics of distribution, structure, temperature mode short-term (diurnal) are reflected, seasonal and long-term freezing of sub-soils and provided geocryological division into districts of the territory of Kazakhstan. The map provides representation about susceptibility of the territory to the most significant in the engineering-geological relation geocryological processes and phenomena.

On the map five groups of areas of susceptibility to hazard and potentially hazard geocryological processes and phenomena are allocated as well as one more group of areas where these processes are absent. The last group unites extreme southern areas where during the cold periods there is mainly short-term freezing of All mountain areas of South-East Kazakhstan belong to the regions with high seismicity that considerably raises degree of risk of formation of dangerous exogenous-geological processes and phenomena including geocryological.

Coastal Dynamics within Built-Up Areas of Chuckhi Peninsula

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Coastal processes causes geotechnical environment of built-up areas to malfunction. Chuckhi peninsula is the habitat for about 10 thousands of indigenous people with both modern and traditional economy is set on the coast. Destruction of permafrost coasts raises the needs of expensive reconstruction or replacement of endangered coastal facilities. To assess and forecast the coastal retreat we studied coastal dynamics, and the factors influencing it based on the archive materials of engineering surveys of the past century, modern satellite imagery, and geodetical surveys. Here we report on the dynamics of the accumulative and abrasive coasts dynamics of the Bering and Chukchi seas for the last 50 years.

Abrasive coast of the Middle Pleistocene Marine terrace in Lorino settlement on the shore of Bering Sea has retreated by 11.7 m for 45 yrs. The maximal retreat rate was observed in 1979-1992 comprising 0.54 m yearly. The factors influencing the rate of coastal retreat are ranged on the basis of analysis of metheorological information, sea ice data, composition, and soil mechanics at the coast.

Accumulative coasts of Inchoun, Neshkan and Uelen communities settled at spits of Chukchi sea have shown the retreat rates of up to 2 m yearly. However, changes in shoreline position for accumulative coasts are regulated mainly by tidal fluctuations and by the balance of sediments in the coastal zone of the sea, with permafrost playing the secondary role.

Our studies widen the range of permanent coastal monitoring of the coast in permafrost area. Factor studies of coastal dynamics in every case are aimed to shift to mechanistical approach of coastal degradation in permafrost zone.

Distribution of Seasonal and Perennial Mounds in the South Tambeyskoye Condensate Field (Yamal Peninsula).

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Researchers at the northern part of the eastern Yamal is inconclusive estimates of the existence, distribution and genesis of the heave mounds [1; 2; 3]. By our assumption region of South Tambeyskoye field (71^0 N and 71-72 ° E) is insufficiently investigated and that is why researchers have different opinions. Frost heaving is a pervasive cryogenic process in the studied area. By field works of "Fundamentproject" in 2011 were found numerous forms of the process as areas heave, single-season mounds, perennial migration mounds and injecting mounds – hydrolaccoliths (pingo).

Transgressions and regressions of the Arctic Basin the taking place during Pleistocene and Holocene led to the formation of the complex of Late-Pleistocene Holocene terraces of marine and lagoon-marine genesis; the deposits from there moved to subaerial conditions and froze. At all geomorphological levels of the research area permafrost have continuous distribution. The continuity of the permafrost is broken by lake and river taliks, on the laida and in flood plains. The most typical mean annual temperature on the dividing areas is minus 5 – minus 6^0C. Large flood plains have generally background temperatures are 1-2 degrees higher than on the divide and are minus 4 – minus 5^0C.

The surface of the lagoonal-marine terraces and the laida the is generally flat and to varying decree it is cut by network of rivers and ravines, it is broken by polygonal incipient cracks, covered by lakes and boggy.

Frost heave of the seasonally-thawed layer grounds is very active in waterlogged and water-cut areas on all geomorphological levels made up of silty clay-lean clay deposits. Seasonal heave irregularity fosters the formation of flat mounds up to 1,0 m high and 5-10 in diameter or flat-dome-shaped elevations with cross-section of 0,5-1,0 m and with the height of not more than 0,5-1,0 m.

Perennial frost heave leads to the formation of migration mineral and peat-mineral mounds, and injection mounds-hydrolaccoliths. Among migration mounds oval mound 2-5 m high prevail, rare 6-8 m. In cross section their size varies from 15 to 100 m. Mounds are made up of loams with high ice content, clays, seldom loamy sands. In the mound strata there is an ice core lying at the depth of 2,0-5,0 m.

Such mounds are found on low geomorphological levels. Mounds are formed in freezing hasyreys, flow lines of made of silty clay-lean clay deposits, with lenses of watered sand; the height of the mounds is not more than 3-4 m and it increases with freezing

The majority of injection mounds- hydrolaccoliths are relict; they are not growing at present and are intensively destroying.

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Mechanisms of Destruction of Frozen Soil

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Communication between the particles of the frozen ground, depending on the proximity to the melting temperature t_{ml} can be plastic ("melting") near t_{ml} and fragile ("sublimation") away from t_{ml} [Konovalov 2009, 2011]. The energy of plastic ties equal to the specific heat of melting (crystallization) Q_{ml}, fragile - specific heat of sublimation Q_c. Different types of links particles of frozen soil is determined and different mechanisms of its destruction. Plastic destruction is deformation of frozen body (its connections particles), with a gradual transition in liquid, flow, which is recorded on the achievement of the values of relative deformation close to the $j_{ml} \approx$ 0,083…0,12. Sublimation corresponds to a complete breakdown in nuclear communication, education at its place of "emptiness", when the relative deformation of the highest - j_c of about 1 (ice value j_c and Q_c, and more j_{ml} and Q_{ml} roughly 12 times). At the macro level such deformation is local, is confined to areas with weak links hub voltage (micro-cracks, structural defects...). It develops unnoticed for an observer in the form of cracking in the direction of compression and fixed on the disorder of the body. Formula durability of plastic permafrost is [Konovalov, 2009, 2011]:

$$\tau_d = \tau_{min} (P_{m..ml} / P)^{1/jml}, \qquad (1)$$

Durability of frozen soil with a low melting temperature is determined by the well-known formula [Regel, etc., 1974], the mind [Konovalov, 2009, 2011]:

$$t_d = \tau_{min} \exp[2 \cdot (T_0/T)(1 - P/P_{m.c}) / j_{ml}] \qquad (2)$$

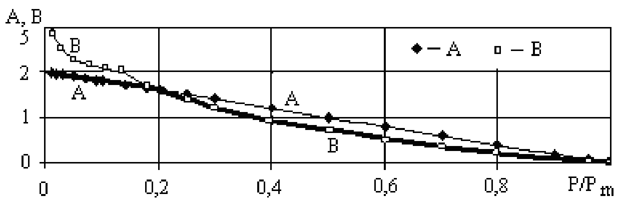
Maximum (conditionally instantaneous) strength plastic - or brittle - frozen ground, in the General case - Pm, the equilibrium of minimum durability τ min,is determined from the equation Clausius - Clapeyron equation, in which substitutes the current temperature of the frozen ground, t < tml , and the corresponding volume of heat (Lml or Lc) and the deformation jml or jc) phase transitions. Replacing indexes at these values of share - f, we obtain a uniform expression for the maximum (instant) strength:

$$P_m = L_f\, t /(j_f \cdot T_0) \qquad (3)$$

Here is the formula (1) and (2) comparable to mind:

$$j_{ml} \ln(t_д /t_0) = 2\,(T_0/T)(1 - P/P_m) = A\,,\ \ j_{ml} \ln(t_д /t_0) = \ln(P_m / P) = B.$$

Attitude T0/T of ordinary ice (ice-I), the existing temperature range 251-273 K, changes in the range of 0.92...1. Dependence of conventional durability A and B from P/Pм at T0/T = 0,96 are presented in Fig. Thick line shows the dependence of the real (i.e. a minimum of A and B) the relative durability (in logarithmic scale) from relative pressure, regardless of the mechanism of destruction.



The dependence of A and B from P/Pм

The figure shows that when $P/P_m \geq 0{,}2$ durability more fragile body (A>B). This means that the critical deformation jпр achieved earlier than the body is falling apart. Therefore, to ensure the sustainability of the projected at such ground constructions durability and strength should be calculated using formula (1), as for plastic body. If $P/P_m < 0{,}2$, on the contrary, more "plastic" longevity (B >A), so the body is falling apart before achieved critical deformation j_{ml}. Therefore, durability and strength in this area should be calculated using formula (2), as for fragile body.

Current Turbation Identification in Podzols of Western Siberia

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Soil material movement has wide distribution in permafrost landscapes. Sometimes top soil horizons are buried by subsoil horizons due to windblow. These processes dating are possible in case of direct observations. However buried layers are located in soils covered by undisturbed herb or/ and moss stratum. Dating presents a problem in this instance because of existing methods are not suitable for current turbation that took place in the end of 20th century– in the beginning of 21th century. Using of artificial radionuclide can help to solve this problem. Chosen radionuclide should have long half-life and to be slightly mobile or to be quickly immobilized under soil conditions. Cesiume-137 satisfies these criteria. Cesium-137 is quickly immobilized in soils and accumulates in topsoil. Therefore if significant 137Cs concentration is detected in moved layers, it age is not more than 70 years.

The aim of our research is to estimate suitable of cesium-137 as geotracer of soil turbation.

Field research was curried out in 2012 in three study area located in Western Siberia, Rissia. The first study area “Purpe” occurs in the middle part of the Pur river basin, near Gubkinsky town (Yamalo-Nenets Autonomous Okrug). The second study area “Noyabrsk” is located in the Ob and the Pur rivers watershed, near Noyabrsk sity (Yamalo-Nenets Autonomous Okrug). The third study area “Turtus” occurs in the north of Uvatsky District of Tyumen Oblast. Turbicpodzols are the typical soils of study area “Purpe” and “Noyabrsk”. Turbicgleysols are the typical soils of study area “Turtus”.

From 7 crossovers 38 soil samples were collected. Cesium -137 specific activity decreases from topsoil horizons to subsoil horizons. But significant 137Cs specific activity (2±1 Bq/kg) was detected in 3 samples from buried layers with high organic carbon concentration while it specific activity is 0 Bq/kg in background layers consist of carbon-poor material.

Obtained data show that turbations of soil material with high organic carbon concentration take place in the end of 20th century– in the beginning of 21th century.

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Session 1: Subsea permafrost

ДИНАМИКА КРОВЛИ ПОДВОДНОЙ МЕРЗЛОТЫ В ПРИБРЕЖНОЙ ЗОНЕ МОРЯ ЛАПТЕВЫХ

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Подводная мерзлота (субаквальные многолетнемерзлые породы, СММП) в арктических морях изучена крайне слабо. Неизвестны ее мощность и границы распространения на относительно приглубом шельфе. Установлено активное преобразование льдистых многолетнемерзлых пород в мелководной зоне арктического шельфа. Данные, полученные по немногочисленным буровым профилям на прибрежном мелководье, показывают значительные вариации в уклонах поверхности и темпах деградации мерзлоты сверху, при довольно «высоких» температурах (-1, -1,5°С) в ее толщах на расстоянии уже в первых километрах от берега.

Установлено, что средний уклон (от берега) кровли подводной мерзлоты в прибрежно-шельфовой зоне морей Восточной Сибири – 0,011 (0,62º). Диапазон уклонов – 0,0002-0,1. Установлено также, что скорость деградации верхних горизонтов реликтовых субаквальных многолетнемерзлых пород (СММП) составляет первые десятки сантиметров в верхней части подводного берегового склона, уменьшаясь до первых миллиметров в год в нижней его части. Эта скорость определяется динамическим режимом береговой зоны, составом, строением и мощностью залегающих на кровле мерзлоты осадков, температурой и соленостью придонного слоя воды, а также характером гидро-литодинамических процессов в прибрежной зоне шельфа. Очевидных изменений темпов деградации субаквальных многолетнемерзлых пород в прибрежной зоне арктических морей, в связи с климатическими изменениями в Арктике, пока обнаружить не удалось.

Выявлена сложная структура верхних горизонтов СММП, состояние которых на многих участках нестабильно в силу существования локальных геотермических, гидрогеологических и тектонических аномалий. Наземная (береговая) криогенная система и донная (верхние горизонты СММП на подводном береговом склоне) динамически тесно зависимы друг от друга. Особенности эволюции верхних горизонтов СММП зависят от ряда факторов: темпов отступания или выдвижения берегов, температурного режима и солености придонной воды, уклонов подводного берегового профиля, морфологии береговой зоны и конфигурации береговой линии; степени открытости к морскому влиянию, характера осадков, слагающих берег и подводный береговой склон, льдистости субстрата, особенностей гидро-литодинамикических параметров.

Практическое значение исследований подводной мерзлоты связано с уточнением изменения батиметрии прибрежных фарватеров (просадки дна при деградации льдистых СММП), с выявлением инженерной основы для любых видов работ на шельфе, а также с поиском газоконденсатных месторождений на шельфе.

Session 2: Permafrost hydrology and hydrogeology

МЕРЗЛОТА И ПОДЗЕМНЫЕ ВОДЫ СРЕДНЕГОРЬЯ ПРИПОЛЯРНОГО УРАЛА

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Геотермические наблюдения в слабо изученной осевой зоне Приполярного Урала, на гольцовом водоразделе хребта Малдынырд, проведены в четырнадцати скважинах. Температура мерзлоты на глубине 20м понижается с приближением к крутым, до отвесных, склонам с -1 до -4°. Вследствие бокового охлаждения пород геотермический градиент отрицательный либо нулевой в интервалах до 100-175м; глубже — положительный: 0,72°/100м. Мощность мерзлоты определена на отметке рельефа

1293м, по скважине с выстойкой 162 суток после 45 суток бурения. При температуре -1,5° на глубине 433м и указанном градиенте мощность мерзлоты составит 640м. По менее выстоенной скважине, промеренной до 386м, расчетная мощность мерзлоты 620м. Прежние оценки: предположительная – 300м (Баранов, 1977); по замерам до глубины 116м, - 490м (Оберман, 1981). Промороженную толщу слагают метаморфические породы (Є3-О1) и обломочные отложения. В последних встречаются линзы льда мощностью до 0,5м. Ультрапресный лед выполняет полости, трещины в коренных породах, отмечен до глубины 130м; глубже льдистость прослеживается по геофизическим данным. Судя по глубинам встречи льда, мощность морозные породы составляет 0-15м. Мерзлота, залегающая глубже, имеет сплошное распространение на отметках 1100м и выше. Несплошная мерзлота наиболее развита у подножия хребта, на отметках 600-650м.

Источники вод сезонноталого слоя фиксируются с отметок около 1200м и ниже, в ноябре - декабре источники полностью истощаются, обнаруживая себя склоновыми наледями, площадью в десятки – сотни $м^2$. Разгрузке вод подрусловых, подозерных таликов способствуют морены: на пересечении ручья с валом боковой морены формируется наледь площадью $70000м^2$. Модуль подземного стока, определенный по расчленению гидрографов р. Балбанью, непосредственно выше и ниже озера Бол.Балбанты, составил 2,9 и 5,0 $л/с•км^2$. Аномальность последней величины обусловлена субавальной разгрузкой вод подозерного талика, подпруженных «плотиной» конечной морены. В подземных водах преобладают гидрокарбонаты кальция; сухой остаток воды 0,01-0,07г/л.

В упомянутом озере отмечалась линейная полоса из восьми полыней (фоновая мощность льда 1,2-1,5м) со струями газа, предположительно азота. Учитывая приуроченность этой полосы к фронтальной части регионального надвига, полагаем, что здесь происходит восходящая разгрузка глубинных флюидов по сквозному талику. Концентрация нефтепродуктов и водорастворенного органического вещества здесь и в других многочисленных водопунктах, также расположенных в естественных условиях, аналогично приуроченных к зонам дизъюнктивов, на отметках до 900м, - достигает, соответственно, 0,7 и 2,9мг/л. Эти компоненты определялись в двух лабораториях, включая аккредитованную Тимано-Печорского научного центра, специализирующуюся на исследованиях вод нефтяных месторождений. Согласно заключению заведующего лабораторией кандидата наук С.А. Данилевского, анализировавшиеся пробы являются природными углеводородными смесями ореолов миграционных потоков углеводородов.

То-есть, даже в условиях мощной мерзлоты Приполярного Урала отмечается разгрузка подмерзлотных вод по сквозным таликам.

Session 3: Permafrost biogeochemistry

МИКРОЭЛЕМЕНТЫ В ДОННЫХ ОТЛОЖЕНИЯХ ОЗЕР Г. ЯКУТСКА

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Донные отложения озер являются важным источником информации о климатических, геохимических и других условиях и позволяют оценить современное экологические состояние воздушной и водной сред. Многие загрязняющие вещества депонируются донными отложениями и поэтому могут рассматриваться, не только как показатели качества воды, но и как источник вторичного загрязнения. При изменении физико-химических условий (pH, Eh, температуры, состава газов) соединения, связанные с донными отложениями могут растворяться, поступать в воду и далее в пищевую цепь. При этом некоторые относительно инертные или безвредные для окружающей среды неорганические вещества могут преобразоваться в растворимые и токсичные формы (например, переход элементарной ртути в метилртуть.

Автором поведена оценка геоэкологического состояния озер г. Якутска и интенсивности их загрязнения на основе изучения содержания микроэлементов в донных отложениях (ДО). Были исследованы ДО как крупных (Белое, Сайсары, Сергеляхское, Ытык-Кюель и др.), так и небольших озер. Пробы ДО отбирались в зонах аккумуляции, где создаются условия седиментации мелкодисперсного материала с хорошими сорбционными способностями, из слоя 0-15 см. Концентрация микроэлементов в ДО определялась методами атомно-абсорбционной спектроскопии и приближенно-количественного спектрального анализа. Общее количество отобранных ДО - 40 проб.

Для ДО озер характерен значительный диапазон солености, которая изменяется в пределах 0,011-4,548%. Наибольшее засоление ДО наблюдается в сильно загрязненных озерах (Хомустах, Теплое и др.). В целом на территории города большинство озер с повышенной соленостью ДО (>0,15%) приурочено к 1 надпойменной террасе, где расположены районы с высокой плотностью городской застройки. Повышение солености ДО озер города, обусловленное как климатическими, так и техногенными причинами, определяется, в первую очередь, возрастанием концентрации ионов хлора, натрия и магния, между которыми наблюдается высокая значимость корреляционных связей. В тоже время повышение солености ДО не сопровождается одновременным возрастанием концентрации микроэлементов.

Содержание большинства микроэлементов в ДО озер г. Якутска значительно ниже ПДК. В то же время, концентрация группы преимущественно халькофильных элементов (As, W, Ag, Pb, Mo, Co, Cu, Hg, Zn) значительно превосходит ПДК. Дефицитным в ДО является комплекс халько- и литофильных элементов, концентрация которых заметно ниже кларковых: V, Ni, B, Li, Ga, Nb, Sn, Cr, Ge, Y. Содержание большинства химических элементов в донных отложениях и почвах находятся примерно на одном уровне, что предполагает их перенос с водосбора в акваторию озер в твердой фазе в виде первичных и вторичных минералов.

В период исследований (с 1998 по 2011 гг.) отмечено повышение концентрации микроэлементов в ДО для Cd, Ag, W, Sn, концентрация которых возросла в 8-19 раз. Вдвое и трое увеличилась концентрация таких токсичных элементов как Pb, Cu, Hg и Zn.

Эколого-геохимическая оценка ДО выполнена путем сравнения с уровнем предельно допустимых концентраций для почв – ПДК, так как санитарные нормы для ДО не разработаны.. Степень концентрирования химических элементов (средние и максимальные концентрации) в донных отложениях городских озер по сравнению с санитарными нормами для почв.

Выводы. Большинство озер с повышенной соленостью находится в пределах 1-й надпойменной террасы р. Лена, в «старых» районах города с высокой плотностью застройки. Донные отложения активно накапливают компоненты-загрязнители – Pb, Cu, Zn, Cd, Sn, Ag, Cu, W концентрация которых в последнее десятилетие значительно выросла.

Степень загрязненности большинства ДО озер города оценивается как допустимая и умеренная. В некоторых озерах загрязнение достигает опасной и даже чрезвычайно опасной степени.

Session 4: Permafrost and trace gas exchange

МЕТАН И МЕТАНОБРАЗУЮЩИЕ АРХЕИ В ВЕЧНОЙ МЕРЗЛОТЕ АНТАРКТИДЫ

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По сравнению с другими континентами и компонентами криосферы, вечная мерзлота Антарктиды изучена слабо, о ее вкладе в глобальный биогеохимический цикл известно крайне мало.

В отличие от Арктики, антарктическая мерзлота характеризуется низким содержанием органического углерода (от сотых долей до 1.5 %) и ее роль в потоке парниковых газов в атмосферу в глобальном масштабе сегодня незначительна. Однако, в средне- и долгосрочной перспективе вклад антарктической мерзлоты как источника углерода может возрастать по мере освобождения территории ото льда и увеличения мощности деятельного слоя как за счет колонизации новыми видами растений и микробными сообществами, так и за счет разгрузки резервуаров законсервированного в ней метана. Исследование мерзлых отложений свободных ото льда оазисов Антарктиды показало, что метан присутствует в морских и озерных отложениях, а также в отложениях временных водотоков. Так на станции Беллинсгаузен метан был обнаружен в отложениях морской террасы и в озерных отложениях на станциях Прогресс, Новолазаревская и в оазисе Бангера.

Показано присутствие биогенного метана в эпикриогенных осадках: среднеплейстоценовых озерных отложениях Сухих Долин (долина Майерса). В выходящих на поверхность песчаниках формации Сириус (Сухие Долины, г. Фэвер) установлено присутствие абиогенного метана, а также его гомологов (этана и пропана) и этилена.

Анализ сообщества архей в многолетнемерзлых отложениях морской террасы на станции Беллинсгаузен и озерных отложениях оазиса Бангера методом анализа клоновых библиотек генов16S рРНК выявил доминантные филотипы, наиболее близкие к метаногенам археям в многолетнемерзлых породах морского и озерного происхождения. Толща морских отложений характеризовалась большим разнообразием доминантных и минорных филотипов родов *Methanosarcina, Methanobrevibacter, Caldivirga, Methanogenium, Methanolobus* и *Methanoculleus*, двумя доминантными филотипами класса Methanomicrobia. Разнообразие архей в отложениях оазиса Бангера оказалось более низким и характеризовалось лишь двумя представителями класса Methanomicrobia. Исследование накопительных культур метаногенов из многлетнемерзлых отложений долины Майерса выявило доминирование в них метаногенов рода Methanosarcina.

Проведенные исследования в целом подтверждают биогенную природу метана в многолетнемерзлых отложениях Антарктиды и роль этих отложений как резервуара метана, масштабы которого еще требуется оценить.

Исследования проведены при поддержки гранта РФФИ 12-05-01085.

ВЛИЯНИЕ ВКЛЮЧЕНИЙ ПЕРЕОХЛАЖДЕННОЙ ВОДЫ НА УСТОЙЧИВОСТЬ МЕТАСТАБИЛЬНЫХ ГАЗОВЫХ ГИДРАТОВ

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Интерес к поведению газовых гидратов при отрицательных температурах обусловлен рядом причин. Природные газовые гидраты залегают в толщах мерзлых пород, и их диссоциация может в сильной степени повлиять на глобальное изменение климата. Разработка газогидратных технологий хранения газа, основанных на способности природных гидратов сохранять в условиях низких температур (< 273К) долговременную устойчивость при давлении газа значительно ниже равновесного.

Принято считать, что аномальная устойчивость газовых гидратов вне области их термодинамической стабильности при температурах ниже 273 К обусловлена образованием на поверхности гидратных частиц слоя льда, препятствующего свободному выделению газа из гидратов. Не так давно обнаружено существование метастабильных газовых гидратов при давлениях ниже равновесного давления лед-гидрат-газ, когда лед отсутствовал в образцах [1, 2]. Устойчивость таких гидратов не связана с эффектом их самоконсервации.

При гидратообразовании переход всей воды в гидрат, как правило, не происходит, и непрореагировавшая вода присутствует в кристаллических образцах гидратов в форме жидких включений. При переходе гидрата в метастабильное состояние, при температурах ниже температуры плавления льда, переохлажденная вода может некоторое время оставаться в состоянии переохлажденной жидкости. Самопроизвольное замерзание переохлаждённой воды сопровождается появлением в газогидратной системе льда, который может повлиять на устойчивость метастабильнго гидрата. Однако влияние замерзания непрореагировавшей воды на устойчивость метастабильных газовых гидратов в области отрицательных температур никогда прежде не исследовалось.

Нами изучено влияние включений переохлаждённой воды на устойчивость метастабильных газовых гидратов пропана, на примере газогидратных дисперсий, полученных из “сухой воды”. “Сухая вода” это сыпучий порошок на 90-98 мас. % состоящий из микрокапель жидкой воды, стабилизированных гидрофобными наночастицами [3]. Благодаря микрокапельному строению “сухой воды” и малому размеру водных частиц её дисперсной фазы (от ~2мкм до ~40мкм) [4] переохлажденное состояние воды в газогидратных дисперсиях, полученных на основе “сухой воды” сохраняется длительное время, достаточное для проведения экспериментов по изучению устойчивости метастабильных состояний газовых гидратов. О состоянии системы «сухая вода»-пропан и протекающих в ней фазовых превращениях судили по данным измерения давление-объем-температура (P-V-T) и дифференциального термического анализа при изохорном охлаждении/нагревании системы, снижении давления газа в условиях отрицательных температур.

В результате проведённых исследований показано: (1) - температура начала замерзания включений непрореагировавшей воды (в режиме охлаждения) в газовых гидратах снижается с увеличением степени перехода воды в гидрат; (2) самопроизвольное замерзание включений переохлаждённой воды в метастабильных газовых гидратах инициирует их разложение на лёд и газ.

Работа выполнена при частичной финансовой поддержке РФФИ (проект № 12-08-31357), программы ФНИ гос. академий наук на 2013–2020г. (приоритетное направление VIII.77), междисциплинарного проекта СО РАН № 144, Научно-исследовательской программы Тюменской области на 2013г, Совета по грантам президента РФ грант НШ 558220125.

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УСТОЙЧИВОСТЬ “СУХОЙ ВОДЫ” К ЗАМЕРЗАНИЮ/ ОТТАИВАНИЮ, ОБРАЗОВАНИЮ/ ДИССОЦИАЦИИ ГАЗОВЫХ ГИДРАТОВ

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Природные газовые гидраты способны сохранять в условиях низких температур (< 273К) долговременную устойчивость при давлении газа значительно ниже равновесного. Принято считать, что аномальная устойчивость газовых гидратов вне области их термодинамической стабильности при температурах ниже 273 К обусловлена образованием на поверхности гидратных частиц слоя льда, препятствующего свободному выделению газа из гидратов. Механизм формирования этого слоя льда остается мало понятым.

Один из предложенных механизмов самоконсервации гидратов предполагает, что диссоциация гидратов при температурах ниже 273К может протекать через промежуточную метастабильную фазу (переохлаждённую воду). В настоящее время получены достоверные экспериментальные доказательства диссоциации газовых гидратов на переохлаждённую воду и газ [1,2].

Нами предложено использовать “сухую воду” для получения модельных газогидратных дисперсий, предназначенных для изучения влияния переохлаждённых состояний воды на поведение газовых гидратов вне их современной зоны стабильных состояний.

“Сухая вода”, полученная интенсивным смешиванием жидкой воды, воздуха, гидрофобного аэросила может содержать до 98 мас.% жидкой воды и при этом иметь консистенцию сыпучего порошка [3]. Малые размеры капель дисперсной фазы “сухой воды” (от одного до нескольких десятков микрон) [4] и наличие рыхлого слоя аэросила, разделяющего эти капли, создают условия для возникновения устойчивого переохлаждённого состояния воды в газогидратных системах, полученных из “сухой воды”.

Однако использование “сухой воды” в исследованиях метастабильных состояний газогидратных систем при температурах <273К осложняется тем, что происходит частичное разрушение дисперсий “сухой воды” при замерзании/оттаивании, образованию/диссоциации газовых гидратов [5,6].

Стабильность дисперсных систем в сильной степени зависит от их состава. Однако не проводилось исследований влияния содержания стабилизатора в “сухой воде” на её устойчивость к замерзанию /оттаиванию воды, образованию/диссоциации газовых гидратов.

Нами изучено влияние содержания аэросила в “сухой воде” на её устойчивость. Для характеристики степени разрушения дисперсии после проведения циклов замерзания/оттаивания воды, образования/диссоциаци газовых гидратов определялась доля жидкой воды, выделившейся при разрушении дисперсии. Циклы замерзания/оттаивания воды, образования/диссоциаци газовых гидратов проводились в стеклянном реакторе объемом несколько кубических сантиметров. Это позволяло визуально контролировать состояние системы в процессе проведения экспериметов. В качестве газа гидратобразователя использован пропан.

В результате проведённых исследований установлено что, устойчивость “сухой воды” возрастает с ростом содержания стабилизатора. 10 мас.% стабилизатора обеспечивают устойчивость “сухой воды” к процессам замерзания /оттаивания воды, образования/диссоциации газовых гидратов. Это позволяет использовать газогидратные дисперсии, полученные из “сухой воды”, с содержанием аэросила 10 мас.% и более, для изучения метастабильных состояний, возникающих в газогидратных системах при отрицательных температурах.

Работа выполнена при частичной финансовой программы ФНИ гос. академий наук на 2013–2020г. (приоритетное направление VIII.77), междисциплинарного проекта СО РАН № 144, Научно-исследовательской программы Тюменской области на 2013г, Совета по грантам президента РФ грант НШ 558220125.

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ВЛИЯНИЕ ИНГИБИТОРОВ НА ИНДУКЦИОННЫЙ ПЕРИОД ГИДРАТООБРАЗОВАНИЯ

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Одной из проблем, с которой сталкивается нефтегазовая отрасль в районах вечной мерзлоты это образование газовых гидратов. На сегодняшний день для предотвращения гидратообразования в России широко используют метанол. Метанол относится к классу термодинамических ингибиторов гидратообразования, смещающих линию трехфазного равновесия газ-вода-гидрат в область более низких температур. Основными недостатками метанола является его большой расход (20-50%) и ядовитость [1]. Поиск альтернативы метанола в 90-х годах привел к открытию нового класса веществ - кинетических ингибиторов гидратообразования. Это в основе своей водорастворимые полимеры, экологически безвредные с относительно низким расходом (0,25-1%). Кинетические ингибиторы гидратообразования по сравнению с термодинамическими ингибиторами имеют ряд ограничений по температуре и времени ингибирования [2,3]. Эти ограничения сдерживают их использование в районах вечной мерзлоты. На сегодняшний день активно ведется поиск и разработка новых экологически безопасных кинетических ингибиторов гидратообразования.

Для исследования влияния ингибиторов на процесс гидратообразования нами был разработан и создан реактор высокого давления с перемешивающим устройством, моделирующим динамику движения потока в технологических линиях. Проведенные гидроиспытания показали возможность использования реактора до 20 МПа и 233К.

Апробация данного реактора по определению индукционного периода гидратообразования производилась на основе дистиллированной воды. Температура образца в экспериментах составляла 274 К и давление 390±10 кПа. В качестве гидратообразующего газа использовали технический пропан (состав в масс. %: С1-0.0165, С2-1.2350, С3-96.5817, iC4-2,1196, nC4-0.0471

В ходе проведения экспериментов установлено, что индукционный период начала гидратообразования существенно зависит от скорости перемешивания исходных компонентов. Так при 1080 об/мин индукционный период начала гидратообразования составляет 90 мин, а при меньшем числе оборотов не зафиксировано образование гидратов в течение 3-х суток.

Для установления влияния кинетических ингибиторов на период начала гидратообразования был использован 0,1% раствор поливинилпирролидона (PVP). Эксперименты проводились при 1080 об/мин в ходе которых подтверждено увеличения индукционного периода начала гидратообразования до 512 мин.

Проведенные исследования показали хорошую воспроизводимость получаемых результатов. По результатам экспериментов подтверждено влияние PVP на увеличение индукционного периода гидратообразования. Дальнейшие исследования предполагают определение влияния на индукционный период начала гидратообразования кинетических ингибиторов синтезированных на основе полиэфиров.

Работа выполнена при частичной финансовой поддержке программы ФНИ государственных академий наук на 2013-2017 годы (приоритетное направление VIII.77.2.), междисциплинарного проекта № 144 СО РАН и Совета по грантам Президента Российской Федерации (грант НШ-5582.2012.5).

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РАДИОУГЛЕРОДНАЯ ДАТИРОВКА ТОРФЯНИКОВ И БУГРОВ ПУЧЕНИЯ БАССЕЙНА РЕКИ НАДЫМ

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Торфяники и бугры пучения, занимающие более 80% площади в бассейне реки Надым, охвачены современным пучением и тепловой осадкой. В связи с этим торфяники и бугры пучения являются объектом наших исследований с 1970 г. Исследования позволили установить современную динамику этих процессов. Для восстановления полной хронологии развития процессов пучения и тепловой осадки было проведено радиоуглеродное датирование торфа и древесины, и проанализирован материал из литературных источников. Из обнажения и керна скважины были отобраны образцы на палинологический анализ, выполненный и проанализированный Т.А. Бляхарчук.

Радиоуглеродные датировки показали, что торф и древесина опробованных бугров пучения моложе 9800 лет, и, следовательно, эти образования являются голоценовыми, что согласуется с выводом Ю.К. Васильчука (2012 г.). Кроме того, было установлено, что верхняя часть разреза бугров пучения часто сложена торфом старше 3 000 лет. Позднее этого рубежа, по-видимому, произошла приостановка торфонакопления на вершинах бугров пучения, которые оказались относительно хорошо дренированными. В настоящее время на вершинах многих бугров пучения происходит разрушение растительного покрова, проявляющееся в образовании ограниченных по площади пятен, на которых торф лишен растительного покрова. Мы предполагаем, что временное восстановление растительного покрова на пятнах может происходить во влажные годы, поэтому на нескольких пятнах нами организована наблюдательная сеть.

Возраст торфа, слагающего бугор в пойме притока реки Надым, (от 3450 до 6945 тыс лет) соответствует указанным выше временным интервалам , но все же в целом несколько моложе, чем возраст торфа бугров пучения на III озерно-аллювиальной равнине.

Торф, слагающий плоскобугристые торфяники также голоценовый, не старше 9 000 лет. Однако верхняя часть разреза торфяников более молодая, чем на буграх пучения. Это свидетельствует о том, что отмеченная ранее приостановка торфонакопления (в последние 3000 лет) на буграх пучения не была обусловлена глобальными климатическими изменениями, а скорее являлась следствием процессов, носящих местный характер.

Детальный палеопалинологический анализ верхней 2-х метровой толщи бугристого торфяника возрастом 4560+-120 лет выявил 7 фаз в развитии растительного покрова отличающихся друг от друга доминированием либо древовидной берёзы, либо ели, либо сосен (лесной и кедровой). Изменение обилия локальных компонентов пыльцевого спектра (пыльцы осоки и эрикоидных кустарничков, а так же, спор сфагнума) показало, что промерзание торфяной толщи произошло на рубеже нашей эры около 2000 лет назад, когда климат стал более сухим и холодным после периода увлажнения во второй половине третьего тысячелетия назад. Палинологические маркеры (максимумы спор сфагнума и пыльцы кедра) указывают на более краткие эпизоды промерзания торфяной толщи, имевшие место, также, около 3000 и 4000 л.н.

Исследования выполнены при поддержке проекта CALM (NSF OPP-9732051, 0PP-0225603); TSP (NSF ARC-0632400, ARC-0520578), при поддержке гранта Президента Российской Федерации (грант НШ -5582.2012.5) и гранта РФФИ (грант 13-05-00811).

КРИОГЕННАЯ ТОЛЩА ГАЗОНОСНЫХ СТРУКТУР ЯМАЛА

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Газоносные структуры в криолитосфере занимают заметную часть разреза кайнозойских отложений. По основным характеристикам криогенной толщи, расположенной над продуктивным горизонтом структуры (градиенты температур, положение изотермы 0°С, мощность мерзлой части толщи и др.), составлено представление о всей криолитозоне Западной Сибири. При средне- и мелкомасштабном картографировании эти характеристики используются для интерпретации криогенных разрезов и интерполяции на участках вне расположения газоносных структур. Газоносная структура - неотектоническое образование, геологический разрез которого состоит из горизонта рыхлых пород плейстоцена и палеогена, перекрывающего толщу уплотненных пород позднего мела (покрышку над продуктивной газоносной залежью раннего мела). В течение плейстоцена на кровле размытых позднекайнозойских отложений накопились осадки раннего и среднего плейстоцена, а отложения позднеплейстоценовых свит стали рельефообразующими для поверхностей многих структур. Геоморфологическое устройство поверхности газоносных структур неодинаково (при неглубоком, до 500-800м, залегании газоносного купола). В пологой части подводного берегового склона шельфа (с глубиной моря около 100-120 м) расположены Русановская и Ленинградская структуры.

Осадконакопление и рельефообразование в суровой климатической обстановке сопровождались активным синхронным промерзанием позднеплейстоценовых отложений и эпихронным - более древних грунтовых толщ. Промерзанием консервировалась та грунтовая влага, которой пропитывались морские отложения и в синкриогенной, и в эпикриогенной частях мерзлой толщи. Вся история осадконакопления в позднем неоплейстоцене была непосредственно связана с синхронным и эпихронным льдовыделением: цементационным, сегрегационным, полигонально-жильным, пластовым, газогидратным.

Верхнюю часть разреза структуры занимает криогенная толща. Положительный градиент температуры от подошвы криогенной толщи до продуктивного горизонта подтверждает тепловое воздействие купола снизу вверх, как это известно из ряда работ Г.Б.Острого, В.В.Баулина, В.Т.Балобаева. Мощность криогенной толщи неодинакова и неоднородна в газоносных структурах с различным геоморфологическим устройством поверхности, геологическим строением надкупольной части разреза пород и глубиной залегания газоносного купола, глубиной залегания отложений различной засоленности.

Особенности криогенной толщи газоносных структур показаны в серии геологических разрезов, сопровождающихся стратиграфической рабочей схемой, в серии геокриологических разрезов и карт мощности. Большинство их опубликованы в томах 1 и 2 издания «Криосфера нефтегазоконденсатных месторождений полуострова Ямал».

ИСПОЛЬЗОВАНИЕ КОЭФФИЦИЕНТА КРИОГЕННОЙ КОНТРАСТНОСТИ ДЛЯ ВОССТАНОВЛЕНИЯ ПАЛЕОМЕРЗЛОТНЫХ УСЛОВИЙ НА ПРИМЕРЕ ПОЗДНЕПЛЕЙСТОЦЕНОВЫХ И ГОЛОЦЕНОВЫХ ОТЛОЖЕНИЙ СЕВЕРО-ВОСТОКА ЯКУТИИ.

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Выполнена работа по изучению состава, свойств и строения позднеплейстоценовых и голоценовых отложений Северо-Востока Якутии. Были исследованы отложения Ледового Комплекса позднего плейстоцена (ЛК) и покровный слой – Быковский полуостров, район пос. Черский (правый берег Колымы), аласные отложения и ЛК – мыс Чукочий. Большую роль в процессе осадконакопления играет криогенное выветривание, которое полностью определило облик этих толщ. Был рассчитан коэффициент криогенной контрастности для восстановления мерзлотных условий на момент накопления толщи. Установлено, что наименее суровые мерзлотные условия в позднем плейстоцене были в районе пос. Черский, на Быковском полуострове и на мысу Чукочий условия были схожи. Показано увеличение роли криогенного выветривания в процессе накопления толщи ЛК, наиболее суровые мерзлотные условия были на границе позднего плейстоцена и голоцена (завершение накопления ЛК и формирование покровного слоя). Формирование Аласного Комплекса (озерно-болотной пачки и таберальных отложений) происходило при более мягких мерзлотных условиях, протаивание и длительное нахождение в талом состоянии отображено в более низких значениях (часто меньше 1) коэффициента криогенной контрастности, чем для соседних останцов ЛК.

ОСОБЕННОСТИ МИКРОБИОМОРФНЫХ СПЕКТРОВ ПОГРЕБЁННЫХ ПОЧВ КОЛЫМСКОЙ НИЗМЕННОСТИ.

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Исследования проводились в Низовьях Колымы, в районе распространения отложений ледового комплекса. Одним из ведущих процессов формирования этих толщ в позднем плейстоцене являлся педогенез. В отложениях стадии МИС 3, установлено присутствие профилей четырех разновозрастных погребенных почв, которые явились объектом исследования.

Будучи открытой информационной системой, почва постоянно получает и сохраняет информацию о факторах своего формирования на протяжении значительных отрезков времени, в том числе в виде комплексов микробиоморф.

Микробиоморфы в почвах разнообразны. Встречаются пыльца и споры, детрит, фитолиты, спикулы губок, панцири диатомовых водорослей, раковины амёб.

Проанализированы особенности микробиоморфных комплексов погребённых почв. В мацерате из палеопочв отмечено повышенное содержание детрита, остатков эпидермиса трав, встречаются лигнифицированные ткани кустарничков. Они так же характеризуются высоким содержанием фитолитов, разнообразием их морфотипов. Встречены фитолиты разнообразных злаков среди которых выделяется группа овсяниц. Обнаружены фитолиты осок, хвощей, некоторых двудольных трав. Реже встречаются хвойные, элементы низкорослой остепнённой ксерофитной флора, опушенной гидрофильной флоры. В материале верхних горизонтов часто встречаются остатки раковинных амёб, обычно обитающие в растительных подстилках, торфянистых горизонтах почв и торфах.

В профилях погребённых почв содержание пыльцы и спор оценивается как среднее и высокое, что достаточно для реконструкций природной среды. Установлено значительное присутствие дальнезаносной пыльцы (преимущественно деревьев и кустарников). Данная группа пыльцы не может служить индикатором местных фитоценозов, но может с успехом использоваться для сопоставления спорово-пыльцевых диаграмм одновозрастных палеопочв региона, находящихся на значительном расстоянии друг от друга. Локальные компоненты палиноспектра (пыльца некоторых видов, например Valeriana capitata L.) фиксируют местные особенности фитоценозов. Эта группа пыльцы занимает подчиненное положение в спектрах (10-20%), поскольку в неблагоприятных условиях часть растений переходит на вегетативное размножение или на закрытое цветение, что искажает представления о растительном покрове, полученные на основании палинологического анализа. Пыльца анемофильных трав встречается в спектрах постоянно, энтомофильных – гораздо реже. Эти различия обусловлены механизмами опыления.

Микробиоморфные исследования палеопочв дополняют имеющиеся палинологические данные и позволяют детализировать представления о растительном покрове локальных мест их формирования.

В целом изученные спектры комплексов палеофоссилий из позднеплейстоценовых почв показывают, что они формировались в открытых ландшафтах с доминированием травянистых группировок со значительным участием в них злаков, крестоцветных, осоковых, гвоздичных, полыней, невысоких кустарничков и развитым моховым покровом.

СЛЕДЫ СПЛОШНОЙ МНОГОЛЕТНЕЙ МЕРЗЛОТЫ КОНЦА ПЛЕЙСТОЦЕНА НА ЮГО-ЗАПАДЕ ЗАПАДНО-СИБИРСКОЙ НИЗМЕННОСТИ

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Известно (Аубекеров, 1990; Горбунов и др., 1998 и др.), что во время последнего (сартанского) оледенения многолетняя мерзлота распространялась от северного шельфа Западной Сибири до гор на юге Казахстана. Лишь в полосе ~500-470с.ш. предполагается её прерывистый и, возможно, островной характер (Величко и др., 2009). На остальной тер-ритории она была сплошной. Следы рельефа криогенного происхождения на юго-западе Западной Сибири отмечали И.И.Краснов, С.П.Качурин, М.Н.Бойцов, М.Е.Городецкая, В.Д.Тарноградский и мн. др. Гораздо реже публиковались псевдоморфозы по ледовым или ледово-грунтовым жилам для этой территории. При том, к югу от 580с.ш. описывались обычно единичные, реже – парные псевдоморфозы (Аубекеров, Челыхьян, 1974, Аубекеров, 1992 и др.). Большие трудности возникают при определении времени развития многолетней мерзлоты, следы которой отражены в рельефе. Более-менее определённо к сартанскому времени можно отнести псевдоморфозы по ледяным и ледово-грунтовым жилам, залегающим в верхней части первых надпойменных террас. Реликтовый мерзлотный рельеф на «террасовых равнинах» юго-запада Западно-Сибирской низменности и даже полигоны на днищах реликтовых аласных котловин к западу от Омска (Тарноград-ский, 1966), скорее всего, древнее сартанского времени. Следы полигонального рельефа, наблюдаемые на космических снимках, и менее чётко выделяемые на поверхности первых надпойменных террас и низких (ниже «II-й террасовой равнины») водоразделах условно можно сопоставить с концом позднего плейстоцена.

В ходе полевых работ на юго-западе Западно-Сибирской равнины во многих местах наблюдались следы полигонального рельефа на низких уровнях. По публикациям, дешиф-рированию космоснимков и полевым наблюдениям на территории с координатами 57012’-53055’с.ш. и 62056’-73020’в.д выделяются многочисленные участки проявления крупнопо-лигонального, линейно-полигонального, мелкополигонального (мелкоячеистого) рельефа. Ранее на ЮЗ Западной-Сибири отмечались позднеплейстоценовые полигоны до 70 м (Горбунов и др., 1998). Нами наблюдались полигоны более 100 м. Такие крупные полиго-ны характерны для морских побережий (Гарагуля и др, 2001) Нами они наблюдались на удалении более 1500 км от моря, но в районе развития солёных озёр. Степень выражено-сти и сохранности полигонального рельефа заметно различается. Наиболее отчётливо следы такого рельефа проявляются на космоснимках, сделанных осенью или поздней весной, на участках занятых в момент съёмки под пашни. На них хорошо виден пятни-стый, блочно-полигональный рельеф, с полигонами преимущественно квадратной формы. В ходе полевых работ нами в подтаёжном и лесостепном Притоболье были обследованы более 60 карьеров, а также обнажения в бортах долины р.Тобол и выявлена серия разре-зов, геоморфологическое положение которых и стратиграфическая приуроченность сле-дов многолетней мерзлоты позволяет предположить их позднеплейстоценовый-поздне-ледниковый возраст. Наиболее информативен Кыштырлинский карьер в 40 км от Тюмени, 56055’с.ш. и 65049’в.д., абс. отметка 54-57м; на останце первой (?) надпойменной террасы правого борта долины р.Пышмы. Лслбенно хорошо следы палеокриогенеза выражены вверху северо-восточной части карьера. Здесь вскрывается полигональная сеть с многочи-сленными псевдоморфозами по ледяным жилам. Прилегающие к жилам слои в зоне кон-такта, особенно в верхней части, имеют изгиб слоёв вниз. Контакты жил с вмещающими отложениями обычно ожелезнённые. Расстояние между псевдоморфозами – 18-23 м. Возможно, это самое южное поле полигональных псевдоморфоз конца плейстоцена по ледя-ным жилам на ЮЗ Западной Сибири. Работа выполнена при поддержке гранта № 9 интеграционного проекта № 9 СО РАН-ДВО РАН и РФФИ № 11-05-01173.

Session 6: Permafrost modelling and mapping

ТЕРМОКАРСТОВЫЕ ОЗЕРА ЯМАЛА, КАК ИНДИКАТОР КЛИМАТИЧЕСКИХ ИЗМЕНЕНИЙ

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В работе представлены результаты анализа проб воды на концентрацию растворенной органики - cDOM (Colored Dissolved Organic Matter), отобранной из озер Центрального Ямала. Рассмотрена связь cDOM с климатическими характеристиками и глубиной сезонного протаивания пород за 2011-2012 гг. Проанализировано распределение индекса концентрации хлорофилла А тундрового растительного покрова водосборных бассейнов, рассчитанного с использованием данных дистанционного зондирования. Выявлено, что сочетание факторов: значительное увеличение летней среднемесячной температуры воздуха и связанное с этим увеличение глубины сезонного протаивания на ключевом участке в комплексе с увеличением суммы летних осадков повлияло на поступление в водоёмы

Центрального Ямала большего количества органических веществ, что привело к увеличению концентрации cDOM в более теплом 2012 г. по сравнению с 2011 годом.

В ходе полевых экспедиций Института Криосферы Земли СО РАН в 2011 и 2012 годах из 7 термокарстовых озёр Центрального Ямала было отобрано 25 проб. Был произведен лабораторный анализ этих проб на концентрацию cDOM. Результаты были сопоставлены между собой, а также со значениями индекса концентрации хлорофилла А на поверхности водосборных бассейнов этих озер. Расчет индекса Chl-a на поверхности основан на знании того, что растительность интенсивно поглощает волны красной области спектра (650-700 нм) для поддержания происходящего в ней процесса фотосинтеза. Индекс Chl-a рассчитан с использованием космического снимка GeoEye-1 2009 года. Общий вид комбинации каналов спутникового снимка, имеет вид: Chla = (DNgreen + DNnIR)/2 – DNred, где DN – относительное значение яркости пиксела в 11-битной системе каналов GeoEye-1: green, nIR, red – соответственно зеленый, ближний инфракрасный и красный каналы, имеющие диапазоны съемки 510-580, 780-920, 660-690 нанометров соответственно.

Было установлено, что значения концентрации cDOM имеют высокую корреляцию со средним значением индекса Chl-a в водосборных бассейнах (r = 0.89). Из этого был сделан вывод, что характер растительного покрова в водосборном бассейне, его видовой состав являются одним из факторов, которые формируют концентрацию растворенной органики в озере. Поскольку пробы воды были отобраны в полевые сезоны 2011 и 2012 гг., это позволило проследить динамику изменения концентрации растворенной органики в изучаемых озерах. Результаты анализа за 2011 и 2012 гг. демонстрируют достаточно большие различия в значениях. Для объяснения различий в значениях концентрации cDOM нами было проанализировано влияние климатического фактора. Были рассмотрены средние месячные температуры воздуха за летний период 2011 и 2012 гг. и было выявлено, что в 2012 году среднемесячные летние температуры воздуха (по данным станции Марре-Сале) намного выше значений 2011 года (в среднем на 5 градусов). Это привело к тому, что на полигоне произошло довольно значительное увеличение глубины сезонного протаивания (по данным измерений в рамках проекта CALM). Значения СТС в 2012 года значительно выше, чем в 2011 году, а, следовательно, возможно увеличение притока растворимой органики в озера с водосборных бассейнов. Поступление органики может быть также связано с количеством атмосферных осадков, которые инфильтруются в СТС. Сравнение показало, что в период с мая по октябрь 2012 года выпало гораздо больше жидких осадков по сравнению с 2011 годом (по данным метеостанции Марре-Сале). Это, по нашему, мнению, также могло повлиять на концентрацию cDOM в озерах, поскольку осадки играют важную роль в транспортировке вещества с поверхности водосборного бассейна подземным стоком.

ЛАНДШАФТНОЕ КАРТОГРАФИРОВАНИЕ ДЛЯ ЦЕЛЕЙ ГЕОКРИОЛОГИЧЕСКОГО ЗОНИРОВАНИЯ БОЛЬШЕЗЕМЕЛЬСКОЙ ТУНДРЫ

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Геокриологическая зональность, проявляется в закономерных изменениях характера мерзлотных параметров территории. Существуют значительные разночтения при геокриологическом зонировании Большеземельской тундры, требующие уточнения границ геокриологических зон и подзон.

В рамках проведенного исследования в качестве основного источника информации для уточнения и обновления границ геокриологических зон и подзон в пределах Большеземельской тундры использовались топографические карты среднего масштаба (преимущественно 1:100 000 или 1:200 000), данные полевых исследований и материалы дистанционного зондирования. В качестве последних использовались в основном зональные изображения LANDSAT-7\ETM+ с пространственным разрешением 30 метров для тематически ориентированного RGB-синтеза и получения цветных изображений в псевдоцветах, а также цветосинтезированные снимки ASTER\Terra с разрешением 15 метров, снимки субметрового пространственного разрешения, в том числе, представленные на порталах Google-maps и Google Earth и др. Информация обрабатывалась с использованием программ ArcView-3.2, ArcGIS-9.2, GlobalMapper-11, а также специализированного пакета IDRISI.

Геокриологическая зональность в пределах Большеземельской тундры условно соответствует зональным ландшафтам. Они представлены подзонами тундры, преимущественно южной кустарниковой, а также - южной и северной лесотундры и крайнесеверной тайги, которым соответствуют

4 геокриологические подзоны: подзоны тундр и северной лесотундры совпадают с северной криолитозоной, для которой характерно развитие сплошной и прерывистой мерзлоты; подзоны южной лесотундры и северной части крайнесеверной тайги – это южнаяй криолитозона, характеризующейся развитием массивно-островной и островной мерзлоты. Важнейшими индикаторами геокриологической зональности могут служить локальные ландшафты. В связи с этим в основе проведенных работ лежал метод крупно- и средне- масштабного ландшафтного картографирования и ландшафтно-индикационного дешифрирования.

В первую очередь по картам и снимкам определялись локальные (в ранге урочищ) ландшафты-индикаторы. Анализ проводился по 4 основным группам урочищ: лесным, болотным, урочищам торфяников и тундр. Далее для каждой геокриологической подзоны были определены основные группы урочищ-индикаторов.

Практически универсальной группой индикаторов является группа урочищ торфяников: выпуклобугристые торфяники используются в качестве индикаторов при определении южной границы криолитозоны, границы между подзонами прерывистой и сплошной мерзлоты; плоскобугристые торфяники не развиты в подзоне островной мерзлоты; полигональные и плоские заозеренные торфяники характерны для подзоны сплошной мерзлоты; хасыреи выделяются в северной криолитозоне.

Группу *болотных* урочищ, напротив, сложно использовать для индикации. Только грядово-мочажинные болота характерны для подзоны островной мерзлоты, хотя могут присутствовать и южной части подзоны ее массивно-островного распространения.

Группу *тундровых* урочищ можно использовать в качестве индикаторов при разделении северной и южной криолитозоны (по характеру мезорельефа), а также (достаточно условно) при разграничении островной и массивно-островной мерзлоты (по степени распространения тундровых участков) и прерывистой и сплошной мерзлоты (по распространению полого-волнистых тундр с единичными деревьями).

Лесные урочища являются индикаторами границы северной и южной криолитозоны (по характеристике сплошности лесных массивов), границы прерывистой и сплошной мерзлоты (по наличию участков лесов и редколесий). Сосновые леса, как правило, произрастают не севернее подзоны островной мерзлоты.

Не менее значимым показателем при использовании урочищ-индикаторов при геокриологическом зонировании является криогенный рельеф. В южной криолитозоне это, прежде всего, современный бугристый рельеф (в основном бугры в стадии роста), на севере – древний блочный. И тот и другой достаточно хорошо выделяются по снимкам высокого разрешения. Результатом проведенной работы стала мелкомасштабная карта геокриологического зонирования Большеземельской тундры.

ПРОСТРАНСТВЕННЫТ ЗАКОНОМЕРНОСТИ ПРОТАИВАНИЯ ОТЛОЖЕНИЙ ЛЕДОВОГО КОМПЛЕКСА В ГОЛОЦЕНЕ НА ПРИМЕРЕ ТУНДРОВОЙ ЗОНЫ КОЛЫМСКОЙ НИЗМЕННОСТИ

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Приморские низменности Севера Якутии являются ландшафтами, сформированными в результате протаивания позднеплейстоценовых высокольдистых отложений ледового комплекса (ЛК) в голоцене. Потепление климата в конце плейстоцена - начале голоцена способствовало активизации термокарста, ставшего главным рельефообразующим фактором на протяжении голоцена. Особую актуальность исследования подобных районов приобрели в последнее время в связи с оценкой влияния современных изменений климата. Понимание пространственных закономерностей развития термокарста важно для представления о развитии территории в будущем и оценки содержания органического вещества для прогнозирования эмиссии парниковых газов. Появление новых методов – ГИС-технологий с использованием ДДЗЗ дают возможность провести пространственный анализ рельефа на новом уровне, что позволит уточнить и дополнить существующие представления о его развитии в голоцене.

Район исследований - тундровая зона Колымской низменности площадью 45000 км^2. Основными формами рельефа являются водораздельные останцовые поверхности позднеплейстоценовых равнин, сложенных отложениями ЛК (едомы), озерно-термокарстовые котловины (аласы) и долины рек. Для составления карты заозеренности проведена классификация по выделению озер по космическим снимкам Landsat ETM+ 2000 и 2001 года с использованием программного пакета ENVI. Выделение едом, сложенных отложениями ЛК, проводилось вручную по вышеназванным космическим снимкам и топографическим картам масштаба 1:200000. Построение плотностных сеток, оверлейные операции выполнены в программном пакете ArcGIS. Карта распространения глубин термокарстового и термоэрозионного расчленения была получена путем вычитания карты поверхности, построенной по отметкам урезов воды термокарстовых озер и рек из карты поверхности абсолютных высот останцов едомы (отметки высот взяты с топографической карты масштаба 1:200000). По картам распространения термокарстовых озер и едом построены карты заозеренности и едомности (площади озер и едом относительно общей площади исследуемой территории в процентах).

Полученные данные дают представление об общей структуре территории. По данным космических снимков едомы занимают 15 % от всей площади исследуемой территории. Для сравнения тот же показатель по данным карты четвертичных отложений масштаба 1:1000000 составляет 41 %. Две трети территории заняты аласами (63,5%). Средняя заозеренность территории составляет 13,5 %, речные долины и прибрежные маршевые участки занимают около 8%. Значительные по площади участки едом сохранились вдоль речных долин и в районах новейших тектонических поднятий, где их площадь - более 40 %. На большей части таких территорий термокарстовые озера занимают менее 15%. В некоторых районах подзоны южной тундры, отмечается высокая заозеренность (более 40%). Высокая заозеренность характерна для районов обширных депрессий, здесь едома сохранилась на небольших участках и занимает менее 15 % территории. Прилегающие к депрессиям более возвышенные районы отличаются меньшей заозеренностью (менее 20%).

Карта распространения глубин термокарстового и термоэрозионного расчленения дает представление о мощности отложений ЛК, так как глубины расчленения едомы являются функцией мощности отложений ЛК (Каплина и др., 1986). Известная мощность отложений ЛК на исследуемой территории изменяется от 10-15 до 30-40 м (Архангелов и др.,1979; Каплина и др., 1981). Полученная средняя глубина расчленения едомы равна 24-28 метров. Меньшие глубины термокарстового и термоэрозионного расчленения (менее 24 м) характерны для районов тектонических поднятий и для долины р. Бол. Куропаточья. Глубины расчленения более 29 м отмечаются для районов большей части черных долин и для некоторых районов междуречий с сохранившимися останцами едом.

НОВАЯ МЕТОДИКА РАСЧЕТА ИНСОЛЯЦИИ ЗЕМЛИ

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В теориях палеоклимата используются расчеты инсоляции Земли по методике М. Миланковича. Она достаточно сложная и некоторые ее особенности непонятны для ряда исследователей. Поэтому в градостроительных, климатических и др. исследованиях инсоляцию рассчитывают по приближенным методам.

Основную сложность при расчете инсоляции вызывает движение Солнца над поверхностью Земли, которое определяется его долготой. В новой методике долгота определяется на основании точных решений задач 2-х тел. Кроме того, методика рассчитана на компьютерную технологию. В методике М. Миланковича приближенными аналитическими методами решается ряд задач по инсоляции за определенные интервалы времени. Компьютерная технология позволяет эти задачи решать с помощью выборки суточных инсоляций на этих интервалах времени.

В работе рассмотрены основные моменты задачи двух тел, геометрические характеристики инсоляции, распределение солнечного излучения по поверхности Земли и в зависимости от положения Солнца. Приведены алгоритмы расчета суточной инсоляции по дням года, за год, за калорические полугодия, а также представлен алгоритм расчета инсоляции в эквивалентных широтах. Все составляющие инсоляции рассчитаны на конкретных примерах по методике М. Миланковича и новой, и получено их совпадение.

Методика реализована в среде MathCad и представлена для свободного использования. Она позволяет исследователю самому определять виды обработок инсоляции, а не ограничиваться лишь теми, которые были развиты при создании методики. С ее помощью рассчитана динамика инсоляции поверхности Земли на разных широтах за 100 лет, начиная с 1950 г. Результаты расчетов представляют детальную структуру малых изменений инсоляции. Она необходима для исследования причин короткопериодических изменений природных процессов, обусловленных инсоляцией. Эти результаты свидетельствуют о широких возможностях методики. Они позволяют проводить исследования, которые ранее нельзя было выполнить.

ИНФОРМАЦИОННАЯ ГЕОКРИОЛОГИЧЕСКАЯ СИСТЕМА (ГЕОКРИОЛОГИЧЕСКАЯ БАЗА ДАННЫХ) СИБИРСКОЙ ПЛАТФОРМЫ. СОСТОЯНИЕ И ПЕРСПЕКТИВЫ ЕЕ РАЗВИТИЯ.

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Геолого-геофизическая и геокриологическая информация о недрах, накопленная за более чем за 100-летнюю историю освоения природных богатств и научных исследований в настоящее время оказалась рассредоточенной по десяткам различных организаций. Это не могло не отразиться на сохранности информации, ее качестве и доступности.

Вопросы надежного хранения, систематизации, обработки и анализа накопленных данных успешно решаются внедрением современных информационных технологий, в том числе созданием баз данных.

В настоящее время ни в России, ни за рубежом нет завершенных геокриологических баз данных (ГБД). В 1995 году в Институте мерзлотоведения СО РАН были начаты работы по разработке структуры геокриологической базы данных. В соответствии с разработанными положениями была предложена трехуровневая структура (Балобаев и др, 1996). Лаборатория геотермии Института мерзлотоведения СО РАН в рамках инициативного проекта начала формирование третьего уровня - базы фактических данных, включающих в себя структурированную мерзлотно-геотермическую информацию. В процессе работы, появились новые решения, изменения в структуре базы. В настоящее время завершается формирование геокриологической базы данных Сибирской платформы, которая может являться примером или рабочей моделью для разработки Всемирной геокриологической информационной системы (Железняк, 2011).

В основу разработанной геокриологической базы данных Сибирской платформы заложен геолого-структурный принцип, где на основании тектонического районирования (до структур 4-го порядка) собрана и систематизирована информация по физико-географическим условиям и техническим характеристикам скважин и горных выработок, температурному режиму и теплофизическим свойствам горных пород по 246 площадям (2050 скважинам глубиной от 50 до 2000м).

База данных Сибирской платформы создана с использованием многофункциональной системы DELPHI и процессора баз данных Borland Database Engine (BDE), в качестве стандартного языка является SQL - структурированный язык запросов (Structured Query Language). Для реализации запросов в Delphi существует специальный компонент TQUERY, который обладает рядом свойств и методов, позволяющих использовать все преимущества запросов SQL для работы с данными. Это дает возможность манипулировать большими выборками информации.

Система ввода в банк данных позволяет вводить подробную информацию: технические сведения скважин, ландшафтные особенности, мощность мерзлых пород, температуры поверхности, уровень подземных вод, глубину теплооборотов, снежный и растительный покров. Немаловажным является возможность указания сведений об организациях, проводивших работы и предоставивших данные. Также в геокриологической базе данных могут быть представлены теплофизические характеристики, такие как: коэффициент теплопроводности и температуропроводности, объемный вес скелета грунта, влажность, температура на подошве слоя годовых теплооборотов, геотермический градиент. Есть возможность внесения в базу данных карт и мерзлотно-геотермических разрезов, а также отображение экзогенных геологических процессов и явлений. Для наглядности данные по скважинам могут сопровождаться фотографиями.

С целью пространственного представления и визуального анализа имеющейся информации база данных связана с ArcGIS, что дает возможность использования карт любого масштаба. Широкое распространение ArcGIS, дает возможность в будущем к приведению унифицированных форматов хранения и к быстрому обмену данных с другими геокриологическими сообществами. В настоящее время ведется доработка системы для автоматического построения мерзлотно-геотермических разрезов по имеющимся данным скважин.

Работа с базой данных позволяет вести ее систематическое пополнение, просмотр имеющейся информации в табличном и графическом вариантах, выполнять выборку интересующих данных по геоморфологическим условиям, ее статистическую обработку, анализировать ход температуры многолетнемерзлых пород по геологическим структурам, геоморфологическим областям. Это позволит повысить достоверность различных параметров криолитозоны и выявить новые региональные и общие особенности и закономерности. Даст возможность моделировать и прогнозировать изменения состояния криолитозоны.

Администрирование базы данных осуществляется через Институт мерзлотоведения. В ближайшее время мета-база будет выложена на сайте ИМЗ.

ПРИМЕНЕНИЕ ПРОГРАММЫ «ECONORTH» ДЛЯ ОЦЕНКИ УСТОЙЧИВОСТИ ПРИРОДНЫХ КОМПЛЕКСОВ ОДНОЙ ИЛИ СМЕЖНЫХ КАТЕН

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Современная географическая наука, если она хочет отвечать насущным потребностям развивающегося общества, должна ориентироваться на создание продукции, позволяющей принимать обоснованные конструктивные решения при воздействии на окружающую природную среду. В этом отношении перспективны специализированные (ориентированных на широкий круг пользователей, в том числе и не имеющих географического образования) компьютерные программы, учитывающие все возможное разнообразие результатов взаимодействия природных и техногенных систем. Этим подобные программы коренным образом отличаются от традиционных материалов типа оценочных карт, которые дают статичную, зачастую мало обоснованную и недостаточно убедительную для неспециалиста картину. Первым пробным камнем является программа «Econorth», созданная В.П. Марахтановым в лаборатории геоэкологии Севера географического факультета МГУ.

В практической деятельности нередко приходится оценивать воздействие на окружающую среду объектов, строительство которых затрагивает не 1 – 2 природно-территориальных комплекса (ПТК), а несколько катен. Поскольку такие оценки сложны, целью исследования стала оценка применимости программы «Econorth» в условиях расчлененного рельефа. В качестве модельного выбран район Канкунской ГЭС (Южная Якутия).

Зона водохранилища Канкунской ГЭС будет располагаться в Алданском и частично Нерюгринском районах Южной Якутии. Район строительства находится в необжитой зоне, поэтому все объекты инфраструктуры придется создавать «с нуля», а значит, строительство предусматривает появление различных техногенных нагрузок. Кроме того, район Какунской ГЭС интересен и тем, что правый и левый борт долины р. Тимптон относятся к разным физико-географическим провинциям.

Особенность программы «Econorth» в том, что она позволяет не просто определить устойчивость ПТК, дать ей количественную оценку, но и оценить ее по отношению к процессам разного типа: тепловым, механическим и химическим. Но самое важное – возможность выделить типы воздействия, которые приводят к негативным последствиям. Такой функционал достигается за счет внесения в расчетную матрицу сведений о каждом ПТК (положение в рельефе, наличие ПЖЛ, состав грунтов, льдистость) и задания видов нагрузок. Кроме того, можно сравнить устойчивость при разных типах освоения, определить предпочтительный.

В матрицу были внесены следующие воздействия: постоянное движение транспорта, планировка земной поверхности, заложение карьеров, снегоочистительные работы, сброс промышленных и бытовых незагрязненных вод.

Согласно расчетам, в исследуемом районе наиболее «травматичными» являются постоянное движение транспорта и удаление снежного покрова, которые приводят, прежде всего, к образованию термокарстовых западин, заболачиванию и морозобойному растрескиванию. Причем наиболее губительны снегоочистительные работы. Термоэрозию может вызвать комплекс процессов, среди которых – подпруживание подземных вод вследствие планировки территории. В целом район достаточно устойчив к техногенным нагрузкам. Тем не менее, стоит обратить внимание на субгоризонтальные поверхности, на которых может развиваться термокарст, и склоны, подверженные солифлюкции и сплывам. Наименее устойчивыми оказались дренированные склоны, сложенные тонкодисперсными льдистыми грунтами, что вряд ли соответствует действительности, это побочный эффект обобщения.

Также было проведено сравнение двух типов освоения. Программа «Econorth» очень полезна для детального анализа воздействий, проста в использовании, а главное – позволяет дать конкретные рекомендации по каждому типу воздействий, оценить в отдельности каждый ПТК. Выбор за пользователем: изучать процессы или ПТК. Кроме того, за счет своей наглядности она идеально подходит для обоснования решений, будет удобна для визуализации оценок перед заказчиками. Тем не менее, при работе в конкретном районе приходится прибегать к обобщениям, потому что не все ПТК можно внести в матрицу по отдельности. Это может привести к погрешностям, поэтому при использовании методики лучше работать с более крупными ПТК, чем расположенные в катене.

МОНИТОРИНГ КРИОЛИТОЗОНЫ РОССИИ И СОЗДАНИЕ ЕДИНОЙ НАЦИОНАЛЬНОЙ ИНФОРМАЦИОННОЙ БАЗЫ

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Мониторинг криолитозоны – это унифицированная система наблюдений за состоянием криолитозоны, оценка, контроль и прогноз ее изменения во времени и пространстве под воздействием природно-климатических и техногенных факторов. Наблюдательная сеть объектов мониторинга тяготеет к основным промышленным регионам и принадлежит целому ряду научных организаций, в основном относящимся к отделениям РАН. Продолжительность рядов геокриологических наблюдений в настоящее время достигает 30-40 лет, а на Европейском севере систематические температурные измерения в ряде скважин ведутся более 50 лет. На современном этапе мониторинг криолитозоны в России невозможен без финансовой и технической поддержки различных международных проектов. В рамках проекта CALM (Циркумполярный мониторинг активного слоя) с середины 1990-х гг. в различных регионах России по единой методике было организовано около 20 площадок для наблюдений за температурным режимом и глубиной сезонного протаивания грунтов. В 1999 г. по инициативе Международной Ассоциации Мерзлотоведов было начато изучение динамики берегов в Арктике (проект ACD), в рамках которого в 17 районах Российской Арктики ведутся наблюдения за скоростью разрушения берегов и переноса осадков. В преддверии Международного Полярного 2007/08 года стартовал проект TSP – термическое состояние криолитозоны, который позволил возобновить круглогодичные температурные исследования в нескольких десятках скважин с использованием автоматизированной системы записи и хранения данных.

В результате длительных наблюдений на ряде объектов геокриологического мониторинга получен уникальный массив фактических данных, позволяющий изучать как циклические, так и трендовые изменения мощности сезонноталого слоя и температуры мерзлых грунтов, а также скорость и ритмичность прояления криогенных процессов. Эти данные оказываются чрезвычайно полезными при изучении эволюции криолитозоны в условиях глобального потепления климата и усилении техногенеза.

Практика российских и международных исследований по программам CALM и TSP, а также по коррепондирующимся с ними программам указывают на назревшую необходимость объединения исследований приповерхностной части многолетнемёрзлой толщи в её взаимодействии со смежными геосферами под «зонтиком» единой идеологии и организационных усилий. Тот факт, что многие геокриологические стационары, режимные площадки, ключевые участки уже носят комплексный характер и обследуются специалистами, задействованными в разных текущих программах, говорит о наличии хороших перспектив в этом направлении. Например, под эгидой проекта GTN- P (Глобальная наземная наблюдательная сеть – Мерзлота) Международная Ассоциации по Мерзлотоведению (IPA – MAM) и её Консультативная Комиссии (IAC) провели (5-8 мая 2013, Женева, штаб-квартира ВМО [Всемироной Метеорологической Организации]) рабочее совещание по "Стратегии и Плану Реализации проекта GTN- P" силами национальных корреспондентов из стран-участниц проекта GTN- P. Обсуждались проблемы ведения всемирной базы данных по состоянию и изменчивости приповерхностной мерзлоты. Для отечественных участников очевидным стало, что на современном этапе назрела острая необходимость объединить усилия различных институтов и отдельных энтузиастов-исследователей и приступить к созданию единой российской информационной базы, содержащей результаты многолетних исследований мерзлых толщ в различных регионах на территории криолитозоны.

Следует обратить внимание на то, что колоссальным резервом для расширения информационной базы и верификации теоретических представлений о состоянии и динамике криолитозоны является более тесное взаимодействие с метеослужбой. В связи с этим представляется целесообразным включить в регламент метеонаблюдений измерение температуры воздуха и горных пород до глубины нулевых амплитуд на основных ландшафтах, прилегающих к метеостанциям.

СНЕЖНЫЙ ПОКРОВ ТАЁЖНЫХ И ГОРНЫХ ЛАНДШАФТОВ КРИОСФЕРЫ В ВОСТОЧНОЙ ЯКУТИИ

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Для уточнения различных характеристик снежного покрова, лучшего понимания роли снежного покрова в климатической системе Арктики и более надежной оценки химического состава и количества снега в криосфере, были проведены мониторинговые снегосъемки в пределах таежных и горных ландшафтов Центральной и Восточной Якутии (2010-2012 г.).

Маршрут исследований пересекал восток Центрально-Якутской таёжной низменной равнины и горные системы южной части Верхоянской цепи, Верхояно-Колымской горноскладчатой области (хребты Сэттэ-Дабан, Скалистый, Кумбарский, Брюнгядинский и Сунтар-Хаята) и достигал Оймякона, самого холодного населенного пункта на Земле.

В ходе полевых исследований при помощи снегомерной рейки измерялась высота снега, определялся водный эквивалент снежного покрова с использованием цилиндрического пробоотборника площадью 0,005 м2 в поперечном сечении, твердость поверхности снежного покрова - с помощью твердомера, измерителем зерен - вид и размер снега. Для химического анализа на пыль, ионы и стабильные изотопы воды с помощью чистого снегорезчика отбирались пробы на всю глубину снежного покрова и помещались в чистый герметичный полиэтиленовый мешок. После таяния пробы переливались в чистые герметичные бутылки из полипропилена или стекла.

Высота снежного покрова вследствие антициклонального режима погоды невелика. В горных ландшафтах в бассейне р. Индигирки – она составляет 28 см, в среднетаежных - в бассейне р. Лены – 50 см.

Характерной особенностью снежного покрова региона является его небольшая плотность. Снег выпадает очень сухой и мало уплотняется в течение зимы. К началу снеготаяния его плотность колеблется от 0,160 г/см3 в среднетаежных ландшафтах до 0,138-0,154 г/см3 в горных ландшафтах.

Объемная концентрация пылевых частиц имеет тенденцию к уменьшению в горных ландшафтах и возрастает в относительно заселенных среднетаежных ландшафтах.

В период наблюдений отмечается постоянное возрастание запаса воды в снежном покрове криогенных среднетаёжных и горных ландшафтов, величина которого за два года возросла почти на 60%: с 41 мм в 2010 г. до 66 мм в 2012 г. Исключением являются ландшафты горных пустынь, где наоборот наблюдается снижение запаса воды. Это обстоятельство в значительной степени определило различную водность рек в период половодья.

Особенности географического положения и атмосферных процессов в западной (бассейн р. Лены) и восточной (бассейн р. Индигирки) частях маршрута определяют отличия в химическом составе снега. Восточная, более гористая его часть, располагается в регионе, где ощущается приток насыщенного кислородом влажного полярного воздуха с Тихого океана. В бассейне р. Лены, где распространены преимущественно среднетаежные и горно-таежные ландшафты наблюдается дефицит кислорода, характерный для антициклонального режима Центральной Якутии.

Химический состав снега криогенных ландшафтов независимо от высотных отметок, остается относительно постоянным, гидрокарбонатным или хлоридно-гидрокарбонатным натриево-кальциевым, типичным для фоновых районов Якутии с очень низким уровнем техногенного давления.

Можно отметить увеличение роли соединений азота, преимущественно аммонийной формы, резкое уменьшение минерализации и повышение кислотности снеговых вод в высокогорных ландшафтах. На высотах более 2000 м химический состав снега становится гидрокарбонатным смешанным по составу катионов, среди которых преобладает аммоний.

В перспективе, планируется продолжить систему мониторинга с постоянным отбором монолитов снега для разностороннего изучения различных параметров снежного покрова характерных криогенным ландшафтам.

МИКРОБНЫЕ СООБЩЕСТВА ВЕЧНОЙ МЕРЗЛОТЫ И КСЕРОФИТНЫХ ПОЧВ МОГУТ ДЛИТЕЛЬНО СУЩЕСТВОВАТЬ В УСЛОВИЯХ МАРСИАНСКОГО РЕГОЛИТА

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Изучение устойчивости микроорганизмов в экстремальных биотопах дает основания предполагать, что протекторная роль природной среды может оказаться фактором, существенно корректирующим теоретически предсказываемую продолжительность поддержания жизни клеток в инопланетном грунте и в составе метеоритов.

Цель настоящего исследования – исследование жизнеспособности земных микроорганизмов и естественных микробных сообществ почв и пород в условиях, моделирующих космическую среду и реголит Марса, оценка продолжительности поддержания жизни в марсианском грунте.

Проведено облучение мерзлых пород и аридных почв (моделей марсианского реголита), а также чистых культур бактерий гамма-излучением в градиенте доз 1Гр - 10 кГр при различных температурных режимах (+50°С, 0°С, -50°С) и давлении 0,1 мбар. Изучено влияние присутствия в грунте сильных окислителей - перхлоратов и пероксидов - в концентрациях до 10% вес. и до 15% вес. соответственно. Исследовано совокупное воздействие перечисленных факторов.

Установлено, что бактериальные сообщества экстремальных местообитаний Земли (ксерофитная аридная почва, мерзлые осадочные породы Восточной Сибири и Антарктиды) способны без значительных потерь выдерживать условия космоса и смоделированной марсианской среды: ионизирующего излучения в дозах, соответствующих 5-50 тыс. лет на поверхности Марса, присутствия окислителей, низкого давления и низкой температуры, сохраняя метаболическую и репродуктивную активность. Присутствие перхлората в грунте усугубляет воздействие радиации на микроорганизмы в условиях вакуума и низкой температуры. Однако повреждения сообществ и клеток не катастрофичны. Концентрация пероксида в грунте до 15% и насыщение атмосферы парами перекиси водорода не являются критичными для нарушения механизмов подержания жизнеспособности естественных микробных сообществ. Значительная часть клеток переходит в некультивируемое состояние, сохраняется возможность репарации повреждений и поддержания потенциально готового к репродукции пула клеток.

Показана высокая жизнеспособность в условиях марсианской модели чистых культур бактерий, выделенных из мерзлоты и аридных почв (Kocuria rosea, Arthrobacter polychromogenes, Micrococcus roseus, Micrococcus luteus, Bacillus sp., Cellulomonas sp., Sphingomonas.sp.). Для отдельных штаммов наблюдается увеличение репродуктивной активности и улучшение функционального состояния в определенных режимах воздействия, отмечено положительное влияние кратковременного (2 часа) воздействия вакуума на состояние культур.

Таким образом, предположение о высокой концентрации окислителей в грунте Марса или нижних слоях его атмосферы в сочетании с воздействием других экстремальных факторов: радиации и низкого давления, - не противоречит принципиальной возможности адаптации и длительного выживания в грунте Марса микробных сообществ земного типа.

АКТИВНОСТЬ И БИОРАЗНООБРАЗИЕ МИКРОБИОТЫ ПОЧВЫ И ПОРОД ЛЕДОВОГО КОМПЛЕКСА ЦЕНТРАЛЬНОЙ ЯКУТИИ (РОССИЯ).

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Активность микробоценозов характеризует экосистемные функции современных мерзлотных почв и многолетнемерзлых пород (ММП). Исследовалась микробиота экосистемы термоцирка, который развивается в расположенном на левом берегу реки Алдан ледовом комплексе под воздействием криогенных процессов, разрушающих ММП верхнеплейстоцен-голоценового возраста обнажения Мамонтова гора.

Пробы отбирались в июле 2012 г. из стенки термоцирка для изучения разнообразия и численности микроорганизмов, а также ферментативной активности в зависимости от содержания гумуса, температуры, влажности, pH, состава почв и грунтов. Район характеризуется экстремальными климатическими условиями. В мерзлотных почвах активность микробиоты сезонная, ограничена очень коротким теплым периодом года. В ММП микроорганизмы находятся в латентном состоянии. При оттаивании пород ледового комплекса и обрушении стенок со средней скоростью 5-15 м за летний сезон микробиота почв и ММП сначала попадает в чашу термоцирка, а затем с оттаявшими отложениями - на берег и в русло реки Алдан.

Выявлено существенное снижение численности микробиоты при переходе от мерзлотных почв ($1{,}00\times10^7$) к ММП ($8{,}60\times10^6$). Доминируют бактерии родов *Bacillus, Acinetobacter, Psychrobacter, Phenylobacterium*. Коэффициент микробиологической минерализации в мерзлотных почвах составляет 0,54, а в ММП 0,90 и коррелирует с содержанием гумуса (r=0,64). Мерзлотные почвы и ММП по инвертазной активности оцениваются как бедные, при этом инвертазой были обогащены все исследуемые пробы. Инвертазная активность имеет сильную положительную корреляционную связь (r=0,95) с численностью микроорганизмов, как в мерзлотных почвах, так и в ММП.

Биологическая активность ММП не уступает активности мерзлотных почв. Посредством криогенных процессов за счет реликтовых бактерий повышается разнообразие современных микробоценозов.

Session 9: Permafrost warming and thawing, long-term monitoring

ГЕОТЕМПЕРАТУРНОЕ ПОЛЕ, РАСПРОСТРАНЕНИЕ И МОЩНОСТЬ МНОГОЛЕТНЕМЕРЗЛОЙ ТОЛЩИ ЭЛЬКОНСКОГО ГОРСТА

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Эльконский горст расположен в северной части Алданского щита и представляет собой совокупность блоковых поднятий, сложенных архейскими, раннепротерозойскими и мезозойскими метаморфическими и магматическими телами и образует среднегорный, интенсивно расчлененный рельеф.

Особенности распространения и мощности многолетнемёрзлой толщи Эльконского горста и формирование его геотемпературного поля обусловлены сложным геологическим и геоморфологическим строением.

Сотрудниками лаборатории геотермии Института мерзлотоведения СО РАН в 2007-2011 годах выполнялись мерзлотно-геотермические исследования на территории предполагаемого освоения группы месторождений Эльконского горста. В процессе работ были проведены геотермические исследования в 120 скважинах глубиной от 10 до 1200 м, в лабораторных условиях определены теплофизических свойств основных типов горных пород.

На основании полученных исследований в пределах рассматриваемой территории выделено 3 области, отличающиеся характером распространения, температурным режимом и мощностью многолетнемерзлых толщ: северная – область развития талых пород с островной многолетней мерзлотой, температура пород здесь варьирует от -1,0 до +2,50С, а мощность многолетнемерзлой толщи от первых до 80 м; центральная – область прерывистого распространения многолетнемерзлых пород с температурой пород от -2,0 до +2,5 ºC и мощностью многолетнемерзлой толщи от первых до 150 м. южная – занимает около 90% площади - область сплошного, редко прерывистого распространения многолетнемерзлых пород; температура пород в большинстве случаев изменяется от +0,5 до – 2,5ºC, а мощность многолетнемерзлой толщи изменяется от 30-50 до 330 м. По расчетным данным максимальное значение многолетнемёрзлой толщи под водоразделами Курунг и Билеберда может достигать 450 м.

В нижних частях склонов западной и северной экспозиций, в пределах конусов выноса, отмечены участки с реликтовой мерзлотой мощностью до 70м верхняя граница которых находится на глубине 20-30 м от поверхности.

Температурный режим горных пород на глубине годовых теплооборотов изменяется в зависимости от экспозиции склонов. В пределах склонов северных экспозиций температура пород изменяется от +2,5 до – 3,50С.

В пределах склонов южной и юго-западной экспозиций почти повсеместно зафиксированы положительные температуры от 0,5 до 1,80ºС, лишь на склонах ЮВ экспозиции в 69 % измеренных скважин отмечены положительные температуры, в 31 % – отрицательные или нулевые.

В пределах плоских водоразделов многолетнемерзлые породы не обнаружены. Температура пород на глубинах 10 м изменяется от 0,1 до 2,50ºС. Высокие фильтрационные свойства трещиноватых горных пород федоровской свиты в пределах Приалданского плато благоприятствуют интенсивной инфильтрации атмосферных осадков и поверхностных вод. Это приводит к тепловому эффекту, препятствующему многолетнему промерзанию пород, для таких площадей характерны талые участки со сравнительно высокой температурой от +1,5 до +2,50С.

Впервые для структуры Эльконского горста выполнены определения теплофизических свойств основных типов пород. На основании этих исследований установлено, что коэффициент теплопроводности горных пород варьирует от 1,47 до 4,20 Вт/(м•К), а объёмный вес скелета – от 2236 до 3235 кг/м3.

Выполненные геотермические исследования, анализ каротажного материала, позволили охарактеризовать геотемпературное поле до глубины 1500 м. С помощью прямых измерений и расчетов установлено, что температура пород на глубине залегания абсолютной отметки 500 м варьирует от - 1,0 до +5,2ºС. Геотермический градиент в подмерзлотной зоне с глубин 600 м в зависимости от состава пород изменяется от 1,66 до 2,20 ºС/100 м.
Впервые для структуры Эльконского горста определена величина внутриземного теплового потока Эльконского горста, которая составляет 44 мВТ/м2.

ВЛИЯНИЕ ПРИРОДНЫХ ГЕОСИСТЕМ ЛОКАЛЬНОГО УРОВНЯ (ФАЦИЙ) НА ГЛУБИНУ ПРОТАИВАНИЯ ПОРОД ВЛЕСОТУНДРЕ И ЮЖНОЙ ТУНДРЕ (НА ТЕРРИТОРИИ УРЕНГОЙСКОГО МЕСТОРОЖДЕНИЯ)

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С целью создания комплексного Западно-Сибирского зонального трансекта мониторинга сезонно-талого слоя (СТС) экспедиционным отрядом ИКЗ СО РАН в 2008 году были организованы два режимных полигона. Они расположены в центральных континентальных районах Западной Сибири, на левобережье р. Пур, в подзонах южной лесотундры и южной тундры в районе Уренгойского нефтегазоконденсатного месторождения (НГКМ). Главная задача наших исследований - оценить влияние почвенно-растительного покрова на локальную изменчивость мощности СТС и состояния многолетнемерзлых пород (ММП) в разных геосистемах и в разных природных зонах. В качестве гипотезы принята теория об «экосистемно-обусловленных» и «климатически-обусловленных экосистемно-модифицированных» мерзлых толщах, характерных, соответственно, для южной криолитозоны с несплошным распространением неустойчивых высокотемпературных ММП и для северной криолитозоны со сплошной низкотемпературной мерзлотой [Shur Y. L., Jorgenson M. T., 2007].

Для решения задачи на полигонах проведены ландшафтно-геохимические исследования, разработана типизация природных геосистем локального уровня (в ранге фаций), с применением ГИС-технологий построены крупномасштабные (1:5 000) карты-схемы природных геосистем, определена надземная фитомасса доминантных растительных сообществ. Ежегодно, в конце теплого сезона года проводятся измерения мощности СТС и температуры ММП.

В южной лесотундре полигон расположен на IV озерно-аллювиальной равнине, сложенной суглинисто-песчаными отложениями. На водораздельной поверхности многолетнемерзлые породы (ММП) залегают с поверхности, а ландшафтная (фациальная) структура разнообразна и мозаична: мелкобугристые тундры, лога с кустарниками, торфяники, болота. Запасы надземной фитомассы достигают 3 кг/м2. Глубина протаивания связана с мощностью органогенного горизонта почв (Мт). На торфяниках, где Мт=0,5-3 м, она минимальна и составляет 30-50 см, в мелкобугристых тундрах (Мт=0,2-0,4м) -0,7-1,2м, в кустарниковых логах (Мт=0,05-0,4м) – 1-1,6м. Песчаные придолинные участки заняты лиственично-лишайниковыми редколесьями, где кровля ММП опущена на глубину 3-8 м. Глубина сезонного промерзания в среднем изменяется от 0,8-1 м до 1,4-1,6 м [Ukraintseva et al., 2010, 2011] .

В южной тундре полигон расположен на III морской равнине, сложенной преимущественно суглинистыми отложениями. На площадке доминируют травяно-кустарничково-мохово-лишайниковые тундры с редкими пятнами-медальонами. Запасы фитомассы снижаются (1,5-2,5 кг/м2), мощность органического горизонта почв достаточно однородна и составляет 4-10 см. Растительность южной тундры менее пестрая, чем растительность южной лесотундры, снижается биоразнообразие доминантных экосистем [2].

Таким образом, в южной лесотундре, где растительный покров разнообразен и мозаичен, растительность оказывает существенное влияние на локальные особенности сезонно-талого слоя, обусловливает чередование участков с пониженной кровлей ММП и поверхностным их залеганием. Это экосистемно-обусловленная мерзлота. В тундре роль почвенно-растительного покрова существенно снижается, формируются «климатически-обусловленные экосистемно-модифицированные» мерзлые толщи [Shur Y. L., Jorgenson M. T., 2007].

Получены данные метеостанций Новый Уренгой (южная лесотундра) и Тазовский (южная тундра). Данные температур проанализированы по среднемесячным значениям. Проверка проводилась t-критерием Стьюдента для зависимых выборок. Статистически значимые различия по данным метеостанций отмечены в период с марта по август, в период с сентября по февраль, значимых различий нет. Таким образом, зональные различия температуры воздуха, во-многом определяющие тепловое состояние пород на территории Уренгойского месторождения, проявляются исключительно в весенне-летний период.

Исследования выполняются при поддержке Совета по грантам Президента Российской Федерации (грант НШ-5582.2012.5), в рамках Международных проектов TSP и CALM, грантов РФФИ, научных программ РАН и СО РАН; а также при организационной помощи ООО «Газпром добыча Уренгой».

ФАКТОРЫ, ОПРЕДЕЛЯЮЩИЕ ТЕМПЕРАТУРУ ПОРОД НА ЦЕНТРАЛЬНОМ ЯМАЛЕ, И ИХ СВЯЗЬ С ИЗМЕНЕНИЯМИ КЛИМАТА

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В работе рассмотрены основные факторы, оказывающие влияние на формирование температурного режима пород верхней части разреза в условиях Центрального Ямала.

Цель исследования - установить степень влияния различных природных факторов на формирование температуры пород и оценить воздействие климата, как основного фактора.

Факторы включают в себя: растительный покров (мох), сумму атмосферных осадков и температуру воздуха.

Наблюдения проводились на геокриологическом стационаре "Васькины Дачи" в 5 термометрических скважинах до глубины 1,5 м в течение последних 5 лет. Скважины располагаются на разных террасовых уровнях, одна скважина расположена на склоне.

В конце марта 2013 года на стационаре проведена снегомерная съемка, в результате которой установлено, что под влиянием ветра происходит перераспределение снега в зависимости от формы рельефа. Таким образом, на плоских водораздельных поверхностях толщина снежного покрова не превысила 0,11 м, на выпуклой поверхности водоразделов снег практически полностью сдувается, на склонах - может достигать толщины более 2 м.

В результате наблюдений и обработки полученных данных выявлено следующее. В районе скважин, расположенных на плоских поверхностях площадок VD-1 и VD-2, толщина мохового покрова составляет 0,06 и 0,03 м соответственно. Толщина снежного покрова на этих площадках не превышает значения 0,11 м. При данных условиях на обеих площадках формируется одинаковый температурный режим пород. На глубине 0,25 м в разные годы (с 2008 по 2011) среднегодовая температура пород изменяется от -3,4°C до -6,8°C.

Третья термометрическая скважина располагается на плоской поверхности площадки VD-3. Толщина мха на этой площадке минимальна и составляет 0,02 м. Здесь значения среднегодовой температуры пород на этой же глубине в разные годы изменяются от -2,9 до -6,8°C.

Скважина, расположенная на выпуклой поверхности останца (VD CALM), характеризуется наличием мохового покрова толщиной 0,03 м ператур пород за 2007, 2008 и 2011 на глубине 0,25 м имеют значения соответственно -5,3°C, -5,0 °C и -4,2°C.

Пятая скважина располагается на склоне и характеризуется наличием мохового покрова толщиной 0,1 м. Толщина снега здесь достигает значения 0,83 м. Среднегодовая температура пород имеет положительные значения до глубины 1 м (от +0,1°C до +1,4 °C).

Таким образом, наибольшее влияние на формирование температурного режима пород оказывает снежный покров как теплоизолирующий фактор. В скважинах, расположенных на площадках с высотой снега до 0,11 м среднегодовые температуры пород на разной глубине связаны со среднегодовой температурой воздуха с коэффициентом корреляции не ниже 0,9. В скважине, расположенной на склоне, где высота снега достигает 0,83 м, коэффициент корреляции среднегодовой температуры пород и среднегодовой температуры воздуха не превышает 0,78.

Ход среднегодовой температуры пород на площадках, где снег отсутствует, либо его толщина менее 0,1 м, повторяет ход среднегодовой температуры воздуха. На площадке, где снег имеет толщину 0,8 м и более, ход среднегодовой температуры пород незначительно повторяет ход среднегодовой температуры воздуха, при этом наблюдается задержка по фазе в 1 год.

Session 10: Permafrost engineering, constructions on frozen ground

УСТРОЙСТВА ДЛЯ УПРАВЛЕНИЯ ТЕМПЕРАТУРНЫМ РЕЖИМОМ ПОДЗЕМНОГО КРИОХРАНИЛИЩА СЕМЯН РАСТЕНИЙ В Г. ЯКУТСКЕ

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Семена растений при определенных отрицательных температурах и низкой влажности способны длительное время сохранять свою жизнеспособность. В настоящее время во многих странах возведены хранилища генетических ресурсов растений, в которых необходимая для долговременного хранения семян растений отрицательная температура создается холодильными установками или естественным холодом с дополнительным искусственным охлаждением. Существенными недостатками таких хранилищ являются большие затраты энергии и возможность нарушения необходимого температурного режима хранения семян при перебоях энергоснабжения. Альтернативным более экономичным и надежным способом обеспечения оптимального температурного режима в криохранилищах для долговременного хранения семян растений является использование естественных источников холода.

Исследованиями сотрудников Института биологических проблем криолитозоны СО РАН установлено, что оптимальными для длительного сохранения жизнеспособности и генетической целостности семян растений являются температуры порядка минус 6…10 оС. В криолитозоне такие температуры мерзлых пород характерны только для арктических и высокогорных районов. Поэтому при строительстве подземных криохранилищ на большей части территории распространения многолетнемерзлых пород требуется дополнительное круглогодичное охлаждение окружающих их мерзлых горных пород.

В г. Якутске построено Федеральное криохранилище I очереди путем реконструкции подземной лаборатории Института мерзлотоведения СО РАН. Температура пород на глубине расположения хранилища минус 2,3 оС . Для круглогодичного поддержания оптимальной температуры в камерах хранения семян применены воздушные охлаждающие устройства конвективного действия, в которых циркуляция холодного воздуха происходит под действием естественной тяги. Для летней стабилизации температуры в подземном сооружении, построенном в толще многолетнемерзлых пород, впервые используется технология охлаждения, основанная на известном законе сдвига фаз температурных колебаний в породах. Применение этой технологии позволяет поддерживать температуру в подземном сооружении на необходимом уровне в течение всего теплого периода года.

В докладе показаны основные требования к применению новой технологии стабилизации температуры в подземных сооружениях, построенных в массиве мерзлых пород, по природно-климатическим условиям территории их строительства. Приведены схемы и основные параметры криохранилища и охлаждающих устройств. Будут представлены результаты наблюдений за работой охлаждающих устройств и температурным режимом криохранилища и вмещающих мерзлых пород за первый неполный год работы сооружения.

ЭКЗОГЕННЫЕ ГЕОЛОГИЧЕСКИЕ ПРОЦЕССЫ НА ОБЪЕКТАХ ИНФРАСТРУКТУРЫ МАГИСТРАЛЬНОГО ГАЗОПРОВОДА БОВАНЕНКОВО-УХТА

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Центральный Ямал характеризуется развитием всех экзогенных геологических процессов, развитых на равнинных территориях, сложенных многолетнемерзлыми породами (ММП). Наиболее активными среди них являются криогенные процессы. Большинство из них при строительстве и эксплуатации промышленных и гражданских объектов являются неблагоприятными или опасными.

Детальные инженерно-геокриологические исследования района Байдарацкой губы проведены в связи со строительством газопровода Бованенково-Ухта в 80-х годах прошлого века. В 2004 г. инженерно-геокриологические изыскания продолжены вновь. В связи со сложностью геокриологических условий и активностью криогенных процессов за период проведения изысканий три раза была изменена ось трассы газопровода.

В 2006 г. проведены исследования криогенных процессов в естественных природных условиях в районе Байдарацкой губы. В летне-осенний период в 2006 г. в состав работ были включены полевые маршрутные, режимные и аэровизуальные наблюдения. Выявлены условия и характеристики развития криогенных процессов, их современное состояние. Наиболее активными процессами в 2006 г. являлись русловые процессы, термоденудация, термоабразия по берегам термокарстовых озер и дефляция. Несмотря на преобладание на обследованной территории поверхностей с отсутсвием активных криогенных процессов, практически на всех элементах рельефа с сильнольдистыми ММП и крупными ледяными включениями, имеются участки с проявлениями неблагоприятных или опасных криогенных процессов.

В 2008 г. в состав наблюдательной сети включены четыре объекта строительства. Площадка временного городка строителей расположена на ровном водораздельном пространстве на второй морской террасе. Отсыпанная песчаными грунтами площадка предотвращает механическое и отепляющеее воздействие на многолетнемерзлые породы. База хранения расположена на ровном водораздельном пространстве. Слабонаклонные поверхности прилегают к овражно-балочной сети и долинам рек. Воздействие на окружающую территорию происходит в результате подпора вод из сточного озера, оползания и подмыва бортов дренажной канавы

Карьер песка и площадка буртования расположены на водораздельном пространстве малых рек Сидяпелятосе и Хурехотарка с пологими и крутыми берегами. При разработке карьера песка происходило наиболее значительное воздействие на геологическую среду. Снимается почвенно-растительный и торфяной слои и вскрываются сезонноталые и многолетнемерзлые грунты. В результате активно развивается термоденудация, термокарст, криогенное оползание, термоэрозия.

Ледовая площадка для хранения труб менее всего подвержена техногенному воздействию. Так как работы на ней проводятся в зимнее время, то почвенно-растительный покров нарушен слабо, следовательно, не происходит повышенного протаивания сезонноталого слоя и развития криогенных процессов.

Самой большой активностью обладают криогенные процессы в карьере песка, что обусловлено рядом природных факторов и спецификой разработки грунтов. Карьер расположен в междуречье малых рек. Борта долин имеют достаточные уклоны для развития криогенных склоновых процессов различной активности в естественных условиях. Вскрытие и буртование грунтов сезонноталого слоя, переходного, промежуточного слоев и сильнольдистых ММП приводит к активному стоку воды и термоэрозии, грунтовых потоков, криогенных оползней течения, а также термоденудации. Количество термоэрозионных промоин и криогенных оползней течения не менее чем в 3-5 раз больше, чем на других объектах мониторинга.

ПРОБЛЕМЫ СТРОИТЕЛЬТВА АВТОМОБИЛЬНЫХ ДОРОГ В КРИОЛИТОЗОНЕ РОССИИ

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В условиях глобального изменения климата в последние десятилетия происходят изменения распространения и мощности сезонной и многолетней мерзлоты, криогенного строения и льдистости слагающих ее пород. В результате ухудшаются строительные свойства грунтов, определяющих (в значительной мере) эффективность эксплуатации инженерных сооружений, в том числе автомобильных дорог. Наряду с этим, стала трудно-предсказуемой кинетика и механики развития опасных криогенных процессов и явлений (знакопеременных сезонных деформаций, многолетнего пучения, выпучивания, термокарста, осадок и наледеобразования и т.д.) и инженерно-геологических процессов - заболачивания, оползней, оврагообразования и т.п. Впечатляющий результат воздействия перечисленных процессов и их комплексов в 2012 г. нам удалось наблюдать в процессе рекогносцировочного обследования состояния автомобильных дорог «Лена», «Амур», «Вилюй» и «Колыма, обей протяженностью более 8 тысяч км.

Участки автомобильной дороги «Лена», пересекающие грунтовые комплексы пойменных и надпойменных террас временных и постоянных водотоков, практически все относятся к участкам, в пределах которых геокриологические условия снижают или могут снижать эффективность эксплуатации магистрали. Общая протяженность таких участков по результатам рекогносцировочных обследований на автомобильной магистрали «Лена» составляет не менее 100 км. На автомобильных дорогах «Вилюй» и «Колыма» протяженность таких участков несравненно больше.

Исследования, выполненные на 18 ключевых участках автомобильной трассы «Амур» показали, что основными причинами недопустимых деформаций земляного полотна и разрушения асфальтобетонного покрытия являются:

- деградация многолетнемерзлых грунтов основания автомобильных дорог, характеризующихся сложным криолитологическим строением и высокой льдистостью;
- формирование чаши протаивания желобообразной формы в грунтовом основании автомобильной дороги, с постоянным ее обводнением;
- неравномерные деформации земляного полотна и многолетнемерзлых верхних горизонтов грунтов основания автомобильной дороги;
- выемка льдистых грунтов, способствующая формированию участков дополнительного увлажнения протаивающих грунтов основания.

Основными мероприятиями, которые смогли бы предотвратить появление деформаций на автомобильных дорогах криолитозоны, на наш взгляд, необходимо было бы разработать и реализовать на момент проектирования автомобильных дорог, в крайнем случае, в период их строительства. Но инженерно-геологические изыскания, выполненные в области распространения многолетнемерзлых пород, были столь некачественные, что, не отражали реально существующих геокриологических условий. Отсутствовал и прогноз взаимодействия различных типов конструкций автомобильных дорог в условиях глобального изменения климата.

Возможное решение существующих проблем строительства и эксплуатации автомобильных магистралей в криолитозоне, нам видится их в создании:

- научно-методических полигонов в различных дорожно-климатических районах, для разработки технологий строительства автомобильных дорог с применением инновационных технологий и материалов;
- индивидуальных и типовых конструкций и технологий, применительно к каждой из дорожно-климатических зон России;
- условий, на территории научно-методических полигонов для адаптации известных технологий, применявшиеся в других природно-климатических областях России.
- региональных пакетов нормативных документов регламентирующих весь цикл работ - от выбора направления строительства автомобильных дорог до эксплуатации и возможной их утилизации;
- пакета нормативных документов, учитывающих не только административного деления России, но и унифицированное районирование дорожно-климатических условий и их трансформации в результате динамики естественных климатических ритмов в течение времени эксплуатации автомобильных дорог;

РАСПРОСТРАНЕНИЕ ТАЛИКОВ ПОД ЗДАНИЯМИ ЯКУТСКОЙ ТЭЦ

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Якутская ТЭЦ находится в северо-восточной части Якутска на берегу городской протоки р. Лены. Она расположена на аллювиальной террасе, возвышающейся над уровнем меженных вод на 9-10 м и имеющей ширину около 3 км. В районе ЯТЭЦ по данным Н.И. Салтыкова мощность вечномёрзлой толщи достигала 180-200 м, а средние годовые температуры грунтов на глубине 15 м непосредственно на площади застройки до возведения сооружений изменялись от -3 до -5°С.

ЯТЭЦ была введена в постоянную эксплуатацию 7 ноября 1937 г. Она явилось первым крупным промышленным объектом в СССР, построенным на вечной мерзлоте по принципу 1: сохранения многолетнемёрзлого состояния грунтов в его основании. Для этого были разработаны специальные фундаменты (колонны с башмаками, а под основным технологическим оборудованием – сплошные бетонные плиты), проверенные расчётом на выпучивание, и осуществлено создание проветриваемого подполья.

Несмотря на это в течение 75-летней эксплуатации эпизодически возникали проблемы обеспечения устойчивости сооружений из-за частичного оттаивания многолетнемёрзлых грунтов под ними. Они были обусловлены главным образом утечками нагретых производственных вод непосредственно в грунты оснований и вдоль линий их транспортировки из дренажных труб, канализационных сетей и других коммуникаций.

В результате под зданиями образовались таликовые зоны. Для восстановления естественного температурного режима грунтов в проблемных местах устанавливались сезоннодействующие охлаждающие установки (СОУ) системы С.И. Гапеева, проводилась очистка ото льда проветриваемого подполья, осуществлялись постоянный контроль за состоянием коммуникаций и устранение утечек. Ввод в действие СОУ и проведение других мероприятий привёл к частичному промерзанию грунтов и к сокращению площади таликов. Тем не менее, они сохранились и до настоящего времени.

Наиболее высокая температура (до 12°С) и мощность (до 23 м) талика установлена около циркуляционной насосной станции. Он распространяется вокруг неё на 25-30 м и захватывает южный угол главного корпуса.

Под зданием водогрейных котлов мощность талика не превышает 17-20 м, а средние годовые температуры были не выше 2,5°С. Вокруг этой части здания многолетнемёрзлые грунты оттаяли до 12,0-19,5 м, а средняя годовая температура в оттаявшем слое достигала 1,7-1,8°С.

Этот же талик узкой полосой простирается до углекислотного цеха (УКЦ), распространяясь под его восточную часть. Точная мощность его пока не установлена. При бурении скважин вокруг УКЦ в 2012 г. глубиной 10-15 м нижняя граница талика не была достигнута, а температура грунтов в его пределах изменялась от +0,9 до +1,5°С.

Около восточной части здания химводоочистки и под ней оттаявшие ранее грунты к 2009 году промёрзли сверху до 7,0-8,2 м. Ниже сохранился талый горизонт, средняя годовая температура которого на глубине 10-11 м достигала 1,0-1,5°С.

Несмотря на большое количество таликов, на большей части ЯТЭЦ грунты находятся в многолетнемёрзлом состоянии. Средняя годовая температура их в интервале 4-10 м под главным корпусом изменялась от близких к нулю значений до -3,9°С. В последние годы площади таликовых зон немного сократились, что свидетельствует о постепенном восстановлении температурного режима грунтов в основании сооружений.

В настоящее время на территории Якутской ТЭЦ сформировалась довольно сложная мерзлотная обстановка, однако достаточно квалифицированные инженерные решения, осуществленные при подготовке строительных площадок, возведении зданий и последующей их эксплуатации обеспечили такой длительный период её безаварийной работы.

НАБЛЮДЕНИЯ ЗА ИЗМЕНЕНИЕМ СОСТОЯНИЯ МЕРЗЛЫХ ГРУНТОВ ПО ИЗМЕРЕНИЯМ РАДИОВОЛНОВОГО ПОВЕРХНОСТНОГО ИМПЕДАНСА

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Приведены результаты наблюдений поверхностного импеданса в диапазоне частот 20…900 кГц на экспериментальных площадках недалеко от г. Якутска, представленных многолетнемерзлыми песчаными грунтами. В ходе наблюдений установлено, что наиболее тесная корреляционная связь поверхностного импеданса мерзлых грунтов с их температурой на глубине до 4 м, структурой и прочностными свойствами мерзлых грунтов в данном районе наблюдается на частотах диапазона 500…900 кГц.

Выделяемый по поверхностному импедансу активного слоя период времени сезонного охлаждения грунтов подразделяется на зону промерзания (ноябрь-февраль) и зону установившегося стабильно мерзлого состояния (март-апрель). Период времени растепления активного слоя подразделяется на зоны интенсивного протаивания, умеренного протаивания и стабильно талого состояния. Размеры этих зон различаются по времени для лесной и открытой площадок. Изменения указанных периодов и зон, позволяют рассматривать их как реакцию мерзлоты на климатические изменения.

Экспериментально получена температурная зависимость эффективного электрического сопротивления мерзлых грунтов, которое определяется по поверхностному импедансу. Понижение температуры мерзлых грунтов от -5 до -8оС привело к увеличению эффективного сопротивления более чем в 4 раза. Изменения средних значений эффективного электрического сопротивления многолетнемерзлых грунтов хорошо соответствуют изменениям среднегодовых значений температуры по данным метеонаблюдений в этом же году. Например, на открытой экспериментальной площадке понижению среднего за год эффективного сопротивления на частоте 171 кГц на 18%, соответствует повышение среднегодовой температуры воздуха на 17%, а понижению среднего за год эффективного сопротивления на 1% - повышение среднегодовой температуры воздуха так же на 1%.

Установлено, что поверхностный импеданс характеризует сезонные и межгодовые изменения температуры, структуры, естественной влажности и объемной льдистости мерзлых грунтов. При этом, поверхностный импеданс на лесной площадке по модулю может уменьшиться летом более, чем в 2 раза в результате увеличения проводимости мерзлых грунтов активного слоя, вызванного оттаиванием содержащегося в нем льда и появлением талой воды. Фазовый угол поверхностного импеданса в лесу может уменьшиться на 45о для частоты 864 кГц, в результате образования талого слоя на поверхности (активный слой), и увеличиться на 20о для частоты 171 кГц, при образовании дополнительно талого слоя на глубине (тонкий проводящий слой).

Показано, что совместное рассмотрение поверхностного импеданса и его фазового угла позволяет проследить с поверхности земли бесконтактным способом изменения в структуре грунтов, вызванные образованием в них сезонноталого слоя, надмерзлотных и межмерзлотных таликов. Кроме того, по параметрам поверхностного импеданса прослеживаются изменения естественной влажности и объемной льдистости мерзлых дисперсных грунтов.

Следовательно, существует возможность оценки степени влияния климатических изменений на состояние мерзлых дисперсных грунтов и геокриологические процессы, происходящие в них, по результатам измерений поверхностного импеданса.

ВЛИЯНИЕ ПРОЦЕССОВ КРИОГЕННОГО ВЫВЕТРИВАНИЯ НА УСТОЙЧИВОСТЬ ЖЕЛЕЗНОДОРОЖНОГО ПОЛОТНА АМУРО-ЯКУТСКОЙ МАГИСТРАЛИ (УЧАСТОК ТОММОТ-КЕРДЕМ)

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Предусмотренная нормами схема дорожного районирования территории России не учитывает региональные особенности отдельных территорий, к числу которых относится и республика Саха (Якутия).

Значительная роль в разрушении горных пород в Якутии, используемые в качестве строительного материала принадлежит процессам криогенного выветривания. Тем не менее, до сих пор нормами и правилами строительства линейных сооружений не отражены количественные критерии учета интенсивности выветривания горных пород во времени.

Таким образом, высокий уровень генерализации территорий, в пределах выделенных дорожно-климатических зон, определяет необходимость нового подхода к детализации существующей схемы дорожно-климатического районирования.

Исходя из вышесказанного, согласно проведенным авторами в 2010-2013 гг. рекогносцировочных и инженерно-геологических исследований в полосе строительства АЯМа на участке железной дороги Томмот-Кердем, отмечается ряд особенностей, характеризующих надежность устойчивости железнодорожного пути:

1. Поскольку при строительстве столь масштабного объекта как АЯМ не маловажную роль играет финансовый аспект, одним из доминирующих факторов при выборе грунтов для отсыпки полотна является дальность возки строительного материала, обычно не превышающая 15 км. Таким образом, практически вне зависимости от геокриологических условий строительства того или иного участка железнодорожной линии для отсыпки железнодорожного полотна используется узкий спектр природного камня в качестве строительного материала – это местные грунты, целесобразность использования которых, в виду слабой устойчивости к процессам криогенного выветривания, на некоторых участках железной дороги ставится под сомнение.

2. Степень разрушенности применяемого одного и того же типа горной породы в качестве строительного материала существенно различалась уже через первые десятки километров. Большинство наблюдавшихся последствий негативного влияния выветривания на устойчивость железнодорожной насыпи приурочены главным образом к участкам пути, проходящих в пределах долин рек и ручье, и их «частота» увеличивалась с продвижением железной дороги на Север.

3. Применяемые на рассматриваемом отрезке железнодорожной линии технические решения из-за недостаточного внимания к процессам криогенного выветривания грунтов, слагающих насыпь, малоэффективны.

Таким образом, решение проблемы разрушения грунтов, слагающих земляную насыпь, под воздействием выветривания в суровых климатических условиях Якутии авторами ведется в следующих направлениях: а) Разработка Методики лабораторных испытаний образцов горных пород по определению их физико-механических свойств с учетом устойчивости к криогенному выветриванию.

Подразумевает следующие подходы:

- заключение о соответствии горных пород для использования в качестве строительного материала обязательно должно учитывать механизмы аэрального (породы находящиеся в естественных условиях без подтока воды), аквального (породы находящиеся в водонасыщенном состоянии) и невального (занимающие промежуточное положение между аквальными и аэральными, характерные условиям у снежников и наледей в весенне-летний период) разрушений грунта. Данные особенности важны ввиду значительного прохождения линии АЯМа по долинам рек и ручьев.

- обоснованное изменение циклов замораживания-оттаивания по определению морозостойкости грунтов в сторону увеличения. Так, рекомендации ГОСТов по определению морозостойкости после 25 циклов замораживания-оттаивания не соответствуют требованиям к грунтам, применяемым при строительстве железных дорог в условиях резко-континентального климата, так как в Якутии в год поверхность железнодорожной насыпи может испытывать более 75 циклов замораживания-оттаивания.

Разрушение горных пород, слагающих насыпь железной дороги, происходит преимущественно в первые годы эксплуатации. Для условий Якутии трем-четырем годам соответствует примерно 400 циклов. Так, например, прочностные свойства (σсж) для образцов пород из мергеля после 400 ЦЗО снизились в нивальных условиях на 62%, в аэральных на 33%. Т.е., мергель после 3-5 лет эксплуатации разрушится по текстурно-структурным неоднородностям до дресвы. Разница в прочности образцов доломита для нивальных условий составила 10%. Динамика дезинтеграции гранита для нивальных условий составила 16%, в аэральных условиях значение прочности понизилось на 10%. (данные приведены для образцов горных пород, отобранных на участке железнодорожной линии Бестужево-Томмот [С.С. Павлов]). Таким образом, горные породы, обладающие изначально прочностными свойствами в пределах 50 Мпа, после 400 ЦЗО более чем на 50% теряют свои основные физико-механические значения.

б) Составление схемы районирования Амуро-Якутской железнодорожной магистрали по степени устойчивости к процессам криогенного выветривания.

в) Составление детализированной схемы дорожно-климатического районирования республики Саха (Якутия), учитывающая влияние процессов выветривания на устойчивость линейных сооружений, которая позволит планировать и разрабатывать более рациональные мероприятия по строительству и содержанию железнодорожной системы.

ДИНАМИКА МЕРЗЛОТНЫХ ХАРАКТЕРИСТИК В РАЗЛИЧНЫХ ЧАСТЯХ Г. ЯКУТСКА

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Якутск – самый крупный город в мире, расположенный в зоне сплошной криолитозоны. Территория города очень разнообразна по геокриологическим условиям. Это разнообразие обусловлено особенностями антропогенного освоения данной территории. Освоение территории Якутска началось почти 4 века назад и проходило постепенно, начиная от нынешней центральной части города, продолжая переходной и заканчивая окраинной областью урбанизации. Современная разница в длительности застройки обуславливает неоднородное распространение культурного слоя, различия в мощности, составе, и степени его засоленности, что предопределило большую вариабельность геокриологических характеристик территории, непосредственно коррелирующие с возрастом застройки.

«Старый» Якутск – это наиболее урбанизированная зона. Возраст застройки здесь составляет более 160 лет. Эта область характеризуется сплошным распространением грунтов культурного слоя. Мощность данного слоя, состоящего из перегноя, строительного мусора и отбросов, накопившихся в течение практически четырехсотлетнего существования города и перемешавшихся с естественным пылевато-суглинистым покровом, меняется в связи с возрастом отдельных участков города и достигает 6-7 м, превышая глубину сезонного оттаивания и значительно изменяя температурный режим мерзлых грунтов в зоне инженерного воздействия. Влажность и засоленность таких грунтов достигают здесь максимальных значений. В связи с накоплением солей, количество незамерзшей воды в льдистых грунтах культурного слоя на участках данной области возрастает настолько, что на месте засоленных разновидностей грунтов при температуре -2,2÷-2,5°С появляются породы с криопэгами. Они имеют малую несущую способность и для построенных на вмороженных сваях инженерных сооружений являются весьма ненадежным основанием.

На территории переходной части Якутска, возраст которой 70-160 лет, отложения культурного слоя имеют «пятнистое» распространение. Застроенные площадки, где он вскрывается, чередуются со слабо урбанизированными или вовсе не застроенными участками, где культурный слой практически отсутствует. Так, у границы переходной части города со старой, культурный слой имеет максимальную мощность и пестроту состава, температуры грунта по глубине, по данным скважин, стремятся к более низким отрицательным значениям, что характерно и для старой части города. Ближе к периферии подстилающие грунты оснований подвержены все менее длительному антропогенному воздействию. В связи с этим, по мере приближения к окраинной части города, в целом, толщина культурного слоя уменьшается, а средние температуры грунта повышаются.

Необходимо отметить, что повторяющиеся в настоящее на территории переходной области Якутска время случаи аварийного сброса бытовых и промышленных минерализованных канализационных стоков постепенно приводят к засолению культурного слоя и подстилающих грунтов и образованию в них криопэгов.

Застройка окраинной области началась недавно, распространение культурного слоя здесь минимально, его мощность соизмерима с глубиной сезонно-талого слоя. Степень антропогенного воздействия на подстилающие мерзлые грунты сводится к минимуму. Развитие криогенных процессов локально и незначительно, температурные характеристики грунтов стремятся к значениям, характерным для естественных условий Центральной Якутии.

Таким образом, культурный слой в старой части города имеет сплошное распространение и оказывает максимальное воздействие на тепловое состояние мерзлых грунтов, характер и степень распространения криогенных процессов. Техногенные преобразования химического состава надмерзлотных вод в совокупности с криогенными процессами негативно отражаются на состоянии подземных коммуникаций, конструкций фундаментов, дорожного покрытия, повышают коррозионную активность грунтов. Природно-техногенные гидрогеологические процессы вызывают аварии, нарушение устойчивости зданий и сооружений и т.д. Из вышесказанного следует, что в настоящее время инженерная инфраструктура исследуемой области формируется в значительно более сложных условиях, нежели в XX в. и ранее. В остальных частях города отложения культурного слоя имеют «пятнистое» распространение и не всегда влияют на тепловое состояние и другие характеристики грунтов.

Session 10: Permafrost processes

ГЕОКРИОЛОГИЧЕСКИЙ РИСК: СОДЕРЖАНИЕ ПОНЯТИЯ И СПОСОБЫ ОЦЕНКИ

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Рассматривается подход к оценке риска необратимого изменения геокриологических условий. В зависимости от ситуации, масштаба исследований и потребностей освоения территории выбирается акцент в характеристике изменений геокриологических условий, определяемый криостратиграфией, температурным режимом грунтов или динамикой геокриологических процессов.

Изменение геокриологических условий приводит к нарушению устойчивости инженерных сооружений, к нарушению режима хозяйственной деятельности, потерям природных ресурсов или нарушению природоохранного законодательства. Нарушение устойчивости инженерных сооружений в результате прямого воздействия геокриологических процессов или в результате изменения характеристик ландшафтов, окружающих зону землеотвода, влечёт за собой ущерб, связанный с затратами на обеспечение технической безопасности инженерного сооружения.

Нарушение режима хозяйственной деятельности влечёт за собой ущерб, связанный с непредусмотренными затратами на эксплуатацию инженерного сооружения.

Потери природных ресурсов или ухудшение их качества влечёт за собой ущерб общественного характера, реже убытки собственника природных ресурсов (чаще всего страдают лесные, водные и рекреационные ресурсы).

Нарушения природоохранного законодательства приводят к непредусмотренным расходам по плате за сверхнормативное воздействие или за воздействие на компоненты окружающей среды на особо охраняемых территориях.

Во всех перечисленных случаях к непредусмотренным убыткам следует также прибавлять расходы на дополнительные изыскания и научные исследования, необходимые для уточнения геокриологической ситуации и выработки повторных геокриологического прогноза и оценки риска.

В ходе оценки рассматриваются пространственные и временные факторы геокриологического риска. К пространственным факторам геокриологического риска относятся:

- Недостаточная геокриологическая изученность территории и непонимание закономерностей распространения высоко льдистых и/или засолённых толщ.
- Неоднородности геокриологического строения грунтов, обусловленные историей развития ландшафта.
- Недостаточная изученность закономерностей развития геокриологических процессов (незнание расположения и природы «слабых звеньев» ландшафта – участков первоочередной активизации неблагоприятных процессов при изменении условий теплообмена на поверхности).
- Неопределённости выбора участков хозяйственного освоения территории в будущем.

К временным факторам геокриологического риска относятся:

- Аномальные климатические воздействия (годы и сезоны с аномальными климатическими характеристиками и единичные экстремальные погодные явления).
- Повторяющиеся (периодические и непериодические) типичные техногенные воздействия, связанные с типичным природопользованием.
- Многолетние изменения ландшафтно-климатических характеристик и частоты аномальных природных явлений.
- Многолетние изменения техногенных воздействий на разных стадиях освоения территории или жизненного цикла предприятия.

Заметим, что аномальные климатические события и типичные техногенные воздействия требуют использования статистического обобщения имеющихся исторических данных, а многолетние изменения ландшафтно-климатических характеристик и техногенных воздействий требуют построения прогнозных сценариев внешних воздействий на толщи многолетнемёрзлых пород.

При оценке геокриологического риска главной задачей профессионала является определение двух ведущих факторов, по одному из «пространственного» и «временного» рядов, по которым выстраивается основная линия геокриологического прогноза, необходимого для определения вероятности наступления необратимого изменения геокриологических условий. Такое изменение затем увязывается с ущербом субъекту природопользования или природным ресурсам выбранной территории, который ожидается во временном интервале геокриологического прогноза. Произведение вероятности наступления необратимого изменения геокриологических условий на величину ущерба и будет соответствовать искомому геокриологическому риску.

ОЛЕДЕНЕНИЕ В ОБЛАСТИ КРИОЛИТОЗОНЫ СИБИРИ КАК ПРОЯВЛЕНИЕ КРИОРАЗНООБРАЗИЯ

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Сегодня на основе системных знаний о холодном мире намечены широкие перспективы криологических исследований. В первую очередь это требует объединения имеющейся информации в систему научных взглядов по всему перечню порожденных холодом явлений, которые могут быть охвачены понятием “криоразнообразие” (Мельников и др., 2013). Холод – понятие антропосенсорное, в физике такой величины нет, но в мерзлотоведении оперировать им приходится постоянно, и можно опереться на значение греческого слова “криос” (χρνος), ставшего основой терминогии этой науки. Оно означает и “холод, мороз”, и “лед”. Ведь греческий язык рожден в субтропиках, где слова, определяющие холод и мороз, привычно ассоциируются с порожденным ими явлением “лед”. Аналогичное происходит в других языках в тех краях. Например, на иврите слово “кор” (קור) означает “холод”, производное от него “кэрах” (קרח) – “лед”, от которого далее образуется слово “кэрхон” (קרחון) – “ледник”.

По сути, понятие “холод” подразумевает состояние среды при отрицательных температурах, и в таком значении оно фактически уже вошло в терминологию, ведь устоявшийся термин “криогенез”, как совокупность различных процессов, протекающих при отрицательной температуре и ведущих к развитию образований из мерзлых, пород, буквально означает “порождаемое холодом”. Однако в отношении ледников ассоциации неоднозначны.

Исходное вещество ледников снег – продукт криогенеза атмосферы; однако ложась на землю, он может порождать скопления преобразованного из него льда и в области криолитозоны, и вне ее. Причем исторически получилось, что ледники второй группы стали изучаться раньше, и на этой основе сформировался устойчивый взгляд об антагонизме образований снежного и мерзлотного происхождения. В итоге до сих пор непривычно рассматривать ледники как продукт охвата их криогенезом и на земной поверхности, даже если они расположены в области криолитозоны. Хотя это лишь означает проявление криогенеза в отношении геологических тел из первично мерзлых, хотя и специфических горных пород – снега и сформированного из него льда. Тем более что из снега и льда состоит и другая форма наземного оледенения – наледи, относимые к мерзлотным явлениям. Просто ледниковый лед – следствие осадочно-метаморфического льдообразования, а наледный – преимущественно конжеляционного.

В Сибири все ледники приурочены к криолитозоне (Шейнкман, 2012), т.е. оледенение является здесь продуктом криогенеза и атмосферы, и литосферы. Будучи объектом науки о ледниках, оно становятся объектом и науки о мерзлых породах, и анализировать его следует с позиций системных представлений криологии Земли, согласно которым все льды, представляя собой проявление криоразнообразия, должны рассматриваться во взаимодействии – как криогенные геосистемы (Мельников и др., 2010). Чтобы показать ситуацию с особым случаем – ледниками в области криолитозоны, т.е. – когда они становятся основным элементом криогенных систем, в названии целесообразно добавить поясняющее слово “гляциальный”, и вести речь уже об оледенении как своеобразной криогенно-гляциальной системе (Sheinkman, 2011).

Охват криогенезом не только исходного вещества ледников в атмосфере, но и их тел на земной поверхности придает им и проводимой ими геологической работе особые черты. Их учет, однако, стал возможен лишь в последние десятилетия, когда появились соответствующие данные, ведь долгое время господствовало мнение об антагонизме образований снежного и мерзлотного происхождения. Тем не менее, как проявление криоразнообразия (Мельников и др., 2013) в рамках криогенно-гляциальных систем формирование ледников как компонента криолитозоны вполне закономерно, и их изучение в этом плане позволяет лучше понять многие криогенные процессы.

ЗАСОЛЕННЫЕ ТАЛЫЕ И МЕРЗЛЫЕ ГРУНТЫ ЯКУТСКА

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Засоленные мерзлые грунты обладают особыми инженерно-геологическими свойствами, определяющими низкую несущую способность и неустойчивость к техногенным воздействиям. Авторами анализируются результаты геокриологического и геохимического мониторинга, проведенного на территории Якутска.

Засоление почв в городе (в отличие от природного) не имеет площадного распространения. Степень засоленности почво-грунтов (глубина 0,10 – 0,20 м) колеблется в широком диапазоне: от незасоленных (0,021%/100г) до сильно засоленных (0,98%/100г), преимущественно в старой части города, где сформировались крупные литохимические аномалии, в пределах которых засоление грунтов превышает 1%/100 г. Химический состав отличается разнообразием, засоление может быть хлоридным, сульфатным и карбонатным.

Для грунтов деятельного слоя (глубина 2-3 м), характерно преимущественно хлоридно-сульфатное засоление, с соотношением анионов SO_4^{2-}>Cl^-> HCO^{3-}. Степень засоленности также изменяется в широком диапазоне: от незасоленных (0,017%/100г) до сильнозасоленных (0,96%/100г).

В многолетнемерзлой толще (глубина 5-6 м) засоленность грунтов уменьшается. В составе солей преобладают гидрокарбонаты и сульфаты, но в местах старой городской застройки фиксируются аномалии сильнозасоленных грунтов с концентрацией до 1%/100г.

Максимальная концентрация солей и наибольшая глубина проникновения и распространения засоленных грунтов отмечена в старой части города, где продолжительность антропогенного воздействия составляет от 150 – 200 до 300 лет, там же расположено большинство (около 70%)

аварийных зданий и сооружений. Минимальная засоленность грунтов наблюдается в относительно новых районах города с продолжительностью техногенеза менее 80 лет.

На территории города глубина распространения засоленных грунтов составляет обычно около 6 м. Однако на ряде участков города засоленные породы достигают глубины 9,0 - 10,0 м и даже 14,0 м. Как правило, это участки существующих или промерзших таликов под озерами или старицами. С помощью дешифрирования старых аэрофотоснимков городской территории (1946 г.) и сравнения с современными космическими снимками было определено местоположение полностью или частично засыпанных озер в центральной части города и определено их положение на современной карте города.

Температура начала замерзания грунтов, засоленных хлоридами и сульфатами магния, натрия и кальция, составляет -2,3°C на глубине 2-5 м и -1,1°C - на глубине 6 м. Переход засоленных грунтов из пластично-мерзлого в твердомерзлое состояние происходит при более низких температурах. Поэтому засоленные мерзлые грунты отличаются пониженной прочностью и малыми значениями сопротивлений сдвигу по поверхности смерзания с фундаментом Они отличаются повышенным коррозийным воздействием на материал фундаментов.

Процесс засоления почво-грунтов и грунтов наносит прямой и косвенный ущерб городскому хозяйству, угрожает устойчивости сооружений, вызывает аварии и разрушения жилых зданий, промышленных площадок и транспортных магистралей, служат причиной чрезвычайных ситуаций, создают экологические проблемы (в частности препятствует озеленению городского ландшафта).

ОСОБЕННОСТИ ТРЕЩИНООБРАЗОВАНИЯ В ТОРФЯНОЙ ТОЛЩЕ ЗОНЫ «ОСТРОВНОЙ» МНОГОЛЕТНЕЙ МЕРЗЛОТЫ

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Проведены работы на Надымском стационаре ИКЗ СО РАН (Тюменская область, ЯНАО, район г. Надым). Исследования трещин в торфяной толще производились на плоскобугристых торфяниках. В ходе изучения особенностей процесса трещинообразования в пределах одного торфяника выявлены трещины двух типов: морозобойные и иссушения.

Морозобойные трещины имеют широкое распространение на территории торфяника. Примером морозобойной трещины может служить трещина в разрезе с координатами N 65°18'; E 72°51'. Разрез приурочен к мелкобугристому торфянику, который разбит понижениями на изометричные образования (полигоны) диаметром 0,5-3 м и относительной высотой 0,1-0,2 м, местами до 0,4 м. Ширина межполигональных понижений 0,2-0,7 м. Различимость полигонов осложнена тем, что понижения зарастают кустарничками. На поверхности полигонов торф более плотный, чем в понижениях. В профиле пространство между соседними полигонами, сложенным более плотным торфом заполняется светлым современным (более сухим, рыхлым и слаборазложенным). На глубине 0,2-0,3 м в понижении вскрывается мерзлота, на прилежащих полигонах мерзлота вскрывается с глубины 0,5 м. Изученные трещины не имеют признаков сингенеза с трещинами иссушения.

Трещины иссушения локализованы на участках лишённых растительного покрова, диаметр, которых может достигать 5-7 м, часто на южных дренированных склонах. На одном из пятен, лишённых растительного покрова, отмечены трещины размером 1 на 2 м на пологом склоне плоскобугристого торфяника, с координатами N 65°17'; E 72°53'. Трещины усыхания, шириной с поверхности до 3 см разбивают поверхность на мелкие блоки, во вскрытом профиле прослеживаются до глубины 0,15-0,2 м.

Исследования профилей торфяной толщи в местах выраженных трещин иссушения не указывает на развитие здесь морозобойного процесса, а содержит следы промерзания-оттаивания с интенсивной миграцией влаги и изменением объёма вещества. Основную роль в переработке торфа в верхней части профиля играет иссушение и промерзание оттаивание.

Отмеченные образования, являющиеся следствием явления трещинообразования, подчёркивают контрастность климатических условий и мозаичность ландшафтного покрова в районе исследований. Морозобойные трещины и трещины иссушения при этом развиваются в разные сезоны года, поэтому теоретически могут развиваться одна по другой. Тем не менее, ландшафтные условия участков развития одного вида трещин затрудняют образование других, поэтому такого не происходит.

ВЗАИМОДЕЙСТВИЕ НЕКОТОРЫХ ОРГАНИЧЕСКИХ ВЕЩЕСТВ С ПОВЕРХНОСТЬЮ ДИСПЕРСНОГО ЛЬДА

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Еще Е. М. Катасонов (1954)указывал, что изменение криогенной текстуры мерзлых пород связано с изменением содержания органических остатков в грунтах. Аналогичные наблюдения были сделаны в лабораторных условиях при промораживании грунтов, обработанных различными смазочными препаратами (Яркин, 1981). Грунтовые воды обогащаются различными веществами, растворяя продукты разложения органических остатков.

При промораживании влажных грунтов возможно формирование мерзлых пород с различной криогенной текстурой в зависимости от содержания органических веществ. Если они способны адсорбироваться на поверхности дисперсного льда, то могут влиять на число зародышей, которые образуются при кристаллизации воды, их размеры и форму. Таким образом, изучение характера взаимодействия органических веществ с поверхностью дисперсного льда важно как с теоретической, так и практической точки зрения.

Если органические вещества взаимодействуют с поверхностью дисперсного льда из их растворов в индифферентном ко льду органическом растворителе, то убыль концентрации вещества в растворе должна быть обусловлена переходом его в жидкоподобную пленку, существующую на поверхности льда. Сорбционная способность вещества (Нечаев, Федосеева, Федосеев, 1981) при этом коррелировала с величиной коэффициента распределения его между водой и органическим растворителем при обычной температуре. Появлялся слой объемного водного раствора при увеличении концентрации таких веществ в системе. Изотерма сорбции была вогнутой относительно оси равновесных концентраций.

Поведение о-бромбензойной кислоты в сорбционных экспериментах отличалось от описанного выше. Во первых, форма изотермы сорбции была выпуклой и подчинялась уравнению адсорбции Ленгмюра. Во-вторых, форма изотермы не изменялась с изменением температуры, что являлось свидетельством взаимодействия молекул этой кислоты именно с поверхностью частиц льда. Такие результаты позволили предположить, что о-бромбензойная кислота может быть использована для оценки удельной поверхности частиц льда. Подтверждение этому было получено при изучении адсорбции о-бромбензойной кислоты на образцах снега, отобранного с разных по температурному и влажностному режиму площадок (Макаров, Федосеев, Федосеева, 1990). В последующем, такой способ оценки удельной поверхности дисперсного льда был использован при изучении динамики миграции растворимых веществ на границе снежного покрова с подстилающим субстратом.

Характер распределения о-бромбензойной кислоты между поверхностью частиц льда и раствором кислоты сохранялся при переходе от растворов в органическом растворителе к растворам в воде. Энергия адсорбционного взаимодействия в случае водных систем была заметно выше.

НЕКОТОРЫЕ РЕЗУЛЬТАТЫ ИССЛЕДОВАНИЯ ИЗОТОПНОГО ФРАКЦИОНИРОВАНИЯ ВОДЫ В ПРОЦЕССЕ СЕГРЕГАЦИОННОГО ЛЬДООБРАЗОВАНИЯ

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Изотопные исследования ледяных образований криосферы - ледниковых покровов, ледников и залежеобразующих подземных льдов стали одним из основных методов получения информации о климатических условиях прошлого. При этом текстурообразующие льды изучены значительно меньше и, несмотря на иной механизм их образования, к интерпретации их изотопного анализа применяются такие же подходы, как и ко льдам, формирующимся из атмосферной влаги. (Michel, 2011, Деревягин и др. 2012). Для того чтобы выяснить, как формируется изотопный состав текстурообразующих льдов, необходимо знать принципы его образования. Однако, в настоящее время отсутствуют данные о различии или его отсутствии в изотопном составе свободной и участвующей в миграции влаги. Тем не менее, можно предположить что вода, участвующая в миграции и формирующая сегрегационный лёд и лёд-цемент, характеризуется свойствами, отличными от таковых у свободной воды и может иметь изотопный состав, отличающийся от изотопного состава свободной воды. Кроме этого, можно предположить, что концентрация и распределение стабильных изотопов кислорода и водорода в текстурообразующих льдах должна изменяться и в результате фазовых переходов.

Внешней средой для грунтовой влаги является сам грунт, степень воздействия которого на распределение влаги и изотопов зависит от минерального состава, размера и особенностей взаимодействия фаз с частицами грунта. Характеристики грунтовых частиц служат факторами, определяющими удельную поверхность и поверхностную энергию минеральной матрицы, а также содержание в грунте незамерзающих при отрицательной температуре некоторых объёмов воды, часто называемым «незамёрзшей водой». Свойства этой воды, находящейся во взаимодействии с ионами, атомами и молекулами, формирующих поверхность грунтовой матрицы, отличаются от свойств объёмной воды, что допускает возможность иного содержания в ней молекул, включающих тяжёлые изотопы водорода и кислорода. Однако кристаллизация такой воды, вероятно, вновь допускает изменение соотношения легких и тяжелых изотопов, как и в свободной воде.

Для подтверждения вышеприведенной гипотезы авторами проведены эксперименты с образцами грунтов каолинита Просяновского месторождения, которые с заданной влажностью и известным изотопным составом использующейся в опыте воды промораживались в установке одномерного промерзания с заданным градиентом температуры. Вода для анализа отбиралась в установке, которая позволяла путём выпаривания грунтовой влаги в герметически закрытом объёме получить всю воду, содержащуюся в пробе. На основании проведенных экспериментов можно сделать следующие выводы. В талой части образца каолинита вода (предположительно, вода, «связанная» с грунтом, но не участвующая в миграции) показала изотопный состав «тяжелее» по кислороду и «легче» по водороду, чем исходная, что согласуется с данными Ю.А. Фёдорова (1999). В мёрзлой зоне с массивной текстурой вода (вода, формирующая лёд-цемент) была «тяжелее» как по кислороду, так и по водороду по сравнению с исходной водой. В верхней части грунта, во втором сверху по мощности ледяном шлире (7 мм), изотопный состав был «тяжелее» как по кислороду, так и по водороду по сравнению с исходной водой, но «легче», чем в массивном горизонте. Наибольшие отличия изотопного состава от исходной воды в сторону «утяжеления» был характерен для тонкого слоя с массивной текстурой, расположенного непосредственно под этим шлиром. Закономерности распределения изотопного состава в верхнем, менее мощном, шлире (3 мм) и подстилающей его части такие же, но менее выраженные.

Полученные данные позволяют предположить, что в миграции влаги к фронту промерзания участвуют наиболее «лёгкие» по изотопному составу объёмы влаги, причём эта миграция наиболее активна в приконтактовых к формирующемуся шлиру льда слоях. Поскольку именно эта «легкая» вода идет на формирование шлира, под ним, формируя массивную текстуру остается самая тяжелая вода. В самом же формировании льда шлира участвует та самая мигрирующая более «лёгкая» вода, но закон дифференциации изотопов при кристаллизации даёт «утяжеление» изотопного состава почти до значений исходной воды. Кроме этого, эффект отмеченной изотопной дифференциации, показывает зависимость от скорости промерзания и роста шлира, и чем меньше первый фактор и больше второй, тем эта дифференциация более значительна.

Полученные данные позволяют утверждать о значительной и достаточно сложной структуре дифференциации изотопного состава связанной влаги при сегрегационном льдообразовании. Поэтому интерпретация изотопных данных текстурообразующих льдов для палеогеографических реконструкций должна вестись на иных принципах, отличных от льдов атмосферного происхождения.

РАСПАД МЕТАСТАБИЛЬНЫХ ГАЗОГИДРАТОВ В РЕЗУЛЬТАТЕ КРИСТАЛЛИЗАЦИИ ПЕРЕОХЛАЖДЕННОЙ ВОДЫ

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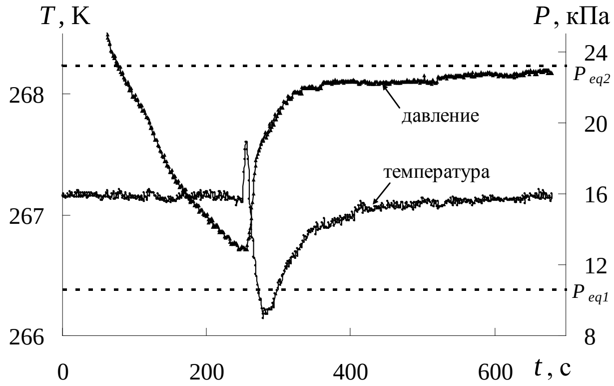
Метастабильные состояния газогидратов реализуются в области *P-T* параметров, ограниченной на фазовой диаграмме линиями равновесия “лед-гидрат-газ” и “переохлажденная вода-гидрат-газ” [1]. Предполагается, что условием перевода гидрата в область метастабильных состояний является отсутствие его прямого контакта с кристаллами льда [2].

В данной работе *P-T* методом исследована устойчивость метастабильных гидратов фреона-12 и пропана к внешним воздействиям. Установлено, что кристаллизация воды инициирует разложение метастабильного гидрата на лед и газ. Об этом в *P-T* экспериментах свидетельствует понижение температуры образца и рост величины давления, которое с течением времени асимптотически приближается к линии равновесия “лед-гидрат-газ” (рис.).

Опытным путем показано, что устойчивость газогидрата в области метастабильных состояний во многом определяется временем жизни переохлажденной воды, контактирующей с его поверхностью. С понижением температуры метастабильный гидрат становиться менее устойчив, т.к. при этом возрастает активность гетероядер нуклеации и сокращается время жизни переохлажденной воды. Установлено, что увеличение скорости понижения давления газа в пределах метастабильной области повышает вероятность кристаллизации переохлажденной воды, и, соответственно, вероятность распада гидрата.



Распад метастабильного газогидрата фреона-12 в результате кристаллизации переохлажденной воды. P_{eq1}, P_{eq2} - соответствующие давления равновесия “переохлажденная вода-гидрат-газ” и “лед-гидрат-газ” при температуре равной 267,2 К.

В свою очередь, перевод метастабильного гидрата через линию равновесия “переохлажденная вода – гидрат - газ” сопровождается его разложением с образованием жидкой фазы воды. Возможен и обратный перевод гидрата из области абсолютной неустойчивости в область метастабильных состояний, если в процессе данного перехода в образце не образуется лед. Установлено, что при одной и той же температуре более устойчивы гидраты фреона, чем гидраты пропана.

В дальнейшем предполагаются аналогичные исследования с использованием широкого класса гидратообразующих газов.

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МЕХАНИЗМЫ РАЗРУШЕНИЯ МЕРЗЛОГО ГРУНТА

Коновалов А.А.

ИПОС СО РАН

Связи между частицами мерзлого грунта в зависимости от близости к температуре плавления $t_{пл}$ могут быть пластичными (“плавильными”) вблизи $t_{пл}$ и хрупкими (“сублимационными”) вдали от $t_{пл}$. [Коновалов 2009, 2011]. Энергия пластичных связей равна удельной теплоте плавления (кристаллизации) $Q_{пл}$, хрупких – удельной теплоте сублимации $Q_с$. Разные типы связей частиц мерзлого грунта определяют и разные механизмы его разрушения. Пластичное разрушение заключается в деформировании мерзлого тела (связей его частиц) с постепенным переходом в жидкообразное, текучее состояние, которое фиксируется по достижению значения относительной деформации, близкого к $j_{пл} \approx$ 0,083÷ 0,12. Сублимация соответствует полному разрыву атомной связи, образованию на ее месте “пустоты”, когда относительная деформация максимальна – $j_с \approx 1$ (у льда величины $j_с$ и $Q_с$ больше $j_{пл}$ и $Q_{пл}$ примерно в 12 раз). На макроуровне такая деформация локальна, приурочена к участкам с ослабленными связями – концентраторам напряжения (микротрещинам, дефектам структуры...). Она развивается незаметно для наблюдателя в форме трещинообразования в направлении сжатия и фиксируется по развалу тела на части. Формула долговечности пластичной мерзлоты имеет вид [Коновалов, 2009, 2011]:

$$\tau_{д} = \tau_{\min} (P_{m..пл} / P)^{1/j_{пр}}, \qquad (1)$$

Долговечность мерзлого грунта с низкой температурой плавления определяется по известной формуле [Регель и др., 1974], приведенной к виду [Коновалов, 2009, 2011]:

$$t_{д} = \tau_{\min} \exp[2 \cdot (T_0/T)(1- P/P_{m.c}) / j_{пр}] \qquad (2)$$

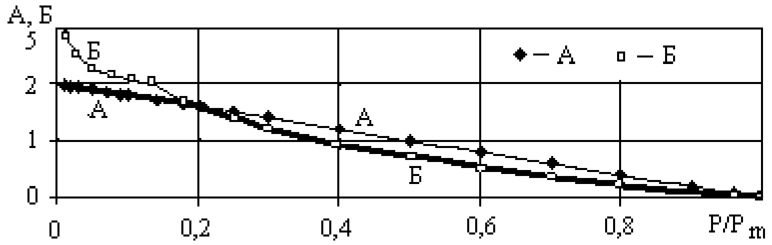
Максимальная (условно мгновенная) прочность пластично- или хрупко- мерзлого грунта, в общем случае - P_m, равновесная минимальной долговечности $\tau_{\min}$,определяется из уравнения Клапейрона - Клаузиуса, в которое подставляется текущая температура мерзлого грунта $t < t_{пл}$, и соответствующие объемные теплоты ($L_{пл}$ или L_c) и деформации ($j_{пл}$ или j_c) фазовых переходов. Заменив индексы при этих величинах на один общий - «ф», получаем единое выражение для максимальной (мгновенной) прочности:

$$P_m = L_ф \, t / (j_ф \cdot T_0) \qquad (3)$$

Приведем формулы долговечностей (1) и (2) к сопоставимому виду:

$$j_{пл} \ln(t_{д} / t_0 = 2 (T_0/T)(1 - P/P_m) = А \,, \; j_{пл} \ln(t_{д} / t_0) = \ln(P_m / P) = Б.$$

Отношение T_0/T у обычного льда (льда I), существующего в диапазоне температур 251-273 К, изменяется в пределах 0,92…1. Зависимости условных долговечностей А и Б от P/P_m при T_0/T = 0.96 представлены на рисунке. Жирная линия отражает зависимость реальной (т.е. минимальной из А и Б) относительной долговечности (в логарифмическом масштабе) от относительного давления, независимо от механизма разрушения.



Зависимость А и Б от $P/P_м$

Из рисунка видно, что при $P/P_m \geq 0{,}2$ долговечность больше у хрупкого тела (А>Б). Это означает, что критическая деформация $j_{пр}$ достигается раньше, чем тело разваливается на части. Следовательно, для обеспечения устойчивости проектируемого на таких грунтах сооружения долговечность и прочность нужно рассчитывать по формуле (1), как для пластичного тела. При $(P/P_m) < 0{,}2$, наоборот, больше “пластическая” долговечность (Б >А), поэтому тело разваливается раньше, чем достигается критическая деформация $j_{пр}$. Следовательно, долговечность и прочность в этой области нужно рассчитывать по формуле (2), как для хрупкого тела.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